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UW1 Utility Vision

This Utility Vision establishes aspirations for the City of Fort Lauderdale's potable water and wastewater utilities to achieve by year 2035. Clean water and sanitation are necessities for communities to thrive and prosper; this carries great emphasis for the City of Fort Lauderdale. The quality, security, and innovativeness of our community's infrastructure will be comparable to the best cities in the United States by 2035, proving that ***the City is, and always will be, ready*** to meet future utility challenges. To build on the improvements throughout the City's water and wastewater systems, such as the progressive water treatment upgrades at the Peele Dixie Water Treatment Plant (WTP), all of our water treatment facilities will be state of the art by 2035, supported by fully integrated water resources management. Wastewater collection and treatment will support and protect the miles of canal networks, intracoastal waterways and coastline to keep Fort Lauderdale beautiful and safe. Water is the bond that connects our community and shapes our future, our goal is to continue practicing preservation of our environment and conservation of our water.

Beginning with the Comprehensive Utility Strategic Master Plan, started in 2015, which builds on previous master planning efforts and unifies all of the main components of the City's utility system, the City is creating a sustainable water system that accounts for energy conservation, climate change and population growth. From our potable water supply to biosolids production, master planning is a valuable resource that provides the City guidance to revitalize utility infrastructure, while at the same time growing it to meet forecasted 2035 population. Master planning is, and will be focused on assessing and improving the water treatment plants, distribution systems, the wastewater treatment plant, sewer systems, and water supply and storage. Furthermore, master planning anticipates ever-changing regulations, and proactively prepares the City to continue to meet and exceed regulatory requirements. The future of Fort Lauderdale will thrive, in part, to a carefully selected path laid out by master planning efforts.

During the City's Visioning initiative conducted in 2013, citizens consistently expressed concern over the sustainability of our long-term water supply. In 2015, this is a well-founded question when considering the residential and commercial growth experienced by the City, and the desire to continue protecting Florida's highest quality ground water sources for future generations. The Vision includes maintaining and improving environmentally friendly policies, including a sustainable water supply into year 2035. With improved efficiency of our reverse osmosis membrane (membrane) treatment processes and the City's continued efforts in monitoring and protecting the Biscayne Aquifer, the Biscayne supply and alternate water supplies will continue to be accessible and provide the ***highest quality water*** through the next 20 years.

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In addition to maintaining our Biscayne Aquifer potable water supply and considering future alternate brackish and surface supplies, the City continues vigorous efforts to maximize water conservation. Even with extensive primary and alternate supplies, year 2035 customers will maintain restraint and use our precious water supply resource judiciously. The City will continue its track record of conservation success as evidenced by setting and achieving its goal of 170 gallon per capita day (gpcd) of unit water demand; in 2009 the City's unit demand was 194 gpcd and has reduced to 170 gcpd in 2015. The City of Fort Lauderdale will lead the way in effective water usage and conservation to continue compliance with the 170 gpcd goal into the future and possibly reduce it further. Continued achievement of water demand goals will be met by continuing to develop, improve and implement conservation concepts and methods from other successful utilities to minimize excessive water consumption. For example, the City could implement the increasingly common practice for institutional, commercial and multi-family residential communities of utilizing a ***grey water irrigation system,*** such as the Living Machine® technology at the San Francisco Public Utilities Commission Headquarters-North America's Greenest Urban Office Building, to avoid using potable water for lawn irrigation.

In 2035, water is not the only resource being conserved. Energy use reduction is already (in 2015) at the forefront of the City's mission for a greater Ft. Lauderdale. The pumping requirements of the membrane treatment process are a large consumer of electricity and in the future, the City will continue to minimize power consumption with energy recovery devices (ERD) that transfer excess energy from the membrane process to supplement pumping energy. ERDs have become a standard tool in all new membrane treatment plants and will continue to save energy in the future. By 2035 utility operators will have the ability to monitor energy usage at key, major equipment and utilize that information to minimize energy costs. Treatment process elements such as motors and lighting will have been strategically replaced with higher efficiency models to optimize energy efficiency. The City has been working on energy initiatives since 2013.

At the center of our energy use reduction efforts lies the George T. Lohmeyer Wastewater Treatment Plant (GTL) which is currently a large consumer of energy. By 2035, the City aims to modify the GTL to produce some of its own energy. Moving towards ideal zero-carbon footprint operations, the GTL could convert previously wasted biosolids into useful resources through a process known as anaerobic digestion. Methane gas produced during the digestion process, in combination with fats/oils/grease and other food waste can be harnessed and used as fuel to

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power significant operations at the GTL. Aeration systems can utilize technology such as vapor pressure swing adsorption (VPSA) to achieve premium efficiency. The biosolids produced from the wastewater treatment process can then be sold to agricultural industries for nutrient rich land applications. Furthermore, the City will continue to search for ways to reuse the reclaimed water produced in a manner that is feasible and beneficial to the community. These improvements will assist the utility achieving the goal of reducing their energy consumption 20 percent by the year 2020 and continue to improve beyond.

In 2035, our water and wastewater systems will achieve top percentile integrity ratings, a vital goal to sustaining our community and our environment. The path to achieve this goal will be assisted by a utility-wide asset management system that helps track and prioritize key repair and replacement capital needs. The asset management system will be geographical information system (GIS)-centric allowing users to visualize priority needs and adjust capital project schedules as condition and risk assessments dictate. The City in 2035 will continue to proactively repair infrastructure and replace when repair requirements are no longer cost effective.

The Utility Goals that will Lead to Our Success

Sector of Infrastructure	Goals established in 2014
Potable Water Treatment	• Improve water quality from Fiveash WTP by investigating different technologies • Increase redundancy in some processes to allow for efficient repair and cleaning • Better monitor and control of pH levels • Determine water quality of Biscayne Aquifer and feasibility of additional wells
Wastewater Treatment	• Investigate feasibility of anaerobic digestion for the purpose of methane capture • Convert biosolids to marketable agricultural land application use • Use reclaimed water as a barrier between potable water and salt intrusion, and expand deep well capacity
Distribution and Transmission	• Increase I/I monitoring and identify projects that will minimize reduce I/I. • Prioritize distribution system projects to prevent water main breaks and customer complaints. • Raise lift station walls, and protect against flooding so that the sewer system is not the first failure to occur during a storm event
Energy and Water Conservation	• Reduce energy consumption 20% by the year 2020. • Increase the use of grey water irrigation, especially in commercial and multi-family buildings. • Analysis of the efficiency of pumps in both process and service capacities • Continued use of energy recovery devices on membrane processes to harness unused residual pressure.

In year 2035, the City will be prepared for changes in climate. Year 2012 had some of the most unusual weather patterns and events in the history of the United States. During this period, Fort Lauderdale suffered extensive damage when seasonal high tides collided with the effects of Hurricane Sandy and subsequent storms as they passed over our coast. National news covered the destruction of a four-block stretch of State Road A1A, which prompted the City to close two lanes of traffic and a bicycle lane to make emergency repairs. Newspaper and social media headlines such as “A1A mess may be wave of our future” and “Floods linger after Sandy” sounded the alarm to act. From that point forward, all future improvements to the water distribution and sewer systems were, and will continue to be, designed with flooding protection and storm resistance in mind. In 2035, vital structures of the treatment facilities will be ***hardened and fortified*** to withstand hurricanes and sea level rise caused by climate change, through efforts such as continued investigation into the impact of sea level rise and proactive wellfield improvements where needed. While ample storage is currently (2015) provided in the potable water system, year 2035 will have expanded and more efficient storage of finished water at the treatment plants and in the distribution system.

The City of Fort Lauderdale Utility Vision for 2035 will be to establish a resilient community that is prepared for the constantly evolving world around us. Not only will the City have rehabilitated and newly created infrastructure that is sustainable and effective, but over time move from being a reactive utility to a proactive one. A comprehensive Capital Improvement Plan and Renewal and Replacement Schedule will identify projects in our water treatment and distribution system that need attention ***before they become problematic***. Inflow and Infiltration (I/I) monitoring on the sewer will be expanded to provide myriad data on the efficiency of the wastewater collection system. Identifying areas for improvement more efficiently leads to a stronger utility, and the City’s utility is determined to remain the strongest it can be.

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UW2 City-Wide SCADA

2.1 Introduction

The control systems at the City of Fort Lauderdale's water and wastewater treatment plants are Supervisory Control and Data Acquisition (SCADA) systems that generally consist of Programmable Logic Controllers (PLC), Human-Machine Interface (HMI), Remote Telemetry Units (RTU), one or more SCADA computers running HMI software and local area communications networks. The SCADA system automatically controls various plant processes and allows plant operators to monitor equipment operation. The various PLC based process controllers contain programming logic to execute the automated sequences required to operate the associated processes and communicate with other PLC based process controllers for signals and commands to facilitate overall plant production. Process controllers are master PLC control panels that contain and execute the control logic for an area of the treatment process.

This section of the CUS Master Plan provides an overview of the existing hardware and software for the SCADA systems for the Fiveash Water Treatment Plant, Peele-Dixie Water Treatment Plant, George T. Lohmeyer Wastewater Treatment Plant (GTL), and Distribution and Collection Systems and provides recommendations for improvements with conceptual cost estimates. Master Plan **Section UW4** discusses recommendations with respect to manual control of specific process components at the Fiveash and Peele-Dixie WTPs.

2.2 Fiveash WTP

2.2.1 Existing Conditions

The plant has been in service since the mid-1950's with many modifications made to the process and SCADA system throughout the years. The latest major modification of the Fiveash WTP SCADA system was performed during project number 10387 – Fiveash Water Treatment Plant Upgrades-Phase 1, which was completed in 2007. The existing process level portion of the SCADA system consists of ABB 800 series and Square D Quantum PLCs that are connected via an Ethernet network. The HMI portion of the SCADA system consists of networked desktop computers and servers also connected via Ethernet. The existing SCADA HMI software is Citect SCADA version 7.40 and the Citect Historian version is 4.50. The desktop computers run Citect SCADA HMI software as view and configuration/engineering nodes and the servers run Citect SCADA I/O server node software. Plant staff is very satisfied with the current Citect SCADA software and desires to maintain, and standardize on, the Citect SCADA software platform. There are local remote I/O panels with Operator Interface Terminals (OITs) at High Service Pumps 4&5 that communicate over Profibus Decentralized Periphery (DP) to the associated process controller. There are no OITs at the remaining high service pumps. The Backwash and Surface Wash Pumps have ABB 800C PLCs that communicate to their associated process controller (ABB 800M) over Ethernet communications protocol. Each gravity filter also has an associated Remote I/O Panel and local OIT that communicates over Profibus to an associated PLC based process controller.

The SCADA network servers are housed in two primary locations; the Primary Control Room and the Secondary Control Room, with process controllers and remote I/O panels located in strategic process areas in the plant.

The Primary Control Room generally contains:

- Operator workstations for monitoring Fiveash WTP systems and the Prospect Wellfield.

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- One operator workstation for offsite SCADA monitoring of remote storage tanks at Poinciana Park and Second Avenue.
- SCADA Server No.1.
- Off Site (Prospect Wellfield) SCADA Server
- Historian Server.
- Terminal Server.
- Ethernet Switch for Process Control Communications.
- Ethernet Switch for SCADA HMI.
- UPS with power distribution system.

The Secondary Control Room generally contains:

- SCADA Server No.2.
- UPS with power distribution system.
- Process Controllers 4302A, 4302B, 4303 and 4304.

The Off Site SCADA System generally consists of:

- Fiber Optic Connection to City I-Net System though a Fiber Optic Patch Panel In the Public Services Administration Building.
- Dedicated Switch/Router in the Public Services Administration Building.
- Fiber Optic Cable between the Public Services Administration Building and Fiveash Operations Building.
- Off-site SCADA Server and workstation in Primary Control Room.
- Off-Site SCADA workstation in the Secondary Control Room.

Process Controllers 4302A & 4302B communicate over Profibus to remote I/O control panels that monitor and control:

- Filter Group 1-11.
- Filter Group 12-22.

Process Controller 4303 communicates over Profibus to remote I/O control panels that monitor and control:

- Hydrotreaters 1, 2, 3 & 4.
- Aeration Basin.
- Reservoir 1 Level.
- Aeration Influent Valve Actuators (direct connect via Profibus).
- Hydrotreaters 1, 2, 3 & 4 Flow Control Valve Actuators and Flowmeters (direct connect via Profibus).
- Lime Storage
- Lime Slakers.
- Existing Digital Command Control (DCC) Panel.

Process Controller 4304 communicates over Profibus to remote I/O control panels that monitor and control:

- Clearwell 1 Level.
- North High Service Pump Station Discharge Pressure.
- Filter Channel Levels

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- Compressed Air System.
- Coagulant Polymer Feed System.
- Washwater Recovery.
- High Service Pumps 12-16 Flow Meters (direct connect via Profibus).
- Clear well 7 Level.
- Clear well 1 Strike Down Valve Actuators and Clear well 7 Strike Down Valve Actuators and Sluice Gates

Process control PLC Panels are installed for:

- Ammonia System.
- Lime Sludge Pump Station.
- High Service Pumps 4 & 5.

Projects No. 10508D – Fiveash Reliability Upgrade and Project No. 11589 – Fiveash Disinfection System Replacement will replace and upgrade many of the existing ABB PLCs and all of the Square D Sy-Max PLCs to Rockwell Automation (Allen-Bradley) CompactLogix units. As part of these projects, a new Allen-Bradley ControlLogix PLC system will be installed in a new Hypochlorite Building for a new Hypochlorite System. The ControlLogix PLC does require new programming software that is not directly compatible with the existing ABB units, therefore a gateway between the two platforms is required for integration.

The following is a summary of the SCADA system improvements contained in Projects 10508D and 11589:

- Primary Control Room:
    - Addition of process control and monitoring workstations in the center console including a wall mounted display; workstations in Chief Operators Office, Process Control Engineer's Office, Plant Manager Office and Lab.
    - Upgraded SCADA Server No.1
    - Upgraded Historian Server
    - Ethernet Switch for HMI workstation subnet
    - Ethernet switches and redundant 1GB fiber optic cables to establish a redundant path to the Secondary Control Room SCADA Servers and Process Controllers. Extension of the redundant path to High Service Pump Station No.2 Switchgear Room for connection of new Process Controller 4301 and local PLCs/OITs at the High Service and Transfer Pumps.
    - Addition of an Off-Site SCADA Server (No.1).
- Secondary Control Room:
    - Addition of local process control and monitoring workstation; addition of workstation in Chief Mechanics Office.
    - Ethernet Switch for HMI workstation subnet.
    - Upgraded SCADA Server No.2
    - Addition of an SQL server to back-up existing Historian
    - Addition of an Off-Site SCADA Server (No.2)
    - Ethernet switches and redundant 1GB fiber optic cables to establish a redundant path to the primary Control Room SCADA Servers.

- Redundant 100 mbs connections to existing Process Controllers 4302A, 4302B, 4303 and 4304.

- New Process Controllers/PLC panels added for:
    - Process Controller 4301 - Diesel Systems including Generators, Diesel Pumps, Diesel Fuel Systems, Air Start System and Vacuum Priming System, Reservoir Levels.
    - Lime Fill System.
    - Fluoride System.
    - Color Polymer System.
    - Backwash Pumps 2 & 3.
    - Transfer Pumps 1 & 2.
    - Surface Wash Pumps 1 & 2.
    - High Service Pumps 4 & 5.
    - Lime Sludge Pump Station.
    - Dry Polymer Batch System.
    - Hypochlorite System.
    - High Service Pumps 6 through 16.
    - Transfer Pumps 1, 2, 3 & 6.
    - Washwater Pump Station.
    - Ammonia Building.
    - Sodium Hypochlorite Facility.
    - Emergency Generator Facility.

- Modifications to the Off-Site SCADA System are:
    - New RTU to convert tone telemetry for pressure monitoring stations at Imperial Point, Harbor Beach, Bayview Drive and Seagrape Drive.
    - New fiber optic media convertor and Firewall for connection to the City's I-net system to monitor Remote Storage Tanks at Poinciana Park and Second Avenue; and Prospect Wellfield.
    - Upgraded switch/router.
    - New Primary and Backup SCADA Servers
    - New SCADA Workstations in the Primary Control Room and the Secondary Control Room.

- New Redundant Ethernet connections and switches in the new Generator Building with a new local PLC panel.

- Addition of redundant 100mbs fiber optic cables and Ethernet Switches in the existing Ammonia Building.

After completion of projects 10508D/11589, there will be approximately ten (10) ABB PLCs and twenty seven (27) ABB remote I/O (RIO) panels remaining.

2.2.1.1 SCADA Network

Plant staff indicates that network security is of primary concern and seeks to secure the SCADA network from external attacks and intrusions. One area of concern for network security is software patch management, including obtaining and implementing regular updates to firmware and software. This is viewed as critical as continuous updates strengthen against vulnerabilities to attacks from external sources or internal sabotage.

Plant staff indicates that Cisco rack mounted Ethernet switches have been reliable and desires to standardize on their product family. Staff also indicates that Hirschman panel mounted Ethernet switches have performed very well and desires to standardize on their family of products for field mounted applications.

Plant staff indicates that the SCADA Servers and Historian Server were recently replaced with new server computers. The new servers are installed with Microsoft Windows Server 2012 with latest patches.

Plant staff indicates that a firewall has been implemented on the City I-net fiber connection to the Prospect Wellfield.

For generating reports, plant staff uses the SQL database imbedded in the Citect Historian software on the historian server and manually configures reports using an SQL interface program. Plant staff has indicated a desire to improve reporting capabilities through implementation of third party software.

The SCADA system presently has no on-call alert management software for remotely notifying off site personnel of critical alarms.

The CUS Master Plan Team observes that the Fiveash SCADA system critical network components are physically separated into two different rooms in the plant to avoid loss of the entire system should a fire occur. This physical separation allows the plant to control the process from either primary or secondary control room without significant interruption. Plant staff indicates that offsite storage of critical programs and data is achieved by plant staff downloading critical programs to a portable storage device and bringing it home so that it is off site in the event of a significant event at the plant.

2.2.1.2 SCADA Controllers

Plant staff indicates difficulty in troubleshooting and maintaining the present SCADA system configuration, specifically in troubleshooting the Profibus networked devices and obtaining service and support for the ABB PLC components. Plant staff indicates a desire to migrate to a common Rockwell Automation (Allen-Bradley) PLC platform due to familiarity, availability of service and support, and user friendliness.

The existing SCADA system communicates with remote I/O panels, flow meters, valve actuators for the filters, high service pumps, transfer pumps and backwash pumps over Profibus DP communications protocol. Plant staff indicates that the Profibus DP network has been problematic and troublesome to troubleshoot and maintain and is not user-friendly. Profibus DP communications is used to communicate between filter valve actuators and flow meters and remote I/O panels to the process area controllers over fiber optic cables, which are connected in a serially sequential fashion at each filter, to the associated filter remote I/O panel. From there, Profibus DP communications is used to communicate from each filter remote I/O panel to the associated process controller. Additionally, Profibus is used to connect all process valve actuators and magnetic flow meters throughout the plant.

Plant staff has indicated a desire for the following:

- Eliminate the Profibus communications protocol for filter valve actuators and flow meters in favor of hard wired signals to the associated process controller and to implement Ethernet communications protocol between process controllers in lieu of Profibus DP.
- Replace all plant valve actuators manufactured by Rotork with similar products manufactured by Limitorque as support for the Rotork valve actuators has been difficult to obtain.
- The Profibus DP network to the filter actuators is difficult to troubleshoot and diagnose.
- Replace the filter remote I/O panels with individual filter process controllers that contain all control logic necessary to control the associated filter and eliminate Profibus DP communications protocol in favor of discrete and analog signals for field devices/instruments and Ethernet for communications to other process controllers and plant SCADA.
- Implementation of a means to take local manual control of a pump or filter if the associated OIT is not functional, as there are presently no local lights or switches to take local manual control of the pump or filter. This subject is addressed with recommendations in **Section UW4** Manual Operations.

2.2.2 Reliability Concerns

The CUS Master Plan Team recommends the City implement the SCADA system modifications put forth in projects No. 10508D – Fiveash Reliability Upgrade and Project No. 11589 – Fiveash Disinfection System Replacement. After these projects are complete, the SCADA system will be of a hybrid configuration with a mixture of Rockwell Automation and ABB PLCs and a mixture of Profibus and Ethernet Communications Protocols. This condition requires interface equipment and programming to bridge the two platforms for system communications between plant processes.

Plant staff have indicated difficulty in maintaining, and troubleshooting, the Profibus DP portions of the network that include communications to valve actuators, flow meters, and from remote I/O cabinets to process controllers, resulting in longer recovery time from control system failures related to the Profibus DP communications. The difficulty in recovery from Profibus communications failures results in longer than expected process interruptions and impacts to overall plant operation. Plant staff also indicates that replacement parts for the Profibus DP flow meters are difficult to obtain and manufacturer support for the valve actuators using Profibus DP is nearly non-existent. The City has begun implementing Limitorque valve actuators in other treatment facilities (GTL Injection Wellfield and Peele-Dixie WTP) with good performance and available support and desires to standardize on their products. Plant staff also indicates that the existing ABB magnetic flow meters for each filter are no longer supported or manufactured by ABB and replacement parts are generally not available.

2.2.2.1 SCADA Network

Network security is of high importance in maintaining system reliability through application of hardware and software intrusion prevention and detection measures. The CUS Master Plan Team recommends the following to fortify network security:

1. Conduct annual IT security awareness sessions for all plant personnel.
2. Install a network intrusion detection system such as Cisco ASA 5505 Adaptive Security Appliance or Checkpoint.
3. Install and configure malware and antivirus protection on all SCADA nodes.
4. Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, engage the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
5. Lockdown SCADA nodes by restricting user access and permissions; disable USB ports; and implement the use of passwords of 10 characters, or higher, using a mixture of letter, numbers, symbols and case sensitivity.
6. Perform hardware site survey every 5 years.
7. Replace existing Cisco Ethernet switches, with new Campus LAN Cisco Ethernet switches.
8. Restrict unauthorized external devices from connecting to the SCADA network.
9. Apply latest security updates and patches on third party application software.
10. Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
11. Implement firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
12. Disable unnecessary software services.
13. Remove or disable unnecessary user accounts.
14. Enable security logging and review security logs for unauthorized access.

The CUS Master Plan Team observes that the Citect SCADA HMI software is of a dated version and recommends migrating to newer editions of the software to maintain system integrity, reliability and reduce vulnerabilities. The CUS Master Plan Team recommends upgrading the existing SCADA system software to Citect SCADA latest version, and to maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.

The CUS Master Plan Team observed that the plant reporting capabilities would be greatly enhanced by implementing a reporting software such as XL Reporter by SyTech, Dream Report by PcVUE solutions, or similar reporting software. Either of these software packages would be useful in improving reporting capabilities. The CUS Master Plan Team recommends that the City obtain trial versions of each product to test the features and determine which is most

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suitable. Upon selection, The CUS Master Plan Team recommends that a maintenance and support agreement be negotiated and that the software be updated every five years to remain current.

The CUS Master Plan Team, together with Plant personnel, have identified that an on-call alert alarm management software, such as Win911 presently in use at the GTL, enhances staff response to alarms and failures resulting in quicker response time and shorter equipment down time. The cost of the software varies depending on the number of alarms and notification means (such as email, voice over IP notifier, smartphone notifier, etc.). The CUS Master Plan Team recommends the City expand the Win911 on-call alert system in use at G.T. Lohmeyer to Fiveash and negotiate a maintenance and support agreement with the manufacturer. The CUS Master Plan Team further recommends the software be updated every five years to remain current.

The CUS Master Plan Team recommends the City standardize on Cisco rack mounted Ethernet switches and Hirschman panel mounted Ethernet switches because of staff familiarity, performance, support, and ease of application. The CUS Master Plan Team further recommends establishing service agreements with Cisco and Hirschman to receive, and implement, software and firmware updates to maintain system reliability and security. The CUS Master Plan Team recommends replacing the network switches every five (5) years to keep current with latest technology that will harden and strengthen network security.

2.2.2.2 SCADA Controllers

The CUS Master Plan Team observes that plant staff has great difficulty in troubleshooting and diagnosing Profibus DP communications protocol. The difficulty plant staff has with maintaining the protocol results in reduced reliability of plant operations due to the amount of time necessary to troubleshoot, diagnose, and repair the cause of communication loss. Specifically, the loss of Profibus DP communications at a filter is difficult to diagnose because of the number of devices connected on the protocol and the inherent configuration of the protocol communications, resulting in the filter rendered inoperable until the problem is resolved. All signals to each associated filter valve, and flow meter, are transmitted over a single set of wires, connected serially, via the communications protocol. Therefore, if the communication is lost over the serially connected set of wires, all signals to the field devices are lost and the control logic cannot control, receive data from, or determine status of these devices. Implementation of traditional discrete and analog signals from field devices (valve actuators, flow meters) at each filter, to an associated filter process controller that contains all control logic necessary to operate the filter greatly reduces the single point failures experienced when the communications protocol fails.

Similarly, plant staff desires to eliminate the use of Profibus communications protocol between Remote I/O panels and their associated PLC or Process Controller. This desire is readily achievable as the SCADA modifications under projects No. 10508D – Fiveash Reliability Upgrade and Project No. 11589 – Fiveash Disinfection System Replacement will result in Ethernet communications implemented as the means of peer-to-peer communications and will set the direction for implementation for the remaining system as recommended herein.

The CUS Master Plan Team recommends modifying each filter control system to implement a filter specific PLC based process controller, with discrete and analog signals to field devices, that communicates to plant SCADA over Ethernet communications protocol and with a local OIT, and basic remote manual controls, to allow local manual control of the filter. The CUS Master Plan Team recommends replacement of the existing filter Rotork valves with Limitorque valve actuators to standardize on the type of valve and actuator implemented in the City plants. The CUS Master Plan Team recommends replacement of filter magnetic flow meters using Profibus DP for signal communications with units that transmit traditional 4-20ma DC signals to the associated filter process controller.

The CUS Master Plan Team recommends replacing all remaining Rotork valve actuators and ABB flow meters using Profibus DP in the plant with Limitorque valves and traditional analog signal magnetic flow meters to standardize the plant. Critical programming to the SCADA system is presently stored off site through a manual means of carrying portable storage devices off site. It is recommended that the City implement the recommendations of section 2.8 of UW-2 to have interconnectivity with other water treatment facilities such that offsite storage can be accomplished automatically.

The CUS Master Plan Team recommends replacing the remaining ABB process controller PLCS, Remote I/O Panels and OITs with comparable products from the Rockwell Automation (Allen-Bradley) ControlLogix family including all control software and interface programming. The CUS Master Plan Team recommends that the SCADA system control hardware (PLCs, Remote I/O Panels, OITs) be upgraded to the latest platform every 15 years. With the Fiveash WTP SCADA system completed in potentially two different phases, the recommended replacement window will also stagger accordingly. While a single phase of SCADA implementation would be more ideal, the City has a portion of the implementation planned for the Fiveash Reliability Upgrades Project. The CUS Master Plan Team also recommends implementing Rockwell Automation ControlLogix Studio 5000 for PLC software programming.

2.2.3 Recommendations

1-5 Years (* indicates minor cost or policy items not included in Table UW2-1, Project UW2-1 Fiveash SCADA Improvements or the Fiveash Reliability Upgrades)

- Replace the remaining ABB PLC process controllers and Remote I/O cabinets, including local OITs, to bring the entire plant to a single platform based on Rockwell Automation ControlLogix.
- Implement the SCADA System modifications put forth in City Projects No. 10508D – Fiveash Reliability Upgrade and Project No. 11589 – Fiveash Disinfection System Replacement.
- Conduct annual IT security awareness sessions for all plant personnel.*
- Check firmware of existing firewall/network intrusion detection system such as Cisco ASA 5512 Adaptive Security Appliance or Checkpoint.*
- Install and configure malware and antivirus protection on all SCADA nodes.*
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
- Lockdown SCADA nodes by restricting user access and permissions; disable USB ports; and implement the use of passwords of 10 characters, or higher, using a mixture of letter, numbers, symbols and case sensitivity.*
- Replace and upgrade existing SCADA workstations.
- Upgrade Existing SCADA servers
- Perform hardware site survey every 5 years.
- Replace existing Cisco Ethernet switches, with new Campus LAN Cisco Ethernet switches.

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- Restrict unauthorized external devices from connecting to the SCADA network.*
- Apply latest security updates and patches on third party application software.*
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
- Implement firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.*
- Disable unnecessary software services.*
- Remove or disable unnecessary user accounts.*
- Enable security logging and review security logs for unauthorized access.*
- Upgrade the existing SCADA system software to Citect SCADA latest version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Upgrade reporting software to XL Reporter by SyTech, or Dream Report by PcVUE solutions. The cost will vary depending on the tag counts and the feature requirements selected. Negotiate and maintain a support and upgrade contract to keep the software current and secure.
- Upgrade existing rack mounted Ethernet Switches identified as a security vulnerability to latest Cisco models with updated firmware and software.
- Maintain service agreement with Cisco hardware.
- Implement hardware refresh schedule.
- Install On-call Alert Management Software.
- Conduct routine network and SCADA self-assessments.*
- Implement system backups and disaster recovery plans.

<u>6-10 years (* indicates minor cost or policy items not included in Table UW2-1)</u>

- Modify the control system for filters 1-22 to implement PLC based process controllers with local touch screen and basic manual controls; replace all existing filter Rotork control valve actuators with Limitorque Valve actuators with discrete and analog signals; replace all filter magnetic flow meters with units communicating over traditional 4-20ma analog signals.
- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
- Upgrade network intrusion detection system.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Upgrade rack mounted Ethernet Switches.
- Perform hardware site survey every 5 years.*
- Conduct routine network and SCADA self-assessments.
- Review implementation of system backups and disaster recovery plans.
- Perform firmware and software updates continuously each year.
- Upgrade selected reporting software to latest version. Maintain a service and support contract for periodic updates and support.
- Maintain service agreement with Cisco hardware.
- Replace and upgrade hardware every 5 years according to refresh schedule.

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- Replace and upgrade existing SCADA workstations.
- Upgrade existing SCADA servers.

11-15 years

- Replace all remaining Rotork valves and ABB flow meters using Profibus DP in the plant with Limitorque valve actuators and traditional analog signal magnetic flow meters.
- Upgrade existing PLCs, Remote I/O Panels and OITs to latest products by Rockwell Automation.
- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Upgrade rack mounted Ethernet Switches.
- Perform firmware and software updates continuously each year.
- Perform hardware site survey every 5 years.
- Conduct routine network and SCADA self-assessments.
- Review implementation of system backups and disaster recovery plans.
- Replace and upgrade hardware every 5 years according to refresh schedule.
- Upgrade existing Hirschman Ethernet switches to latest model.
- Upgrade selected reporting software to latest version. Maintain a service and support contract.
- Maintain service agreement with Cisco hardware.
- Replace and upgrade existing SCADA workstations.
- Upgrade existing SCADA servers including:
    - SCADA Servers 1 & 2 (Plant Process Control)
    - Off-site SCADA Servers 1 & 2
    - Historian Server
    - SQL Server

16-20 years (* indicates minor cost or policy items not included in Table UW2-1)

- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Conduct routine network and SCADA self-assessments.*
- Upgrade Process Control PLCs and Remote I/O's to latest products by Rockwell Automation.
- Upgrade network intrusion detection system.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Upgrade rack mounted Ethernet Switches.
- Review implementation of system backups and disaster recovery plans.
- Perform firmware and software updates continuously each year.*
- Replace the balance of the SCADA system PLCs, Remote I/O Panels and OITs.
- Upgrade selected reporting software to latest version. Maintain a service and support contract for periodic updates and support.
- Upgrade existing Hirschman Ethernet switches to latest model.

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- Replace and upgrade hardware every 5 years according to refresh schedule.
- Replace and upgrade existing SCADA workstations.
- Maintain service agreement with Cisco hardware.

2.2.4 Cost Summary

Table UW2-1 below lists the estimated costs (in 2016 dollars) for the recommended SCADA system improvements at the Fiveash WTP. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Table UW2-1. Fiveash WTP SCADA System

Project Description	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
Replace remainder of existing PLCs and RIO's with Rockwell Automation ControlLogix Platform	$2,500,000	$0	$0
Install a firewall/network intrusion detection system such as Cisco ASA 5512 Adaptive Security Appliance or Checkpoint. Replace/Upgrade every 5 years.	$0	$20,000	$40,000
Implement regular software and firmware patches	$25,000	$25,000	$50,000
Perform hardware site survey every 5 years.	$10,000	$10,000	$20,000
Replace existing rack-mounted Cisco catalyst 4006 series Ethernet switches, with new Campus LAN Cisco Ethernet switches. Upgrade to latest technology every 5 years	$25,000	$25,000	$50,000
Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.	$15,000	$15,000	$30,000
Upgrade Citect SCADA to latest version and maintain maintenance contract	$20,000	$20,000	$40,000
Upgrade reporting software	$20,000	$20,000	$40,000
Maintain service agreement with Cisco hardware. Implement hardware refresh schedule	$10,000	$10,000	$20,000
Install On-call Alert Management Software	$20,000	$10,000	$20,000
Implement system backups and disaster recovery plans. Review every 5 years	$15,000	$15,000	$30,000
Upgrade Existing SCADA servers	$0	$30,000	$60,000
Upgrade Field Mounted Hirschman Ethernet Switches to latest models	$0	$25,000	$50,000
Replace and upgrade existing SCADA workstations	$0	$15,000	$30,000

Project Description	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
Modify the control system for filters 1-22 to implement PLC based process controllers with local touch screen and basic manual controls; replace all existing filter Rotork control valve actuators with Limitorque valve actuators with discrete and analog signals; replace all filter magnetic flow meters with units communicating over traditional 4-20ma analog signals.	$0	$3,300,000	$0
Upgrade Process Control PLCs and Remote I/O's to latest products by Rockwell Automation	$0	$0	$1,000,000
Replace all remaining Rotork valve actuators and ABB flow meters using Profibus DP in the plant with Limitorque valve actuators and traditional analog signal magnetic flow meters.	$0	$0	$500,000
Replace the balance of the SCADA system PLCs, Remote I/O Panels and OITs.	$0	$0	$1,000,000
Totals	$2,660,000	$3,540,000	$2,980,000

2.3 Prospect Wellfield

The existing Prospect Wellfield consists of 29 Biscayne Aquifer wells that deliver raw water to Fiveash WTP for treatment. Wells communicate to Fiveash via spread spectrum radio to a master radio remote telemetry unit (RTU) at the eastern generator building that is connected to the City's fiber optic I-Net system owned by Comcast. Each well has a local pump control panel that contains the well pump motor starter. Each well has a local RTU panel that contains a PLC, spread spectrum radio, power supplies, relays and low voltage surge suppressors.

2.3.1 Existing Conditions

Each well RTU contains a Schneider Electric Company Modicon 612 Micro CPU PLC that is connected to a GE MDS 9070 spread spectrum radio via an RS-232 serial communication cable. Modicon Micro CPU's were introduced by Schneider Electric Corporation in early 1990's and were discontinued in 2006. Although the Micro CPU's are presently supported by Schneider Electric, they will sunset in the next few years. The existing Prospect Wellfield Master PLC is an ABB unit that is obsolete. The existing wellfield radio system is approximately 18 years old and the radio manufacturer is presently phasing out the radio model used in the wellfield.

2.3.2 Reliability Concerns

The existing Modicon PLCs and GE MDS radios are still in working condition and the City staff is generally satisfied with their performance. However, the Modicon PLCs and MDS radios are obsolete and the respective manufacturers have ceased issuing patches and firmware updates. Lack of firmware updates is a security concern as there are potential vulnerabilities to outside attack or hacking into the system. In addition, the PLCs and radios are near or at the end of useable life and the reliability of these units is a concern going forward. The CUS Master Plan Team recommends that the PLCs in each well RTU, as well as the master RTU in the East Generator Building, be upgraded to the Rockwell Automation (Allen-Bradley) ControlLogix platform to be in congruence with the Fiveash SCADA System. The CUS Master Plan Team also recommends that each well, and Master RTU, spread spectrum radio communication be either replaced with fiber optic communication network or upgraded to current MDS family products such as iNet I radio models, iNet II radio models, or MDS Orbit models transmitting Ethernet over spread spectrum frequencies. The iNet radio has backward compatibility with the existing MDS-9810 radio and can be phased out slowly. The Orbit radio has the ability to create a mesh network with other radios that greatly improves reliability through multiple paths back to the master. The Orbit radio is not compatible with existing MDS-9810 radio and require a total replacement for the entire wellfield radio system. The CUS Master Plan team also recommends implementing Firewalls at each well RTU, master RTU and on the I-Net fiber optic system where connected to plant or wellfield networks occur. The City staff indicates a preference for a fiber optic communications network in the wellfield as it is more robust and the communications speed is faster than that over spread spectrum radio.

The CUS Master Plan team recommends a study be undertaken to determine the viability of fiber optic communications versus the various current MDS radio technologies indicated. The CUS Master Plan team recommends the study include radio surveys for the indicated radio technology types including propagation study and required antenna heights as the Ethernet radios (iNet and Orbit) have a shorter communication range than the existing MDS-9810 radio.

Plant staff indicates that the wellfield RTU system does not include the running or fuel level status of the existing generators. Currently, the existing fuel level monitoring system (Veder-Root) is reporting back to the Distribution and Collection SCADA system. The CUS Master Plan Team recommends expanding the Wellfield Master RTU to include running, fail and fuel tank level signals from each generator for Fiveash operator use in managing wellfield operations.

The CUS Master Plan Team recommends implementation of a Water Utilities owned fiber optic based wide area network as described in section 2.8 herein and to connect the Prospect Wellfield Master RTU to the proposed network in lieu of the City's I-net system owned by Comcast.

2.3.3 Recommendations

The following summarizes Plant SCADA system recommendations to increase reliability in 5 year intervals for the next 20 years of plant services:

<u>1-5 Years:</u>

- Perform a study of a fiber optic network versus current radio technology, including radio surveys to identify propagation characteristics and interferences, to determine the most beneficial solution for the City.
- Perform replacement and upgrade of existing Prospect Wellfield Master and Well RTU panels including:
    - New PLC with an appropriate Rockwell Automation platform unit.
    - Upgraded spread spectrum radios or fiber optic connections depending on the recommended study outcome.
    - New Power supplies, surge suppressors, control relays and all other appurtenances.
    - New Enclosures.

- Integrate running and fail signals from existing emergency diesel generators, and available fuel storage levels into upgraded Master RTU unit.
- Replace all uninterruptable power supplies in the wellfield and Master RTU unit.

6-10 years:
- Replacing Well RTU panels not addressed in previous 1-5 years.
- Integrate Prospect Wellfield onto Utilities Owned Fiber Optic wide area network.
- Replace all uninterruptable power supplies in the wellfield and Master RTU unit.

11-15 years:
- Replace all uninterruptable power supplies in the wellfield and Master RTU unit.

16-20 years:
- Perform replacement and upgrade of existing Prospect Wellfield Master and Well RTU panels including:
    - New PLC with an appropriate Rockwell Automation platform unit.
    - Upgraded spread spectrum radios or fiber optic connections as appropriate.
    - New Power supplies, surge suppressors, control relays and all other appurtenances.
    - New Enclosures.
- Replace all uninterruptable power supplies in the wellfield and Master RTU unit.

2.3.4 Cost Summary

Table UW2-2 below lists the estimated costs (in 2016 dollars) for the recommended SCADA System improvements at the Prospect Wellfield. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Table UW2-2. Prospect Wellfield SCADA System.

Project Description	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
Perform a study of a fiber optic network versus current radio technology, including radio surveys to identify propagation characteristics and interferences. Repeat when radios are upgraded in the future.	$130,000	$0	$30,000
Perform replacement and upgrade of existing Prospect Wellfield Master and Well RTU Panels including PLC, radios, enclosures, including power supplies, surge suppressors, control relays and all other appurtenances.	$315,000	$50,000	$315,000
Integrate running and fail signals from existing emergency diesel generators, and available fuel storage levels into upgraded Master RTU unit.	$25,000	$0	$0
Replace all uninterruptable power supplies in the wellfield every five years.	$6,000	$6,000	$12,000
Integrate Prospect Wellfield Fiber Optic (if recommended by the study). Cost will wary based on the recommended topology.	$0	$750,00	$0
Total	$476,000	$806,000	$357,000

2.4 Peele-Dixie WTP

2.4.1 Existing Conditions

The Peele-Dixie WTP (nanofiltration plant) construction was completed in 2008. The existing process level portion of the SCADA system consists of Schneider Electric Quantum PLCs that are connected via Ethernet communications to SCADA. The HMI portion of the SCADA system consists of networked desktop computers and servers also connected by Ethernet. The existing SCADA HMI interface software is Citect SCADA 7.40 and the Citect Historian is version 4.50. The desktop computers run Citect SCADA HMI software as view and configuration/engineering nodes and the servers run Citect SCADA I/O server node software. Plant staff is very satisfied with the current Citect SCADA software and desires to maintain, and standardize on, the Citect SCADA software platform.

Communications between process controller PLCs and remote input/output (RIO) subsystems, variable frequency drives, and local OIT displays is Profibus DP. Although the existing SCADA system at the Peele-Dixie WTP is less than 10 years old, the existing Quantum PLC that is running Concept 2.4 software is outdated. The Concept software replacement, Unity software, is only compatible with the new Quantum PLC platform.

The SCADA network servers are housed in one server room in the Membrane Building. There is no second server room on site.

The process level portion of plant SCADA consists of two (2) master process controller PLCs (Membrane Building and Chemical Building); four (4) membrane treatment skid controller PLCs; Cleaning System Process Control PLC; and eight remote I/O panels.

The Membrane Building Process Controller PLC connects via Profibus DP to:

- Remote I/O and OIT display for the Antiscalant Chemical System.
- Remote I/O and OIT display for the Sulfuric Acid Chemical System.
- Remote I/O and OIT display for the Concentrate Disposal System.
- Remote I/O and OIT display for the Generator Building.
- Concentrate Disposal Pump Variable Frequency Drives (VFDs) (total of 3).
- Remote I/O and OIT display for miscellaneous Membrane Building Process Systems.
- Membrane Feed Pump VFDs (total of 4).

The Membrane Building Process Controller PLC connects via Ethernet to:

- Diesel Fuel Inventory and Monitoring System.
- Plant SCADA servers and workstations
- Membrane treatment skid controller PLCs.
- Cleaning System Process Controller PLC.
- Chemical Building Process Controller PLC.

The Membrane Building Process Controller PLC connects via Modbus to:

- Electrical Power Monitors in the Membrane Building Power Distribution Switchgear.

The Chemical Building Process Controller PLC connects via Profibus DP to:

- Local OIT display.
- Remote I/O and OIT display for the Corrosion Inhibitor Chemical System.
- Remote I/O and OIT display for the Sodium Hypochlorite Chemical System.
- Remote I/O and OIT display for the Fluoride Chemical System.
- Remote I/O and OIT display for the Sodium Hydroxide Chemical System.
- Remote I/O and OIT display for the Transfer Pumps.
- Remote I/O and OIT display for the High Service Pumps.
- High Service Pump VFDs (total of 2).

The Chemical Building Process Controller PLC connects via Ethernet to:

- Plant SCADA servers and workstations

Each Membrane Skid Controller connects via Profibus DP to:

- Local OIT display.
- Membrane treatment skid control valves.
- Membrane treatment skid magnetic flow meters.

The Cleaning System Process Controller PLC connects via Profibus DP to all cleaning system related control valve actuators.

The Plant control room generally contains:

- SCADA workstations and large screen display(s).

The Membrane Building Server Room generally contains:

- SCADA Server No.1.
- SCADA Server No.2.
- Virtual Domain Controllers (2)
- Historian Server.
- Terminal Server.
- One core and two access Ethernet switches for Process Control Communications.
- Ethernet Switch for SCADA HMI interface.
- Rack mounted UPS system.

SCADA Operator workstations are located in:

- Chief Operators Office.
- Process Lab.
- SCADA Administrator.

There is a 100mbs redundant fiber optic data highway connecting the plant SCADA with the Membrane Building Process Controller PLC and the Chemical Building Process Controller PLC.

The SCADA system was originally furnished with wireless LAN access points for use with notebook computers or wireless pen tablets. Plant staff has disconnected the wireless access points as they are a security vulnerability to the SCADA system.

The plant communicates to the Dixie Wellfield via a dedicated fiber optic cable, owned by Comcast, to a SCADA switch in the Membrane Building Server Room.

The existing lime softening plant on site is not part of this evaluation as it has been shut down.

2.4.1.1 SCADA Network

Plant staff indicates that network security is of primary concern and seeks to secure the SCADA network from external attacks and intrusions. One area of concern for network security is software patch management, including obtaining and implementing regular updates to firmware and software. This is viewed as critical as continuous updates strengthen against vulnerabilities to attacks from external sources or internal sabotage.

Plant staff indicates that the existing Cisco 3560 rack mounted Ethernet switches are approximately 10 years old and are likely vulnerable to possible attacks, however, they have been reliable and plant staff desires to standardize on their product family. Staff also indicates that Hirschman panel mounted Ethernet switches have performed very well and desires to standardize on their family of products for field mounted applications.

Plant staff is upgrading the existing SCADA and historian servers to Dell Power Edge R series and phasing out existing Dell Power Edge 2850 units.

The current Citect SCADA version is 7.40 and the Citect Historian version is 4.50. The City's staff is satisfied with the current Citect SCADA software and no full replacement SCADA software is needed in the near future.

For generating reports, plant staff uses the SQL database imbedded in the Citect Historian software on the historian server and manually configures reports using an SQL interface program. Plant staff has indicated a desire to improve reporting capabilities through implementation of third party software.

The SCADA system presently has no on-call alert management software for remotely notifying off site personnel of critical alarms.

2.4.1.2 SCADA Controllers

Plant staff indicates that the Profibus DP network has been problematic and troublesome to troubleshoot and maintain and is not user-friendly. Profibus DP communications is used to communicate process control valve actuators and flow meters with process control PLCs or remote I/O panels over fiber optic cables, which are connected in a serially sequential fashion.

Plant staff indicates that the OIT originally mounted on the exterior of the remote I/O cabinet for the high service pumps has been replaced, and relocated, due to damage from sunlight. The replacement unit is installed in the interior of the high service pump remote I/O cabinet that requires the door to be opened for viewing, thereby exposing the interior components to weather elements. Similarly, interfacing with the OIT during wet weather conditions is a safety issue and is not desirable.

Plant staff indicates the OIT originally mounted to the exterior of the remote I/O cabinet for the transfer pumps has also been replaced in similar fashion as the one associated with the high service pumps. Plant staff also indicates that the Profibus “chain” at the clear well/degasifier and high service pumps is a problem because one break in the cable and the all of the connections on the chain are lost.

Plant staff has indicated a desire for the following:

- Eliminate the Profibus communications protocol for process valve actuators and flow meters in favor of hard wired analog and discrete signals to the associated process controller and to implement Ethernet communications protocol between process controllers and RIO panels or VFDs.
- Replace all plant valve actuators manufactured by Rotork with similar products manufactured by Limitorque as support for the Rotork valve actuators has been difficult to obtain, particularly units that communicate over Profibus DP.
- Implementation of a means to take local manual control of a pump or filter if the associated OIT is not functional, as there are presently no local lights or switches to take local manual control of the pump or filter. This subject is addressed with recommendations in **Section UW4** Manual Operations.
- Migrate to a common Rockwell Automation (Allen-Bradley) PLC platform due to familiarity, availability of service and support, and user friendliness.

2.4.2 Reliability Concerns

Plant staff indicates difficulty in maintaining, and troubleshooting, the Profibus DP portions of the network that include communications to valve actuators, flow meters, and from Remote I/O cabinets to process controllers, resulting in longer recovery time from control system failures related to the Profibus DP communications. The difficulty in recovery from Profibus

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communications failures results in longer than expected process interruptions and impacts to overall plant operation. Plant staff also indicates that replacement parts for the Profibus DP flow meters are difficult to obtain and manufacturer support for the valve actuators using Profibus DP is nearly non-existent. The City has begun implementing Limitorque valve actuators in other treatment facilities (GTL Injection Wellfield and Peele-Dixie WTP) with good performance and available support and desires to standardize on their products. Plant staff also indicates that the existing ABB magnetic flow meters are no longer supported, or manufactured, by ABB and replacement parts are generally not available.

2.4.2.1 SCADA Network

Network security is of high importance in maintaining system reliability through application of hardware and software prevention and detection measures. The CUS Master Plan Team recommends the following to fortify network security:

1. Conduct annual IT security awareness sessions for all plant personnel.
2. Install a network intrusion detection system such as Cisco ASA 5505 Adaptive Security Appliance or Checkpoint.
3. Install and configure malware and antivirus protection on all SCADA nodes.
4. Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
5. Lockdown SCADA nodes by restricting user access and permissions; disable USB ports; and implement the use of passwords of 10 characters, or higher, using a mixture of letter, numbers, symbols and case sensitivity.
6. Perform hardware site survey every 5 years.
7. Replace existing Cisco catalyst 3560 series Ethernet switches, with new Campus LAN Cisco Ethernet switches.
8. Restrict unauthorized external devices from connecting to the SCADA network.
9. Apply latest security updates and patches on third party application software.
10. Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
11. Implement firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
12. Disable unnecessary software services.
13. Remove or disable unnecessary user accounts.
14. Enable security logging and review security logs for unauthorized access.
15. Implement fire walls on outward looking connections, such as the Dixie Wellfield fiber optic connection, and update firmware yearly. Replace fire walls every five years.

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The CUS Master Plan Team observes that the Citect SCADA HMI software is a dated version and recommends migrating to newer editions of the software to maintain system integrity, reliability and reduce vulnerabilities. The CUS Master Plan Team recommends upgrading the existing SCADA system software to Citect SCADA latest version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.

The CUS Master Plan Team observes implementing a reporting software, such as XL Reporter by SyTech, or Dream Report by PcVUE solutions (or similar reporting software) will enhance system reporting capabilities. The CUS Master Plan Team recommends the City obtain trial versions of each product to test features and determine the most suitable solution. Upon selection, The CUS Master Plan Team recommends negotiating a maintenance and support agreement with the manufacturer and updating the software every five years to remain current.

The CUS Master Plan Team, together with Plant personnel, have identified that an on-call alert alarm management software, such as Win911 presently in use at the GTL, enhances staff response to alarms and failures resulting in quicker response time and shorter equipment down time. The cost of the software varies depending on the number of alarms and notification means (such as email, voice over IP notifier, smartphone notifier, etc.). The CUS Master Plan Team recommends the City expand the Win911 on-call alert system in use at G.T. Lohmeyer to Fiveash and negotiate a maintenance and support agreement with the manufacturer. The CUS Master Plan Team further recommends the software be updated every five years to remain current.

The CUS Master Plan Team observes that there is only one server room in the Membrane Building that houses both the primary SCADA server and the secondary SCADA server. The CUS Master Plan Team recommends identifying a second location, on site, where a second server room could be established and to install fully redundant SCADA servers, domain controllers, historian server, UPS systems, workstations and Ethernet switches that would allow for a quick recovery of plant SCADA control if there is a fire, or other disaster, in the Membrane Building Server Room. The CUS Master Plan Team further recommends extending the redundant fiber optic Ethernet data highway to the secondary server room.

2.4.2.2 SCADA Controllers

The CUS Master Plan Team observes plant staff has great difficulty in troubleshooting and diagnosing Profibus DP communications protocol. The difficulty with maintaining the protocol results in reduced reliability of plant operations due to the amount of time necessary to troubleshoot, diagnose, and repair the cause of communication loss. Specifically, the loss of Profibus DP communications at the high service, or transfer pumps causes a loss of communications to all of the devices on the connection. When communications is lost, pumping operations becomes hindered, especially distribution pumping until the problem is resolved. All signals to each associated process valve actuator, flow meter, variable frequency drive and remote I/O panel are transmitted over a single set of wires, connected serially, via the communications protocol. Therefore, if the communications is lost at any point over the serially connected set of wires, all signals to the field devices are lost and the control logic cannot control, receive data from, or determine status of these devices. Implementation of traditional discrete and analog signals from field devices (valve actuators, flow meters, VFDs) to an associated process controller that contains all control logic necessary to operate the process, would greatly reduce the single point failures experienced when the communications protocol fails.

The CUS Master Plan Team observes the current Schneider Electric Quantum PLC platform, and associated Concept programming software, are outdated and have been phased out by Schneider Electric. City staff has expressed a desire to standardize on Rockwell Automation (Allen-Bradley) ControlLogix PLC platform for all City PLC systems.

The CUS Master Plan Team recommends a comprehensive SCADA Control System Upgrade to include:

- Replacement of existing SCADA process control system components with products of the ControlLogix family offered by Rockwell Automation:
  - Membrane Building Process Controller PLC.
  - Chemical Building Process Controller PLC.
  - Cleaning System Process Controller PLC.
  - Membrane Treatment Skid Controller PLCs (total of 4).

- Replacement of existing SCADA remote I/O panels with process control PLCs using Rockwell Automation ControlLogix family products and distribute control logic of the related process to the associated process controller:
  - Antiscalant Chemical System.
  - Sulfuric Acid Chemical System.
  - Concentrate Disposal System.
  - Corrosion Inhibitor System.
  - Sodium Hypochlorite System.
  - Fluoride System.
  - Sodium Hydroxide System.
  - Transfer Pumping System.
  - High Service Distribution Pumping System.
  - Generator Building.
  - Membrane Building Miscellaneous Systems.

- Maintain Ethernet communications protocol between existing Process Controllers and add Ethernet communications protocol to all new Process Controllers.

- Elimination of the Profibus DP communications to field devices and VFDs. Implements traditional discrete and analog signals from field devices to process controllers. Implement traditional analog and discrete control from VFDs to associated process controllers and Ethernet communications for non-critical information related to VFD status and performance.

- Replace all existing OITs with Rockwell Automation Panel View Plus units:
  - Antiscalant Chemical System.
  - Sulfuric Acid Chemical System.
  - Concentrate Disposal System.
  - Corrosion Inhibitor System.
  - Sodium Hypochlorite System.
  - Fluoride System.
  - Sodium Hydroxide System.
  - Transfer Pumping System.
  - High Service Distribution Pumping System.

  - Generator Building.
  - Membrane Building Miscellaneous Systems.
  - Each Membrane Treatment Skid (total of 4).

- Replace all existing magnetic flow meters presently communicating over Profibus DP with units communicating over traditional analog signals.

- Replace existing Rotork valve actuators with new Limitorque valve actuators with traditional analog and discrete signals.

If the existing lime softening plant at the facility were to be brought back on line, the recommendations listed above could be implemented at the same time, as the SCADA system would require expansion into that facility for integration.

2.4.3 Recommendations

<u>1-5 Years (* indicates minor cost or policy items not included in Table UW2-3):</u>

- Conduct annual IT security awareness sessions for all plant personnel.*
- Check firmware of existing firewall/network intrusion detection system such as Cisco ASA 5512 Adaptive Security Appliance or Checkpoint.
- Install and configure malware and antivirus protection on all SCADA nodes.*
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, engage the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
- Lockdown SCADA nodes by restricting user access and permissions; disable USB ports; and implement the use of passwords of 10 characters, or higher, using a mixture of letter, numbers, symbols and case sensitivity.*
- Perform hardware site survey every 5 years.
- Replace existing Cisco series Ethernet switches and rack mounted Ethernet switches identified as a security vulnerability with new Campus LAN Cisco Ethernet switches with updated firmware and software.
- Restrict unauthorized external devices from connecting to the SCADA network.
- Apply latest security updates and patches on third party application software.*
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
- Implement firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Disable unnecessary software services.*
- Remove or disable unnecessary user accounts.*
- Enable security logging and review security logs for unauthorized access.*
- Upgrade the existing SCADA system software to Citect SCADA latest version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Upgrade reporting software to XL Reporter by SyTech, or Dream Report by PcVUE solutions. The cost will vary depending on the tag counts and the feature requirements selected. Negotiate and maintain a support and upgrade contract to keep the software current and secure.
- Maintain service agreement with Cisco hardware. Implement hardware refresh schedule.*

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- Install On-call Alert Management Software.
- Conduct routine network and SCADA self-assessments.*
- Implement system backups and disaster recovery plans.
- Identify and establish a second on-site SCADA server room and install fully redundant SCADA servers, domain controllers, historian server, UPS systems, workstations and Ethernet switches. Extend the existing redundant fiber optic Ethernet data highway to the second SCADA server room.
- Implement a comprehensive SCADA control system upgrade as described in section 2.4.2.2 SCADA Controllers.

6-10 years:

- Conduct annual IT security awareness sessions for all plant personnel.
- Upgrade network intrusion detection system.
- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
- Perform hardware site survey every 5 years.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Conduct routine network and SCADA self-assessments.
- Review implementation of system backups and disaster recovery plans.
- Perform firmware and software updates continuously each year.
- Upgrade selected reporting software to latest version. Maintain a service and support contract for periodic updates and support.
- Upgrade rack mounted Ethernet Switches.
- Maintain service agreement with Cisco hardware.
- Replace and upgrade hardware every 5 years according to refresh schedule.
- Replace and upgrade existing SCADA workstations.

11-15 years:

- Conduct annual IT security awareness sessions for all plant personnel.
- Upgrade network intrusion detection system.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Upgrade existing PLCs, Remote I/O Panels and OITs to latest products by Rockwell Automation.
- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Perform firmware and software updates continuously each year.
- Perform hardware site survey every 5 years.
- Conduct routine network and SCADA self-assessments.
- Review implementation of system backups and disaster recovery plans.
- Replace and upgrade hardware every 5 years according to refresh schedule.
- Upgrade existing Hirschman Ethernet switches to latest model.

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- Upgrade rack mounted Ethernet Switches.
- Upgrade selected reporting software to latest version. Maintain a service and support contract
- Maintain service agreement with Cisco hardware.
- Replace and upgrade existing SCADA workstations.
- Upgrade existing SCADA servers including:
    - SCADA Server No.1.
    - SCADA Server No.2.
    - Virtual Domain Controllers (2)
    - Historian Server.
    - Terminal Server.

<u>16-20 years:</u>

- Conduct annual IT security awareness sessions for all plant personnel.
- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Upgrade network intrusion detection system.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Conduct routine network and SCADA self-assessments.
- Upgrade Process Control PLCs and Remote I/O's to latest products by Rockwell Automation.
- Upgrade rack mounted Ethernet Switches.
- Review implementation of system backups and disaster recovery plans.
- Perform firmware and software updates continuously each year.
- Replace the balance of the SCADA system PLCs, Remote I/O Panels and OITs.
- Upgrade selected reporting software to latest version. Maintain a service and support contract for periodic updates and support.
- Replace and upgrade hardware every 5 years according to refresh schedule.
- Replace and upgrade existing SCADA workstations.
- Maintain service agreement with Cisco hardware.

2.4.4 Cost Summary

Table UW2-3 below lists the estimated costs (in 2016 dollars) for the recommended SCADA system improvements at the Peele-Dixie WTP. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

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Table UW2-3. Peele-Dixie WTP SCADA System.

Project Description	1-5 year Cost	6–10 year Cost	11-20 year Cost
Implement Comprehensive SCADA control system upgrade as described in 2.4.2.2	$2,000,000	$0	$0
Identify and establish a second on-site SCADA server room and install fully redundant SCADA servers, domain controllers, historian server, UPS systems, workstations and Ethernet switches. Extend the existing redundant fiber optic Ethernet data highway to the second SCADA server room.	$400,000	$0	$0
Install a firewall/network intrusion detection system such as Cisco ASA 5512 Adaptive Security Appliance or Checkpoint. Replace/Upgrade every 5 years.	$0	$20,000	$40,000
Implement regular software and firmware patches.	$25,000	$25,000	$50,000
Perform hardware site survey every 5 years.	$10,000	$10,000	$20,000
Replace existing Cisco catalyst 3560 series Ethernet switches, with new Campus LAN Cisco Ethernet switches. Upgrade to latest technology every 5 years.	$25,000	$25,000	$50,000
Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.	$15,000	$15,000	$30,000
Upgrade Citect SCADA to latest version and maintain maintenance contract	$20,000	$20,000	$40,000
Upgrade reporting software.	$20,000	$20,000	$40,000
Maintain service agreement with Cisco hardware. Implement hardware refresh schedule.	$10,000	$10,000	$20,000
Install On-call Alert Management Software	$20,000	$10,000	$20,000
Implement system backups and disaster recovery plans. Review every 5 years.	$15,000	$15,000	$30,000
Upgrade Existing SCADA servers	$0	$30,000	$60,000
Upgrade Field Mounted Hirschman Ethernet Switches to latest models	$0	$25,000	$50,000
Replace and upgrade existing SCADA workstations	$0	$15,000	$30,000

Project Description	1-5 year Cost	6–10 year Cost	11-20 year Cost
Upgrade existing PLCs, Remote I/O Panels and OITs to latest products by Rockwell Automation.	$0	$0	$2,000,000
Totals	$2,560,000	$240,000	$2,480,000

2.5 Dixie Wellfield

The existing Dixie Wellfield was completed in 2008 and it supplies water to the Peele-Dixie Membrane Water Treatment Plant. There are a total of eight wells: PW-27, PW-28, PW-29, PW-30, PW-31, PW-32, PW-33, and PW-34. The wells communicate to Peele-Dixie WTP via a self-healing fiber optic network ring to a master PLC located at the Dixie Wellfield Generator Building. The Master PLC is connected to a dedicated fiber optic I-Net system owned by Comcast to the Peele-Dixie WTP. The self-healing fiber optic network is a single mode fiber loop around the wellfield. Each well consists of a local pump starter control panel that contains the well pump motor starter and a local RTU (Remote Telemetry Unit) panel that contains the local PLC, fiber optic network repeater/switch, power supplies, relays and low voltage surge suppressors. The pump starter control panel and RTU panel are mounted on an outdoor rack.

2.5.1 Existing Conditions

Each well RTU panel contains a Schneider Electric Company Modicon TSX Momentum PLC that is connected to a Hirschman Industrial Ethernet switch via a CAT-6 Ethernet cable. Hirschman Industrial Ethernet switches are self-healing ring managers, and repeaters, for the self-healing fiber optic network. There is no radio communication at the Dixie Wellfield. The master PLC panel located at the Dixie generator building also consists of a Modicon TSX Momentum PLC with self-healing Hirschman Industrial Ethernet switch. The Comcast I-Net fiber optic cable is connected to a Cisco Catalyst 3560 Ethernet switch in a communication rack, in the Generator Building, that is also connected to the wellfield master PLC. There is an existing Phoenix Contact rack mounted UPS system in each well RTU panel that powers the entire RTU panel including the PLC and Ethernet switch.

City staff indicate there are two wells drilled along SW 43rd way to supply future reverse osmosis treatment at Peele-Dixie but are not yet developed with control equipment. City staff indicate there are possibly two to four additional wells yet to be drilled for future water supply for reverse osmosis treatment. City staff indicate there is piping and conduit in the ground between the wells along SW 43rd Way and SR 7 for future use when the wells are developed. The SCADA system for these wells would then be added in the future and they are presently excluded in the CUS Master Plan.

City staff has indicated that the self-healing fiber optic communications network has not always performed adequately as communications with some of the wells are lost when power is turned off at an individual well. The Hirschman panel mounted Ethernet switches act as a pass through node on the network and require power to perform. When the well control panel main disconnect is opened, the RTU loses power and the local UPS operate until the battery reserves are exhausted. To rectify this issue, each well control panel requires modifications to separate power to the RTU from the power to the well pump such that turning off power to work on the well pump would not interrupt communications on the fiber optic network. Separating power supplies is not the recommendation added to the subsequent list and table. Alternatively, the fiber optic system could be re-design as a star configuration, with repeaters as needed, from the

Generator Building to each well such that loss of one well does not affect communications to/from others.

2.5.2 Reliability Concerns

City staff indicate there has not been any issue with individual well TSX Momentum PLCs. However, the City desires to standardize control systems around Rockwell Automation (Allen-Bradley) equipment at all of its treatment plants and related facilities. Plant staff is very satisfied with the existing Hirschman Industrial Ethernet switches at Dixie Wellfield and desire to standardize on Hirschman products going forward. City staff indicate the master PLC has been reliable, however, desire to convert this unit to a Rockwell Automation (Allen-Bradley) ControlLogix unit when the individual wells are converted. With the exception of the loss of communications when an individual well control panel is without power for service, reliability has not been a concern for Dixie Wells SCADA system.

City staff indicates the wellfield RTU system does not include the fuel level status of the existing generator fuel system. Currently the existing fuel level monitoring system (Veder-Root system) is reporting back to the Distribution and Collection SCADA system. The CUS Mater Plan Team recommends expanding the wellfield Master RTU to include the diesel fuel tank level status.

2.5.3 Recommendations

The following summarizes the Dixie wellfield SCADA system recommendations in order to increase reliability, in 5 year intervals, for the next 20 years of plant services:

1-5 years:

- Integrate generator fuel storage level into Master RTU unit.
- Replace all uninterruptable power supplies in the well RTU panel and Master RTU unit.
- Upgrade existing rack mounted Ethernet Switches identified as a security vulnerability to latest Cisco models with updated firmware and software.
- Install pressure transmitters on the Dixie Wellfield raw water transmission system as discussed in Section WA13.

6-10 years:

- Perform replacement and upgrade of existing Dixie Wellfield Master and Well RTU panels including:
    - New PLC of an appropriate Rockwell Automation platform unit.
    - New Hirschman Industrial Ethernet switch, similar model or up-to-date model at the time of replacement.
    - Power supplies, surge suppressors, control relays, and all other appurtenances.
    - Enclosures.
- Replace all uninterruptable power supplies in the well RTU panel and Master RTU unit
- Upgrade existing rack mounted Ethernet Switches identified as a security vulnerability to latest Cisco models with updated firmware and software.
- Implement a star configuration for fiber optic cables from the generator building to each well. Use existing raceways and install minimum 12 strand multi-conductor single mode fiber optic cables and terminate to each Hirschman fiber optic media convertor. Upgrade existing Ethernet switch in generator building to accommodate individual fibers from each well.

11-15 years:

- Replace remaining wellfield PLC system for the Dixie wellfield with new Rockwell Automation PLC system, not all wells are replaced in 5-10 years period.
- Upgrade existing rack mounted Ethernet Switches identified as a security vulnerability to latest Cisco models with updated firmware and software.
- Replace all uninterruptable power supplies in the well RTU panel and Master RTU unit.

16-20 years:

- Replace all uninterruptable power supplies in the well RTU panel and Master RTU unit.
- Upgrade existing rack mounted Ethernet Switches identified as a security vulnerability to latest Cisco models with updated firmware and software.

2.5.4 Cost Summary

Table UW2-4 below lists the estimated costs (in 2016 dollars) for the recommended SCADA System improvements at the Dixie Wellfield. The cost presented anticipates all recommended work being performed by an independent contractor (not City personnel).

Table UW2-4. Peele-Dixie Wellfield SCADA System.

Project Description	1-5 year Cost	6–10 year Cost	11-20 year Cost
Integrate generator fuel storage level into Master RTU unit.	$10,000	$0	$0
Perform replacement and upgrade of existing Dixie Wellfield Master and Well RTU panels.	$0	$300,000	$300,000
Upgrade existing rack mounted Ethernet Switches to latest Cisco Models. Replace every 5 years.	$5,000	$5,000	$10,000
Replace all uninterruptable power supplies in the well PLC and Master PLC panel.	$5,000	$5,000	$10,000
Implement a star configuration for fiber optic cables from the generator building to each well. Use existing raceways and install minimum 12 strand multi-conductor single mode fiber optic cables and terminate to each Hirschman fiber optic media convertor. Upgrade existing Ethernet switch in generator building to accommodate individual fibers from each well.	$0	$150,000	$0
Totals	$20,000	$460,000	$320,000

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2.6 George T. Lohmeyer WWTP

2.6.1 Existing Conditions

The George T. Lohmeyer Wastewater Treatment Plant (GTL) was originally constructed in the late 1970's and there have been many expansion projects, and some in-house projects, to improve the GTL WWTP SCADA system over the years. In a 1998 Sludge Dewatering Facilities Renovation project, Allen-Bradley SLC-500/03 PLCs were installed with each Belt Filter Press Local Control Panel that connect to an Allen-Bradley PLC (PLC-5/20E) process area controller PLC located at the existing PLC-2A control panel over RS-485 serial communication. Existing PLC-2A communicates with Plant SCADA system via Ethernet communications. In a 2001 Effluent Pump Station Expansion project, a redundant Allen-Bradley PLC (PLC-5/40E) system was installed in Administration Building with an associated remote I/O (RIO) system installed in the Effluent Pump Station. The redundant PLC system communicates with Plant SCADA via Ethernet communication. During 2003 and 2004, the existing outdated Johnson Control (J&C) PLC systems were replaced with ABB PLC 800M units at the existing Pretreatment Building, Generator/Switchgear Building, Sludge Pump Station No.3, Sludge Holding Tanks Building, Dewatering Building, and off-site Deep Injection Well Electrical Building.

The existing process level portion of the SCADA system consists of ABB 800M series, Allen-Bradley PLC-5/40E series, Allen-Bradley PLC-5/20E series, Allen-Bradley SLC-500/03 series, and Allen-Bradley MicroLogix 1100 that are connected via an Ethernet network. There are a total of 8 ABB PLCs and 11 Allen-Bradley PLCs systems at the GTL.

The HMI portion of the SCADA system consists of networked desktop computers and servers that communicate via Ethernet communications protocol. The existing SCADA HMI software is Citect SCADA version 7.40 with Citect Historian version 4.50. Within the last year, plant staff upgraded the Domain Controller Servers, SCADA Servers, Historian Server, and Server UPS system to new units installed with Microsoft Window Server 2012. There are thirteen (13) existing work stations/computers that run Citect SCADA HMI software as view nodes and the three (3) SCADA servers that run Citect SCADA I/O server node software that also have configuration/engineering functions. Plant staff is very satisfied with the current Citect SCADA software and desires to maintain, and standardize, on the Citect SCADA software platform.

SCADA communications among process areas take place over two fiber optic network rings (redundant rings) routed between the Pretreatment Building, Sludge Pump Station No.3, Effluent Pump Station and the Deep Injection Wellfield. The SCADA communication also takes place over three (3) single (6-strand) star-topology fiber spurs from the redundant fiber rings to the Generator/Switchgear Building, Sludge Holding Tanks Building, and Dewatering Building. On the eastern end of the plant, the fiber optic ring is multi-mode fiber optic cables. On the western end of the plant, the fiber optic ring is single-mode fiber optic cables.

The SCADA network servers are housed in one SCADA server room on the top floor of the Effluent Pump Station Building.

The SCADA server room generally contains:

- In Rack No.1 - Upgraded Domain Controller No.1
- In Rack No.1 - Upgraded Primary SCADA Server
- In Rack No.1 – UPS system with batteries
- In Rack No.2 – Cisco 4006 Network Switch with fiber optic and RJ45 ports

- In Rack No.2 – Video Network Switch
- In Rack No.2 – Historian Server
- In Rack No.2 – DVR system for camera system
- In Rack No.2 – Upgraded Domain Controller No.2
- In Rack No.2 – UPS system with batteries
- In Rack No.3 – Cisco 4006 Network Switch with fiber optic and RJ45 ports patch panels
- In Rack No.3 – Cisco 2950 Series Ethernet Switch
- In Rack No.3 – Backup Domain Controller
- In Rack No.3 – Secondary SCADA Server
- In Rack No.3 – UPS system with batteries
- In Rack No.4 – PA system, gate controller, and telephone system
- There is one spare unpowered standby – SCADA Server (No.3) in the rack No.5

Process Controllers (PLC-1A and PLC-1B), in the Pretreatment Building, communicate over Profibus DP to remote I/O racks, internal to the process controller panel, that monitor and control:

- Pretreatment related processes
- Liquid Oxygen (Lox) Plant
- Packaged Screening System that contains a MicroLogix PLC
- Sludge Pump Station No.1
- Clarifiers No.1 and No.2
- Biological Reactors
- Sanitary Pump Station No.1
- Scum Pump Station No.1

Process Controller (PLC-2) located at Sludge Dewatering Building communicates over Profibus DP to remote I/O racks, internal to the process controller panel, that monitor and control:

- Belt Filter Press Sludge Feed pumps
- Truck Scale
- Polymer and Sludge Pumps

Process Controller (PLC-2A) located at Sludge Dewatering Building is used as a gateway for the Allen-Bradley PLC (SLC-500/03) installed inside each packaged Belt Filter Press Local Control panel (total of 7) and I/O's related to the conveyors.

Process Controller (PLC-4) located at Sludge Pump Station No.3 communicates over Profibus DP to remote I/O racks, internal to the process controller panel, that monitor and control:

- Clarifier No.10 Control Valve Actuators
- Clarifier No.11 Control Valve Actuators
- Sludge Pump Station No.2
- Sludge Pump Station No.3
- Chlorine Storage
- Chlorine Evaporators
- Emergency Chlorine Scrubber

Process Controller (PLC-5) located at Generator/Switchgear Building communicates over Profibus DP to remote I/O racks, internal to the process controller panel, that monitor and control:

- Generator System
- Switchgear

Process Controller (PLC-6) located at Administration Building communicates over Allen-Bradley RIO protocol to remote I/O racks, internal to the process controller panel, that monitor and control:

- Effluent Pumps
- Plant Non-Potable Water pumps
- Secondary Effluent
- Fine Screens
- Sump Pumps

Process Controller (PLC-7) located at Sludge Holding Tanks Building communicates over Profibus DP to remote I/O racks, internal to the process controller panel, that monitor and control:

- Clarifier No.8 Control Valve Actuators
- Clarifier No.9 Control Valve Actuators
- Sludge Holding Tank Valves and Blowers
- Scrubber System
- Sludge Transfer Pumps to Dewatering Building

The remote process controller (PLC-8) located at Deep Injection Well Electrical Building (DIW) monitors and controls the DIW system including well valve actuators, instruments, storm water pump station, and sanitary lift station. A single fiber optic cable (12 strands) connects the DIW PLC with the plant SCADA system.

Existing servers in the SCADA Server room are a mixture of Dell PowerEdge R710, R720, R620, and T410 models. Existing Ethernet switches are Cisco 4006 Chassis and Cisco 2950 series. Rack mounted UPS in each server rack are APC Symmetra units. Plant staff has indicated a desire to standardize network servers on products from Dell and around Cisco products for Ethernet Switches and external looking network firewalls.

2.6.1.1 SCADA Network

The existing Cisco network switches 4006, 3500, and 2950 are very old. Plant staff has indicated that network security is of primary concern and seeks to secure the SCADA network from external attacks and intrusions. One area of concern for network security is software patch management, including obtaining and implementing regular updates to firmware and software. This is viewed as critical as continuous updates strengthen against vulnerabilities to attacks from external sources or internal sabotage. Plant staff indicates that Cisco rack mounted Ethernet switches have been reliable and desires to standardize on their project family. The Cisco switches are in need of replacement.

Plant staff indicates that the SCADA Servers, Historian Servers, Domain Controller Servers, etc. were recently replaced with new server computers. New server computers are installed with Microsoft Windows Server 2012 with latest patches. The new server computers carry 5-year warranty. The plant replaces the servers every 5 years and the cost is covered in the O&M budget.

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For generating reports, plant staff uses the SQL database imbedded in the Citect Historian software on the Historian Server and manually configures reports using an SQL interface program. Plant staff has indicated a desire to improve reporting capabilities through implementation of third party software.

There is an existing on-call alert management software (WIN911 software) at the GTL for notifying on site personnel of critical alarms thru PA (public Address) system and for remotely notifying off site personnel.

The CUS Master Plan Team observes the plant SCADA system critical network components are physically located in one room on the upper level of Effluent Pump Station Building. Currently, all server computers including the primary SCADA server, secondary SCADA server, and stand-by SCADA server are located in the same room. If a disaster were to strike that room, or the Effluent Pump Station, the entire plant SCADA system be down, potentially for an extended period of time. Plant staff indicates offsite storage of critical programs and data is achieved by plant staff downloading critical program to a portable storage device and bringing it home, so that it is off site, in case of a significant event at the plant.

2.6.1.2 SCADA Controllers

The existing ABB PLCs have 2 Ethernet ports for redundancy. The ports are connected to the redundant fiber optic rings to provide two paths of communication to plant SCADA. Existing ABB PLCs communicate to associated RIO panels over Profibus DP communication protocol using a master and slave Profibus DP module.

The existing Allen-Bradley PLC-5 family communicates over Ethernet and the SLC-500 family communicates over Data Highway DH485 which is problematic when the communication link goes down. RS-485 serial communication protocol is still widely in use, however, Ethernet communication protocol is becoming industry standard. The GTL does not have Profibus DP communication to local flow meters, valve actuators, etc. that has been problematic at Fiveash WTP and Peele-Dixie WTP.

Plant staff has indicated difficulty obtaining service and support for the ABB PLC components in the past. Plant staff indicates a desire to standardize and to migrate to a common Rockwell Automation (Allen-Bradley) PLC platform, due to familiarity, availability of service and support; and user friendliness.

2.6.2 Reliability Concerns

The existing PLC SLC-500 family communicates through Modbus RS-485 and plant staff has difficulty in troubleshooting when the communication link breaks down. The existing Allen-Bradley SLC-500 PLC family is still available from Rockwell Automation (Allen-Bradley) but its software is outdated and support is not available. The existing Allen-Bradley PLC-5/40E and PLC-5/20E PLCs are obsolete as parts and support are no longer available from Rockwell Automation (Allen-Bradley) however, parts are still available from third party suppliers not affiliated with Allen-Bradley. With the mixture of PLC manufacturers, and platforms, as well as communications protocols, troubleshooting and maintaining the current SCADA system is cumbersome and time consuming and results in reduced reliability of plant operations due to the amount of time necessary to troubleshoot, diagnose, and repair the cause of communication loss.

The CUS Master Plan Team observes the entire plant is not connected on the redundant fiber optic communications ring and interruptions in communications to the process areas connected in the star portion of the fiber optic communication system result in interruption of plant operations for the area lost. This has not historically been an issue for the GTL; fiber optic ring or star network loss has not occurred in 20 years.

2.6.2.1 SCADA Network

Network security is of high importance in maintaining system reliability through application of hardware and software prevention and detection measures. The CUS Master Plan Team recommends the following to fortify network security:

1. Conduct annual IT security awareness sessions for all personnel.
2. Install a network intrusion detection system such as Cisco ASA 5505 Adaptive Security Appliance or Checkpoint.
3. Install and configure malware and antivirus protection on all SCADA nodes. Plant staff indicate Symantec Endpoint is deployed at G.T. Lohmeyer and it is updated frequently.
4. Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, engage the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
5. Lockdown SCADA nodes by restricting user access and permissions; disable USB ports; and implement the use of passwords of 10 characters, or higher, using a mixture of letter, numbers, symbols and case sensitivity.
6. Perform hardware site survey every 5 years.
7. Replace current Cisco Catalyst 4006, 3500, and 2950 series switches, with new Campus LAN Cisco Ethernet switches.
8. Restrict unauthorized external devices from connecting to the SCADA network.
9. Apply latest security updates and patches on third party application software.
10. Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
11. Implement firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
12. Disable unnecessary software services.
13. Remove or disable unnecessary user accounts.
14. Enable security logging and review security logs for unauthorized access.

The CUS Master Plan Team observes the Citect SCADA HMI software is of a dated version and recommends migrating to newer editions of the software to maintain system integrity, reliability and reduce vulnerabilities. The CUS Master Plan Team recommends upgrading the existing

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SCADA system software to Citect SCADA latest version and maintaining an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.

The CUS Master Plan Team observes implementing a reporting software, such as XL Reporter by SyTech, or Dream Report by PcVUE solutions (or similar reporting software) will enhance system reporting capabilities. The CUS Master Plan Team recommends the City obtain trial versions of each product to test features and determine the most suitable solution. Upon selection, The CUS Master Plan Team recommends negotiating a maintenance and support agreement with the manufacturer and updating the software every five years to remain current.

The City maintains a maintenance and support agreement be with Win911 and the software updated every 18 to 24 months as new versions are available.

The CUS Master Plan Team recommend the standardization on Cisco rack mounted Ethernet switches for plant SCADA, because of staff familiarity, performance, manufacturer support and ease of application. The CUS Master Plan Team further recommends maintaining a service agreement with Cisco to receive and implement software and firmware updates to strengthen system reliability and security. The CUS Master Plan Team recommends implementing a hardware refresh schedule to replace these switches every five (5) years to capture to product updates and improvements in industry standards, and to assist with maintaining network security.

The CUS Master Plan Team recommends creating a secondary server room on the west side of the GTL, e.g., in the LOX building or Generator Building to house the secondary server and back-up network system to reduce risk of a catastrophic event in the Effluent Pump Station from rendering the control system inoperative for an extended period of time. The CUS Master Plan Team recommends that redundant SCADA servers, domain controllers, historian servers, UPS systems, network Ethernet switches, video and access control system components be implemented, and activated, in the secondary SCADA control room. The CUS Master Plan Team also recommends extending the redundant fiber optic ring to the new secondary SCADA control room for full redundancy and increased reliability, in the plant.

2.6.2.2 SCADA Controllers

The CUS Master Plan Team recommends replacing the existing ABB process controller PLCs and Remote I/O panels with comparable products from the Rockwell Automation (Allen-Bradley) ControlLogix, or CompactLogix as appropriate families including appropriate software and interface control logic programming to establish a common PLC platform in the plant. The CUS Master Plan Team recommends eliminating the use of Profibus DP communications protocol between Remote I/O panels and their associated PLC during the ABB PLC and associated Remote I/O replacement.

The CUS Master Plan Team recommends replacing the existing Allen-Bradley SLC-500 PLCs, PLC-5 PLCs, and associated Remote I/O panels, with comparable products from Rockwell Automation (Allen-Bradley) CompactLogix family including all control software and control logic programming. The CUS Master Plan Team recommends using Ethernet communication protocol for all peer-to-peer communications between process controllers PLCs, as well as, between process controller PLCs and associated Remote I/O panels. The CUS Master Plan Team also recommends implementing Rockwell Automation ControlLogix Studio 5000 for PLC software programming.

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The CUS Master Plan Team recommends integrating the Generator/Switchgear Building, Sludge Holding Tanks Building, and Dewatering Building process areas into the plant SCADA network redundant fiber optic ring by implementing/adding new fiber optic cables and conduits to the existing star-topology fiber spurs and intercepting the redundant ring for integration. After this implementation, the plant fiber optic system will be truly redundant rings, in both a physical implementation perspective, and a connectivity topology perspective. The CUS Master Plan Team also recommends performing a fiber optic power budget and loss budget study to confirm the existing multi-mode fiber optic cables are adequate for the plant before adding new fiber optic cables.

The CUS Master Plan Team recommends that the SCADA system related to any local control panels, such as belt filter press local control panel, influent screen local control panel, bar screen local control panel, etc. retain the existing local manual control functions during the PLC replacement.

The CUS Master Plan Team recommends that the SCADA system control hardware (PLCs, Remote I/O panels) be upgraded to the latest platform every 15 years.

Critical programming to the SCADA system is presently stored off site through a manual means of carrying portable storage devices off site. It is recommended that the City implement the recommendations of section 2.8 of UW-1 to have interconnectivity with other treatment facilities such that offsite storage can be accomplished automatically.

2.6.3 Recommendations

The following summarizes the GTL SCADA system recommendations in order to increase service reliability, in 5 year intervals, over the next 20 years:

1-5 years (* indicates minor cost or policy items not included in Table UW2-5):

- Replace the eight existing ABB PLC and associated I/O system with Rockwell Automation (Allen-Bradley) PLC and I/O system, either ControlLogix or CompactLogix.
- Create secondary server room and implement redundant domain controllers, SCADA servers, network switches, UPS, etc.
- Extend existing redundant fiber optic communications network to Generator/Switchgear Building, Sludge Holding Tanks Building, and Dewatering Building, including fiber optic power budget and loss budget study.
- Conduct annual IT security awareness sessions for all plant personnel.*
- Check firmware of existing firewall/network intrusion detection system such as Cisco ASA 5512 Adaptive Security Appliance or Checkpoint.*
- Install and configure malware and antivirus protection on all SCADA nodes.*
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
- Lockdown SCADA nodes by restricting user access and permissions; disable USB ports; and implement the use of passwords of 10 characters, or higher, using a mixture of letter, numbers, symbols and case sensitivity.*
- Perform hardware site survey every 5 years.
- Replace existing Cisco catalyst 4006 series Ethernet switches, with new Campus LAN, 2950 series and 3500 series Ethernet switches by Cisco.

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- Restrict unauthorized external devices from connecting to the SCADA network.*
- Apply latest security updates and patches on third party application software.*
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
- Implement firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.*
- Disable unnecessary software services.*
- Remove or disable unnecessary user accounts.*
- Enable security logging and review security logs for unauthorized access.*
- Upgrade the existing SCADA system software to Citect SCADA latest version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Upgrade reporting software to XL Reporter by SyTech, or Dream Report by PcVUE solutions. The cost will vary depending on the tag counts and the feature requirements selected. Negotiate and maintain a support and upgrade contract to keep the software current and secure.
- Upgrade existing rack mounted Ethernet Switches identified as a security vulnerability to latest Cisco models with updated firmware and software.
- Maintain service agreement with Cisco hardware. Implement hardware refresh schedule.
- Conduct routine network and SCADA self-assessments.*
- Replace and upgrade hardware every 5 years according to refresh schedule.*
- Replace and upgrade existing SCADA workstations.
- Implement system backups and disaster recovery plans.
- Update On-call Alert Management Software.

<u>6-10 years (* indicates minor cost or policy items not included in Table UW2-5):</u>

- Replace remaining 11 Allen-Bradley PLCs (PLC-5 family and SLC-500 family) and associated I/O system with Rockwell Automation (Allen-Bradley) ControlLogix or CompactLogix PLC and I/O system so that the entire GTL is on a single PLC platform.
- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
- Upgrade network intrusion detection system.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Upgrade rack mounted Ethernet Switches.
- Perform hardware site survey every 5 years.
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
- Conduct routine network and SCADA self-assessments.*
- Review implementation of system backups and disaster recovery plans.
- Perform firmware and software updates continuously each year.*

- Upgrade selected reporting software to latest version. Maintain a service and support contract for periodic updates and support.
- Upgrade existing SCADA servers.
- Maintain service agreement with Cisco hardware.
- Replace and upgrade hardware every 5 years according to refresh schedule.
- Replace and upgrade existing SCADA workstations.
- Update On-call Alert Management Software.

<u>11-15 years (* indicates minor cost/policy items not included in Table UW2-5):</u>

- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Upgrade rack mounted Ethernet Switches.
- Perform firmware and software updates continuously each year.*
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
- Perform hardware site survey every 5 years.
- Conduct routine network and SCADA self-assessments.*
- Review implementation of system backups and disaster recovery plans.
- Replace and upgrade hardware refresh every 5 years according to hardware refresh schedule.
- Upgrade existing unmanaged (field mounted) Ethernet media converters and switches to latest model.
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
- Upgrade selected reporting software to latest version. Maintain a service and support contract.
- Maintain service agreement with Cisco hardware.
- Replace and upgrade existing SCADA workstations.
- Update On-call Alert Management Software.
- Upgrade existing SCADA servers including:
    - SCADA Servers (Primary and secondary)
    - Historian Server
    - Domain Controller Servers (Primary and secondary)

<u>16-20 years (* indicates minor cost/policy items not included in Table UW2-5):</u>

- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support Conduct routine network and SCADA self-assessments.
- Upgrade Process Control PLCs and Remote I/O's to latest products by Rockwell Automation.*
- Upgrade network intrusion detection system.

- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Upgrade rack mounted Ethernet Switches.
- Review implementation of system backups and disaster recovery plans.
- Upgrade existing unmanaged (field mounted) Ethernet media converters and switches to latest model.
- Perform firmware and software updates continuously each year.*
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
- Replace the balance of the SCADA system PLCs, Remote I/O Panels and OITs.
- Upgrade selected reporting software to latest version. Maintain a service and support contract for periodic updates and support.*
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
- Replace and upgrade hardware every 5 years according to refresh schedule.
- Replace and upgrade existing SCADA workstations.
- Maintain service agreement with Cisco hardware.*
- Update On-call Alert Management Software.

Note: The PLC replacement at the GTL is not as critical as the Fiveash WTP and implementation can be moved to a later 5 year interval.

2.6.4 Cost Summary

Table UW2-5 below lists the estimated costs (in 2016 dollars) for the recommended SCADA system improvements at the GTL. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Table UW2-5. GTL SCADA System.

Project Description	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
Replace existing ABB PLC and RIO system with Rockwell Automation (Allen-Bradley) ControlLogix or CompactLogix Platform.	$2,000,000	$0	$0
Extend redundant fiber optic ring to Generator/Switchgear Building, Sludge Holding Tanks Building, and Dewatering Building, including fiber optic power and loss budget study.	$100,000	$0	$0
Create a secondary server room with relocating of the redundant Servers and network components.	$200,000	$0	$0
Replace remaining outdated Allen-Bradley PLC and RIO systems with Rockwell Automation	$0	$300,000	$0

Project Description	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
(Allen-Bradley) ControlLogix or CompactLogix Platform.			
Install a firewall/network intrusion detection system such as Cisco ASA 5512 Adaptive Security Appliance or Checkpoint. Replace/Upgrade every 5 years.	$0	$20,000	$40,000
Implement regular software and firmware patches.	$25,000	$25,000	$50,000
Perform hardware site survey every 5 years.	$10,000	$10,000	$20,000
Replace existing Cisco and other Ethernet switches to latest technology every 5 years.	$25,000	$25,000	$50,000
Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.	$15,000	$15,000	$30,000
Upgrade Citect SCADA to latest version and maintain maintenance contract.	$20,000	$20,000	$40,000
Upgrade reporting software.	$20,000	$20,000	$40,000
Maintain service agreement with Cisco hardware. Implement hardware refresh schedule.	$10,000	$10,000	$20,000
Update On-call Alert Management Software.	$20,000	$10,000	$20,000
Implement system backups and disaster recovery plans. Review every 5 years.	$15,000	$15,000	$30,000
Upgrade Existing SCADA servers.	$0	$30,000	$60,000
Upgrade Field Mounted Ethernet Switches to latest models.	$0	$25,000	$50,000
Replace and upgrade existing SCADA workstations.	$0	$15,000	$30,000
Upgrade Process Control PLCs and Remote I/O’s to latest products by Rockwell Automation.	$0	$0	$1,000,000
Totals	$2,460,000	$540,000	$1,480,000

2.7 Distribution and Collection System

2.7.1 Existing Conditions

The City's Distribution and Collection (D&C) System, managed by the D&C Division consists of 186 wastewater lift stations, 3 master re-pump stations, 4 stormwater pump stations, 7 master wastewater flow monitoring stations and numerous water distribution pressure monitoring sites. A small number of the pump stations, or lift stations, are abandoned in place and some are in the process of rehabilitation/construction. City staff indicates more lift stations will be added in the near future. Wastewater is collected in the smaller lift stations and is pumped to the GTL through a series of larger pump stations to master re-pump stations. Each lift station, or small pump station, has a local control panel that houses the power distribution breakers, pump starters, control relays and appurtenances, as well as a local PLC, RTU, Verizon cellular radio, PanelView touchscreen, power supplies, din-rail mounted UPS, relays, and low voltage surge suppressors.

For larger capacity lift stations, and pump stations, the power distribution system consists of a distribution panelboard with stand-alone local starters (either Variable Frequency Drives (VFDs) or Solid State Reduced Voltage Starters (SSRVS)); or a Motor Control Center (MCC) that contains feeder breakers and motor starters (either VFDs or SSRVS). Larger capacity pump station and lift stations have a stand-alone RTU panel mounted in the associated dry well, or adjacent to the well control panel above grade. In some older variety of lift stations, the RTU panels are integrated into the MCC structure.

Each wastewater lift station has an RPZ (reduced pressure zone, backflow prevention assembly), and a pressure indicating transmitter for potable water connected to the lift station RTU with monitored pressure transmitted back to D&C SCADA.

Master Re-pump Stations have a stand-alone RTU panel that contains a local PLC, Verizon cellular radio, PanelView touchscreen, power supplies, din-rail mounted UPS and separately mounted battery, relays, low voltage surge suppressors, etc.

Lift stations, pump stations and master re-pump stations communicate over Verizon cellular to a dedicated AT&T T1 landline routed from an AT&T switching station to the D&C SCADA system in the Utilities Administration Building. The connection between Verizon Cellular and AT&T landline is coordinated between the communications vendors and the City has no control of the data over those networks.

Presently, only 136 out of the 186 wastewater lift stations; all four (4) storm water pumping stations and all seven (7) wastewater master meters are communicating over Verizon cellular and the dedicated T1 lines to the D&C SCADA system. The City is actively working to connect the remaining lift stations to the Verizon Cellular and the AT&T T1 network by 2018.

The City is currently purchasing 8 additional water pressure monitoring stations. The data from these stations will be transmitted via the same Verizon wireless/AT&T T1 landline to the D&C server as the existing lift stations and pump stations. The City desires to send the pressure monitor station information to the Fiveash WTP for operator use in operating the high service pumps. Currently, there is a fiber connection between the Administration Building and the Fiveash WTP for enterprise system communication, but there is no direct SCADA connection between the D&C SCADA server at the Administration Building and the SCADA servers at the Fiveash WTP.

The HMI portion of the D&C SCADA system consists of networked desktop computers and servers connected via Ethernet. The current Citect SCADA version is 7.40 and the Citect Historian version is 4.50. D&C SCADA network servers are housed in the Administration Building Server room with City enterprise LAN network switches and servers. The D&C SCADA server rack contains:

- Cisco ASA-5512 Firewall No.1
- Cisco ASA-5512 Firewall No.2
- Cisco Router 2800 Series No.1
- Cisco Router 2800 Series No.2
- Citect SCADA Primary Server
- Citect SCADA Secondary Server
- Domain Controller Server
- Spare Server with Citect SCADA installed
- Citect Historian Server
- Cisco Router for Fiveash with media converter
- Cisco 3560G Switch for Video System
- Lenel Access Control System

The D&C SCADA network has one fiber optic connection to the Central Maintenance Building and there is a Cisco Ethernet switch at that location.

Existing D&C system servers are Dell PowerEdge model R720 with one Dell PowerEdge R620 server. The existing firewall is a Cisco ASA 5512 unit. The Ethernet switches are Cisco Catalyst 3550 series and Cisco 2800 series. The UPS system for D&C servers is APC unit.

Each lift station, or pump station, contains a Rockwell-Automation (Allen-Bradley) MicroLogix 1100 PLC that is connected to a Hirschman Ethernet Switch and then to a Verizon cellular radio (AirLink LS300 by Sierra) via an Ethernet cable (CAT.5 or CAT.6 cable). There is a Rockwell Automation (Allen-Bradley) touchscreen Panel View-Plus 600 connected to the Hirschman Ethernet Switch. MicroLogix 1100 PLCs were introduced by Rockwell Automation in early 2005 and are actively supported. Rockwell Automation also introduced the MicroLogix 1400 PLCs in early 2008, which also are actively supported. The primary difference between the MicroLogix 1400 and MicroLogix 1100 PLCs are higher I/O count, faster high-speed counter, pulse train output, enhanced network capabilities, and backlight on the LCD panel. Both MicroLogix PLCs require RSLogix 500 PLC software for programming/editing.

Each re-pump station contains a Rockwell-Automation (Allen-Bradley) CompactLogix L35E PLC processor, ProSoft Modbus module, power supply, and I/O modules. The CompactLogix PLC is connected to a Hirschman Ethernet Switch and then to a Verizon cellular radio (AirLink LS300) via CAT.6 Ethernet cable. There is a Rockwell Automation (Allen-Bradley) touchscreen PanelView Plus 1000 mounted on the front of the RTU/PLC control panel and connected to the Hirschman Ethernet Switch. CompactLogix PLCs were introduced in early 2001 with many product family revisions since that time with varying degrees of support available. The CompactLogix PLC requires Rockwell Automation Design Studio 5000 (renamed from RSLogix 5000) PLC software for programming/editing.

The CUS Master Plan Team observes the existing PLC system and cellular communication system are viable and can remain in service for many years to come.

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2.7.1.1 SCADA Network

City staff indicates that network security is of primary concern and seeks to secure the SCADA network from external attacks and intrusions. One area of concern for network security is software patch management, including obtaining and implementing regular updates to firmware and software. This is viewed as critical as continuous updates strengthen against vulnerabilities to attacks from external sources or internal sabotage. City staff also indicates concern over loss of control of the data from remote sites to the D&C SCADA system over the Verizon and AT&T communications media.

City staff indicates a desire to standardize network servers on products from Dell and Cisco products for Ethernet Switches and external looking network firewalls. City staff also indicates a desire to standardize rack mounted UPS systems on products from APC.

City staff indicates that the SCADA Servers and Historian Server were recently replaced with new server computers. The new servers are installed with Microsoft Windows Server 2012 with latest patches.

City staff indicates that a firewall has been implemented for the dedicated AT&T T-1 connections.

For generating reports, City staff uses the SQL database imbedded in the Citect Historian software, on the historian server, and manually configures reports using an SQL interface program. City staff indicates a desire to improve reporting capabilities through implementation of third party software.

The SCADA system presently has no on-call alert management software for remotely notifying off site personnel of critical alarms.

The CUS Master Plan Team observes that the D&C SCADA system critical network components are all located in the Administration Building Server Room. There is risk that the D&C SCADA system could be lost should a fire occur at that location.

City staff indicates that offsite storage of critical programs and data is achieved by plant staff downloading critical programs to a portable storage device and bringing it home so that it is off site in the event of a significant event at the Administration Building.

2.7.1.2 SCADA Controllers

Existing SCADA system controllers at the collection system pump stations, lift station, and re-pump stations communicate with D&C SCADA server over Verizon wireless and dedicated AT&T T1 lines. Associated level transmitters (air bubbler system) and local floats are hard-wired to associated RTU/PLC system and the PLC program resides in the local RTU/PLC. If the communication link is broken between individual lift stations, pump stations or master re-pump stations and the D&C server, the lift stations, pump stations or master re-pump stations continue to operate automatically in a stand-alone fashion. The motor controllers at each lift station, pump station, or master re-pump station are connected to the local RTU/PLC via Ethernet, or Modbus, communication protocol. City staff indicates that they are implementing hard-wire analog and discrete signals from the VFDs to the local RTU/PLC system for critical control signals to avoid loss of communication with the device if the connecting cable is severed or the communications link is lost. City staff indicates a desire to keep the existing Ethernet or Modbus communication link from the VFDs or SSRVS monitoring of non-critical signals and data only.

2.7.2 Reliability Concerns

The existing Rockwell-Automation (Allen-Bradley) CompactLogix PLCs and MicroLogix 1100 PLCs are in good working condition and City staff is generally satisfied with their performance. However, The CUS Master Plan Team is recommending, in various portions of Section UW2, that GTL, Fiveash WTP, and Peele-Dixie WTP migrate to the ControlLogix and CompactLogix platform, with Design Studio 5000 PLC software, for standardization. The CUS Master Plan Team recommends, over time, to migrate lift station PLCs to CompactLogix as panels are replaced, or station upgrades occur for standardization. There will be an impact to the existing lift station/pump station control panel due to the physical size of the CompactLogix unit. PLCs at master re-pump stations are presently CompactLogix family products and the CUS Master Plan Team does not recommend replacement, but does recommend firmware upgrades when applicable.

Currently, pump run times are either manually recorded on a daily basis, or recorded at the local PLC. Pump run times recorded have experienced communications link issues. The CUS Master Plan Team recommends runtime monitoring issues be resolved so D&C staff have access to current lift station pump run times.

City staff indicates the D&C SCADA system can see GTL influent flows, but has no access to the GTL for feed forward data to assist with GTL operational control. GTL staff indicates a desire to balance pump station flows in an emergency, or peak flow events, by having the feed forward information of the flows heading to the plant. City staff actively assists in controlling GTL influent flow primarily by monitoring, and locally controlling, flows at the A-Re-pump and the B-Re-pump stations during peak flow events. Having this information available at the GTL would greatly improve plant operational performance during high influent flow conditions as the plant can predict the amount of flow apparent in the collection system that will be delivered to the plant influent. The CUS Master Plan Team further recommended developing an automated control algorithm that helps manage wastewater collection system flows to support GTL operations.

In 2003 the City performed a radio survey for 900 MHz and 2.4 GHz communications for applicability to the collection system and it was determined, at that time, there were many obstacles (trees and buildings) blocking signals requiring the implementation of many repeaters for reliable system operation. Radio technology has significantly improved/changed since that time with the introduction of a self-healing mesh radio technology that can be used to perform both transmitter and a repeater functions. The mesh radio network provides multiple paths for signal transmission and automatically re-routes the signal to the path of least delay. The technology will also automatically detect loss of communication in a path and re-route signal transmissions around the missing communication link. The CUS Master Plan Team recommends the City consider further investigation of this technology through a feasibility and radio propagation study to determine applicability of the technology to the existing transmission and collection system communications network.

VFDs and SSRVS at the wastewater lift stations, pump stations, and re-pump station are discussed in **Section WA16** of the master plan.

2.7.2.1 SCADA Network

Network security is of high importance in maintaining system reliability through application of hardware and software prevention and detection measures. The CUS Master Plan Team recommends the following to fortify network security:

1. Conduct annual IT security awareness sessions for all personnel.
2. Install and configure malware and antivirus protection on all SCADA nodes.
3. Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, engage the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.
4. Lockdown SCADA nodes by restricting user access and permissions; disable USB ports; and implement the use of passwords of 10 characters, or higher, using a mixture of letter, numbers, symbols and case sensitivity.
5. Perform hardware site survey every 5 years.
6. Replace current Cisco Catalyst 3500, 3560G, and 2800 series switches with new Campus LAN Cisco Ethernet switches.
7. Restrict unauthorized external devices from connecting to the SCADA network.
8. Apply latest security updates and patches on third party application software.
9. Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
10. Implement firewalls on all data communication connections to outside sources that could be subject to unwanted intrusion.
11. Disable unnecessary software services.
12. Remove or disable unnecessary user accounts.
13. Enable security logging and review security logs for unauthorized access.

The CUS Master Plan Team observes the Citect SCADA HMI software is of a dated version and recommends migrating to newer editions of the software to maintain system integrity, reliability and reduce vulnerabilities. The CUS Master Plan Team recommends upgrading the existing SCADA system software to Citect SCADA latest version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.

The CUS Master Plan Team observes the D&C SCADA system reporting capabilities would be greatly enhanced by implementing a reporting software such as XL Reporter by SyTech, or Dream Report by PcVUE solutions, or similar reporting software. Either software packages would be useful to improve reporting capabilities. The CUS Master Plan Team recommends the City obtain trial versions of each product to test features and determine which product is most suitable for the application. Upon selection, the CUS Master Plan Team recommends negotiating a maintenance and support agreement with the manufacturer and the software be updated every five (5) years to remain current.

The CUS Master Plan Team, together with Plant personnel, have identified that an on-call alert alarm management software, such as Win911 presently in use at GTL, enhances staff response to alarms and failures resulting in quicker response time and shorter equipment down time. The cost of the software varies depending on the number of alarms and notification means (such as email, voice over IP notifier, smartphone notifier, etc.). The CUS Master Plan Team recommends the City expand the Win911 on-call alert system in use at the GTL to Fiveash and negotiate a maintenance and support agreement with the manufacturer. The CUS Master Plan Team further recommends the software be updated every five years to remain current.

The existing Cisco Network switches (3500, 3560G, and 2800 series) have been sunset by Cisco meaning firmware updates are no longer issued by the equipment manufacturer and the network security is at risk.

The CUS Master Plan Team recommends standardizing on Cisco rack mounted Ethernet switches and Hirschman panel mounted Ethernet switches, for D&C SCADA, due to staff familiarity, performance, manufacturer support and ease of application. The CUS Master Plan Team further recommends maintaining a service agreement with Cisco and Hirschman to receive and implement software and firmware updates to strengthen system reliability and security. The CUS Master Plan Team recommends implementing a hardware refresh schedule to replace these switches every five (5) years to capture product updates, and improvements in industry standards, and to assist with maintaining network security.

The CUS Master Plan Team recommends creating a secondary server room at the Central Maintenance Building to house a secondary server and back-up network system for D&C SCADA to reduce risk of a catastrophic event in the Administration Building Network Room from rendering the control system inoperative for an extended period of time. The CUS Master Plan Team recommends that redundant SCADA servers, domain controllers, historian servers, UPS systems, and network Ethernet switches, be implemented, and activated, in the secondary server room. The CUS Master Plan Team also recommends obtaining an additional new T1 line (preferably from a different service provider than current AT&T) to the secondary server room in the Central Maintenance Building. By obtaining the additional T1 line, or lines, from a different service provider, the system can be still in operation when one of the service provider's network is down.

2.7.2.2 SCADA Controllers

The CUS Master Plan Team recommends using hard-wired signals for critical control signals from VFDs to the associated local RTU/PLC at each lift station, pump station, or master re-pump station and use Modbus, or Ethernet, for monitoring of the VFDs less critical parameters.

Critical programming of the SCADA system is presently stored off site through a manual means of saving critical files to portable storage devices and physically carrying the portable storage devices off site by City staff. It is recommended that the City implement the recommendations of section 2.8 of **Section UW2** to have interconnectivity with other utility facilities such that offsite storage can be accomplished automatically.

2.7.3 Recommendations

The following summarizes the D&C SCADA system recommendations in order to increase service reliability in 5 year intervals, for the next 20 years:

<u>1-5 years (* indicates minor cost/policy items not included in Table UW2-6):</u>

- Study feasibility of a self-healing radio network for applicability to City Distribution and Collection system.
- Create a secondary server room at Central Maintenance Building and implement redundant D&C SCADA network equipment including switches, servers, workstations, UPS and additional T1 line.
- Conduct annual IT security awareness sessions for all plant personnel.
- Install a network intrusion detection system such as Cisco ASA 5512 Adaptive Security Appliance or Checkpoint.*
- Install and configure malware and antivirus protection on all SCADA nodes.
- Conduct quarterly vulnerability scans. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.*
- Perform firmware and software updates each year.
- Lockdown SCADA nodes by restricting user access and permissions; disable USB ports; and implement the use of passwords of 10 characters, or higher, using a mixture of letter, numbers, symbols and case sensitivity.
- Perform hardware site survey every 5 years.*
- Replace existing Cisco catalyst 3500, 3560G, and 2800 series Ethernet switches, with new Campus LAN Cisco Ethernet switches.
- Restrict unauthorized external devices from connecting to the SCADA network.
- Apply latest security updates and patches on third party application software.*
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.
- Implement firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.
- Disable unnecessary software services.*
- Remove or disable unnecessary user accounts.*
- Enable security logging and review security logs for unauthorized access.*
- Upgrade the existing SCADA system software to Citect SCADA latest version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.*
- Upgrade reporting software to XL Reporter by SyTech, or Dream Report by PcVUE solutions. The cost will vary depending on the tag counts and the feature requirements selected. Negotiate and maintain a support and upgrade contract to keep the software current and secure.
- Upgrade existing rack mounted Ethernet Switches identified as a security vulnerability to latest Cisco models with updated firmware and software.
- Maintain service agreement with Cisco hardware and implement hardware refresh schedule.*
- Implement On-call Alert Management Software, e.g., expanding GTL's system.
- Conduct routine network and SCADA self-assessments.*
- Implement system backups and disaster recovery plans.

6-10 years (* indicates minor cost/policy items not included in Table UW2-6):

- Implement a self-healing radio system if determined feasible.
- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Conduct quarterly vulnerability scans and implement regular software and firmware patches. If staff is unable to perform this on a regular basis, secure the services of an outside company to review available software and firmware patches on SCADA network hardware and implement updates as appropriate.*
- Upgrade network intrusion detection system.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.*
- Upgrade Ethernet Switches to latest technology.
- Upgrade Field Mounted Ethernet Switches to latest models.
- Perform hardware site survey every 5 years.
- Replace the balance of the SCADA system PLCs (including Allen-Bradley), Remote I/O Panels and OITs.
- Conduct routine network and SCADA self-assessments.*
- Review implementation of system backups and disaster recovery plans.*
- Perform firmware and software updates each year.
- Upgrade selected reporting software to latest version. Maintain a service and support contract for periodic updates and support.*
- Update On-call Alert Management Software.
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.*
- Maintain service agreement with Cisco hardware.*
- Replace and upgrade hardware every 5 years according to refresh schedule.
- Replace and upgrade existing SCADA workstations.
- Upgrade existing SCADA servers.

11-15 years (* indicates minor cost/policy items not included in Table UW2-6):

- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.*
- Upgrade Ethernet Switches to latest technology.
- Upgrade Field Mounted Ethernet Switches to latest models.
- Perform firmware and software updates each year.
- Perform hardware site survey every 5 years.
- Conduct routine network and SCADA self-assessments.*
- Review implementation of system backups and disaster recovery plans.*
- Replace and upgrade hardware every 5 years according to refresh schedule.*
- Upgrade existing Hirschman Ethernet switches to latest model.
- Upgrade selected reporting software to latest version. Maintain a service and support contract.*
- Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.*
- Maintain service agreement with Cisco hardware.

- Update On-call Alert Management Software.
- Replace and upgrade existing SCADA workstations.
- Upgrade existing SCADA servers including:
    - SCADA Servers (Primary and secondary)
    - Historian Server
    - Domain Controller Servers (Primary and secondary)

16-20 years (* indicates minor cost/policy items not included in Table UW2-6):

- Upgrade the existing SCADA system software to latest Citect SCADA version and maintain an on-going maintenance contract with the Citect SCADA supplier for periodic updates and support.
- Conduct routine network and SCADA self-assessments.*
- Upgrade PLCs and Remote I/OS to latest products by Rockwell Automation.*
- Upgrade network intrusion detection system.
- Upgrade firewalls on all data communication connections to outside sources (not internal to the plant) that could be subject to unwanted intrusion.*
- Upgrade Ethernet Switches to latest technology.
- Upgrade Field Mounted Ethernet Switches to latest models.
- Review implementation of system backups and disaster recovery plans.*
- Perform firmware and software updates each year.
- Upgrade selected reporting software to latest version. Maintain a service and support contract for periodic updates and support.*
- Update On-call Alert Management Software.
- Replace and upgrade hardware every 5 years according to refresh schedule.
- Replace and upgrade existing SCADA workstations.
- Maintain service agreement with Cisco hardware.
- Upgrade existing SCADA servers.

2.7.4 Cost Summary

Table UW2-6 below lists the estimated costs (in 2016 dollars) for the recommended SCADA system improvements for the Distribution and Collection System. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Table UW2-6. Distribution and Collection SCADA System.

Project Description	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
Self-healing radio feasibility study	$150,000	$0	$0
If self-healing radio is feasible, design and installation phase	$0	$2,500,000	$0
Create a secondary server room with relocating of the redundant Servers and network components	$100,000	$0	$0
Replace remaining outdated Allen-Bradley PLC and RIO systems with Rockwell Automation (Allen-Bradley) ControlLogix or CompactLogix Platform	$0	$300,000	$0

Project Description	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
Install a network intrusion detection system such as Cisco ASA 5512 Adaptive Security Appliance or Checkpoint. Replace/Upgrade every 5 years.	$20,000	$20,000	$40,000
Implement regular software and firmware patches.	$25,000	$25,000	$50,000
Perform hardware site survey every 5 years.	$10,000	$10,000	$20,000
Replace existing Cisco catalyst 3500, 3560G, and 2800 series Ethernet switches, with new Campus LAN Cisco Ethernet switches. Upgrade to latest technology every 5 years.	$25,000	$25,000	$50,000
Automate third party application patching with patch management software, such as Shavlik or Dameware Patch Manager.	$15,000	$15,000	$30,000
Upgrade Citect SCADA to latest version and maintain maintenance contract	$20,000	$20,000	$40,000
Upgrade reporting software	$20,000	$20,000	$40,000
Maintain service agreement with Cisco hardware. Implement hardware refresh schedule.	$10,000	$10,000	$20,000
Install On-call Alert Management Software	$20,000	$10,000	$20,000
Implement system backups and disaster recovery plans. Review every 5 years.	$15,000	$15,000	$30,000
Upgrade Existing SCADA servers	$0	$30,000	$60,000
Upgrade Field Mounted Ethernet Switches to latest models	$0	$25,000	$50,000
Replace and upgrade existing SCADA workstations	$0	$15,000	$30,000
Upgrade PLCs and Remote I/O's to latest products by Rockwell Automation	$0	$0	$1,000,000
Totals	$430,000	$3,040,000	$1,480,000

2.8 Utilities Owned Fiber Optic Wide Area Network Connecting Fiveash WTP, Peele-Dixie WTP, GTL and D&C SCADA Systems

2.8.1 Existing Conditions

Currently, there is no direct, City owned, connection between the SCADA systems of the Fiveash WTP, Peele-Dixie WTP, GTL and Distribution and Collection System. There are fiber optic connections between Fiveash WTP and Prospect Wellfield; Peele-Dixie and Dixie Wellfield; Fiveash and Second Avenue and Poinciana Park Ground Storage Tank/Re-pump Stations that are owned by COMCAST and leased to the City. The agreement between COMCAST and the City calls for these connections to be exclusive with only City utilities traffic on these fibers. It is unknown how secure COMCAST'S network is relative to the City's data and the ability for malicious intrusion by outside parties to occur. There is an AT&T owned T1 line to the Utilities Administration Building that routes all collection system pump station data to D&C SCADA and there is a fiber optic cable from Utilities Administration to Fiveash WTP for enterprise system connections. As with the COMCAST fiber system, it is unknown how secure the data transmitted over the AT&T T1 line, and subsequent Verizon Cellular connections from individual D&C pump stations is. City staff have expressed concern over the loss of control with regards to data security through third party vendor communications means.

The CUS Master Plan Team observes off-site storage of critical SCADA configuration and data is handled locally through the use of portable storage devices with the data stored at the homes of key plant personnel. While this has been effective in reducing the possibility of significant down time if the software, and data, become corrupt, the control of the data is no longer directly within the City confines and the media storage devices could be compromised when outside of the City's control.

As observed in **Section 2.7 of UW4** the D&C SCADA system does not have any means to share data with the GTL for use in managing plant operations during high influent flow events.

As observed in **Section 2.2 of UW4** there is a fiber connection through COMCAST from Fiveash to Poinciana Park and Second Avenue Storage Tanks for monitoring and control interface, however, Peele-Dixie cannot see the same data as there is no connection from these pump stations to Peele-Dixie.

The CUS Master Plan Team observes that the City's water and wastewater utilities would operate in a more efficient and reliable manner if there is a utilities owned and managed wide area fiber optic network connecting these sites such that appropriate data, automated data backup storage and transmission and collection network visibility are available in the various SCADA systems at the plants.

2.8.2 Recommendations

The CUS Master Plan Team recommends the implementation of a City wide, Utilities Owned, fiber optic network that is managed by dedicated utilities staff that is independent of the existing City IT managed system and is not leased over third party owned infrastructure. Utilities operations would benefit from the wide area network connection by having a secure means of interconnection of the plants to share operational data; provide multiple sites for automated back-up storage of critical programming and data; and allow for quicker recovery time of the SCADA system in the event of a disaster at one of the plants. The CUS Master Plan Team recommends the City create a network administrator position to manage the wide area network and act as a liaison between plant SCADA staff and City IT staff.

The CUS Master Plan Team recommends that the fiber optic network be implemented in a phased approach:

- First Phase: Fiber optic cables installed between Fiveash, Peele-Dixie, GTL and Utilities Administration and the wide area network established. It may be possible to use right-of-way easements along City roads for the fiber optic cables, manholes and conduit installation.
- Second Phase: Extend fiber optic cables to Dixie Wellfield, Prospect Wellfield, Poinciana Park and Second Avenue Storage Tanks and integrate into the utilities network.
- Third Phase: as discussed in Section 2.7.2 of UW-2, The CUS Master Plan Team recommends the investigation implementation of a mesh radio network for collection system pump station and transmission system pressure monitoring stations. The proposed fiber optic network could be further extended to key locations within the D&C system, such as master re-pump stations or other strategic locations, such that the mesh radio network could be "clustered" to a master radio that is connected to the fiber optic wide area network. The CUS Master Plan Team recommends the City include in the mesh radio network study where strategic locations are for master radio connections and transition to the fiber optic network.

To further enhance security of the proposed wide area network system. The CUS Master Plan Team recommends creating a De-Militarized Zone (DMZ) as a buffer between the utilities WAN and individual plant SCADA networks to manage transmission of data between the various SCADA systems. Not all data on each system needs to be visible from all other plant SCADA systems. The DMZ can establish which data is made available publically whereby various plant SCADA system can obtain, or push, data to and from the DMZ. Most advanced firewalls have the scalability to allow multiple DMZs and specify type of traffic.

In order to minimize risk of unauthorized access to the SCADA network The CUS Master Plan Team recommends:

1. Control network traffic via Access control Lists.
2. Monitor network traffic on the SCADA network through an Intrusion Detection System IDS and Intrusion Prevention System (IPS).
3. Secure connectivity for any authorized remote support of control systems, firewalls and wireless devices.
4. The utilities wide area network should be physically and logically isolated from other City enterprise networks. There should be no interconnectivity between them to risk contamination by a breach of either systems.
5. The SCADA network should not have direct access to the Internet.
6. Periodically apply security patches to servers in DMZ.
7. Segment the SCADA network in different security zones and deploy distributed firewalls for additional access controls.
8. Investigate the applicability of Unified Threat Management (UTM) devices and software for regulating external access into the SCADA network. The UTM aggregates firewall,

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intrusion prevention, gateway antivirus and anti-spam, VPN and content filtering. Typically the system is a single device that is plug and play into the network and can be configured from a web based interface.

a. Advantages include:

   i. Reduction of overall system complexity through consolidation of functions normally performed by separate devices and/or software packages;

   ii. Single hardware device;

   iii. Reduced training and management of multiple devices and software packages;

   iv. Ability to assign user identity information in addition to IP addresses and network data.

b. Disadvantages include:

   i. Possible single point failure for network traffic; would possibly have to implement multiple units for backup if one fails.

   ii. Single point of compromise if the UTM has vulnerabilities, or is not kept up to date with latest patches, both software and firmware.

   iii. Possible bandwidth issues if traffic exceeds capability of the device.

2.8.3 Cost Summary

Table UW2-7 below lists the estimated costs (in 2016 dollars) for the recommended Utilities owned fiber optic wide area network. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

The costs presented below for establishment of the fiber optic wide area network are conceptual in nature as it is beyond the scope of this document to determine exact routings and associated installation costs. Costs assume implementation of 144 strand single mode fiber in two possible different means of installation: direct burial method and raceways with pull boxes.

Table UW2-7. Utilities Owned Fiber Optic Wide Area Network.

Project Description	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
Phase 1: Direct buried option	$3,000,000	$0	$0
Phase 1: Conduit with pullbox option	$4,000,000	$0	$0
Phase 2: Direct buried option	$0	$1,500,000	$0
Phase 2: Conduit with pullbox option	$0	$2,500,000	$0
Phase 3: Direct buried option	$0	$0	$3,000,000
Phase 3: Conduit with pullbox option	$0	$0	$4,000,000
Miscellaneous Network Equipment	$150,000	$150,000	$300,000
Establish Utilities WAN administrator	$409,090	$566,229	$1.368,847
Total:	$7,669,090	$4,728,229	$8,668,847

2.9 Aggregate SCADA Systems Cost Summary

The 20 Year CIP costs for the utility-wide SCADA projects are summarized below (in 2016 dollars) and presented in the CIP report section.

Location	1-5 Year Cost	6–10 Year Cost	11-20 Year Cost
Fiveash WTP Improvements	$2,660,000	$3,540,000	$1,980,000
Prospect Wellfield Improvements	$476,000	$756,000	$357,000
Peele-Dixie Membrane WTP Improvements	$2,560,000	$240,000	$2,480,000
Dixie Wellfield Improvements	$20,000	$460,000	$20,000
GTL Improvements	$2,475,000	$540,000	$1,480,000
Distribution & Collection Improvements	$530,000	$3,040,000	$1,480,000
Utilities Wide Area Network	$7,669,090	$4,726,229	$8,668,847
Total	$16,390,090	$13,302,229	$16,465,847

UW3 Treatment Plants Electrical Study

3.1 Introduction

The electrical systems at the water treatment plants (WTPs), the wellfields serving the WTPs, and the wastewater treatment plant (WWTP) vary in age and condition. This section of the report summarizes the existing systems, identifies major safety and reliability concerns with the systems, and provides recommendations for improvements with conceptual cost estimates for the improvements. The information presented herein is based on a combination of field visits, discussions with City staff, and previous City reports/documents and is to the best of CUS Master Planning Team's knowledge.

The City has two (2) wellfields, three (3) WTPs, and one (1) WWTP that provide water and wastewater service within the City's service area and to adjacent wholesale customers. The Fiveash WTP is located in the north part of the City and is served by the Prospect Wellfield that is located approximately 2 miles northwest of the Fiveash WTP. The Peele-Dixie WTP is located in the southwest portion of the City and includes both a lime softening process train (currently out of operation) and a nanofiltration membrane process train. Raw water is provided for the Peele-Dixie WTP from the Dixie Wellfield located approximately 1 mile northwest of the WTP. The George T Lohmeyer WWTP (GTL) is the City's sole WWTP and is rated at 56.6 MGD (see Section WW-08). The GTL is located in the southeast portion of the City. All of the facilities were evaluated except the Peele-Dixie lime softening process train based on the CUS Master Plan team's recommendation in Section WA5 to keep the facility inactive.

The electrical system considerations for the treatment plants are also important with regards to energy conservation and the City's goal of reducing energy consumption 20% by the year 2020: the treatment plants are the largest energy users in the City. Replacement of older electrical motors with "high efficiency" motors is addressed in Sections **WA13** and **WW16**.

Recommended modifications to control/electrical systems to improve local manual operation of specific process equipment are addressed in Section UW4 - Manual Operations.

3.2 Fiveash WTP

3.2.1 Existing Conditions

Fiveash WTP has been in service since mid-1950 with many modifications to the process and electrical power distribution systems as the plant's capacity has increased. There are some panelboards remaining from the 1950's era facility still in service today. The majority of Fiveash WTP's power distribution system was installed in the late 1970's to early 1980's and is at the end of its useful life.

The existing power distribution system at Fiveash WTP receives normal utility power from FPL at 4.16kV through an on-site utility transformer vault containing four (4) utility service transformers grouped in two (2) pairs. FPL serves the Fiveash WTP with two (2) 13.2kV primary feeders, one (1) preferred, and one (1) emergency. Each pair of transformers has an automatic oil immersed transfer switch that switches between the normal and emergency feeder when utility power is lost. The utility transformers in the vault were upgraded within the last 18 months by FPL. Power is metered on the primary feed entering Fiveash WTP from Powerline Road.

There are four (4) medium voltage fused switches in an electrical room adjacent to the utility transformer vault that provide four (4) services to Fiveash WTP and the Utilities Administration

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Building. Power from the four (4) medium voltage fused switches is distributed at 4.16kV to the following locations:

- MCC_5203 (North High Service Pump Switchgear): Serves medium voltage North High Service Pumps 4 & 5. (Installed in 1995)
- SWGR5204 (OSW2 – Outdoor Switchgear #2): Serves medium voltage Backwash Pump P_3202 (BWP-2) and Utilities Administration through a local pad-mounted step-down transformer. (Installed in 1970's).
- MCC_5201 (High Service Pump Starter HSP-SW-1): Serves High Service Pumps P_6212 (HSP-12), P_6213 (HSP-13), and 4.16kV-480/277V step-down transformer XFMR5502 (HT-2). (Installed in 1970's)
- MCC_5202 (High Service Pump Starter HSP-SW-2): Serves medium voltage High Service Pumps P_6209 (HSP-9), P_6210 (HSP-10), P_6211 (HSP-11), P_6214 (HSP-14), P_6215 (HSP-15), P_6216 (HSP-16) and 4.16kV-480/277V step-down transformer XFMR5501 (HT-1). (Installed in 1970's)

Emergency power is derived from two (2) existing 900kW, 480V emergency diesel generators. There is no emergency power for the 4.16kV system as High Service Pumps P_6209 (HSP-9), P_6210 (HSP-10) and P_6211 (HSP-11) are diesel-electric pumps that operate on diesel engines when utility power is lost. High Service Pumps P_6206, P_6207, and P_6208 are diesel engine driven only. The diesel generators and diesel high service pumps were installed in the early 1980's (record drawings dated 1982).

Low voltage power (480V) is derived from 4.16kV-480/277V step-down transformers XFMR5501 (HT-1) and XFMR5502 (HT-2) to MCC_5503 (MCC K) and MCC_5504 (MCC J) that were all installed at the same time as the diesel equipment in 1982. Each MCC contains a main breaker and automatic transfer switch to distribute normal and emergency power to the remainder of Fiveash WTP. Appendix UW3-A contains a listing of the low voltage panels/switchgear and the equipment/areas the motor control centers feed.

A large portion of the existing electrical system is very old (40 to 60 years old), particularly the 240V system conductors and equipment, as most are original installations in the 1950's and subsequent upgrades throughout the 1970's. A large portion of the 480V system was installed in the late 1970's/early 1980's and is at the end of its useful life. The power distribution system was expanded over the years without regard to redundancy or reliability where a failure of one breaker, or cable, could result in loss of the entire treatment process capability.

In 2005, a Short Circuit and Device Coordination Study was undertaken and plant wide electrical systems maintenance and testing activities took place. The 2005 short circuit study is outdated and no arc flash component was included. Electrical maintenance testing found a number of deficiencies, some that were addressed during preventative maintenance activities, and some that were deemed in need of capital improvement projects to rectify. According to Fiveash WTP staff, no additional maintenance testing, or rectification of system deficiencies identified during those activities, has yet occurred.

Conducting short circuit and arc flash studies and establishing an Arc Flash Safety Program are requirements of NFPA 70 (NEC), OSHA, and NFPA 70E electrical safety codes. The Arc Flash studies are to be reviewed and updated on a maximum five (5) year basis and sooner if significant modifications are made to the power distribution system. Compliance with these requirements establishes safe work practices for electrical power distribution systems and significantly reduces the risk of exposure of plant personnel to injury or death. Equal in importance is good maintenance of the power distribution system components including regular preventative maintenance and testing activities. The plant has not conducted a review of the 2005 short circuit and device coordination study and has not established an Arc Flash Safety Program. In addition, no system wide electrical maintenance testing activities have taken place since 2005. This is a serious electrical power distribution system deficiency that the CUS Master Plan team recommends addressing as soon as possible.

There have been historical capital improvement projects to address process deficiencies that also include electrical system upgrades. Specifically, since 2000, the following projects have included modifications to Fiveash WTP power distribution system components:

- Project #10387 Volume 5: Fiveash North High Service Pumps: Modified and refurbished MCC_5203 (North High Service Pump Switchgear). This equipment also had preventative maintenance in the NETA testing project in 2005
- Project #10508B Fiveash Bid Package B: Replaced outdated and failing MCC_5312 (MCC B) with new outdoor rated unit and located to the northwest side of Aeration Basin #2; Demolished and removed outdated MCC_5638 (MCC-D) and replaced with new Panels PNL_5312 and PNL_5625 for re-connection of existing loads; replaced starters associated with sludge agitator pumps P_2101 and P_2102; Routed new feeder conductors from MCC_5311 (MCC G) to new MCC_5312 (MCC B) and new feeder conductors from MCC_5312 to existing loads served. Routed new feeder conductors from PNL_5625 (replacement of MCC D) to existing loads served by previous MCC D.
- Project #10387 Volume 6: Fiveash Reliability Upgrades Phase 1: Replaced the medium voltage conductors for P_3202 Backwash Pump #2 from the starter to the pump motor; Added UPS_5702, UPS_5703, XFMR5710, XFMR5720, MCC_5309. Added panels:
    - PNL_5304.
    - PNL_5305.
    - PNL_5702.
    - PNL_5703.
    - PNL_5302.
    - PNL_5303.
    - PNL_5306.
    - PNL_5307.
    - PNL_5308.
    - PNL_5309.
    - PNL_5310.
    - PNL_5702.
    - PNL_5703.
    - PNL_5704.
    - PNL_5705.
    - PNL_5706.
    - PNL_5707.
    - PNL_5708.

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- PNL_5709.
- PNL_5710.
- PNL_5711.
- PNL_5624.
- PNL_5625.

- Project 10508D Fiveash Reliability Upgrades (in final design and review stage as of the writing of this document) will replace SWGR5204 (OSW2) and install two new 1250kW emergency diesel generators to replace the existing 900kW units. New conductors will be installed from SWGR5204 to MSTR3202 (Backwash Pump #2 Starter) and to XFRM5303 (pad mounted transformer serving the Utilities Building). The spare fused switch in SWGR5204 will be used to power a new pad-mounted 4.16kV-408/277V transformer for the new Hypochlorite Building. New electrical/generator spaces are included in the Hypochlorite Building to accommodate the new emergency diesel generators and power distribution switchgear. The existing generators will be abandoned in place. New control panels for the diesel-electric pumps will be installed as part of the project. Additional features of the Fiveash Reliability Upgrades project include:
  - New power panel for the lime system.
  - New power panel for the re-purposed Chlorine Building Evaporator Room.
  - New power panels in the High Service Pump Room.
  - New power panel in the computer room.
  - New UPS and distribution panel in the Secondary Control Room.
  - Short circuit, device coordination and arc flash study.
- Utilities staff indicates that there is an in-house initiative to bring all existing diesel engines (including the existing 900kW emergency diesel generators) into compliance with Reciprocating Internal Combustion Engines National Emission Standards for Hazardous Air Pollutants (RICE NESHAP) requirements.
- Fiveash WTP staff indicates that there is an in-house initiative to re-lamp existing fixtures (or replace if appropriate) with LED energy saving units.

3.2.2 Safety and Reliability Concerns

The age of the majority of the normal and emergency power distribution systems is of significant concern. Much of the equipment has reached the end of its useful life and replacement parts are now difficult to acquire. There are conductors that were indicated as suspect during the maintenance and testing activities performed in 2005 that have not been replaced or re-tested subsequent to those tests. The CUS Master Planning Team is concerned that there could be catastrophic failure of the aged equipment leading to loss of treatment capacity, fire or personnel injury. The 240V system power distribution equipment dates to the original installation of Fiveash WTP in the 1950's and is long past its useful life.

This report anticipates Project 10508D Fiveash Reliability Upgrades being completed as currently planned by the City to improve safety and reliability at the plant. If the Fiveash Reliability Upgrades project does not move forward as planned, the CUS Master Plan Team recommends expediting recommended electrical improvements via another contracting mechanism.

Transformers XFMR5501 and XFMR5502 are 4.16-480/277V step-down units that derive the 480V power to Fiveash WTP. These units are paper impregnated insulation type units that were installed in the early 1980's. They are in an air conditioned environment; however, they are subject to moisture intrusion from humidity if the conditioned environment fails. These units are past their useful life and are candidates for replacement. New regulations for transformer efficiency issued by the Department of Energy (DOE) in 2016 will result in an increase in energy efficiency of all transformer types and will result in overall energy savings as less energy is lost to heat. The CUS Master Plan Team recommends that the City replace all of Fiveash WTP's transformers as well as the electrical equipment recommended for replacement due to age that would result in substantial energy savings as identified in Section WA13.

Presently, there is no plant Arc Flash Safety program nor Arc Flash labels affixed to electrical equipment as required by NEC, OSHA and NFPA 70E national codes. There has also not been an update to the Short Circuit and Device Coordination Study since 2005. Updates are required every five (5) years. The absence of an updated Short Circuit and Device Coordination Study and an Arc Flash Safety program is in violation of the current codes listed above and exposes plant workers to potential dangers. This is a significant electrical system deficiency which the CUS Master Plan team recommends to be rectified as soon as possible.

The basis for updating a short circuit, device coordination and Arc Flash Study are accurate plant one line diagrams. Presently, the Fiveash WTP one-line drawings do not reflect the most current state of the power distribution system. Inaccurate plant drawings hinder staff's ability to efficiently diagnose and troubleshoot problems that occur at Fiveash WTP. Therefore, the CUS Master Plan Team recommends Fiveash WTP drawings be updated to reflect the current as-installed condition.

High Service Pumps P_6212, P_6213, P_6214, P_6215 and P_6216 and Transfer Pumps P_6301, P_6302, P_6303 and P_6304 have local pump control panels with PLC's and touch screen operation interface terminals (OIT). Fiveash WTP staff has indicated that it is generally not possible to operate the pump if the OIT or PLC is not functioning and that a means of back-up manual control is needed to bypass the OIT or PLC, so that the pump may be used if necessary during critical operations. Issues identified with the local control of the HSPs are addressed in section **UW4**.

There is redundancy in the power distribution system and pumping systems for the high service and transfer pumps such that a single point failure will not prevent Fiveash WTP from delivering water to the distribution system. However, there are concerns with regards to reliability and redundancy in other areas of Fiveash WTP. Specifically:

- There is a single feeder from MCC_5504 (MCC J) to MCC_5311 (MCC G) that is the source of all power to the Hydrotreaters, Lime System, Lime Sludge System, chemical systems, control systems and networking systems. The loss of this circuit (conductors, breaker, and bus of MCC_5311) would significantly hinder the treatment operations of Fiveash WTP.
- Hydrotreaters HYD_2101 and HYD_2102 are powered from MCC_5312 (MCC B), at 480V, and Hydrotreater HYD_2103 is powered from MCC_5615 (MCC F2), at 240V. Hydrotreater HYD_2104 is powered from 480V panel PNL_5303 with control power from panel PNL_5709. MCC_5312 (MCC B), MCC_5615 (MCC F2) and panel PNL_5303 are each powered from MCC_5311 (MCC G). The feeder for MCC_5615 (MCC F2) is tapped from MCC_5614 (MCC F1) on the line side of the main breaker. If MCC_5614 (MCC F1) fails, it is possible that MCC_5615 (MCC F2) may not receive power, depending on the failure of MCC_5614 (MCC F1). MCC_5311 (MCC G), MCC_5614 (MCC F1) and MCC_5615 (MCC F2) are all at, or near, the end of their useful life. The feeder conductor to MCC_5311 (MCC G) was not insulation-resistance tested during the 2005 testing activities because plant staff were concerned that the cable would fail and severely disrupt plant operations.

- The sludge agitator pumps for the Hydrotreaters are not powered from the same bus as the Hydrotreaters. Sludge Agitator Pumps P_2101 and P_2102 are powered from PNL_5630 (Power Panel No.1) which derives power from PNL_5629 (Mezzanine Power Panel), SWBD5616 (Switchboard GP). Similarly, Sludge Agitator Pump P_2103 is powered from MCC_2638 (MCC D) which also is powered from SWBD5616 (Switchboard GP). It is interesting to note that Sludge Agitator Pump P_2104 is powered from the same bus (MCC_5615) (MCC F2) as Hydrotreater HYD_2104 that it serves. Loss of power to the agitators pump would hinder the Hydrotreaters' ability to function. Having these items powered from separate locations in the power distribution system creates additional possible failure points.
- Panel PNL_5303 contains feeder breakers for all valves associated with Hydrotreaters HYD_2103 & HYD_2104 and derives power from MCC_5311 (MCC G). PNL_5302 contains feeder breakers for all valves associated with Hydrotreaters HYD_2101 & HYD_2102 and derives power from MCC_5312 (MCC B), same as Hydrotreaters HYD_2101 & HYD_2102, which ultimately derives power from MCC_5311 (MCC G). Again, having these powered from separate locations create possible failure points.

Fiveash WTP staff has indicated that the grounding and bonding system at the plant is in deteriorating condition, and in some cases, missing. A uniform grounding grid of low impedance is important to power system performance and personnel safety.

During certain flow events consistent pressure output is difficult to maintain, therefore the addition of variable frequency drives to a minimum of two (2) high service pumps would improve distribution system pressure control. In addition, Section WA13 Water Energy Conservation addresses this recommendation from an energy savings perspective.

3.2.3 Recommendations

The following summarizes Fiveash WTP power distribution system recommendations to increase safety, reliability and energy efficiency in 5 year intervals for the next 20 years of plant service:

<u>1-5 years</u>:

- Perform update to Short Circuit and Device Coordination Study and add Arc Flash. Establish an Arc Flash Program for personnel training and execution of work on live equipment. Affix Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on Fiveash WTP power distribution system.
- Replace Medium Voltage Switches (service disconnects) SW_5101, SW_5102, SW_5103, and SW_5104 in 5kV room adjacent to the transformer vault, including conductors and raceways.
- Replace MCC_5202 and MCC_5201 Medium Voltage starters for high service pumps 9-16 and feeder breakers for both 4.16-480v step down transformers for MCC'S 5504 (MCC J) and 5503 (MCC K). Includes all conductors, raceways and controls.
- Remove Panel PNL_5602 (Panel LPHS-3) from MCC_5202 and replace with a new panel and step-down transformer to replace associated XFMR5601.
- Replace XFMR5501 and XFMR5502 including conductors and raceways.
- Replace MCC_5504 (MCC J) and MCC_5503 (MCC K) including all raceways, conductors and controls.

- Replace MCC_5311 (MCC G), including all conductors, raceways and controls and address single point failure with additional feed from MCC_5503 (MCC K). Incorporate MCC_5313 (MCC E) into new MCC_5311 (MCC G) and eliminate MCC_5313 (MCC E). Install new conductors and raceway to loads served from MCC_5313 (MCC E) to new MCC_5311 (MCC G).
- Replace/Convert MCC_5614 (MCC F1) and MCC_5615 (MCC F2) from 240V to 480V including all equipment motors, and implement step down transformers for 240V panelboards presently connected to the MCC's. Relocate all components associated with Hydrotreater HYD_2103 (including injector pump, agitator pump and associated valves) to MCC_5614 and all components associated with Hydrotreater HYD_2104 to MCC_5615. Move power feeds from MCC_5311 to MCC_5503 (MCC K) and MCC_5504 (MCC J) to improve reliability.
- Replace switchboard SWBD5616 (Switchboard GP) including conductors and raceway.
- Replace XFMR5612 (XFRM T2) that serves SWBD5616 (Switchboard GP) including conductors and raceways.
- Replace Panel PNL 5630 (Power Panel No.1) including conductors and raceway.
- Replace general circuit breaker panelboards including:
    - PNL_5631 (Panel A)
    - PNL_5632 (Panel B)
    - PNL_5633 (Panel C)
    - PNL_5634 (Panel D)
    - PNL_5617 (Panel G)
    - PNL_5611 (Panel LPF)
    - PNL_5604 (Power Panel LPHS1) including associated XFMR5603 and double throw transfer switch SW_5505.
    - PNL_5604A
    - PNL_5604B
    - PNL_5605
- Convert motors on the 240V system to 480V, replace associated starters and re-feed from the 480V system. Advantage of this approach is less current draw in the motor and losses in the conductors. The goal is to standardize motors 10 HP and larger on 480V to the greatest extent possible. Medium voltage motors should remain on the 5kV system.
- Replace MSTR3202 (Backwash Pump 2 motor starter including all control wiring and raceway.
- Add medium voltage variable frequency drives to two high service pumps for distribution pressure control.
- Replace Surface Wash Pump No. 1 (P_3301) motor starter, conductors, and raceways.

6-10 years:

- Update Short Circuit, Device Coordination and Arc Flash Study (required every five (5) years).
- Perform electrical maintenance testing.
- Replace MCC 5301 (MCC H) on second floor electrical room behind control room, including all wiring, raceways and controls.
- Presently, Hydrotreaters HYD_2101 and HYD_2102 are powered from MCC_5312 (MCC B) with associated sludge agitator pumps. Associated valves are powered from a common power panel PNL_5302. A loss of power to MCC_5312 would prevent both treatment units from operation. Segregate Hydrotreater HYD_2101

and all associated components to a new motor control center dedicated to Hydrotreater 1 with a separate feed from MCC_5311 (MCC G) such that a loss of power on either MCC only affects one Hydrotreater.

- Replace general circuit breaker panelboards and associated transformers including branch circuit wiring and raceway for:
  - PNL_5623 (5KV Switch Room)
  - PNL_5314 (Panel WW)
  - PNL_5608 (Panel LPOC-2)
  - PNL_5609 (Panel LPOC)
  - PNL_5610 (Panel LPOC-1)
  - PNL_5611 (Panel LPF)
  - PNL_5607 (Panel LPCC)
- Continue to convert motors on the 240V system to 480V, replace associated starters and re-feed from the 480V system.

<u>11-15 years:</u>

- Update Short Circuit, Device Coordination and Arc Flash Study.
- Perform electrical maintenance testing.
- Replace MCC_5203 (North High Service Pump Switchgear) including all associated conductors and raceways.

<u>16-20 years:</u>

- Update Short Circuit, Device Coordination and Arc Flash Study.
- Perform electrical maintenance testing.
- Replace power distribution system associated with the Aqua Ammonia Building.

3.2.4 Cost Summary

The table below lists the estimated costs (in 2015 dollars) for the recommended electrical power distribution system improvements at the Five Ash WTP. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Fiveash WTP Electrical Power Distribution System

Project Description	1-5 year Cost	5–10 year Cost	10-20 year Cost
Perform Short Circuit Device Coordination and Arc Flash Study	$160,000	$60,000	$120,000
Perform Electrical Maintenance Testing	$500,000	$250,000	$500,000
Replace medium voltage fused service disconnect switches	$300,000	$0	$0
Replace MCC_5202 and MCC_5201 Medium Voltage starters for high service pumps 9-16 and feeder breakers for both 4.16-480v step down transformers for MCC'S 5504 (MCC J) and 5503 (MCC K). Includes all conductors, raceways and controls	$1,660,000	$0	$0
Remove Panel PNL_5602 (Panel LPHS-3) from MCC_5202 and replace with a new	$200,000	$0	$0

panel and step-down transformer to replace associated XFMR5601.			
Replace XFMR5501 and XFMR 5502	$440,000	$0	$0
Replace MCC_5504 and MCC_5503 (MCC'S J&K)	$1,300,000	$0	$0
Replace MCC_5311; add second feed; incorporate/eliminate MCC_5313	$350,000	$0	$0
Replace/Convert MCC_5614 to 480V and dedicated to HYD_2103	$220,000	$0	$0
Replace/Convert MCC_5615 to 480V and dedicate to HYD_2104	$220,000	$0	$0
Replace SWBD5616	$210,000	$0	$0
Replace XFMR 5612	$115,000	$0	$0
Replace PNL 5630	$230,000	$0	$0
Replace General Circuit Breaker Panelboards, Transformers, and branch circuits	$800,000	$600,000	$0
Replace MCC 5301	$0	$240,000	$0
Separate HYD_2101 and HYD_2102 onto separate MCC's	$0	$210,000	$0
Replace MSTR3202 (Backwash Pump 2)	$130,000	$0	$0
Replace MCC_5203	$0	$0	$300,000
Replace Aqua Ammonia Building power system	$0	$0	$580,000
Replace Surface Wash Pump No. 1 (P_3301) motor starter, conductors, and raceways.	$80,000	$0	$0
Add medium voltage variable frequency drives to two high service pumps for distribution pressure control.	$150,000	$0	$0
Convert motors on the 240V system to 480V, replace associated starters and re-feed from the 480V system.	$350,000	$200,000	
Total	$7,415,000	$1,560,000	$1,500,000

3.3 Prospect Wellfield

3.3.1 Existing Conditions

The Prospect Wellfield is located NW of the Fiveash WTP (See **Figure UW3-1**) and consists of 29 Biscayne Aquifer wells that deliver raw water to Fiveash for treatment. The wellfield was constructed in two different phases with the first phase (original phase; west wellfield) constructed in the 1950's with the Fiveash WTP, and the second phase (east wellfield) constructed in the late 1970's, early 1980's when the plant was expanded.

The first phase constructed wells PW_25, PW_26, PW_27 and PW_28. Additional wells PW_30, PW_31, PW_32, PW_33, PW_34 and PW-35 were added in the mid-1960 to early 1970's time frame. The second phase (eastern wells) installed wells PW_36, PW_37, PW_38, PW_39, PW_40, PW_41, PW_42, PW_43, PW_44, PW_45 , PW_46, PW_47, PW-48 and PW_49. In 2004 additional wells PW_50, PW_51, PW_52, PW_53 and PW_54 were installed.

In the first phase, the west generator building with 480V normal and emergency power distribution equipment was constructed. Normal utility power is derived from overhead lines and pole mounted transformers to a service entrance rated main breaker, automatic transfer switch and motor control center and emergency diesel generator. The existing motor control center was relocated from other City facilities and is of 1980's vintage. The MCC primarily contains feeder breakers for Wells PW_25, PW_26, PW_27 and PW_28 to supply 480V normal and emergency power. There is also a feeder breaker for a local lighting transformer and circuit breaker panelboard. City maintenance staff indicate that replacement parts are still available. The existing generator is a 500kW unit that is approximately 30 years old and was relocated from the Police Department to the West Generator Building to provide emergency power to the wells. The unit is good condition with low operating hours for the age and City maintenance staff maintains it in good working order; however it is not presently compliant with EPA requirements for emergency standby generator emissions treatment. The automatic transfer switch was relocated together with the generator and is of the same approximate age as the generator.

Wells PW_30, PW_31, PW_32, PW_33, PW-34, PW_35 receive 480V utility power only and are fed from overhead lines and pole mounted transformers. Wells PW_25, PW_26, PW_27 and PW_28 are fed from the generator building by underground direct buried feeder conductors from the MCC to each well.

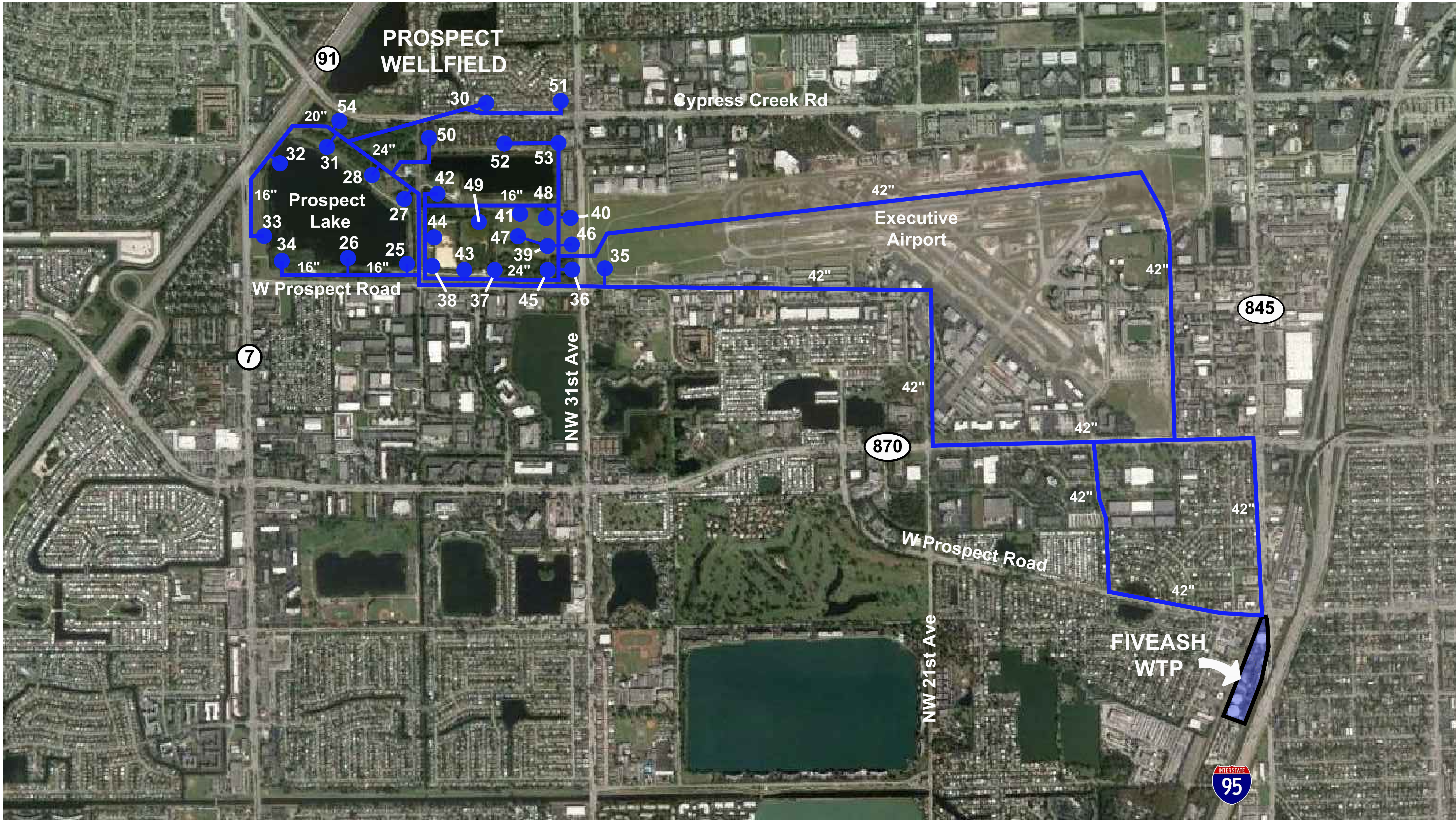
The second phase constructed a second generator building that contains main distribution switchboard (480V), an automatic transfer switch, and two distribution panelboards (labeled as motor control centers) that have individual feeder breakers to wells PW_36, PW_37, PW_38, PW_39, PW_40, PW_41, PW_42, PW_43, PW_44, PW_45, PW_46, PW_47, PW-48 and PW_49. There are two (2) emergency diesel generators that provide emergency power to the wells through two automatic transfer switches. Each generator is 750 kW and supplies emergency power to seven (7) wells. It is observed that these units were installed in 2009 at the same time the electrical power distribution equipment was installed.

Wells PW_50, PW_51, PW_52, PW_53 and PW_54 receive 480V utility power only and are fed from overhead lines and pole mounted transformers.

There are no as-built one line diagrams of the entire wellfield to document the existing system for troubleshooting and analysis.

Presently, the feeder cables to PW_44, PW_46, and PW-48 are in need of replacement.

Section UW3 accepted December 19, 2016.



LEGEND

- WELL
- RAW WATER TRANSMISSION LINES

Graphic Scale in Feet
0 1500' 3000'

N

DWG: R:\Projects\134001-P FtLauderdale CUSMP\Design\Drawings\PreliminaryDesign\134001 Fiveash Well Location Map.dwg

RE

CITY OF FT. LAUDERDALE
FIVEASH WATER TREATMENT PLANT
WELL LOCATION MAP

FIGURE UW3-1

Each well has a local well house that contains a main disconnect, local control panel, small transformer, circuit breaker panel board and an RTU. The well houses are all original installation with various internal electrical systems repairs and upgrades performed over the years. It is observed that the well houses for Wells PW_25 through PW-28, PW_30 through PW_35 and PW-36 through PW 49 are of varying size and layout but expose maintenance personnel to the elements when servicing equipment. It was observed at PW-25 that there is a personnel hazard when the motor control panel is open and the well house door is open as it traps personnel between the doors and the adjacent pump casing. Maintenance staff indicates that the well houses installed for PW_50 through PW_54 are of a good design as they are walk-in style that allows for maintenance personnel be out of the elements when performing maintenance and repair activities.

Maintenance staff indicates that there is an effort underway to replace local full voltage starters with solid state reduced voltage starters.

Maintenance staff indicated that the direct-buried underground feeder to PW_48 is in the process of being replaced (by maintenance staff) and the feeders to PW_44 and PW_46 also need to be replaced. In general, maintenance staff indicates that direct buried cables are harder to maintain and repair/replace than those installed in conduit duct banks.

3.3.2 Safety and Reliability Concerns

Presently, there is no wellfield Arc Flash Safety program or Arc Flash labels affixed to electrical equipment in compliance with NEC, OSHA and NFPA 70E requirements. There has not been a Short Circuit, Device Coordination and Arc Flash Study performed on the wellfield power distribution equipment. There are no wellfield one line diagrams from which to produce the study. Similarly, there are no well field electrical plan drawings depicting the locations of existing direct buried power and control/signal cables.

Staff indicates that no electrical maintenance testing has taken place on the wellfield power distribution system, and repairs are made only when equipment fails, rather than preventative maintenance before equipment fails.

The well house and electrical equipment at all wells, except PW_50 through PW_54, are original vintage and, while still functioning, are approaching the end of useful life. It is observed that there is non-functioning instrumentation and, in the case of PW_25, potential personnel safety hazards when working on electrical systems. The CUS Master Plan Team recommends performing a production well head electrical systems rehabilitation for all wells, except PW_50 through PW_54, including new well control house, modeled after those installed for wells PW_50 through PW_54, well pump control panel, feeder disconnect switches, low voltage transformer and circuit breaker panelboard, and SCADA control recommendations set forth in UW 2. It is further recommended that when a well house is rehabilitated that the feeder cable to the associated generator building be replaced with new conductors in conduit duct bank with in-ground pull boxes approximately every 500 feet. If fiber optic communications are implemented, as recommended in UW-2 SCADA Systems, the CUS Master Plan Team recommends that the fiber be routed in a conduit in the same duct bank as the power conductors to each of the wells.

Fiveash WTP staff indicates that the underground feeder cables to wells PW_25, PW_26, PW_27, and PW_28 have been replaced by plant staff and are in good condition. Presently, the feeder cables to PW_44, PW_46, and PW_48 are in need of replacement; maintenance staff is in the process of replacing the feeder to PW_48; the condition of the feeder conductors to the remaining wells is unknown.

The 500 kW emergency diesel generator in the Western Generator Building is not presently in compliance with EPA emissions requirements for a generator manufactured prior to 2006 and the City is at risk of non-compliance penalties from the EPA should an inspection or audit of the installation be conducted by EPA. It is recommended that the City address the non-compliance as soon as possible by either adding a diesel oxidation catalyst to the unit or replacing the generator with an emissions-compliant unit.

The condition of the existing well field grounding system is unknown. Each generator building has a system ground rod and service grounding conductor. Wells served from the generator buildings have equipment grounding conductors routed to the wells. The existing generator buildings do not presently have lightning protection installed.

3.3.3 Recommendations

1-5 years:

- Perform Short Circuit, Device Coordination and Arc Flash Study. Establish an Arc Flash Program for personnel training and execution of work on live equipment. Affix Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Generate accurate as-built one line diagrams of the entire well field. Generate accurate plan drawings of the well field to depict locations of direct buried power, signal and control wiring, as well as, FPL facilities contained in the well field.
- Perform electrical maintenance testing on the entire well field power distribution system.
- Perform grounding system survey and testing.
- Address the EPA emissions non-compliance of the 500 kW emergency diesel generators in the Western Generator Building as soon as possible by either adding a diesel oxidation catalyst to the unit or replacing the generator with an emissions compliant unit.
- Replace underground feeder conductors to PW_44 and PW_46 in underground raceway with pull boxes approximately every 500 feet (New feeder to Well 48 presently being installed).
- Perform electrical systems rehabilitation at wells PW_25, PW_26, PW_27 and PW_28, and wells PW_30 through PW_34, including new electrical/control houses, electrical systems equipment and controls modeled after those installed in wells PW_50 through PW-54 and in conjunction with SCADA recommendations in UW-2. Change from full voltage starters to solid state reduced voltage starters in conjunction with the well electrical systems rehabilitation.
- Replace starters with Reduced Voltage starters for Wells PW_36 - PW_49.
- Install lightning protection at West Generator and East Generator Buildings.

6-10 years:

- Update Short Circuit, Device Coordination and Arc Flash Study. Update Arc Flash Labels on electrical equipment as appropriate (required every five (5) years).
- Perform electrical maintenance testing on the entire well field power distribution system.
- Perform electrical systems rehabilitation at wells PW_36 through PW-49 including new well electric/control houses, electrical systems equipment and controls modeled after those installed in wells PW_50 through PW-54 and in conjunction with SCADA recommendations in UW-2.

- Replace underground feeder conductors to wells PW_36 through PW_43, PW_45, PW_47 and PW_49 in underground raceway with pull boxes approximately every 500 feet.

11-15 years:

- Update Short Circuit, Device Coordination and Arc Flash Study. Update Arc Flash Labels on electrical equipment as appropriate (required every five (5) years). Perform electrical maintenance testing on the entire well field power distribution system.
- Renew/Rehabilitate Western Generator Building emergency generator building including main breaker, automatic transfer switch, motor control center, lighting transformer, circuit breaker panel board, emergency diesel generator, wiring and raceways.

16-20 years:

- Update Short Circuit, Device Coordination and Arc Flash Study. Update Arc Flash Labels on electrical equipment as appropriate.
- Perform electrical maintenance testing on the entire wellfield power distribution system.
- Renew the electrical equipment in well houses PW_50, PW_51, PW_52, PW_53, and PW_54.

3.3.4 Cost Summary

The table below lists the estimated costs (in 2015 dollars) for the recommended electrical power distribution system improvements at the Prospect Wellfield. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Prospect Wellfield Electrical Power Distribution System

Project Description	1-5 year Cost	5–10 year Cost	10-20 year Cost
Perform Short Circuit Device Coordination and Arc Flash Study	$25,000	$15,000	$45,000
Perform Electrical Maintenance Testing	$100,000	$100,000	$300,000
Perform Grounding/Bonding system survey and testing.	$25,000	$0	$0
Add lightning protection to east and west generator buildings.	$35,000	$0	$0
Generate Accurate As-built One Line Drawings and electrical plans of the entire wellfield	$60,000	$0	$0
Address the EPA emissions non-compliance of the 500 kW emergency diesel generator in the Western Generator Building as soon as possible by either adding a diesel oxidation catalyst to the unit or replacing the	$500,000	$0	$0

generator with an emissions compliant unit.			
Replace underground feeder conductors to Wells PW_44 and PW_46	$150,000	$0	$0
Perform electrical systems rehabilitation at wells PW_25, PW_26, PW_27 and PW_28, and wells PW_30 through PW_34, including new well control houses, electrical systems equipment and controls	$1,600,000	$0	$0
Replace starters with Reduced Voltage starters for Wells PW_36 - PW_49.	800,000		
Install lightning protection at West Generator and East Generator Buildings.	$0	$100,000	$0
Perform electrical systems rehabilitation at wells PW_36 through PW-49 including new well control houses, electrical systems equipment and controls	$0	$2,100,000	$0
Replace underground feeder conductors to PW_36 through PW_43, PW_45, PW_47 and PW_49 in underground raceway with pull boxes approximately every 500 feet.	$0	$600,000	$0
Renew/Rehabilitate Western Generator Building including main breaker, automatic transfer switch, motor control center, lighting transformer, circuit breaker panel board, emergency diesel generator, wiring and raceways.	$0	$0	$1,200,000
Renew the electrical equipment in well houses PW_50, PW_51, PW_52, PW_53 and PW_54	$0	$0	$250,000
Total	$3,295,000	$2,815,000	$1,795,000

3.4 Peele-Dixie WTP

3.4.1 Existing Conditions

The Peele-Dixie WTP site contains two water treatment plants: a retired lime softening facility constructed in 1926 that is designated a historical site; and a membrane treatment (nanofiltration) plant completed in 2008. The power distribution system of the lime softening facility is not addressed herein due to retired status. This document focuses on the Peele-Dixie membrane treatment plant (Peele-Dixie WTP) power distribution system.

Peele-Dixie WTP receives utility power from two pad-mounted utility owned transformers that are served by primary distribution lines along State Road 7. At the time of construction, FPL installed a primary distribution switch, together with the step down transformers, and intercepted the overhead lines on State Road 7 to create separate feeds from two different substations; one from the north and one from the south. Power metering is measured at the secondary of each transformer and is totalized to determine a single plant demand.

Peele-Dixie WTP has two utility services, one from each utility transformer, for normal utility power and two (2) 1750 kW emergency diesel generators for emergency power. Normal and emergency power is distributed from Switchgear SWGR5301 arranged in a main-tie-main configuration with utility main breakers and generator transfer breakers paired together to operate a power transfer scheme for each service. Under normal operating conditions, Peele-Dixie WTP loads are powered from both utility services and both generators when utility power is lost. The bus-tie breaker provides redundancy to allow the entire facility to be powered from either service or emergency diesel generator if there is a failure of one utility feed, utility main breaker or emergency diesel generator. A listing of the switchgear/panels and the associated equipment/areas they feed is provided in Appendix UW3-A.

3.4.2 Safety and Reliability Concerns

Peele-Dixie WTP electrical power distribution system was constructed approximately seven (7) years ago and is in very good condition. Operations staff indicates that all switchgear, VFDs, motor control centers, panel boards, and emergency diesel generators are operating properly and very few problems with the system have occurred.

Peele-Dixie WTP staff indicates that, post construction, there were lightning protection and grounding/bonding issues experienced. Peele-Dixie WTP staff engaged a lighting protection/grounding/bonding contractor to investigate the system and make corrections. Presently, there are no apparent grounding and bonding issues of the plant electrical system or lightning protection system.

The emergency generators at Peele-Dixie WTP were installed post 2006 and comply with RICE NESHAP requirements for emergency standby service. Peele-Dixie WTP is not currently on any FPL Customer Incentive Load Control (CILC) rate structure that requires a minimum guaranteed available operating hours of Peele-Dixie WTP on emergency generator power. Peele-Dixie WTP emergency diesel generators do not require any modifications at this time to meet current RICE NESHAP tier emission regulations. It is not known if regulations will change in the future that may require modifications to the units for compliance.

Existing panel board surge protective devices are integral to the panels they protect and require the entire panel to be de-energized for replacement when they fail. In some cases replacing the surge protection modules requires shutting the entire plant down since the panel(s) feed key Peele-Dixie WTP valves and other equipment that are required when the membrane treatment process is active. While the surge protection devices have protected Peele-Dixie WTP equipment thus far, there is concern that delays in replacing a failed surge protector (waiting for a plant shutdown) could leave equipment exposed to damage. It has also been identified that the installed model of surge protective devices in panel boards is no longer manufactured by the panel board manufacturer and replacement units require modifications to the panel board for installation. Peele-Dixie WTP staff expressed desire to migrate away from the integral style surge protective device to externally mounted units connected through a branch circuit breaker.

Operations personnel indicate that the high service distribution pumps do not have any local means for operator manual control should Peele-Dixie WTP control system fail. It was suggested that the adjacent remote I/O rack panel be modified with “Local-Auto” and “Start/Stop” switches for each high service distribution pump and that the control logic in the PLC be adjusted to accept inputs from the “Local-Auto” switch that would inform the program if the pump is to be controlled from the pump control strategy or by hand. The “Local/Auto” and “Start/Stop” switches would require direct hardwire interface to the respective motor starter control logic circuits for manual operation.

High Service Distribution Pumps P_6203, P_6204 and P_6205 are controlled by solid state reduced voltage starters that bring the pump up to full speed while reducing the inrush current experienced by the power distribution system and pump motor. Peele-Dixie WTP staff has indicated that replacing the solid state reduced voltage starters with variable frequency drives may improve distribution system controllability.

Presently, there is no plant Arc Flash Safety program nor Arc Flash labels affixed to electrical equipment in compliance with NEC, OSHA and NFPA 70E requirements. There has not been an update to the Short Circuit and Device Coordination Study since initial construction in 2008. That study did not include an arc flash analysis component.

Staff indicates that no electrical maintenance testing has taken place on the Peele-Dixie WTP power distribution system since initial acceptance testing at the end of construction. Peele-Dixie WTP staff has performed some limited maintenance, testing and repairs in-house.

Peele-Dixie WTP staff is replacing existing fluorescent lamps with corresponding LED types as an energy efficiency initiative. Site lights have been retrofitted with LED light bars to replace the metal halide units originally installed. Lighting controls, such as occupancy sensors or a lighting control system, are not being addressed by plant personnel.

3.4.3 Recommendations

1-5 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Establish an Arc Flash Program for personnel training and execution of work on live equipment. Affix Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire Peele-Dixie WTP power distribution system.
- Replace/Retrofit existing panel boards with integral surge protective devices to external mounted units connected through a branch circuit breaker.

6-10 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash (required every five (5) years). Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire Peele-Dixie WTP power distribution system.
- Replace UPS_5701and UPS 5702 with new units and appropriate battery capacity.

11-15 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire Peele-Dixie WTP power distribution system.
- Replace variable frequency drives for High Service Distribution Pumps P_6201 and P_6202; Membrane Feed Pumps P_2501, P_2502, P_2503 and P_2504; Concentrate Booster Pumps P_7401, P_7402, P_7403.

16-20 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire Peele-Dixie WTP power distribution system.

3.4.4 Cost Summary

The table below lists the estimated costs (in 2015 dollars) for the recommended electrical power distribution system improvements at the Peele-Dixie WTP. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Peele-Dixie Membrane Plant Electrical Power Distribution System

Project Description	1-5 year Cost	5–10 year Cost	10-20 year Cost
Update Short Circuit Device Coordination and Arc Flash Study	$60,000	$40,000	$80,000
Perform Electrical Maintenance Testing	$150,000	$150,000	$300,000
Replace/Retrofit existing panel boards with integral surge protective devices to external mounted units connected through a branch circuit breaker.	$100,000	$0	$0
Replace UPS_5701and UPS_5702 with new units and appropriate battery capacity.	$0	$60,000	$0
Replace VFDs for High Service Pumps P_6201 and P_6202; Membrane Feed Pumps P_2501, P_2502, P_2503 and P_2504; Concentrate Booster Pumps P_7401, P_7402, P_7403.	$0	$0	$500,000
Total	$310,000	$250,000	$880,000

3.5 Dixie Wellfield

3.5.1 Existing Conditions

The Dixie Wellfield is located northwest of the Peele-Dixie WTP (See **Figure UW3-2**) and consists of 8 Biscayne Aquifer wells that deliver raw water to the Peele-Dixie WTP for treatment. The Dixie Wellfield construction was completed in 2008 at the same time as the Peele-Dixie Membrane Plant was completed. The Dixie Wellfield (wellfield) power distribution system receives normal utility power from a local utility pad mounted transformer adjacent to the wellfield generator building and utility power metering is on the secondary of the transformer. Utility power is delivered at 480V. There is a 1250kW standby diesel generator on site to supply emergency power if utility power is lost. The generator building power distribution system consists of a service entrance rated utility main breaker, automatic transfer switch (ATS_5301), and main switchboard SWBD5301. A local distribution panel board (PNL_5302), 480-120.208 XFMR5601 and circuit breaker panel PNL_5601 provide convenience and generator support power to the generator building.

Normal and emergency power is distributed in wellfield from SWBD5301 through feeder breakers and pad mounted transformers that step voltage up to 4.16 kV for distribution to the various wells, where there are corresponding pad mounted transformers to step the voltage down to 480V for use at the well. An exception to this is Well 28 which receives 480V power directly from SWBD5301 due to the relatively close proximity of the well to the generator building. All 4.16 kV distribution cables are direct buried armored type. One distribution circuit serves Wells 27 and 33; another circuit serves Wells 29 and 34; a third circuit serves Wells 30, 31 and 32.

Each well contains a pad mounted step down transformer (except Well 28); a service entrance rated main breaker; well pump control panel; and mini-power center for general power at the well.

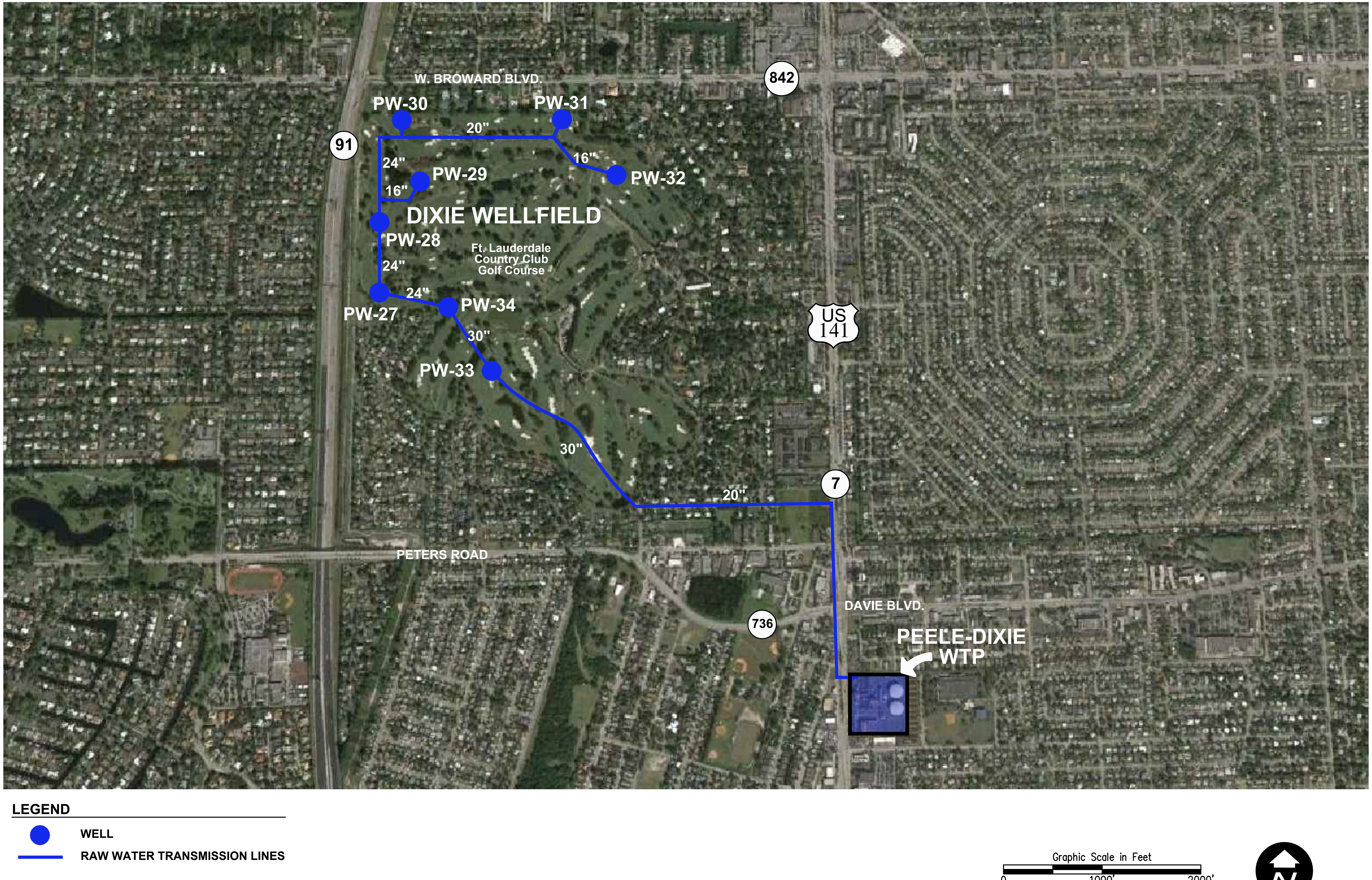
The emergency diesel generator capacity is sufficient to operate all wells in the wellfield. According to City staff, a lightning protection system was included as part of the grounding system for each well facility during construction.

3.5.2 Safety and Reliability Concerns

Utilities operations and maintenance personnel indicate that the wellfield power distribution system is in very good condition and has had minimal problems to date.

Presently, there is neither a wellfield Arc Flash Safety program nor are there Arc Flash labels affixed to electrical equipment in compliance with NEC, OSHA and NFPA 70E requirements. There has not been an Arc Flash Study performed on the wellfield power distribution equipment. An initial Short Circuit and Device Coordination Study was performed at the time of construction, however this study has not been updated subsequently.

It is observed that the emergency diesel generator is a pre-2006 model and does not presently comply with EPA requirements for emissions; therefore, the City is at risk of non-compliance penalties from the EPA should an inspection or audit of the installation occur. The CUS Master Plan Team recommends that the City implement a diesel oxidation catalyst system for emissions compliance to the existing generator.



DWG: R:\Projects\134001-P FtLauderdale CUSMP\Design\Drawings\PreliminaryDesign\134001 Peele Dixie Well Location Map.dwg

CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
WELL LOCATION MAP

FIGURE UW3-2

3.5.3 Recommendations

1-5 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Establish an Arc Flash Program for personnel training and execution of work on live equipment. Affix Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire wellfield power distribution system.
- Implement a diesel oxidation catalyst system to the existing emergency diesel generator for compliance with EPA emissions regulations.

6-10 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash (required every five (5) years). Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire wellfield power distribution system.

11-15 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire wellfield power distribution system.

16-20 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire wellfield power distribution system.
- Replace solid state reduce voltage starters and well control panels at Wells DW_27, DW_28, DW_29, DW_30, DW_31, DW_32, DW_33, and DW_34.

3.5.4 Cost Summary

The table below lists the estimated costs (in 2015 dollars) for the recommended electrical power distribution system improvements at the Dixie Wellfield. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Dixie Wellfield Electrical Power Distribution System

Project Description	1-5 year Cost	5–10 year Cost	10-20 year Cost
Perform Short Circuit Device Coordination and Arc Flash Study	$50,000	$20,000	$60,000
Perform Electrical Maintenance Testing	$100,000	$100,000	$300,000
Implement a diesel oxidation catalyst system to the existing emergency diesel generator for compliance with EPA emissions regulations.	$100,000	$0	$0
Replace solid state reduce voltage starters and well control panels at Wells D_27, D_28, D_29, D_30, D_31, D_32, D_33, and v34.	$0	$0	$500,000
Total	$250,000	$120,000	$860,000

3.6 George T. Lohmeyer WWTP

3.6.1 Existing Conditions

The GT Lohmeyer WWTP (GTL WWTP) was originally constructed in the 1950's, was replaced with a larger plant in 1978, significantly expanded in 1984 and underwent other capacity increases in 1994, 2001 and 2003. GTL WWTP presently has four 4.16kV utility power services distributed at two locations within the plant. There are three utility transformer vaults onsite at GTL WWTP supplying normal utility power (4.16kV) to the various services. Service Point 1 is located in the Generator/Electrical Building with the plant emergency diesel generator. Utility Transformer Vault No.1 is located adjacent to the Electrical/Generator Building and contains two 13.2kV-4.16KV utility transformers connected in parallel. Normal and emergency power is distributed from SWGR5201 (5kV Switchgear No.1) to plant loads primarily on the west end of the GTL WWTP site. Service Points 2, 3 and 4 are located in the Control Building/5kV switchgear room and consist of two 4.16kV switchgear assemblies constructed in a ring bus arrangement with bus-tie breakers. Utility Transformer Vaults No.2 and No.3 are adjacent to the control building with Transformer Vault No.2 containing four 13.2-4.16kV utility transformers, two pairs each connected in parallel, supplying power to two normal services to SWGR5202 (5kV Switchgear No.2). The third utility transformer vault contains two 13.2kV-4.16kV utility transformers supplying normal power service to SWGR5303 (5KV Switchgear No.3).

FPL has three primary distribution feeders to GTL WWTP, with two being preferred and a third as an alternate back-up. Each transformer vault contains oil switches that perform primary distribution feeder switching when power is lost, or if maintenance on a distribution feeder is necessary. The primary distribution feeders come from two different power utility substations. FPL recently upgraded a feeder transfer switch in the vaults to perform a near-instantaneous transfer between feeders such that loss of power on one feeder does not affect GTL WWTP. This entire system arrangement meets Class 1 reliability requirements as there are multiple sources of power into GTL WWTP, together with multiple independent feeder sources from the power utility.

Existing SWGR5201 (5kV Switchgear No.1) appears to have been installed in the 1978 capacity increase expansion and contains utility main breaker and emergency generator breaker in a transfer scheme to switch between utility power and emergency power if utility power is lost. Existing 2225kW, 4.16kV standby emergency diesel generator GEN_5401 was replaced in 2007 and is maintained with a service contract to an outside maintenance contractor. Existing SWGR5201 (5kV Switchgear No.1) contains 6 feeder breakers distributing power to:

- Cryogenic Plant Main Air Compressors/Motor Starters:
  - CMP_1101/MSTR1201 and USS_5310 Pretreatment Building.
  - CMP_1201/MSTR1101 and CMP_1301/MSTR1301 and USS_5309 Pretreatment Building.
- USS_5303 (USS #3) Sludge Pump Station No.1/USS_5305 (USS #5) Sludge Holding Tanks/USS-5311 (USS#11) in Sludge Pump Station #3.
- USS_5302 (USS #2) Electrical/Generator Building.
- USS_5301 (USS #1) Electrical/Generator Building.

There is a medium voltage feeder that connects with existing unit substations USS_5303, USS_5305, and USS_5311 that, though a tie at USS_5311, can be connected to feeder 2F2 in existing SWGR5202. There is not sufficient capacity in the feeder to operate any of the Effluent Pumps if the power is lost at SWGR5202 or SWGR5203.

The City recently bid project P11710 “GT Lohmeyer Emergency Generator Connections and Switchgear Upgrades”, designed by CDM Smith, that replaces SWGR5201 (5kV Switchgear No.1) and existing USS_5301 (USS#1) and USS_5302 (USS#2) in the Electrical/Generator Building. The project will also install a medium voltage fused load break switch as a means of connection of a portable emergency diesel generator, and new unit substations and motor control center in the generator building. A separate project will also add selective catalytic reduction to GEN_5401 to comply with RICE NESHAP requirements and allow the cryogenic plant to remain on the Customer Incentive Load Control rate structure with FPL. The new SWGR5201 will have the following feeder breakers distributing power to:

- Cryogenic Plant Main Air Compressors/Motor Starters CMP_1103/MSTR1103 and USS_5310 Pretreatment Building.
- Cryogenic Plant Main Air Compressor/Motor Starter CMP_1101/MSTR1101.
- Transformer No.1 for new USS_1 Switchboard in Electrical/Generator Building.
- Transformer No.2 for new USS_2 Switchboard in Electrical/Generator Building.
- Cryogenic Plant Main Air Compressors/Motor Starters CMP_1201/MSTR1201 and USS_5309 Pretreatment Building.
- USS_5303 Sludge Pump Station No.1/USS_5305 Sludge Holding Tanks/USS_5311 Sludge Pump Station #3.

The project will install new 5kV feeder circuits to the electrical equipment listed above and new conductors to the Utility Transformer Vault No.1 and to Emergency Generator GEN_5401. New USS_1 and USS_2 are designed in a main-tie-main configuration for reliability and redundancy. New USS_1 will feed a new MCC_5501 in the generator building. New USS_2 will feed existing MCC_5502 in the Cryogenic Building. A listing of panels/switchgear and the equipment/areas they serve is included in Appendix UW-3A.

Section WW16 recommends that the existing Cryogenic Plant be replaced with a different technology that will significantly reduce the power requirements of the process for liquid oxygen generation. Replacement/upgrade of the electrical power distribution system components associated with the Cryogenic plant should occur as part of the conversion of the process to ensure reliable operation of the entire facility.

3.6.2 Safety and Reliability Concerns

Discussions with GTL WWTP staff indicate the following:

- GTL WWTP recently implemented a product from POM Energy Concepts on Motor Control Centers that the manufacturer indicates will save energy and protect against transients and lightning strikes. The units indicate that they meet the requirements of UL 1449, but are not labeled with a UL 1449 label. GTL WWTP staff indicates that they constantly trip and that there are concerns with how the unit is connected as no grounding conductor is installed.
- Service and replacement parts are no longer available for the medium voltage solid state reduced voltage starters (SSRVS) that serve as an alternate means to control the effluent pumps. Presently, MSTR6663, the SSRVS that serves Effluent Pumps P_6663 and P_6664, is out of service as the contractor has failed and there are no replacement parts for it.
- The underground conduit and wire system is in deteriorating condition and is in need of replacement.
- Process areas Sludge Pump Stations 1, 2 and 3 needs to be re-wired as the conduit and wire systems are corroded and exposed.
- The existing Clarifier power and control systems need to be re-wired as the conduit and wire systems are corroded and exposed.
- Sludge Holding Tank Building needs to be re-wired as the conduit and wire systems are corroded and exposed.
- Chlorine Building power distribution system is deteriorated and is in need of re-wiring as the conduit and wire systems are corroded and exposed.
- Scum pump stations/plant drain pump stations/sanitary lift stations are in need of rehabilitation with new control panels, power and control wiring. Wiring and raceways are corroded and control panels are deteriorated.
- There are still support/replacement parts for the Robicon Medium Voltage VFD’s available from Siemens/Robicon. Siemens/Robicon has proposed to the City to perform an upgrade to the power system components within the drives for approximately $300,000. This would extend the life of the units for approximately 10 years.
- GTL WWTP staff indicates that the majority of the 480V VFD’s have been replaced since 2008 with new units.
- All of the unit substations are in very poor condition and are in need of replacement due to the damp and corrosive atmosphere in many GTL locations.
- GTL WWTP staff indicates that no update to the Short Circuit and Device Coordination Study performed in 2005 has occurred. Plant staff indicates that there is no Arc Flash Safety program or Arc Flash Labels affixed to electrical equipment at the site.
- GTL WWTP staff indicates that no electrical maintenance testing on the plant power distribution equipment has occurred since 2005.
- GTL WWTP staff indicates that there is no master set of electrical plant drawings to use as reference for troubleshooting and reference.
- GTL WWTP staff indicates that there are concerns with regards to plant grounding and that there are no lightning protection systems at the facility.
- GTL WWTP staff indicates that there is an initiative to re-lamp all interior lighting fixtures with LED light bars in place of existing lamps. Street lighting is not being

addressed by plant staff and would likely require a plant wide lighting design to implement LED lighting fixtures.

- GTL staff indicates the new Multilin 750 Feeder Relays have been implemented in existing SWGR5202 for all feeder and main breakers.
- The CUS Master Plan team recommends in WW16 to replace the existing Cryogenic Plant with VPSA technology. The CUS Master Plan team recommends replacement/Rehabilitation of the existing electrical power distribution and control systems be addressed as part of the technology conversion. The CUS Master Plan team recommends replacing the existing pneumatic based control system with a PLC based system and the existing motor control centers replaced with new units equipped as appropriate for the replaced/rehabilitated system.
- The CUS Master Plan Team discussed with GTL and City Engineering staff the need for additional onsite emergency generator power to operate all processes necessary to meet average daily flow in the event the entire power utility distribution system were to fail. The GTL experienced an occurrence after Hurricane Wilma where the utility power distribution grid collapsed and was not able to be re-energized for five days. As indicated prior in this study, the plant power distribution system, as presently installed, meets the EPA requirements for Class 1 Reliability as there are multiple sources of power, both on site and through the power utility. Switchgear 5201 has both normal and emergency diesel power available, with multiple utility feeders that are selected by FPL when one has lost power. SWGR5202 and SWG5203 are connected in a ring bus arrangement utilizing multiple bus-tie breakers and multiple utility services for sources of power. Utility Transformer Vaults 2 and 3 have multiple distribution feeders and high speed transfer switches to select between power sources. Internal to GTL, all unit substations and motor control centers are arranged in a main-tie-main configuration that also allows multiple sources of power to be available should a local failure render the equipment unpowered.

There is a medium voltage feeder that can connect SWGR5201 with SWGR5202 if such a significant failure of any of the utility transformer vaults would cause an extended power outage. The feeder connects SWGR5202 feeder breaker 2F2 to a SWGR5201 feeder breaker through medium voltage connections at USS_5311, USS_5305 and USS_5303. There is limited capacity in the feeder as it was not intended to power the entire east end of GTL WWTP. Rather, it was intended to provide general power to the Administration Building and other process buildings, but not operate the Effluent Pumps, if the outage occurred at Utility Transformer Vaults 2 and 3. Existing 2250kW GEN_5201 is not intended to operate the entire GTL WWTP, including effluent pumps, rather it is sized to supply operational emergency power to the entire east side and general emergency power to the west side of the GTL WWTP if necessary. This is the prevailing concern discussed with the City.

It is important to note that the events that occurred after Hurricane Wilma were unique and somewhat extreme. The high voltage transmission lines connecting the power grid of South Florida were damaged and had to be repaired. It was not the substations or local distribution feeders that suffered damage, it was upstream of that. Since Hurricane Wilma, FPL has taken significant steps to strengthen their power grid to add resiliency to the critical components of the system to reduce the possibility of widespread outages related to storm events. GTL WWTP personnel did not indicate that long periods of utility power outages have occurred (other than after Hurricane Wilma) in the last many years. It is also important to note that, during the area wide power outage following Hurricane Wilma, GTL WWTP flows significantly decreased until the area power was restored as there was no power to homes, businesses and to many of the lift stations in the collection system to generate flows into the plant.

If it is the City's desire to have on site emergency power generation of a capacity to support full GTL WWTP operations, a new generator/electrical facility with a capacity of approximately 10MW would be required on site. The facility would likely contain:

- Four to six 4.16kV generators, depending on the nominal capacity of the unit.
- 5kV generator output paralleling switchgear with controls for each generator
- 5kV distribution switchgear with feeder breakers and medium voltage distribution system throughout the GTL WWTP.
- Unit substation(s) for local power use
- Depending on the location of the facility, new FPL feeders and transformer vault may be necessary.

Advantages of this approach would be:

  - Complete on-site power capability to operate GTL WWTP at full treatment capacity without utility power available.
  - New power distribution equipment, emergency generators, feeder circuits.

Disadvantages of this approach would be:

  - Physical location: a facility of this nature would require a large footprint of a building approximately 100'Lx50'Wx20'H not including any additional transformer vault or fuel storage facilities.
  - Cost: could be in the $15-$20M range or higher.
  - Available plant real-estate: GTL WWTP is significantly built out and there is no room for expansion. It may require eliminating/re-purposing/re-configuring some existing process buildings to accommodate the facility. Adding a second story to the administration building is a potential option and would need further study to determine the viability of this alternative.

To fully understand the feasibility of a facility of this nature at GTL WWTP, a study would be required to determine, in detail, criteria, options and cost impacts of design and implementation.

- An alternate approach to complete on-site emergency power generation is to supplement the existing power distribution system with local means of connecting portable diesel generators of a smaller capacity at various locations around GTL WWTP. This approach does not require significant re-work of the GTL WWTP power distribution system and allows for point application of critical power if it became necessary. An example of this approach is in City Project P11710 "GT Lohmeyer Emergency Generator Connections and Switchgear Upgrades", designed by CDM Smith, where a fused load break switch will be added to new SWGR5201 to allow application of a portable diesel generator for temporary emergency power if GEN_5201 fails. This same approach can be applied at both 4.16kV and 480V in select critical areas of GTL WWTP. Locations for consideration are:
  - Apply 5kV fused load break switch to feeder 2F5 in SWGR5203 that would allow, through an interlocking scheme, the application of emergency power to operate one or two effluent pumps.
  - Apply 480V generator connection switchboard to USS_5311 or USS_5312 in Sludge Pump Station No.3.

- Apply 480V generator connection switchboard to USS_5307 or USS_5308 in Effluent Pump Station.

Adding generator connection switchboards to unit substations in Pretreatment, Sludge Pump Station No. 1, Sludge Pump Station No.2, Sludge Holding Tanks and Cryogenic Plant Motor Control Centers would not be as beneficial as these units are already receiving emergency diesel generator power and would benefit from the new 5kV fuse load break switch connection of a portable diesel generator, if used.

3.6.3 Recommendations

CDM Smith published “Central Region Wastewater System 2015 Renewal and Replacement Report” dated June 2015 that provides a condition assessment of plant equipment and provides recommendations for renewal and replacement in a schedule for 20 year cycles beginning with FY2015/2016. The City has also developed a Capital Improvement Plan (CIP) for FY2015-2019 that identifies projects related to electrical systems at GT Lohmeyer WWTP.

The project recommendations from the report and the CIP projects already identified by the City (and projected FY costs) are supported by REI/Hillers and are included in this study as described herein.

***1-5 years*:**

- City Project# FY20150276 Electrical Testing & Maintenance (FY 2016): Perform electrical, testing, maintenance and emergency repairs by a NETA certified contractor.
- City Project# 11917 Electrical Upgrades (FY 2016): Replace conduit, wire, disconnect switches, terminal boxes, and associated supports from Reactor #1 to Generator and Cryogenic Buildings; Replace MCC-2, MCC-2A, MCC-10A, LP-13 and TP-2 and wall mounted transformer in Cryogenic Building.
- City Project# 11710 Emergency Generator (FY2015): Replace Service Point 1 4.16kV switchgear; 4.16kV feeders to Cryogenic Building; unit substation in generator building, add 5kV load break switch for connection of a portable emergency diesel generator. This project has been executed and will be constructed.
- City Project# FY20150278 Motor Control Centers Rehabilitation (FY 2017): Replace various motor control centers in GTL WWTP. The units to be replaced are not identified in the project description.
- CDM Smith Recommendation: Effluent Pump VFD Upgrade (FY2019-2020)
  - It is not clear as to whether the project includes Solid State Reduced Voltage Starters or Just the Variable Frequency Drives. The report indicated $300,000 in FY19-20, and given the current issues with the solid state starters and the available upgrades to the medium voltage VFD’s GTL WWTP staff have discussed with Siemens/Robicon, it would be recommended to apply the funds to updating the VFD’s and to commission a project to replace the medium voltage solid state reduced voltage starters.
- CDM Smith Recommendation: Preventative Maintenance Electrical Components (FY2015-FY2035).
- CDM Smith Recommendation: Electrical Testing and Maintenance (Arc Flash) (FY2015-2016):
  - City project FY20152076 budgets $158,000 for electrical maintenance testing in FY16-17. CDM Smith’s budget item appears to imply performing electrical

maintenance testing and an Arc Flash study every five years beginning in FY15-16. The City project does not appear to address the Arc Flash component. To do so, the entire Short Circuit and Device Coordination Study from 2005 would have to be updated with Arc Flash analysis added. Arc Flash labels could then be generated and applied to the power distribution system equipment. The City could then follow CDM Smith's recommendation of performing the study update and electrical maintenance testing every five years.

- CDM Smith Recommendation: Unit Substations: The report gives a per-unit cost and the number of units but does not specify in which fiscal years to apply the costs.
  - For the purposes of this study, the proposed unit costs have been spread out over a 4 year period beginning in FY16-17 through FY19-20 assuming two units per FY as they are generally in pairs by process location. The recommended order of replacement based upon age and condition is:
    - Pretreatment Building: USS_5309 and USS_5310.
    - Sludge Pump Station No.1: USS_5303 and USS_5304.
    - Sludge Holding Tank: USS_5305 and USS_5306.
    - Sludge Pump Station No.3: USS_5311 and USS_5312.
- CDM Smith Recommendation: Motor Control Centers (FY2015-2016; FY2016-2017):
  - The City has identified project FY20150278 for Motor Control Center Rehabilitation with a budget of $1,000,000 for FY17-18. CDM Smith recommends a budget of $3,000,000 in FY15-16 and $1,250,000 in FY16-17. The aggregate value of $4,250,000 would appear to cover all of the motor control centers in GTL WWTP including replacement of power conductors and control circuits. It is not clear as to which units are to be addressed in which order. It is assumed that MCC_5503 and MCC_5510A (Cryogenic Plant) will be addressed under other CIP activities and are not included considered for this CIP recommendation. The following is a recommendation of order of importance with respect to implementation for the remaining Motor Control Centers:
    - MCC_5503 & MCC_5504 (Sludge Pump Station No.1).
    - MCC_5504A (Sludge Pump Station No.2). It is further recommended that PNL_5303 be replaced at that time.
    - MCC_5505 & MCC_5506 (Sludge Holding Tanks).
    - MCC_5511 & MCC_5512 (Sludge Pump Station No.3).
    - MCC_5509 & MCC_5510/MCC-5510B (Pretreatment).
    - MCC_5507B & MCC_5508B (Administration Building).
    - MCC_5507, MCC_5508, MCC_5507A, MCC_5508A (Effluent Pump Station).
  - Motor Control Centers MCC_5507C and MCC_5508C were installed in a renovation of the Solids Dewatering Building in the mid-1990's and will not reach the end of their useful life until approximately FY33-34. A budget of

$500,000 has been applied to FY30-31 for replacement of the units before the end of their useful life.

- Update/generate GTL WWTP electrical documents for plant personnel use in troubleshooting and reference of the electrical power distribution system.
- Commission a study of the GTL WWTP grounding and surge suppression system and implement improvements, including new surge protective devices, and lightning protection system to guard against power surges, lightning strikes and stray voltages and currents in the power distribution system and enhance personnel protection.
- Perform control power and instrumentation circuit replacement, including raceway and conductors, for Sludge Pump Station No.1, Clarifiers No.1, 2 and 3 including exterior wire and raceways complete for reliability and safety of these process areas.
- Re-design site lighting with LED fixtures to improve lighting efficacy and achieve power reduction and energy savings. This recommendation is further addressed in WW16 Energy Conservation.
- The electrical system for the oxygen generation system is addressed in WW16 Energy Conservation. Both alternatives include replacement of the electrical power distribution equipment and motor control centers (MCC's).

6-10 years:

- CDM Smith Recommendation: Preventative Maintenance Electrical Components (FY2015-FY2035).
- CDM Smith Recommendation: 4.16 kV Switchgear Service Points 1-3 (FY2024-2025).
- CDM Smith Recommendation: Electrical Testing and Maintenance (Arc Flash) (FY2020-2021; FY2025-2026; FY2030-2031).
- Perform control power and instrumentation circuit replacement, including raceway and conductors, for Sludge Pump Station No.2, Clarifiers No.4, 5, 6 and 7 including exterior wire and raceways complete for reliability and safety of these process areas.
- Perform control power and instrumentation circuit replacement, including raceway and conductors, for Sludge Holding Tanks including exterior wire and raceways complete for reliability and safety of these process areas.
- Perform control power and instrumentation circuit replacement, including raceway and conductors, for Chlorine Building including exterior wire and raceways complete for reliability and safety of these process areas.
- Rehabilitate the electrical power and control systems for the Scum pump stations/plant drain pump stations/sanitary lift stations with new control panels, power and control wiring for reliability and safety of these process components.
- Replace underground medium voltage feeders to improve power distribution system reliability from:
    - SWGR5202 to USS_5311.
    - SWGR5202 to USS_5312.
    - USS_5303 to USS_5305.
    - USS_5304 to USS_5306.
    - USS_5305 to USS_5311.
    - USS_5308 to USS_5312.
    - MAC_5206 to USS_5309.

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- MAC_5205 to USS_5310.
- SWGR5202 FDR2F3 to USS_5312.

- GTL WWTP staff has replaced the all of the 480V VFD's in the last few years, however the nominal expected life is approximately 15 years and a new replacement cycle is necessary to maintain plant operational reliability.
- Apply 5kV fused load break switch to feeder 2F5 in SWGR5203 that would allow, through an interlocking scheme, the application of emergency power to operate one or two effluent pumps to increase reliability in the event there is a complete power loss of the utility power distribution system.
- Apply 480V generator connection switchboard to USS_5311 or USS_5312 in Sludge Pump Station No.3 to increase reliability in the event there is a complete power loss of the utility power distribution system.
- Apply 480V generator connection switchboard to USS_5307 or USS_5308 in Effluent Pump Station to increase reliability in the event there is a complete power loss of the utility power distribution system.

11-15 years:

- CDM Smith Recommendation: Preventative Maintenance Electrical Components (FY2015-FY2035).
- CDM Smith Recommendation: Electrical Testing and Maintenance (Arc Flash) (FY2025-2026).
- Replace Existing Medium Voltage VFD's for Effluent Pumps for maintainability and reliability.

16-20 years:

- CDM Smith Recommendation: Preventative Maintenance Electrical Components (FY2015-FY2035).
- Replace 4.16 kV Switchgear Service Points 1-3 (FY2033-2034):
  - The CDM Smith Report budgets replacement of all three 5kV switchgear assemblies with two units in FY24-25 and one unit in FY33-34. City project P11710 "GT Lohmeyer Emergency Generator Connections and Switchgear Upgrades" will replace SWGR5201in FY15-16. SWGR5202 is approximately 30 years old and will be approaching the end of its useful life in FY24-25 where CDM Smith indicated two units to be replaced; only one would now require replacement. SWGR5203 would not approach the end of is useful life until FY2040-2041 and the monies budgeted in FY34-35 could be applied elsewhere.
- CDM Smith: Electrical Testing and Maintenance (Arc Flash) (FY2030-2031).
- Replace all 480V VFD's for GTL WWTP maintenance and reliability.

3.6.4 Cost Summary

The table below lists the estimated costs (in 2015 dollars) for the recommended electrical power distribution system improvements at the G. T. Lohmeyer WWTP. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

GT Lohmeyer WWTP Electrical Power Distribution System

Project Description	1-5 year Cost	5–10 year Cost	10-20 year Cost
Perform Electrical Maintenance Testing	$158,000	$0	$0
Electrical Upgrades Reactor 1 conduit/wire to generator and Cryogenic Building; Replace MCC_2, MCC_2A, MCC_10A, LP_-13A, TP_2	$3,506,611	$0	$500,000
Replace Service Point 1 4.16kV Switchgear; 4.16kV feeders to Cryogenic Bldg.; Generator Building Unit Substation; add 5kV load break switch for portable generator connection	$2,490,321	$0	$0
Motor Control Centers Rehabilitation	$1,000,000	$0	$0
Effluent Pump VFD Upgrade	$300,000	$0	$1,500,000
Preventative Maintenance Electrical Components	$348,975	$348,975	$767,745
Electrical Maintenance Testing (Arc Flash)	$203,535	$203,535	$407,070
4.16kV Switchgear Service Points 1-3	$0	$2,575,562	$1,287,781
Unit Substations	$5,151,128	$0	$1,287,782
Motor Control Centers	$4,250,000	$0	$500,000
Replace medium voltage solid state reduced voltage starters for Effluent Pumps	$450,000	$0	$0
Update Plant Electrical Documents	$80,000	$0	$0
Commission Study of Grounding and Surge Protective System	$75,000	$0	$0
Implement Lighting protection system throughout plant.	$400,000	$0	$0
Replace control instrumentation and power wire for SPS No.1 and Clarifiers 1,2 and 3	$2,000,000	$0	$0
Replace control instrumentation and power wire for SPS No.2 and Clarifiers 4,5, 6 and 7	$0	$2,800,000	$0
Replace control instrumentation and power wire for Sludge Holding Tanks	$0	$800,000	$0
Replace control instrumentation and power wire for Chlorine Building	$800,000	$0	$0
Rehabilitate Scum Pump, Plant Drain, Sanitary Lift Station with new electrical and control	$300,000	$0	$0
Replace medium voltage feeders	$0	$900,000	$0
Replace 480V Variable Frequency Drives	$0	$400,000	$400,000
Apply 5KV Fused Disconnect Switch to Feeder 2F5 in SWGR5203	$0	$350,000	$0
Apply 480V generator connection switchboard to USS_5311 or USS_5312 in Sludge Pump Station No.3	$0	$250,000	$0
Apply 480V generator connection switchboard to USS_5307 or USS_5308 in Effluent Pump Station	$0	$300,000	$0
Total	$21,513,570	$8,928,072	$6,650,378

3.7 George T. Lohmeyer Injection Well Field

3.7.1 Existing Conditions

The Lohmeyer Injection Well Field consists of five deep injection wells, a monitoring well and a power distribution and control building. The power distribution building receives utility power from a local pad mounted transformer and there is no on-site emergency power system. The existing power distribution and control building contains the service main breaker; a 480V motor control center; a 240V motor control center; step down transformer; air compressors with common control panel; circuit breaker panelboard.

The 480V MCC contains feeder breakers for:

- Gate Operator No.2 (not used)
- Backflush Pump (not used)
- Well No.4 480V Distribution Panel
- Step Down Transformer to MCC-1 (240V MCC)
- Well No.5 Motorized Valve
- Backflush Pump Motorized Valve (not used)
- Motor Controllers for Sanitary Lift Station Pumps 1 & 2.
- Well No.3 Motorized Valves

The 240V MCC contains feeder breakers for:

- PP-1 and transformer #2.
- Deep Well Sample Building Station No.1
- Deep Well Sample Building Station No.2
- Motor Controls for Building Sump Pumps
- Motor Controls of Storm Drain Pumps
- Power Panel PP-1.

Deep injection wells 1, 2, 3 and 5 have local disconnect switches for motor operated valves and a control/signal junction box for control and monitoring signals. Well 4 has a 480V distribution panelboard for valves, a local 120/208V circuit breaker panel board and transformer and a control/signal junction box.

Maintenance staff indicates that there are no electrical as-built drawings of the deep injection well field available for use in troubleshooting and repair. There are drawings of Well 4 as a rehabilitation was completed in the last few years.

Maintenance staff indicates that much of the site lighting in the Well Field does not work or the power circuit wiring is damaged.

Maintenance staff indicates that there is a general flooding issue in the Well Field such that all of the in ground pull boxes are submerged under heavy rain events and this has caused faults and signal failures in power and control circuits throughout the Well Field.

None of the electrical equipment observed in the Well Field have appropriate arc flash labels applied.

Operations staff indicate that when utility power is lost to the Well Field for an extended period of time (greater that the capacity of the local UPS units on PLC 8 in the Control Building) well operations becomes hindered as plant staff are forced to perform a rotational swap of UPS units that are charged at GTL so that control and monitoring functions can continue. Operations staff indicates that valves associated with the injection wells will fail in place and can be manually operated from hand wheels mounted on the valve if necessary.

The CUS Master Plan Team observed that Wells 1, 2, 3 and 5 have local field control panels, for surge tank control, that are in reasonably good condition. The team also observed a sump pump control panel for a manhole near a truck maintenance building and a well sample pump control panel for Well 2 that are in deteriorating condition but functional. Surge tank control panels associated with Well 4 are of a recent installation and are expected to maintain serviceable life through the master plan period.

3.7.2 Safety and Reliability Concerns

It is important for personnel safety and efficiency of operations to have accurate electrical one line and plan drawings. The CUS Master Plan Team recommends that accurate as-built documentation of the well field electrical systems be developed.

No compliant arc flash labels are observed by the CUS Master Plan Team on well filed electrical equipment. The CUS Master Plan Team recommends an Short Circuit, Device Coordination and Arc Flash study be conducted for the well field and be updated every five (5) years.

The CUS Master Plan team observed that flooding is a major concern in the well field that impacts the ability for operations to access process equipment and causes faults in power, control and instrument wiring throughout the well field. Plant staff have indicated that there are numerous splices in both power and control conductors in the below ground raceways and pull boxes. Maintenance staff indicates that the flooding has caused dirt and mud to collect in the raceways and it is no longer possible to pull out damaged conductors for replacement. The CUS Master Plan Team recommends that the well field drainage system be upgraded to properly handle large storm events to channel water away from completely submerging electrical raceways and in ground pull boxes. The CUS Master Plan Team recommends that the in ground power, control and signal duct banks and wiring to the following well field process areas be replaced:

- Wells 1,2,3,5
- Sanitary Lift Station
- Storm water Pump Station

The power distribution equipment in the Well Field Control Building is approximately 30 years old and is in good condition with parts still available for replacement or modification. However, this equipment is approaching the end of its useful life in the next 10 years. The CUS Master Plan Team recommends that a Well Field Control Building be rehabilitated with new electrical power distribution equipment and associated electrical systems. The CUS Master Plan Team also recommends the addition of a portable generator connection with manual transfer switch to the Well Field Control Building 480V power distribution system to facilitate the implementation of a temporary portable generator if utility power is interrupted for a significant period of time.

The CUS Master Plan Team observe that site lighting at wells 1,2,3 and 5 is mostly non-functional and this is a concern for personnel safety, and security, if nighttime work is to be performed. The CUS Master Plan Team recommends a complete rehabilitation of the site lighting system and to implement energy saving LED type fixtures.

The CUS Master Plan Team observe that electrical disconnect switches, panels and raceways at Wells 1,2,3, and 5 are showing signs of deterioration and recommend that the equipment, wiring and raceways be rehabilitated.

The CUS Master Plan Team could not determine the status of the existing Well Field grounding system and recommend that a grounding system survey be performed to determine its condition.

3.7.3 Recommendations

1-5 years:

- Perform Short Circuit, Device Coordination and Arc Flash Study. Establish an Arc Flash Program for personnel training and execution of work on live equipment. Affix Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Generate accurate as-built one line diagrams of the entire wellfield. Generate accurate plan drawings of the well field to depict locations of direct buried power, signal and control wiring, as well as, FPL facilities contained in the well field.
- Perform electrical maintenance testing on the entire wellfield power distribution system.
- Perform grounding system survey and testing.
- Replace electrical panels, disconnect switches, raceways and wiring at Injection Wells 1 and 2.
- Replace in ground power, control and signal raceway and wiring from Well Control House to Wells, 1, 2, 3 and 5 including new in ground pull boxes.
- Perform site lighting replacement for Injection Well Field site including Wells, roadway and control building exterior.

6-10 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Replace electrical panels; disconnect switches; raceways and wiring at Injection Wells 3 and 5.
- Perform electrical systems rehabilitation of the Well Control Building including new utility service disconnect, 480V motor control center, 240V

motor control center, circuit breaker panelboards, lighting transformers, lighting, receptacles and other electrical appurtenances.

- Add generator connection means and manual transfer switch to facilitate portable emergency generator connection if utility power is lost for an extended period of time.

11-15 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Perform electrical maintenance testing on the entire wellfield power distribution system.

16-20 years:

- Update Short Circuit and Device Coordination Study to include Arc Flash. Affix updated Arc Flash Labels to electrical equipment that is compliant with NFPA 70E and OSHA requirements.
- Replace electrical panels, disconnect switches, raceways and wiring at Injection Well 4.
- Replace in ground power, control and signal raceway and wiring from Well Control House to Well 4 including new in ground pull boxes.

3.7.4 Cost Summary

The table below lists the estimated costs (in 2015 dollars) for the recommended electrical power distribution system improvements at the Lohmeyer Deep Injection Well Field. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Lohmeyer Deep Injection Well Field Electrical Power Distribution System

Project Description	1-5 year Cost	5–10 year Cost	10-20 year Cost
Perform Short Circuit Device Coordination and Arc Flash Study	$30,000	$20,000	$60,000
Generate accurate as-built one line diagrams of the entire wellfield. Generate accurate plan drawings of the well field to depict locations of direct buried power, signal and control wiring, as well as, FPL facilities contained in the well field.	$45,000	$0	$0
Perform Electrical Maintenance Testing	$100,000	$100,000	$200,000
Perform grounding system survey and testing.	$40,000	$0	$0
Replace electrical panels, disconnect switches, raceways and wiring at Injection Wells 1 and 2.	$300,000	$0	$0
Replace in ground power, control and signal raceway and wiring from Well Control House to Wells, 1, 2, 3 and 5 including new in ground pull boxes.	$600,000	$0	$0
Perform site lighting replacement for Injection Well Field site including Wells, roadway and control building exterior.	$350,000	$0	$0
Replace electrical panels, disconnect switches, raceways and wiring at Injection Wells 3 and 5.	$0	$350,000	$350,000
Perform electrical systems rehabilitation of the Well Control Building including new utility service disconnect, 480V motor control center, 240V motor control center, circuit breaker panelboards, lighting transformers, lighting, receptacles and other electrical appurtenances.	$0	$800,000	$0
Add generator connection means and manual transfer switch to facilitate portable emergency generator connection if utility power is lost for an extended period of time.	$0	$150,000	$0
Replace electrical panels, disconnect switches, raceways and wiring at Injection Well 4.	$0	$0	$300,000
Replace in ground power, control and signal raceway and wiring from Well Control House to Well 4 including new in ground pull boxes.	$0	$0	$200,000
Total	$1,465,000	$1,420,000	$1,110,000

3.8 Aggregate Electrical Power Distribution Systems Cost Summary

Location	1-5 year Cost	5–10 year Cost	10-20 year Cost
Fiveash WTP Electrical System Improvements	$7,415,000	$1,560,000	$1,500,000
Prospect Wellfield Improvements	$3,295,000	$2,815,000	$1,795,000
Peele-Dixie Membrane WTP Electrical System Improvements	$310,000	$250,000	$880,000
Dixie Wellfield Improvements	$250,000	$120,000	$860,000
GTL Electrical System Improvements	$21,514,000	$8,928,000	$6,650,000
Lohmeyer Deep Injection Well Field	$1,465,000	$1,370,000	$760,000
Total	$34,249,000	$15,043,000	$12,445,000

3.9 20 Year CIP Table

The 20 Year electrical-related water and wastewater CIPs are represented in sections WA7 and WW9, respectively.

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APPENDIX UW3-A

ADDITIONAL ELECTRICAL EQUIPMENT INFORMATION

Five Ash WTP

- MCC_5504 (MCC J) (480V):
  - Contains starters for:
    - Transfer Pumps P_6303 (TP #3) and P_6306 (TP#6).
  - Contains feeder breakers for:
    - Air Start Compressors CMP_9302 and CMP_9303.
    - Instrument Air Compressor CMP_9201.
    - Utilities Building Lab.
    - One of two feeders to XFMR5603/PNL_5604/PNL-5605.
    - MCC_5301 (MCC H).
    - MCC_5311 (MCC G).
    - PNL_5304 (Clearwell Strike Down Valves)
  - There is a bus-tie breaker with MCC_5503 (MCC-K).
- MCC_5503 (MCC K) (480V):
  - Contains starters for:
    - Transfer Pumps P_6301 (TP #1) and P_6302 (TP#2).
    - Wash Water Transfer Pumps P_3401 (WWTP #1); P_3402 (WWTP #2); P_3403.
    - Surface Wash Pump P_3302 (SWP#2).
    - Backwash Pump P_3203 (BWP #3).
    - Exhaust Fans EF-1 through EF-8, EF-10, EF-11, EF-14, HV-1.
  - Contains feeder breakers for:
    - Air Start Compressor CMP_9301.
    - Sump Pump Control Panel.
    - Vacuum Pump Control Panel.
    - Vacuum Priming System Control Panel.
    - Cranes/hoists.
    - ASR Well Control Panel PNL_5315.
    - XFMR5601/PNL_5602 (Power Panel LPHS in MCC_5202.
    - Heater H-3.
    - Slide Gates SG-1 and SG-2.
    - PNL_5305 (Filter Gallery).
    - PNL_5305 (Sludge Pumps, Filter Gallery Valves, XFMR/UPS System).
    - Panel PNL_5314 (Panel WW); which serves:
      - P_3511 (Washwater Recovery Pump 1).
      - P_512 (Washwater Recovery Pump 2).
      - P_3513 (Washwater Recovery Pump 3).

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            - P_3514 (Washwater Recovery Pump 4).
            - Washwater Recovery Local Control Panel.
    - MCC_5309 (Main Switchgear Room) which serves:
            - P_7211 Washwater Recovery Pump.
            - P_7212 Washwater Recovery Pump.
            - P_7221 Washwater Recovery Pump.
            - P_7222 Washwater Recovery Pump.
- MCC_5301 (MCC H) (480V):
    - Contains starters for:
        - EF-12, EF-13, and HV-2.
    - Contains Feeder Breakers for:
        - HVAC-1/CU-1.
        - Elevator.
        - Miscellaneous welding receptacles.
        - Hot Water Heater.
        - Electric Gate (Powerline Road Entrance).
        - Transformer XFMR 5711 and Distribution Panel PNL_5607 (Panel LPCC); which serves:
            - Panel PNL_5608.
            - Panel PNL_5609.
            - Panel PNL_5610.
            - Panel PNL_5611.
- MCC_5311 (MCC G) (480V):
    - Contains Feeder Breakers for:
        - XFMR 5612/Switchboard GP.
        - MCC_5312 (MCC B).
        - MCC_5313 (MCC E).
        - XFMR5613 and MCC_5614 & MCC 5615 (MCC F1 & F2).
        - Power feed to Mechanic's Shop.
        - PNL_5303 (Hydrotreater #4)
- MCC_5312 (MCC B) (480V):
    - Contains Starters for:
        - Two spare units once used for lime blowers.
        - Center Lime Blower BIO_1210.
        - Lime Building Hoist.
    - Contains Feeder Breakers for:
        - Hydrotreaters 1&2 Control Panel (2 circuits).
        - PNL_5626 (MPZ near north ground storage tank for chemical systems); PNL_5627 and PNL_5628.
        - Tapped feeder serving Fluoride System and Control Panel.
        - PNL_5302 (Aeration Basin #2)
- MCC_5313 (MCC E) (480V):
    - Contains Feeder Breakers for:

            - XFMR_5619/PNL_5620 (In MCC E).
            - Influent Sump.
            - Re-carbonation Sump.
            - On-site lift station.
- MCC_5614 (MCC F1) (240V):
    - Contains Starters for:
        - Plant Water Booster Pump.
        - Injector Pump Treatment Unit #3.
        - Injector Pump Treatment Unit #4.
    - Contains Feeder Breakers for:
        - PNL_5621 and PNL_5641 (Ammonia Building).
- MCC_5615 (MCC F2) (240V):
    - Contains Starters for:
        - Hydrotreater Unit 3.
        - Hydrotreater Unit 4.
        - P_2124 Sludge Agitator Pump #4.
- SWBD5616 (Switchboard GP) (240V)
    - Contains feeder breakers for:
        - PNL_5629 (Mezzanine Power Panel) which serves:
            - PNL_5631 (Panel A-Mezzanine Lighting Panel). (Installed in 1953).
            - PNL_5632 (Panel B-HSP 4&5 area lighting). (Installed in 1953).
            - PNL_5633 (Panel C- Polymer Area). (Installed in 1953).
            - PNL_5634 (Panel D-Operator's Gallery). (Installed in 1953).
            - PNL_5635 (Panel H-Pipe Gallery).
            - Elevator Machine Room.
            - Priming System Panel.
            - Chlorine Room Hoist.
            - PNL_5630 (Power Panel No.1) that serves:
                - P_2101 Sludge Agitator #1.
                - P_2102 Sludge Agitator #2.
                - P_3501 Surface Wash Pump #1.
                - Control Room AHU/ACU.
                - Pipe Gallery Exhaust Fan.
            - MCC_5638 (MCC D)
            - PNL_5624 Lime Slaker 1-4 Power Panel.
            - PNL_5625 (North High Service Pump Room) that serves:
                - AC Units.
                - PNL_5618.
                - Exhaust Fans.

- MCC_5638 (MCC D) (240V)
  - Contains starters for:
    - Lime Blower.
    - Rotolock.
    - Lime Air Compressor #4.
    - Chlorine Injector.
    - Plant Water Pressure Pump.
    - P_2123 Agitator Pump #3.
    - Sprinkler Booster Pump.
    - Chlorine Evaporator #1.
    - Chlorine Evaporator #2.
    - PNL_5639 (Panel LB next to MCC B).
    - PNL_5640 (Panel LD next to MCC D).
- Power Panel PNL_5305 (480V):
  - Contains feeder breakers for:
    - Sludge Tank Mixer M_7600.
    - P_7101 Sludge Pump.
    - P_7102 Sludge Pump.
    - P_7103 Sludge Pump.
    - PNL_5306 (Filter Gallery).
    - PNL_5307 (Filter Gallery).
    - PNL_5308 (Filter Gallery).
    - PNL_5309 (Filter Gallery.
    - PNL_5310 (North High Service Pump Room).
    - XFMR5710/UPS_5702/PNL_5702 serving:
      - PNL_5711.
      - PNL_5704 (Filter Gallery).
      - PNL_5705 (Filter Gallery).
      - PNL_5702 (Treatment Units 1&2).
      - PNL_5709 (Treatment Units 3&4).
      - PLC system remote I/O racks.
    - XFMR5720/UPS_5703/PNL_5703 serving:
      - PNL_5706 (Filter Gallery).
      - PNL_5707 (Filter Gallery).
      - PNL_5710 (Diesel/Electric HSP Room).
      - Equipment Racks in Secondary Control Room.
    - Air Compressor in Filter Gallery and associated instrument air dryer.
- Power Panel PNL_5305 (120/208V):
  - Containing Feeder Breakers Serving:
    - MXR_7100 Sludge Tank Agitator.
    - Sludge Pumps P_7101, P_7102, P_7103, P_7104.
    - M_7100 Sludge Tank Mixer.

                - Filter panels PNL_5306, PNL_5307, PNL_5308, and PNL_5309.
                - XFMR5710/UPS_5702.
                - XFMR5720/UPS_5703.
                - Instrument Air Compressor and associated dryer.
        - UPS Power Panel PNL_5702 (120/208V):
            - Containing Feeder Breakers Serving:
                - PNL_5704.
                - PNL_5705.
                - PNL_5706.
                - PNL_5709.
                - PNL_5711.
                - PLC System RIO Racks.
        - UPS Power Panel PNL_5703 (120/208V):
            - Containing Feeder Breakers Serving:
                - PNL_5706.
                - PNL_5707.
                - PNL_5710.
                - Network Equipment Racks in Secondary Control Room.

Peele Dixie WTP

Power from SWGR5301 is distributed to:

- Membrane Feed Pump P_2501 and associated variable frequency drive.
- Membrane Feed Pump P_2502 and associated variable frequency drive.
- Membrane Feed Pump P_2503 and associated variable frequency drive.
- Membrane Feed Pump P_2504 and associated variable frequency drive.
- Concentrate Booster Pump P_7401 and associated variable frequency drive.
- Concentrate Booster Pump P_7402 and associated variable frequency drive.
- Concentrate Booster Pump P_7403 and associated variable frequency drive.
- Switchboard SWBD5301.
- Power Panelboard PNL_5301.
- MCC_5301.

Power from Switchboard SWBD5301 is distributed to:

- MCC_5302.
- MCC_5303.
- High Service Distribution Pump P_6201 and associated variable frequency drive.
- High Service Distribution Pump P_6202 and associated variable frequency drive.
- PNL_5306 (Electrical Room Power Panel).
- XFMR5606/PNL_5606 (Chemical Building General Power Panel).
- Electrical Building HVAC.
- Air Compressor CMP_9100.
- XFMR5702/PNL_5702/UPS_5702 (UPS power distribution in Chemical Building).

MCC_5301:

- Contains starters/controls for:
    - Exhaust fans.
    - Cleaning/Neutralizing Tank Transfer Pump P_2802.
    - Cleaning/Neutralizing Tank Mixer M_2850.
    - Cleaning/Neutralizing Tank Immersion Heater CH_2820.
    - Cleaning Pump P_2801.
    - Sulfuric Acid Bulk Storage Transfer Pumps P_8401 and P_8402
    - Antiscalant Bulk Storage Transfer Pumps P_8301 and P_8302.
    - Trench drain pumps.
    - Sample/Recirculation Pump.

MCC_5302:

- Contains starters/controls for:
    - High Service Distribution Pump P_6201.
    - High Service Distribution Pump P_6202.
    - High Service Distribution Pump P_6203.
    - High Service Distribution Pump P_6204.
    - High Service Distribution Pump P_6205.
    - Sodium Hypochlorite Transfer Pumps P_8101 and P_8102.
    - Fluoride Transfer Pumps P_8701 and P_8702.
    - Sodium Hydroxide Bulk Storage Transfer Pumps P_8601 and P_8602.
    - Corrosion Inhibitor Bulk Storage Transfer Pump P_8801 and P_8802.
    - Ammonia Transfer Pumps P_8201 and P_8202.

MCC_5303:

- Contains starters/controls for:
    - Transfer Pump P_6301.
    - Transfer Pump P_6302.
    - Transfer Pump P_6303.
    - Air Stripper Fan FAN_2601.
    - Air Stripper Fan FAN_2602.
    - Clearwell Mixer MIX_6310.
    - Clearwell Mixer MIX_6320.
    - Clearwell Mixer MIX_6330.
    - Injection Well Upper Zone Sample Pump P_1601.
    - Injection Well Lower Zone Sample Pump P_1602.
    - Sample Pumps.
    - Provisions for the following future process equipment:
        - Odor Control Systems.
        - Fourth Transfer Pump.
        - Third Air Stripper Fan.

PNL_5301:

- Contains feeder breakers for:
    - PNL_5302 (Membrane Bldg.) HVAC.
    - PNL_5303 (Membrane Bldg.) Valves.
    - PNL_5304 (Membrane Bldg.) Valves.
    - Motorized Strainer STR_2400.
    - XFMR5601/PNL_5601 (Membrane Bldg.) General Power.
    - XFMR5602/PNL_5602 (Membrane Bldg.) General Power.

- Elevator.
- PNL_5305 (Membrane Building) Serving:
  - XFMR5605/PNL_5605 General Power.
- XFMR_5603/PNL_5603 (Generator Bldg.) Generator Support Power.
- XFMR5701/UPS_5701/PNL_5701 (Membrane Bldg.) UPS power serving:
  - PNL_5702 PLC/Instrumentation Systems.
  - PNL_5703 SCADA System Power.
  - PNL_5705 Generator Bldg. Instrumentation.

GTL WWTP

New Electrical/Generator Building MCC_5501:

- Contains starters for:
  - MIX_2212 (Train A Stage 1).
  - MIX_2213 (Train A Stage 2).
  - MIX_2218 (Train A Stage 3).
  - MIX_2211 (Train B Stage 1).
  - MIX_2214 (Train B Stage 2).
  - MIX_2215 (Train B Stage 3).
  - P_3711 Scum Station #1 Pump #1.
  - P_3712 Scum Station #1 Pump #2.
  - P_2310 Sample Pump.
  - CMP_1895 Air Compressor.
  - Exhaust Fan.
- Contains Feeder Breaker for:
  - New transformer TR-1 and Lighting Panel LP-1.

Existing Cryogenic Building MCC_5502 (Installed 1978):

- Contains starters for:
  - Cooling Tower Fan East.
  - Reactivation Heater.
  - Defrost Heater East.
  - Defrost Heater West.
  - P_9101 Cooling Water Pump 1.
  - P_9102 Cooling Water Pump 2.
  - P_9103 Cooling Water Pump 3.
  - Lube Oil Pump.
  - Purge Blower.
  - P_2302 Sample Pump (Train B).
  - Exhaust Fans.
- Contains feeder breakers for:
  - Product Vaporizers (2).
  - Trailer Loading Receptacle.
  - MCC-5502A (Installed 1978):
    - Contains starters for:

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        - Auxiliary Lube Pump (2).
        - Auxiliary Lube Heater (2).
        -
    - XFMR5605 and PNL_5605 (inside MCC).
- Has bus tie connection to MCC_5510A in Cryogenic Plant.

Existing Cryogenic Building MCC_5510A (Installed 1978):

- Contains Starters for:
    - BLO_2711 Purge Blower 1.
    - Cooling Tower Fan West.
    - P_9104 Cooling Water Pump 4.
    - P_9191 Station #1 Pump #1.
    - P_9192 Station #2 Pump #2.
    - Lube Oil Pump.
    - Exhaust Fan.
    - Vaporizer #2.
- Contains feeder breakers for:
    - Motorized valves (6).
    - Lube Oil Heater.
- Tie Breaker to MCC_5502.

Existing Pretreatment Building USS_5310 (Installed 1984) Serves:

- MCC_5510/MCC_5510B
- MCC_5510A (Cryogenic Plant)

Existing Pretreatment Building MCC_5510/MCC_5510B (Installed 1984):

- Contains starters for:
    - SCN_1211 Fine Screen #1.
    - SCN_1212 Fine Screen #2.
    - SCN_1213 Fine Screen #3.
    - DRIV1312 Grit Chamber Collector Drive #2.
    - P_1421 Grit Pump #3.
    - P_1422 Grit Pump #4.
    - CLA_1426 Grit Classifier #2.
    - CNVR1241 Belt Conveyor.
    - Exhaust Fans (3).
    - MIX_8732 Chemical Mixer #2.
    - P_1024 Seal Water Pump #2.
    - P_1922 Sump Pump Station #2 Pump #2.
    - P_1912 Sump Pump Station #1 Pump #2.
    - P_8363 Hydrogen Peroxide Pump #3.
    - P_8364 Hydrogen Peroxide Pump #4.
    - P_8724 Scrubber Recirculation Pump #3.

    - P_8734 Scrubber Recirculation Pump #4.
    - Instrument Air Compressors (4).
    - P_1272 Sample Pump #2.
- Contains feeder breaker for:
    - Concentration Tank Heater.

Existing Pretreatment Building USS_5309 (Installed 1984) Serves:

- MCC_5509/MCC_5509A.
- Tie Breaker to USS_5510.

Existing Pretreatment Building MCC_5509 (Installed 1984):

- Contains starters for:
    - DRIV1311 Grit Chamber Collector Drive #1.
    - P_1411 Grit Pump #1.
    - P_1412 Grit Pump #2.
    - CLA_1416 Grit Classifier #1.
    - Exhaust Fans (4).
    - MIX_8722 Chemical Mixer #1.
    - P_1014 Seal Water Pump #1
    - P_1921 Sump Pump Station #2 Pump #1.
    - P_1911 Sump Pump Station #1 Pump #1.
    - P_8361 Hydrogen Peroxide Pump #1
    - P_8362 Hydrogen Peroxide Pump #2.
    - P_8723 Scrubber Recirculation Pump #1.
    - P_8733 Scrubber Recirculation Pump #2.
    - Instrument Air Compressors (2).
    - P_1271 Sample Pump #1.
    - BLO_8713 Scrubber Fan #1.
    - Motorized Valves (6).

- Contains feeder breaker for:
    - Concentration Tank Heater.
    - West Gate.
    - Overhead Crane.
    - XFMR5614/PNL_5614.
    - Electric Door.
    - Raw Sewage Sump Pump (Influent).

Existing Sludge Pump Station No.1 USS_5303 (Installed 1984) serves:

- MCC_5503 (MCC-3).

Existing Sludge Pump Station No.1 MCC_5503 (Installed 1978):

- Contains starters for:
  - CLF_3012 Clarifier Drive #1.
  - CLF_3022 Clarifier Drive #2.
  - CLF_3033 Clarifier Drive #3.
  - BLO_2721 Reactor #2 Purge Blower #1.
  - BLO_2722 Reactor #2 Purge Blower #2.
  - P_4211 Return Sludge Pump RAS-1.
  - P_4212 Return Sludge Pump RAS-2.
  - P_4213 Return Sludge Pump RAS-3.
  - P_4811 Seal Water Pump #1.
  - P_4812 Seal Water Pump #2.
  - P_4911 Sump Pump #1 Room #1.
  - P_4912 Sump Pump#2 Room #2.
  - Sample Pumps (2).
  - Exhaust Fans (2).
  - MIX_2221 (Mixer Train D Stage 1).
  - MIX_2222 (Mixer Train D Stage 2).
  - MIX_2223 (Mixer Train D Stage 3).
  - RAS #2 control relays.
  - RAS #3 control relays.
- Contains feeder breakers serving:
  - PNL_5301 (Installed prior to 1978) with feeder breakers for:
    - Motor Operated Valves (11).
  - PNL_5302 (Panel H)/XFMR5618/PNL_5618 (Machine Shop).

Existing Sludge Pump Station No.1 USS_5304 (Installed 1984) serves:

- MCC_5504 (MCC-4).
- MCC_5504A (MCC-4A) Sludge Pump Station No.2.
- Plant Site Lift Station/Test Connection.
- XFMR5602/PNL_5602A/PNL_5602B.
- Tie Breaker to USS_5303.

Existing Sludge Pump Station No.1 MCC_5504 (Installed 1978):

- Contains starters for:
  - MIX_2224 (Mixer Train C Stage 1).
  - MIX_2225 (Mixer Train C Stage 2).
  - MIX_2226 (Mixer Train C Stage 3).

Existing Sludge Pump Station No.2 MCC_5504A (Installed prior to 1978):

- Contains starters for:
  - P_4221 Waste Sludge Pump WAS-1.

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  - P_4222 Waste Sludge Pump WAS-2.
  - P_4223 Waste Sludge Pump WAS-3.
  - CLF_3042 Clarifier Drive #4.
  - CLF_3052 Clarifier Drive #5.
  - CLF_3063 Clarifier Drive #6.
  - CLF_3072 Clarifier Drive #7.
  - P_4921 Sump Pump #1.
  - P_4922 Sump Pump #2.
  - WAS#1 control relays.
  - WAS#3 control relays.
- Contains feeder breaker for:
  - XFMR5606/PNL_5606.
  - PNL_5303 (Installed Prior to 1978) with feeder breakers for:
    - Motor operated valves (5).

Existing Sludge Holding Tank USS_5305 (Installed 1984) serves:

- MCC_5505.
- Tie Breaker to USS_5306.

Existing Sludge Holding Tank MCC_5505 (Installed 1978):

- Contains starters for:
  - P_7121 Sludge Transfer Pump #4 North.
  - P_8823 Chemical Recycle Pump #1.
  - P_8833 Chemical Recycle Pump #2.
  - P_3720 Scum Station #2 Pump #1.
  - P_3731 Scum Station #3 Pump #1.
  - P_9991 Plant Drain Pump #1.
  - Exhaust Fans (2).
- Contains feeder breakers for:
  - XFMR5607/PNL_5607 (Panel L5) in MCC_5505.

Existing Sludge Holding Tank USS_5306 (Installed 1984) Serves:

- MCC_5506.

Existing Sludge Holding Tank MCC_5506 (Installed 1978):

- Contains starters for:
  - P_7641 Sludge Transfer Pump #2.
  - P_7411 Sludge Transfer Pump #3.
  - FAN_8813 Scrubber Fan.
  - P_9992 Plant Drain Pump #2.
  - P_9993 Plant Drain Pump #3
  - P_8824 Chemical Recycle Pump #3.

- P_8834 Chemical Recycle Pump #4
- P_3722 Scum Station #2 Pump #2.
- P_3732 Scum Station #2 Pump #2
- MIX_8822 Chemical Mixer #1
- MIX_8832 Chemical Mixer #2.

- Contains feeder breakers for:
  - GATE3101 Clarifier Gate #10.
  - GATE3111 Clarifier Gate #11.
  - GATE3081 Clarifier Gate #8.
  - GATE3091 Clarifier Gate #9.
  - Sludge Grinder/Control Panel South.
  - Motor Operated Valves (2).
  - XFMR5608/PNL_5608.

Existing Sludge Pump Station No.3 USS_5311 (Installed 1984) Serves:

- MCC_5511.
- Tie Breaker to USS_5312.

Existing Sludge Pump Station No.3 MCC_5511 (Installed 1978):

- Contains starters for:
  - P_4231 Return Sludge Pump RAS#1.
  - P_4232 Return Sludge Pump RAS#2.
  - P_4236 Return Sludge Pump RAS#6.
  - CL2 Disinfection Pump #1.
  - P_2991 Sanitary Pump Station #2 Pump #1.
  - P_4931 Pump Room Sump Pump #1.
  - P_4831 Seal Water Pump #1.
  - CLF_3082 Clarifier Drive #8.
  - CLF_3102 Clarifier Drive #10.
  - BLO_7812 Blower North.
  - P_7214 Sludge North.
  - Exhaust Fans (6).
- Contains feeder breakers for:
  - Motor Operated Valves: (3).
  - Chlorine Storage Overhead Hoist.
  - Chlorine Heater Evaporators (2).
  - XFMR5616/PNL_5616.

Existing Sludge Pump Station No.3 MCC_5512 (Installed In 1978):

- Contains starters for:
  - P_4233 Return Sludge Pump RAS#3.
  - P_4235 Return Sludge Pump RAS#5.
  - P_4237 Return Sludge Pump RAS#7.

Section UW3 accepted December 19, 2016.

  - P_2992 Sanitary Pump Station #2 Pump #2.
  - P_4932 Pump Room Sump Pump #2.
  - P_4832 Seal Water Pump #2.
  - CLF_3092 Clarifier Drive #9.
  - CLF_3112 Clarifier Drive #11.
  - BLO_7822 Blower South.
  - P_7224 Sludge South.
  - Exhaust Fans (5).
- Contains feeder breakers for:
  - Motor Operated Valve.
  - Chlorine Storage Overhead Hoist.
  - Chlorine Heater Evaporators (3).
  - XFMR5617/PNL_5617.

Existing SWGR5202 (5kV Switchgear No.2) located in the Administration Building 5kV switchgear room appears to have been installed in the 1984 expansion and contains two utility service main breakers; a bus-tie breaker; and four feeder breakers. SWGR5202 receives two utility services (Service Points 2&3) from Utility Transformer Vault #2 adjacent to the Administration Building. SWGR 5202 was expanded when existing SWGR5203 was installed to include five additional feeder breakers to power effluent transfer pumps.

Existing SWGR5203 (5kV Switchgear No.3) is located in the Administration Building 5kV Switchgear Room across form existing SWGR5202 and was installed in 2000 as part of the Effluent Pump Upgrade Project. SWGR5203 is connected to existing SWGR5202 through bus extensions and bus-tie breakers. SWGR5203 contains one utility service main breaker; two bus-tie breakers and eight feeder breakers. SWGR 5203 receives one utility service (Service Point 4) from Utility Transformer Vault #3 adjacent to the 5kV Switchgear Room.

SWGR5202 (Installed 1978) Serves:

- USS_5311 Sludge Pump Station No.3.
- USS_5307 (USS-7) Effluent Pump Station.
- USS_5312 Sludge Pump Station No.3.
- USS_5308 (USS-8) Effluent Pump Station.
- 5kV VFD/SSRVS for P_6662 Effluent Pump 2.
- 5kV VFD for P_6661 Effluent Pump 1.
- 5kV VFD for P_6665 Effluent Pump 5.
- 5kV SSRVS shared for P_6661 and P_6665.

SWGR5203 (Installed 2000) Serves:

- 5kV VFD for P_6663 Effluent Pump 3.
- 5kV VFD for P_6664 Effluent Pump 4.
- 5kV SSRVS shared for P_6663 and P_6664.

Section UW3 accepted December 19, 2016.

Existing Effluent Pump Station USS_5307 (Installed 2007) Serves:

- MCC_5507 (MCC-7) Effluent Pump Station.
- MCC_5507A (MCC-7A) Effluent Pump Station.
- MCC_5507B (MCC-7B).
- MCC_5507C (MCC-7C) Sludge Dewatering Building.
- XFMR5603/PNL_5603A (Panel L-7A)/PNL_5603A (Panel L-7B).
- Tie Breaker to USS_5308.

Existing Effluent Pump Station USS_5308 (Installed 2007) Serves:

- MCC_5508 (MCC-8) Effluent Pump Station.
- MCC_5508A (MCC-8A) Effluent Pump Station.
- MCC_5508B (MCC-8B).
- MCC_5508C (MCC-8C) Sludge Dewatering Building.
- XFMR5604/PNL_5604A (Panel L-8A)/PNL_5604A (Panel L-8B).

Existing Effluent Pump Station MCC_5507 (Installed 1984):

- Contains starters for:
    - P_8012 Non-Potable Water Pump #2.
    - P_8013 Non-Potable Water Pump #3.
    - P_8091 Non-Potable Room Sump Pump #1.
    - P_6821 Seal Water Pump #1.
    - Exhaust Fans (4).
- Contains feeder breakers for:
    - Non-Potable Water Pump #3 Speed Controller.
    - Sump #1 Control Panel.
    - STR_8031 Non-Potable Water Strainer Control Panel.
    - Non-Potable Water Room Hoist.
    - HVAC for Computer and Electrical Rooms.

Existing Effluent Pump Station MCC_5508 (Installed 1984):

- Contains starters for:
    - P_8011 Non-Potable Water Pump #1.
    - P_8092 Non-Potable Room Sump Pump #2.
    - P_6823 Seal Water Pump #3.
    - Exhaust Fans (5).
    - Supply Fan.
- Contains feeder breakers for:
    - Non-Potable Water Pump #1 Speed Controller.
    - STR_8032 Non-Potable Water Strainer Control Panel.
    - Elevator.
    - HVAC for Computer and Electrical Rooms.

Section UW3 accepted December 19, 2016.

Existing Effluent Pump Station MCC_5507A (Installed 1984):

- Contains starters for:
  - SCN_6321 Travelling Screen #1.
  - SCN_6322 Travelling Screen #2.
  - P_6811 Screen Spray Pump #1
  - Exhaust Fans (3).
- Contains feeder breakers for:
  - Pump Room Overhead Crane.
  - HVAC .

Existing Effluent Pump Station MCC_5508A (Installed 1984):

- Contains starters for:
  - SCN_6323 Travelling Screen #3.
  - P_8822 Seal Water Pump #2.
  - P_6812 Screen Spray Pump #2.
  - Vent Fan.
- Contains feeder breakers for:
  - Sump #2 Control Panel.
  - HVAC .

Existing Administration Building MCC_5507B (Installed in 1978):

- Contains feeder breakers for:
  - North Gate Controller.
  - XFMR5609/PNL_5609A (Panel L7A)/PNL_5609B (Panel L7B).
  - Administration HVAC
  - Feeder to manual transfer switch SW_5507 and XFMR5610/PNL_5610 (Panel LP2)

Existing Administration Building Station MCC_5508B (Installed 1978):

- Contains feeder breakers for:
  - East Gate Controller
  - XFMR5611/PNL_5611 In Administration Building
  - Administration HVAC.
  - Feeder to manual transfer switch SW_5507 and XFMR5610/PNL_5610 (Panel LP2).

Existing Dewatering Building MCC_5507C (Installed in 1990's):

- Contains starters for:
  - CNVR3011 Press Conveyor #1.
  - CNVR3012 Press Conveyor #2.
  - CNVR6111 Transfer Conveyor #1.
  - BLO_8911 Scrubber Fan #1.

Section UW3 accepted December 19, 2016.

- MIX_1111 Sludge Conditioning Tank Mixer #1.
- MIX_1112 Sludge Conditioning Tank Mixer #2.
- P_8923 Scrubber #1 Recirculation Pump #1.
- P_8924 Scrubber #1 Recirculation Pump #2.
- MIX_8922 Scrubber #2 Chemical Tank Mixer #1.
- P_1601 Sludge Feed Pump #1.
- P_1602 Sludge Feed Pump #2.
- P_1603 Sludge Feed Pump #3.
- P_1604 Sludge Feed Pump #4.
- P_8521 Polymer Transfer Pump #1.
- P_8531 Polymer Batch Tank Mixer #1.
- MIX_6511 Liquid Polymer Tank Mixer.
- P_1811 Seal Water Pump #1.
- Supply Fans (2).
- Exhaust Fans (2).

- Contains feeder breakers for:
  - BFP_2011 Belt Filter Press No.1.
  - BFP_2012 Belt Filter Press No.2.
  - BFP_2013 Belt Filter Press No.3.
  - BFP_2014 Belt Filter Press No.4.
  - Dust Collector Control Panel.
  - Air Compressor Control Panel.
  - XFMR5612/PNL_5612.
  - DRIV8561 Polymer Feed Control Panel #1.
  - DRIV8562 Polymer Feed Control Panel #2.
  - DRIV8563 Polymer Feed Control Panel #3.
  - DRIV8564 Polymer Feed Control Panel #4.
  - DRIV1601 Sludge Feed Pump #1 VSC.
  - DRIV1602 Sludge Feed Pump #2 VSC.
  - DRIV1603 Sludge Feed Pump #3 VSC.
  - DRIV1604 Sludge Feed Pump #4 VSC.
  - Overhead Doors (2).
  - Elevator.
  - HVAC.

Existing Dewatering Building MCC_5508C (Installed in 1990's):

- Contains starters for:
  - CNVR3013 Press Conveyor #3.
  - CNVR3014 Press Conveyor #4.
  - CNVR6112 Transfer Conveyor #2.
  - BLO_8912 Scrubber Fan #2.
  - MIX_1113 Sludge Conditioning Tank Mixer #3.
  - P_8933 Scrubber #2 Recirculation Pump #3.
  - P_8934 Scrubber #2 Recirculation Pump #4.

Section UW3 accepted December 19, 2016.

  - MIX_8932 Scrubber #2 Chemical Tank Mixer #2.
  - P_1605 Sludge Feed Pump #5.
  - P_1606 Sludge Feed Pump #6.
  - P_1607 Sludge Feed Pump #7.
  - P_1609 Sludge Feed Pump #9.
  - P_8522 Polymer Transfer Pump #2.
  - P_8532 Polymer Batch Tank Mixer #2.
  - P_1812 Seal Water Pump #2.
  - Supply Fans (2).
  - Exhaust Fans (3).
- Contains feeder breakers for:
  - BFP_2015 Belt Filter Press No.5.
  - BFP_2016 Belt Filter Press No.6.
  - BFP_2017 Belt Filter Press No.7.
  - Lime System Control Panel.
  - Air Compressor Control Panel.
  - XFMR5613/PNL_5613.
  - DRIV8565 Polymer Feed Control Panel #5.
  - DRIV8566 Polymer Feed Control Panel #6.
  - DRIV8567 Polymer Feed Control Panel #7.
  - DRIV8569 Polymer Feed Control Panel #9.
  - DRIV1605 Sludge Feed Pump #5 VSC.
  - DRIV1606 Sludge Feed Pump #6 VSC.
  - DRIV1607 Sludge Feed Pump #7 VSC.
  - DRIV1609 Sludge Feed Pump #9 VSC.
  - Overhead Doors (2).
  - Shuttle Conveyor Control Panel.

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UW4 Manual Operations

4.1 Introduction

The control systems at the City of Ft. Lauderdale's (City's) water treatment plants and the wastewater treatment plant are based largely on programmable logic controllers (PLCs) and local area communication networks which automatically control the various plant processes and allow plant operators to monitor equipment operation and use remote manual control to operate the equipment if necessary.

The plant control systems generally consist of local PLCs and remote input/output (I/O) racks in the general area to process equipment. The various process area PLCs contain programming logic to execute the automated sequences required to operate the associated processes and communicate with other process PLCs for signals and commands to facilitate overall plant production. Operator interface terminals (OITs) are provided at strategic locations throughout the plants for operator monitoring while away from the main control room or for operator local manual control of process equipment (through the control system) for testing, troubleshooting or emergency intervention.

In the years past, many control systems included manual control features that bypassed the PLC control system and allowed local operation of equipment if the control system failed. The robustness of current control system components and communication systems have reduced the need for this level of manual control which overrides safety features as well as equipment protection features of the PLC control systems. All discussions in this report relating to manual control refer to manual control through the PLC control system, which maintains the safety and equipment protection features of the system. Overall recommended SCADA system improvements at the plants and related facilities are addressed in Section UW2 which includes alternatives for increasing the reliability of the plant control/communication systems.

This section of the CUS Master Plan identifies process equipment which currently cannot be operated manually through the control systems from the local panels, and provides recommendations for improvements with conceptual cost estimates for the improvements. The information presented herein represents the CUS Master Plan team's available knowledge, and is based on a combination of field visits, discussions with City staff, and previous City reports/documents.

The CUS Master Plant team evaluated issues with manual control of process equipment at Fiveash WTP and the Peele-Dixie WTP, which were identified during discussions with City staff at electrical and I&C coordination meetings. Manual control of process equipment at GTL WWTP is considered acceptable at this time based upon the discussions.

4.2 Fiveash WTP

4.2.1 Existing Conditions

According to plant personnel, the age of the control equipment is a factor in the limitations for manual control of key process equipment at Fiveash. While the reliability of the communication between control system components, and the communication equipment itself, is an issue being addressed as part of the reliability upgrade project, and **Section UW2** of this report, failure of basic system components such as local OITs make it impossible for an operator to have a level of manual control, local to the equipment, for certain key process equipment. The operator must go to the motor starters/VFD or actual equipment, such as valve actuators, to manually control the equipment.

Section UW4 accepted December 16, 2016.

4.2.2 Manual Control Concerns

Based on meetings with plant staff, the local manual operation of the filter equipment, transfer pumps, and high service pumps were identified as critical when the associated local OITs fail. The CUS Master Plan team has identified three (3) primary areas where operators have difficulty in performing local manual control when conditions warrant: the filtration system including associated backwash and surface wash pumps; the transfer pumps; and high service pumps. The team identified that the failure of local OIT's create a difficult condition of local manual operation for these process components as there is no direct means to manually operate local to the equipment. Operators are required to walk away from the process components to go to a motor starter, or valve, to manually control the device. The concern is when these units are controlled manually from the motor starter, VFD, or on-board valve controls, important safety interlocks are bypassed because the associated PLC is bypassed. While the equipment can still be manually controlled through SCADA at the Control Work Stations, having the ability to manually control the equipment, and maintain important safety interlocks, from a local panel to the equipment is recommended.

City project 10508D Reliability Upgrades will replace the pump control panels for the high service pumps, transfer pumps, backwash pumps and surface wash pumps that will contain latest technology OITs. The project does not require additional manual means of local control in the event of OIT failure. Each gravity filter has nine (9) electric motor actuated valves associated with the filter surface wash, backwash and production operations; one (1) valve per filter is a modulating valve and the remaining valves are open/close. Each gravity filter has a local remote I/O panel with OIT that communicates on a Profibus DP network to one of two process controllers dedicated for filter operation. Each of the nine (9) valves associated with each filter are connected to the same Profibus DP network as the associated remote I/O panel. The OIT is located on the filter gallery mezzanine and not at the associated filter remote I/O rack where the majority of the valves and instruments are. Failure of a filter OIT creates a potentially hazardous condition as the only way to locally control the valves is to physically access the valve actuators. Approximately 30% of the valve actuators require a ladder to access; are located in a pit; or are otherwise difficult to access due to piping arrangements.

The CUS Master Plan team makes no further recommendation for the filter OIT panels as **Section UW2** makes recommendations to ultimately replace the existing remote I/O panels with Rockwell Automation (Allen-Bradley) based PLC panels with new OITs.

4.2.3 Alternatives

4.2.3.1 Backwash Pumps, Surface Wash Pumps, and Pump Control/Isolation Valves;

The CUS Master Plan Team recommends that Remote Auto/Local Manual and Start/Stop switches be added to the control panels for the high service pumps, transfer pumps, backwash pumps and surface wash pumps. The switches are to interface with the associated pump process controller and the associated control logic programming be modified to integrate the actions of these switches. Additional controller I/O points, terminations and wiring are to be added as appropriate.

Control system programming includes modifications to the sequence of operation for the pump control/isolation valve operation as appropriate for pump operation.

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The estimated project cost for this alternative is **$68,600** based on $12,000 per panel (installed; including new UL labeling for existing panel), $20,000 for programming, 30% contingency, and 20% of the estimated construction costs for non-construction related costs.

4.2.3.2 Filter Valves

Section UW2 provides recommendations for upgrades to the filter system communications that are not upgraded as part of City project 10508D Reliability Upgrades. Converting the valve control/communication from Profibus DP to Ethernet prior to the reliability upgrades being completed is not feasible as the necessary infrastructure will not be in place to facilitate the full conversion. **Section UW-2** further makes recommendations to eliminate Profibus DP communications to existing valves and flow meters; however, the time of implementation is in the 6-10 year time frame. As indicated, there are a number of the valves that are in difficult to access locations that could be hazardous to operators.

As an interim measure, the CUS Master Plan team identified an alternative that does not modify the control communications of the valve to afford local manual valve control in a safe manner for operations. The approach is to install a small vendor control panel, offered by Rotork, containing Remote Auto (PLC)/Local Manual switches and open/close buttons for the valves. One remote panel is required for each valve. The wiring from the switches/buttons is directly connected to the valve actuators without affecting the existing Profibus DP communication. The panel would also include open and closed indicator lights based on signals from the valve actuators. For the modulating valves, a percent opening readout is included based on feedback signals from the valve actuators. The CUS Master Plan Team recommends implementation of this panel on the valves that are located in areas that are potentially hazardous for operations personnel to access. Two valves per filter, for a total of 44, plus approximately another 16 valves throughout the plant are identified as difficult for operations personnel to access.

The estimated project cost for this alternative is **$210,000** based on $2,100 per switch/button panel (installed) for open/close valves and $3,200, per panel, for modulating valve panels, 30% contingency, and 20% of the estimated construction costs for non-construction related costs. **Section UW2** recommends ultimately replacing the communication system for the valve actuators which would not affect the operation of the switch/button stations tied directly to the pump PLC panels.

4.2.4 Recommendations

The CUS Master Plan Team does not recommend making significant modifications to the existing SCADA control system prior to City project 10508D Reliability Upgrades. **Section UW2** addresses upgrades to the remaining SCADA control system standardized on Rockwell Automation (Allen Bradley) components. The recommendations presented below do not affect the proposed improvements to the control/SCADA system presented in **Section UW2**.

Section UW-2 makes recommendations that address the City's concerns about the current filter communications and valve control configuration. However, design and construction of these recommendations will take many years to implement. However, the existing installation has approximately 60 Rotork valves that are in difficult to access locations for plant operations personnel. Implementation of the recommended remote manual control panel for these valves, as an interim measure, would address the accessibility concern by plant operations.

Fiveash WTP control system recommendations, to increase operator safety and reliability by enabling the filtration system to be operated manually from local panels, in 5 year intervals for the next 20 years of plant service are:

***1-5 years*:**

- Add local control switches/buttons to local PLC panels for backwash supply pumps and surface wash pumps.
- Add local control switches/buttons to valve actuators that are difficult to access, approximately 60 valves.

4.2.5 Cost Summary

The table below lists the estimated costs (in 2016 dollars) for the recommended SCADA system improvements at the Fiveash WTP. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Fiveash WTP Manual Control System

Project Description	1-5 year Cost
Add local control switches/buttons to local PLC panels for backwash supply pumps and surface wash pumps	$68,600
Add local control switches/buttons to valve actuators for filters	$210,000

4.3 Peele-Dixie WTP

4.3.1 Existing Conditions

Based on the age of the plant and according to plant personnel, there are only a few limitations for manual control of key process equipment at Peele-Dixie. While the reliability of the communication between control system components and the communication equipment itself is discussed in **Section UW2**, failure of basic system components such as local OITs make it impossible for an operator to have a level of manual control, local to the equipment, for certain key process equipment.

As discussed in **Section UW2**, the majority of the control system at Peele-Dixie utilizes a "Profibus DP" network communication platform and Schneider Electric Quantum control equipment. **Section UW2** addresses converting the plant control system to Rockwell Automation (Allen-Bradley) equipment and associated network communication based on the CUS master plan team's agreement that this is desired to standardize control equipment and communications.

4.3.2 Manual Control Concerns

The transfer and high service pump systems (and associated motor actuated discharge valves) each have a local I/O panel with an OIT communicating with process control PLCs via Profibus DP. The CUS master plan team has identified operational issues with the local touch screen OITs for the high service and transfer pumps. The existing operator interface for the high service pumps was replaced, approximately within the last year, with a new unit as it had failed due to sun damage. The new unit was installed inside the panel on a dead front door. When operations personnel access the replacement OIT, the panel front door must be opened thereby exposing the interior remote I/O components to the elements, and potentially, operations personnel to shock hazard. Similarly, the OIT on the front of the transfer pump panel has been damaged due to exposure to sunlight.

4.3.3 Alternatives

For local, manual control of the transfer pumps and high service pumps, the only option identified as feasible is to install manual switches/buttons for the pumps as follows:

- Remote Auto (PLC)/Local Manual selector switches for pumps
- Start/stop pushbuttons
- Speed control potentiometers for pumps controlled by variable frequency drives

Control system programming would include the proper sequence of operation for the pump control/isolation valves in order for the pump to start.

Expansion of each I/O rack will be necessary to accommodate the additional discrete and analog inputs and the control strategy logic in PLC_4302 will require modification to integrate the actions required of the new local control switches. Integration of the control wiring in the remote I/O rack will maintain necessary protections and interlocks for the pumps and process.

The estimated project cost for this alternative is **$70,200** based on $15K for the modifications to the high service pump I/O panel (installed; including new UL labeling), $10K for the modifications to the transfer pump I/O panel, $20K for programming of PLC_4302, 30% contingency, and 20% of the estimated construction costs for non-construction related costs. **Section UW2** recommends ultimately replacing the pump I/O panels with new panels with Rockwell Automation (Allen-Bradley) equipment; switches/buttons for local operation can be easily added to the new panels.

4.3.4 Recommendations

Based on the conversion of the SCADA/control system to standardize on Rockwell Automation (Allen-Bradley) equipment being planned more than 10 years in the future, installing the manual controls for the transfer pumps and high service pumps in the next five years is recommended for operator safety reasons.

The following summarizes Peele-Dixie WTP electrical/control system recommendations to increase reliability by enabling the transfer pumps and high service pumps to be operated manually, in 5 year intervals, for the next 20 years of plant service:

<u>1-5 years</u>:

- Add manual control switches for transfer pumps Nos. 1, 2, and 3 and HSPs Nos. 1, 2, 3, 4, and 5.

4.3.5 Cost Summary

The table below lists the estimated costs (in 2016 dollars) for the recommended SCADA system improvements at the Peele-Dixie WTP. The costs presented anticipate all recommended work being performed by an independent contractor (not City personnel).

Peele-Dixie WTP Manual Control System

Project Description	1-5 year Cost
Add manual control switches for transfer pumps and HSPs	$70,200

4.4 Aggregate Electrical Power Distribution Systems Cost Summary

Location	1-5 year Cost
Fiveash WTP Manual Controls	$278,600
Peele-Dixie WTP Manual Controls	$ 70,200
Total	**$348,800**

UW5 Comprehensive Utility Asset Management System

5.1 Introduction

Asset management systems (AMS) help utilities, such as the City of Fort Lauderdale (City), maintain infrastructure by tracking assets in organized databases and by using software that monitors asset condition, performance, and reliability. In order to continue to make strategic decisions and provide the City's population with an ongoing high level of service, the City is planning a more robust asset management system to proactively identify, prioritize and schedule asset repair and replacement. The ideal AMS should integrate with, and enhance other City asset management efforts. Nevertheless, the Utility functions of the AMS are of the upmost importance and were the primary factors in the selection process, constituting the bulk of the asset management efforts. Coordination between the selected AMS and systems used by other City departments was considered secondary when selecting the best AMS for the Utility Division's needs. There are a host of software providers that provide asset management systems; this report is focused on reviewing viable software products that would be the central cog in the City Utility Division planned AMS.

A sub-category of asset management is computerized maintenance management. Computerized maintenance management systems (CMMS) allow utilities to manage work orders, assess equipment/labor costs, and create planned and preventive maintenance programs. The City's new AMS is intended to be a progressive tool that will encompass CMMS components in order to facilitate efficient allocation of resources and funds. The ability to monitor assets allows utilities to prioritize repairs, create work plans, and establish preventative care measures to potentially reduce both capital and labor costs. Additionally, real-time field reports and planned work order tracking allow City staff to maximize quality service provided to the City's customers.

5.2 Asset Management Existing Conditions

Ideally, the planned AMS should enhance and integrate with the City's existing and future asset management efforts. Some of the City's historical and current asset inventory related to billing services exists in a legacy Hansen database, which the City is currently phasing out. The City's billing staff now uses Cayenta's Customer Information System (CIS) software for utility billing purposes, and utilizes QScend's Q-Alert software for work order generation. Cognos software is used to transfer the billing-related asset information from Hansen and migrate this information to Cayenta using the recently purchased Cayenta Work Order Management software module. The ability of the new utility asset management software to work with these existing programs is essential in order to provide an efficient and organized solution for the City. Although many AMS options include similar functionality to Q-Alert, the City's billing staff has expressed satisfaction with Q-Alert. Thus the AMS is not intended to replace Q-Alert for the current City billing and customer service purposes. Currently, the Utilities Division maintains simple asset data lists for Fiveash WTP, GTL WWTP and Peele Dixie WTP that are separate from the billing-customer service related asset information. The Distribution and Collection Section maintains asset information for pipes in its state-of-the-art geographical information system (GIS) and pump information is contained in stand-alone data lists.

5.3 Needs Assessment

To identify and assess the City's needs for asset management, the CUSMP Team developed a list of asset management criteria. The CUS Master Plan team then presented the criteria tabulation to City staff in the form of a survey, where eight (8) staff members ranked each

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criterion as "Most Important", "More Important", or "Important". Each criterion had a weighted score, with "1" being important, "2" being more important, and "3" being most important. The ranked results of the needs assessment survey are shown in **Figure UW5-1**. After the survey took place, further input was gathered through a meeting with City staff. City staff determined additional criterion of importance, such as dynamic master planning capabilities, ease of use for field personnel, and viability of the company.

During the needs identification process, the CUS Master Plan team formed a vision of the City's future asset management system. Out of the identified facets of asset management, the City staff indicated that asset inventory, field data collection, inventory control, and GIS integration/mapping were the most important parameters to meet their needs. The City staff also identified asset accounting, work management, and customer service as being reasonably important. The survey results indicated that the AMS should encompass asset inventory and CMMS, as well as provide risk/financial analysis capabilities. The system should also include information on the age/condition of the existing assets, as well as determine the level of maintenance needed. In addition, survey participants indicated the AMS should aid management staff in understanding the tradeoffs and implications of management decisions about the assets, and use better information to justify proposed rate increases or capital investments.

Figure UW5-1. City Asset Management Needs

* Denotes items added and polled after the survey

5.4 Software Evaluation

Noting that there are literally hundreds of AMS software products currently available on the market, this evaluation focused on products that have been successfully used in the water and wastewater industry in the United States. Acknowledging that there are other vendors and products that may work well for the City, the scope of this evaluation was thusly narrowed. Various software developers were identified based on industry knowledge, available web rankings and references that demonstrated efficacious implementation with water and wastewater utilities in Florida and the United States.

AMS software such as Cityworks, Infor/Hansen, NEXGEN, Oracle (with Geonexus), Cartegraph, IBM Maximo (with Geonexus), Facility Dude, Accela, Lucity, Cayenta (potentially with Geonexus), Utility Cloud, and Inframap were considered and could probably all meet some or most of the asset management needs for the City. That stated, the CUS Master Plan team, narrowed the list to meet the City's requested needs most efficiently. Five (5) software options were selected to be further examined for the City's new AMS with the results are compiled and presented in **Table UW5-1** for the six (6) options:

- Cayenta with GeoNexus
- Cityworks
- NEXGEN
- Utility Cloud
- City selected ERP software (Infor)
- InfraMap

The City selected Infor in 2016 as its Enterprise Resource Planning (ERP) Software for use City-wide (above and beyond utilities); Infor offers its own supplementary asset management module. Infor was not recommended in the short list for AMS, however, the City can further evaluate the associated asset management module and compare to the examined AMS options. The CUS Master Plan team prepared cost estimates for the five listed options including implementation and presents these figures in **Table UW5-2**.

5.5 Shortlisted Software

5.5.1 Cayenta with GeoNexus

Cayenta Utility Management System is a full featured, highly configurable application that is designed to integrate common information and tasks. It can be part of Cayenta's full, integrated suite of solutions including Financial Management, Operations Management, and Human Resources. Cayenta provides billing and asset features but most importantly has a proprietary integration tool that will allow import/export from open database connectivity (ODBC) and from electronic data interchange (EDI) connections. Cayenta is less development oriented through a third party programmer/consultant and more geared toward a limited configuration of its own product (less features, but much more cost effective). Currently, the City has already purchased the Utility Billing Solution and the Work Management Module from Cayenta, allowing the additional Asset Management Module to be easily incorporated into their current system. In addition, Cayenta assumes responsibility for the integration within existing City systems using its own software. GeoNexus is a middleware that currently connects asset management products such as Oracle and IBM's Maximo to GIS. According to the GeoNexus representative, integration with Cayenta is currently being developed. The GeoNexus connection to GIS will allow a more robust utilization of GIS data and read/write capabilities. Cayenta provided the following municipal clients as references: Intermountain Rural Electric Cooperative (IREC) and the Columbia River Public Utilities Department. IREA described Cayenta as “highly configurable and fairly well thought-out” but noted that lack of data collection due to budget and manpower constraints was preventing them from utilizing Cayenta fully.

5.5.2 Cityworks

Cityworks is a browser based solution, which leverages the use of ESRI, SQL Server, Oracle, Citrix and Amazon Web Service databases. Cityworks is fully compatible with Microsoft Office and can support other third party applications that are typically managed by a utility’s IT department. Cityworks is GIS-centric in that ESRI ArcGIS geodatabases are directly utilized. Cityworks provides a foundation for an effective enterprise asset management program to improve asset utilization, extend asset life and performance while reducing capital costs and asset-related operating costs. Cityworks is a proven and genuine GIS-centric computerized maintenance management system that forms the foundational core for a GIS-centric asset management. Cityworks also requires customized third party software to provide capital planning functionality. The following similar municipal clients use Cityworks: City of Miami Beach, FL, Orlando Utilities Commission, FL, Marco Island, FL, Palm Bay, FL and St. Johns County, FL.

5.5.3 NEXGEN

NexGen is backed by over 25 years of practical asset management program and software implementation experience. NEXGEN Asset Management is web-based software that was developed specifically to support a comprehensive asset management program and CMMS. The user-friendly asset management software is an all-in-one solution that seamlessly integrates with many different technologies, eliminating the cumbersome task of coordinating among many different software programs. NexGen provides built-in, robust capital planning tools to aid in the City’s future projections and project efforts. Utility engineers designed the NEXGEN system. NEXGEN has the capability to communicate with the City’s existing Cayenta financial software; however, the extent and ease of integration would require further investigation. Typically, NEXGEN operates as a complete system capable of asset management and CMMS without the need for external software. The following similar municipal clients use NEXGEN: City of Durham, NC, City of Corona, CA, Central Marin Sanitation Agency, CA and the City of Tualatin, OR. NEXGEN provided the following information in response to the City’s questions:

- NEXGEN manages the configuration and upgrades for the hosted option. NEXGEN will upgrade the OS and manage any server optimization on AWS.
- NEXGEN will notify the City in advance of updates and get approval before updates to the City’s database.
- NEXGEN prefers to read directly from ESRI web services that can be hosted on City servers or remote servers. This allows the City’s real time GIS changes to be reflected in NEXGEN. If ESRI web services is not available, NEXGEN can read imported shape files or imported ESRI geodatabase feature classes.
- In order to make GIS functional in the NEXGEN software, the City will need to provide NEXGEN with a path for the web service GIS. NEXGEN will work with City GIS staff to determine layers for specific asset classes. NEXGEN will work with City staff to identify fields for the locations and classes to establish the asset hierarchies.
- The functionalities of the desktop and mobile application are similar. The desktop software will have more querying functionalities of assets than the mobile. The mobile will utilize the location services on the mobile device to optimize searching of assets

nearby. The querying functionalities are different for the desktop and field mobile users. The desktop software and mobile apps are designed specifically for the users' requirements.

5.6 Other Software to Consider

5.6.1 Utility Cloud

Utility Cloud is a web-based mobile asset, operations, workforce and data management application that is customizable to meet a variety of organizational needs. Utility Cloud combines the benefits of cloud and mobile technologies to provide reliability using any device online or offline. In addition, Utility Cloud could provide seamless data exchanges with GIS while having no additional impact to the City's IT resources. Utility Cloud does not currently offer capital planning tools, built-in risk analysis tools, or asset accounting (budgeting, depreciation, forecasting). While it did not make the final shortlist, Utility Cloud was initially selected because it demonstrated a very clean and user-friendly display, and emphasized ease of use for field workers.

5.6.2 ERP Software

The City recently selected Infor as its proposed ERP software. Although not included in the procurement of the ERP, Infor also is a well-established asset management software provider. Infor's asset management module is advantageous because it would integrate with the ERP software package, and would have fast-tracked procurement, compared to the other options. The City should request purchase and maintenance pricing as Infor is typically a higher end software that competes with Oracle and IBM who were screened due to pricing.

5.6.2.1 Infor – Enterprise Asset Management (EAM)

Infor Enterprise Asset Management (EAM) is a configurable enterprise-grade asset management software. Infor allows the user to improve capital asset management in ways that increase reliability, enhance predictive maintenance, ensure regulatory compliance, reduce energy usage, and support sustainability initiatives. The City could provide services that are more responsive to citizens by using Infor EAM to manage preventive maintenance and upkeep of municipal water, sewer, and transit systems as well as all equipment. However, the City has prior negative experience with Infor, the owner of Hansen. During the migration of data from Hansen, Infor had difficulty providing the City support to easily extract and transfer data.

5.6.3 InfraMap

InfraMap is a field-oriented tool that is efficient because of its relatively low cost, and its focus on usage in the field rather than as a desktop application. InfraMap can tie into Cityworks, as well as other programs using a SQL database, but the field crews utilizing the program will only need to put information into InfraMap. It generates excel spreadsheet reports, and has been used for a variety of assets including pumps, motors, pipeline, valves, hydrants, etc. Other Florida utilities such as Miami-Dade, City of Cocoa, City of Port Orange, City of Boynton Beach, and Orlando Utilities Commission (OUC) have been using InfraMap for years.

Table UW5-1. Asset Management Software Comparison

Category/Feature	*Software*			
	1. Cayenta w Geonexus	2. Cityworks	3. NEXGEN	4. Utility Cloud
Asset Management				
Asset/Inventory	Y	Y	Y	Y
Field Inventory Data Collection	Y	Y	Y	Y
Capital Planning Functionality	N	N	Y	N
Asset Accounting (Budgeting, Depreciation, Forecasting)	Y	Y	Y	N
Condition Assessment	Y	Y	Y	Y
Risk Analysis	Y[1]	Y[2]	Y	N
Human Capital Management	Y	Y	Y	Y
Dynamic Master Planning Capability	N	N	Y	Y
CMOM Planning & Reporting	Y	Y	Y	Y
CMMS				
Open API	Y	Y	Y	Y
Inventory Control	Y	Y	Y	Y
Work Management (Work Order Generation, Work Planning Tools, etc.)	Y	Y	Y	Y
Service/Customer Relationship Management (issue or incident logging)	Y	Y	Y	Y
Planned and Preventative Maintenance	Y	Y	Y	Y
Customizable Reporting Features	Cognos	Crystal Reports	Excel and/or Google Sheets	Excel and/or Google Sheets
IT/Other				
Viability of the Company	Est. 1995 (Approx.)	Est. 2005	Est. 2004	Est. 2011
ESRI GIS Integration	Y	Y	Y	N
GIS Mapping	Y	Y	Y	Y
Interface Flexibility/Customization	Y	Y	Y	Y
Internet Connectivity Required	N	Y	Y	N
Ease of Use in Field	Y	Y	Y	Y

[1]Cayenta Analytics must be purchased to perform risk analysis functionality.
[2]Third-party software is required to perform risk analysis functionality.

Table UW5-2. Asset Management Software Cost Comparison

Cost	Software					
	1. Cayenta	2. Cityworks	3. NEXGEN	4. Utility Cloud	5. Infor (Selected for ERP)	6. InfraMap
Capital Cost[1]	$247,000	$0	$100,000-$125,000 capital	$0	City to solicit	$0
Annual Cost	$61,800	$90,000	$20,000-25,000	$41,800	City to solicit	$35,000 (50 licenses) or $50,000 (100 licenses)
Notes/ Other	Includes three added modules	Open APIs needed might incur additional cost	--	Labor billed at $150 per hour.	City to solicit	$20,000 for Implement-ation and $10,000 for training

[1]Capital cost does not include implementation services.

5.7 Conclusion and Recommendations

Based on this evaluation, the available AMS programs were narrowed down to six (6) AMS software programs. This short list is based on the software's' ability and adequacy to meet the City's needs. The Infor software (selected for the ERP) and Cayenta are advantageous because they will utilize components of software that the City already has in-place, and Cityworks is advantageous because it offers a "GIS-centric" approach to asset management. NEXGEN has the advantage of integrated asset management and CMMS tools including risk assessment and dynamic master planning. NEXGEN also has the lowest annual cost. Utility Cloud is beneficial because of its clean and easy-to-use display, its ability to generate reports through simple programs such as excel and google sheets, and it does not need interconnectivity to function in the field. InfraMap is advantageous because of its focus on usage by field workers, rather than as a desktop software.

Of the six (6) AMS options, the CUS Master Plan team narrowed the shortlist to the selection of three (3) companies (NEXGEN, Cityworks and Cayenta), which performed in-house demonstrations for the City. During the demonstrations, City staff asked questions to the AMS developers, and provided feedback based on initial impressions of the three (3) short-listed software options. From the three (3) options that were demonstrated, NEXGEN appeared to best suit the City's identified needs for a comprehensive asset management software. Based on the analysis, the CUS Master Plan team developed CIP projects displayed in the Water CIP section, and recommends the following alternatives:

- Level 1 (In house Software) – The City creates a data management plan that defines what, where and how asset data will be stored. In-house spreadsheets, database software and GIS software (ESRI) will be utilized. Financial and utilities databases would be consolidated and conformed as feasible. This is the initial implementation step in an asset management system and could serve as Phase 1 of the implementation.
- Level 2 (Field Data Collection and Applications) – Since the City already has 15 years of R&R projects identified, the focus of this level would be on CMMS field personnel

support. In addition to Level 1, purchase software such as NEXGEN, InfraMap or Utility Cloud that is focused on field support and data collection.
- Level 3 (Full Scale AM/CMMS) - Implement a comprehensive, large-scale asset management software; NEXGEN meets the most needs out of the three (3) short-listed software packages and has the lowest annual cost, however, any of the three shortlisted softwares would suffice.
- The City should proceed with pricing from Infor; however, the Infor software does not seem utility specific, is higher cost and has not been successful for the City in the past.

The benefits of implementing a full scale AM/CMMS are as follows:

- Help determine the level of maintenance and replacement needs to successfully prolong and renew the utility infrastructure
- Help management staff to understand the tradeoffs and implications of management decisions about the assets, and use better information to justify proposed rate increases or capital investments
- Provide field crews key information when they need it
- More efficient field work processing and paperless task tracking
- Better inter department communication and real time information
- Dynamic master planning to keep planning initiatives fresh and current
- Improved inventory tracking and management
- Justifiable asset prioritization

In order to proceed, the CUS Master Plan team recommends the following actions:

Level 0 (Year 2016)

1. Determine the initial level of AM/CMMS to pursue.

Level 1 (Year 2016-2018)

2. Complete a simple AM/CMMS data management plan.
3. Implement the data management plan by modifying and constructing spreadsheets/databases/geodatabases to house the appropriate data and interconnect.
4. Complete update of existing asset data.
    a. Complete migration of data into Cayenta.
    b. Complete the GIS utility geodatabases, especially stormwater.
    c. Ensure connection and uniformity of asset data between GIS and Cayenta.
5. Develop data collection plan.
6. Begin data collection implementation and populate database with new data.
    a. Input data on the equipment and components of Peele Dixie WTP, Fiveash WTP, and GTL WWTP. This task will require a significant effort, as there is no current log of a majority of treatment plant components.

Level 2 and 3 (Year 2018-2019)

7. Determine how to proceed contractually with selection, purchase and implementation; to minimize procurement costs, the City could consider contract piggybacking.
8. Implementation of selected AMS.
    a. Determination of preferred implementation method (Level 2 or Level 2 and 3).
    b. Contract implementation services.
    c. Training of personnel and data transfer to AMS.
    d. Continue data collection implementation.

UW6 Strategic Initiatives

The City of Fort Lauderdale (City) has reinvigorated strategic planning efforts since its 2011 Centennial with progressive initiatives in order to navigate the challenging future in an environmentally sustainable way. Fusing the collective values and aspirations expressed by a diverse cross-section of the City with technical expertise, the City produced the following key strategic planning documents:

- Vision Plan (Fast Forward Fort Lauderdale 2035) – adopted unanimously in April 2013 is an inspirational view of the future and what the Fort Lauderdale community wants to become.
- Five-year Strategic Plan (Press Play Fort Lauderdale: Our City, Our Strategic Plan 2018) - organized the City into strategic area teams, bringing focus and coordination to build community.
- Sustainability Action Plan (2011 Update and 2015 Progress Report-Making Waves) - a concerted effort to actively integrate sustainability into City operations and services.
- Regional Climate Action Plan (RCAP), part of the Southeast Florida Regional Climate Change Compact established in January 2010, is a collaborative effort by Palm Beach, Broward, Miami-Dade, and Monroe Counties to create a unified plan to prepare for the effects of Climate Change.
- 10-Year Water Supply Plan – (November 2014) identifies issues associated with a sustainable water supply for the City.
- Other "Green" initiatives – as identified by the City's Sustainability Division.

These efforts outline strategic initiatives to help the City achieve its future goals. An inventory of water and wastewater related strategic initiatives from the documents was compiled and organized into groups as shown in **Table UW6-1**. For the purposes of this Master Plan, strategic initiatives are categorized into six (6) groups. Examples of initiatives that fall into each group are listed in the table. In the process of project grouping, it is noted that some projects fall into more than one strategic-initiative category. For example, a water main replacement project achieves infrastructure renewal, and also reduces water leakage and improves water conservation. From a big picture perspective (the Water-Energy Nexus), reducing water leakage can decrease the needed demand in the system, which in turn reduces energy consumption of the pumps. For the purposes of the Master Plan, projects were categorized by their primary purpose though co-benefits exist for most.

With the guidance provided by its strategic planning documents, the City has mobilized significant resources and effort into building the community. The strategic initiatives guide development of community improvement projects going forward. The City's current 5-Year Community Investment Program (CIP) includes strategic initiatives. This Comprehensive Utilities Strategic Master Plan will propose CIP projects under the guidance of meeting strategic and green initiatives. The current and proposed CIP was tabulated to reflect the capital costs associated with implementing initiatives which support sustainability and climate resiliency. A preliminary estimate of capital utilities projects was compiled and is presented in **Table UW6-2**.

Once complete, the Comprehensive Utilities Strategic Master Plan will estimate overall savings and performance indicators or benchmarks for comparison which support the City's Strategic Initiative Plans. The City is committed to providing reliable service, maintaining safe and healthy living conditions and building a prosperous, sustainable, and resilient coastal community.

Section UW6 accepted March 30, 2016.

Table UW6-1. Comprehensive Utility Master Plan Strategic Initiatives Categories and Examples

	Initiative Category	Initiative Examples	Source Report	Source Report Section	Additional Initiatives Supported
1	**Energy Conservation**	Reduce energy use in City facilities by 20% by 2020 (2 CM 38 3 Electricity consumption)	Sustainability Action Plan, 2011	Energy, Goal 1, Action 1.1.2	Climate Resilience
		Integrate electricity reduction goal into Community Investment Plan (CIP) (3 CM 35 3 Funding plan)		Energy, Goal 1, Action 1.1.3	Climate Resilience
		Reduce inflow and infiltration (1 PW 38 5 Engineering study)		Water, Goal 2, Action 2.1.1	Water Conservation, Infrastructure Renewal, Climate Resilience
		Install energy efficient pumps and motors to replace old, less efficient equipment	Green Initiatives	Public Works	Treatment Improvements, Infrastructure Renewal, Reduce Solid Waste
		Increase the use of the City's existing wastewater disposal system by increasing overall system efficiency, which reduces the per capita cost and energy use footprint required to properly treat the City's wastewater			
		Replace the George T. Lohmeyer WWTP oxygen generation system with more efficient technology	2015 Master Plan	Wastewater Energy Efficiency	Treatment Improvements, Reduce Solid Waste
		Upgrade the George T. Lohmeyer WWTP biological reactors and aerators with more efficient technology	2015 Master Plan	Wastewater Energy Efficiency	Treatment Improvements, Reduce Solid Waste
2	**Water Conservation**	Continue escalation of high-user potable water fees in single-family zoning (1 PW 40 4 Rate shed.)	Sustainability Action Plan, 2011	Water, Goal 1, Action 1.1.2	Climate Resilience
		Implement energy management systems to reduce energy consumption and save money	Five-year Strategic Plan, 2013	Internal Support, Goal 12, Objective 3, Initiative 4	Energy Conservation, Treatment Improvements, Climate Resilience
		Replace leaking water mains to reduce waste of treated drinking water	Green Initiatives	Public Works	Energy Conservation, Treatment Improvements, Infrastructure Renewal, Climate Resilience
3	**Treatment Improvements**	Improve George T. Lohmeyer WWTP process and biosolids treatment systems (2 PW 19 3)	Sustainability Action Plan, 2011	Water, Goal 2, Action 2.1.2	Energy Conservation, Reduce Solid Waste
		Improve potable water quality and color	2015 Master Plan	Water Quality Enhancement	Water Conservation, Infrastructure Renewal, Climate Resilience
4	**Infrastructure Renewal**	Reduce inflow and infiltration (1 PW 38 5 Engineering study)	Sustainability Action Plan, 2011	Water, Goal 2, Action 2.1.1	Energy Conservation, Water Conservation, Climate Resilience
		Remove on-site disposal systems within the City and the uncontrolled discharge of untreated wastewater and associated nutrients into the shallow groundwater and near-shore environment (improperly operated or maintained septic systems can also result in public health risks)	Green Initiatives	Public Works	Energy Conservation, Treatment Improvements, Climate Resilience
		Use corrosion resistant materials to extend the lifespan of constructed projects when possible	Green Initiatives	Public Works	Energy Conservation
		Rehabilitate facilities wherever possible instead of replacing to reduce waste disposal, material requirements, and energy usage	Green Initiatives	Public Works	Energy Conservation, Treatment Improvements, Climate Resilience
5	**Climate Resilience**	Reduce inflow and infiltration (1 PW 38 5 Engineering study)	Sustainability Action Plan, 2011	Water, Goal 2, Action 2.1.1	Energy Conservation, Water Conservation, Treatment Improvements, Infrastructure Renewal
		Develop a regional saltwater intrusion baseline and utilize saltwater intrusion models to identify infrastructure at risk of contamination and infiltration by saltwater with increases in sea level	10 Year Water Supply Plan, 2015	Action item WS-2	Energy Conservation, Water Conservation, Infrastructure Renewal
		Utilize inundation maps and stormwater management models to identify areas and infrastructure at increased risk of flooding and tidal inundation with increases in sea level	10 Year Water Supply Plan, 2015	Action item WS-3	Energy Conservation
		Evaluate the impacts of rising sea and groundwater levels and develop strategies for implementing reclaimed water and stormwater reuse projects that account for current and future conditions	10 Year Water Supply Plan, 2015	Action item WS-4	Energy Conservation, Treatment Improvements
		Address excessive infiltration and inflow (I/I), and develop performance indicators	Five-year Strategic Plan, 2013	Infrastructure, Goal 2, Objective 1, Strategic initiative 7	Energy Conservation, Infrastructure Renewal
6	**Reduce Solid Waste**	Study wastewater plant and recommend improvements to the WWTP's solid waste disposal system (2 PW 19 3)	Sustainability Action Plan, 2011	Water, Goal 2, Action 2.1.2	Energy Conservation, Treatment Improvements
		Examine the possibility of using sludge from water and wastewater operations more efficiently	Five-year Strategic Plan, 2013	Infrastructure, Goal 2, Objective 4, Strategic initiative 4	Treatment Improvements, Climate Resilience

Section UW6 accepted March 30, 2016.

Table UW6-2. 20-Year Utility Community Investment Program Summary Categorized by Strategic Initiatives[1,2,3]

	Initiative Category	FY 2017-2021 Projects Currently in 5-Year CIP	FY 2017-2021 CUSMP Additional Projects	FY 2022-2026	FY 2027-2031	FY 2032-2036	20-Year Total
1	Energy Conservation	$49,342,707	$47,351,815	$30,234,193	$23,408,998	$10,780,435	161,118,148
2	Water Conservation	$1,620,911	$1,230,000	$900,000	$680,000	$980,000	5,410,911
3	Treatment Improvement	$59,457,119	$39,355,500	$61,320,000	$4,440,000	$8,490,000	173,062,619
4	Infrastructure Renewal	$80,395,325	$180,552,895	$222,953,278	$269,886,212	$188,921,846	942,709,557
5	Sea Level Rise Adaptation	$16,486,731	$24,249,250	$4,127,750	$25,180,000	$44,780,000	114,823,731
6	Reduce Solid Waste	$1,600,605	$4,100,000	$15,097,000	$3,500,000	-	22,697,000
	Total	$208,903,398	$296,839,460	$334,632,222	$327,095,210	$253,952,281	$1,419,821,966

[1] For a complete list of CIP projects refer to **Sections UW7**, **WA7** and **WW9**
[2] All figures in this table are 2016 dollars
[3] The current City CIP also contains approximately $114,000,000 in unfunded initiatives.

Section UW6 accepted March 30, 2016.

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UW7 Utility Wide Community Investment Program

The Utility Wide Community Investment Plan (CIP) and CUSMP recommended projects provides a short term (five-year), mid-term (ten to fifteen-year) and long-term (twenty-year) capital improvements necessary for the City's management of water and wastewater systems to provide reliable and quality service. The Utility Wide CIP and the CUSMP recommended projects include categories for Utility Wide report sections. Funding methods for the improvements are proposed based on existing and potential funding resources.

Table UW7-1 summarizes the City's Community Investment Plan (CIP) for utility wide, water and wastewater components and fund groupings. **Table UW7-2** and **Table UW7-3** present the City's 5-year Utility Wide CIP for Funds 451 (Regional Wastewater) and Fund 454 (General Capital Projects/Water & Sewer Master Plan), respectively. **Table UW7-4** and **Table UW7-5** present the additional CUSMP-recommended Utility Wide projects for the 20-year planning horizon also for Funds 451 (Regional Wastewater) and 454 (Water & Sewer Master Plan), respectively. The CIP tables are organized by the City's CIP fund and are sorted by the primary CUSMP task and the project number.

Section UW7 accepted April 14, 2017.

Table UW7-1. Projected CIP Summary and CUSMP Recommended Projects Comparison

Central Regional WW Fund (451)						
UW2 SCADA Regional	Planned CIP	$379,937	$647,307	$0	$0	$0
	Unfunded CIP	--	$0	--	--	--
	CUSMP Additional	$0	$2,475,000	$540,000	$740,000	$740,000
UW3 Electrical Regional	Planned CIP	$1,774,962	$6,143,497	$0	$0	$0
	Unfunded CIP	--	$1,961,421	--	--	--
	CUSMP Additional	$0	$18,171,959	$10,348,072	$5,248,073	$1,942,510
WW Regional Total	Planned CIP	$19,451,269	$53,825,594	$0	$0	$0
	Unfunded CIP	--	$17,635,200	--	--	--
	CUSMP Additional	$0	$55,054,885	$54,214,400	$76,116,000	$28,258,200
Subtotal Planned CIP:			*$31,339,283*	*$0*	*$0*	*$0*
Subtotal Unfunded CIP:			*$10,329,021*	--	--	--
Subtotal CUSMP Additional:			*$50,790,878*	*$65,102,472*	*$82,104,073*	*$30,940,710*
Fund 451 TOTAL:			$92,459,182	$65,102,472	$82,104,073	$30,940,710
Water and Sewer Master Plan Fund (454)						
UW2 SCADA City	Planned CIP	$1,148,934	$1,648,934	$0	$0	$0
	Unfunded CIP	--	$0	--	--	--
	CUSMP Additional	$0	$13,385,090	$13,242,229	$7,642,925	$7,642,925
UW3 Electrical City	Planned CIP		$0	$0	$0	$0
	Unfunded CIP	--	$0	--	--	--
	CUSMP Additional	$0	$11,380,000	$4,855,000	$3,940,000	$2,135,000
UW4 Manual Ops.	Planned CIP		$0	$0	$0	$0
	Unfunded CIP	--	$0	--	--	--
	CUSMP Additional	$0	$348,800	$0	$0	$0
UW5 Asset Mgmt.	Planned CIP	$0	$0	$0	$0	$0
	Unfunded CIP	--	$0	--	--	--
	CUSMP Additional	$0	$625,000	$150,000	$125,000	$125,000
UW6 Strategic 454	Planned CIP	$1,351,788	$1,472,538	$0	$0	$0
	Unfunded CIP	--	$22,997,500	--	--	--
	CUSMP Additional	$0	$500,000	$0	$500,000	$500,000
WA Total	Planned CIP	$36,593,788	$89,517,619	$0	$0	$0
	Unfunded CIP		$20,695,662	--	--	--
	CUSMP Additional	$0	$136,713,476	$159,347,270	$148,725,212	$81,198,646
WW City Total	Planned CIP	$16,476,807	$55,547,909	$0	$0	$0
	Unfunded CIP	--	$50,406,104	$91,935,250	$84,058,000	$131,410,000
	CUSMP Additional	$0	$58,185,250	$91,935,250	$84,058,000	$131,410,000
Subtotal Planned CIP:			*$148,187,000*	*$0*	*$0*	*$0*
Subtotal Unfunded CIP:			*$94,099,266*	--	--	--
Subtotal CUSMP Additional:			*$221,137,616*	*$269,529,750*	*$244,991,137*	*$223,011,571*
Fund 454 TOTAL:			**$463,423,882**	**$269,529,750**	**$244,991,137**	**$223,011,571**

Please refer to this link for the existing Fort Lauderdale 2016 to 2002 Community Investment Plan.
http://www.fortlauderdale.gov/departments/city-manager-s-office/budget-cip-and-grants-division/community-investment-plans

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Table UW7-2. City of Fort Lauderdale
Utility Wide Community Investment Plan - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	UW2	P12114	ELECTRICAL/SCADA EVALUATION	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.	379,937	-	-	-	-	-	379,937	-	-	-	-
451	UW2	P12256	REGIONAL RE-PUMP SCADA	This project will update the supervisory control and data acquisition (SCADA) system at B and E repumps. It will also provide funds for permitting, assistance during the bid process, construction cost estimate for all items, services during construction, and the final certification. The City will provide construction observation services.	The SCADA system has a useful life of five years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. This system was installed in 2011.		267,370	-	-	-	-	267,370	-	-	-	-
451	UW3	FY 20170524	GTL ELECTRICAL MAINTENANCE AND TESTING (ARCFLASH)	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.		-		-	-	203,535	203,535	-	-	-	-
451	UW3	P11917	ELECTRICAL UPGRADES	Consultant's scope of work will include final design activities which include plans and specifications permitting bidding and subsequent field QA/QC of installed electrical upgrades to ensure adequacy during construction at George T. Lohmeyer Wastewater Treatment Plant (GTL WWTP). Additionally it is estimated that construction cost would be approximately $3,000,000.	City's Utilities Operations staff have identified the need to replace electrical conduits wires local disconnects red terminal boxes an associated supports from Reactor 1 to the generator building and Cryogenic building. Replacement of MCC-2 MCC-2A MCC-10A LP-13A TP-2 and wall mounted transformer in the Cryogenic building.	502,039	2,000,000	915,000	-	-	-	3,417,039	-	-	-	-
451	UW3	P12172	G T LOHMEYER WWTP ELECTRICAL MAINTENANCE	This project consists of electrical system testing and maintenance by an International Electrical Testing Association (NETA) certified electrical equipment testing and maintenance firm. The work will be to perform testing, maintenance, and emergency maintenance on the existing electrical systems and equipment at the City of Fort Lauderdale's George T. Lohmeyer Wastewater Treatment facility.	Due to the plant's age and the corrosive environment in which it operates, it is necessary to assess the condition of the various electrical components, conduits, and control panels throughout the facility. The scope of testing shall include: •Electrical equipment testing, maintenance by a NETA certified testing firm on existing electrical systems and equipment; •Perform a thermographic survey of major electrical equipment; and •Establish comprehensive maintenance and testing program for all electrical system equipment identified in these specifications using the manufacturer's recommendations and NETA Maintenance Testing Specifications (MTS) for Electrical Power Systems.	199,286	-	-	-	-	-	199,286	-	-	-	50,000
451	UW3	P12176	GTL MOTOR CONTROL CENTERS REHABILITATION	This project is for upgrades of various Motor Control Centers based on the Electrical Reliability Study. The study resulted in recommendations for the George T. Lohmeyer Wastewater Treatment Plant.	There are many Motor Control Centers within the facility that are past their useful life, and are no longer supported with parts and materials by the original manufacturers.	1,073,637	1,250,000	-	-	-	-	2,323,637	-	-	-	1,911,421
451	UW6	P12132-451	RICE/NESHAP UPGRADE TO GENERATORS	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.	100,000	-	-	-	-	-	100,000	-	-	-	-
Totals						**2,254,899**	**3,517,370**	**915,000**	**-**	**-**	**203,535**	**6,890,804**	**-**	**-**	**-**	**1,961,421**

Table UW7-3. City of Fort Lauderdale
Utility Wide Community Investment Plan - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	UW2	P11685	WATER MONITORING SYSTEM (SCADA)	CIP 2017-2021 for Description	CIP 2017-2021 for Justification	397,194	-	-	-	-	-	397,194	-	-	-	-
454	UW2	P12051	CONTRACT SUPERVISORY CONTROL & DATA ACQUISITION	Request for specialized contractor to implement a supervisory control and data acquisition (SCADA) system within the Utilities Bureau. The contractor will be responsible for creating constructing and updating the necessary systems/equipment throughout the various water plants the wastewater plant and the water/wastewater distribution and sewer collection system.	Currently the status of the City's SCADA is at approximately 70% and with this effort the system will be brought to 100%. SCADA systems improve operations and monitoring of utility systems and will be used to reduce infiltration/inflow (I/I) of the gravity wastewater sewer systems.	350,000	-	200,000	100,000	200,000	-	850,000	-	-	-	-
454	UW2	P12222	REHAB 3 SCADA PUMP PANELS AT FIVEASH WTP	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	400,000	-	-	-	-	-	400,000	-	-	-	-
454	UW2	P12239	FIREWALLS	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.	1,740	-	-	-	-	-	1,740	-	-	-	-
454	UW6	FY 20150219	ADVANCED METERING INFRASTRUCTURE IMPLEMENTATION	Implement Advanced Meter Infrastructure (AMI) throughout the water distribution system. The system will provide smart meters with two-way communication between the meter and utility and between the meter and our neighbors (smart grid). Project costs include the purchase and installation of 62,425 water meters with AMI Radio Modules a Citywide AMI network infrastructure billing integration with Cayenta system and project management.	Automated meter reading technology has been proven to identify lost revenues by capturing low-flow usage lost in large meters stopped meters and illegal consumption. Additionally the leak detection technology available in the system will pinpoint water loss. The system will provide asset management via GPS eliminating meter tampering and theft. Operational efficiencies will result from reduced administrative paperwork costly field investigations and availability of remote turn offs for non-payment. Eliminate field visit for rechecks and move-in/move-outs. Reduced risk due to personnel injuries and lost time accidents. Approved as a secondary backflow preventer eliminating the need for costly notifications and inspections. Provides maximum day and peak hour flows for modeling and design of water mains. Promotes sustainability, encourages water conservation, limits vehicles on the road, reduces paper tracks, and predicts changes in water usage trends and demands.		-	-	-	-	-	-	-	-	-	22,900,000
454	UW6	P11586	C12 & 13 INTERCONNECT - BROWARD COUNTY	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	360,000	-	-	-	-	-	360,000	-	-	-	-
454	UW6	P11858	COMPREHENSIVE UTILITIES STRATEGIC MASTER PLAN	Water and Sewer Master Plan identifies the water and sewer capital improvements necessary to meet the needs of the Fort Lauderdale utility service area for the next 20 years including identification of near-term (5-years) needs.	Master planning is necessary to address changing regulatory requirements system capacities and to identify aging and/or otherwise compromised systems components for rehabilitation or replacement prior to failure to assure continued service. It also offers Commission based support for Water & Sewer related projects.	36,322	-	-	-	-	-	36,322	-	-	-	-
454	UW6	P11877	FLCC REMEDIATION ACTION PLAN	CIP 2017-2021 for Description	CIP 2017-2021 for Justification	305,466	-	-	-	-	-	305,466	-	-	-	-
454	UW6	P12132-454	RICE/NESHAP UPGRADE TO GENERATORS	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.	400,000	-	-	-	-	-	400,000	-	-	-	-
454	UW6	P12178	UTILITIES STORAGE BUILDING (STEEL PREFAB)	This project is to construct a prefabricated steel building such as a "Butler" building to store equipment and materials for use in utilities projects. The pipe yard/depot at the Public Works compound is at its maximum capacity. There are no available covered storage spaces to keep components out of the weather.	Pipe components such as valves and repair clamps have rubberized parts that need to be stored in locations out of the elements to prevent decomposition and premature failure. The electrical components and panels have the same requirements. The materials used for sidewalk repairs and construction materials should also be stored in a dry space. As City crews undertake additional responsibilities, storage spaces becomes critical for the components' quality.	250,000	-	-	-	-	-	250,000	-	-	-	97,500
454	UW6	P12259	PUBLIC WORKS ADMINISTRATION AIR CONDITION	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	-	120,750	-	-	-	-	120,750	-	-	-	-
Totals						**2,500,722**	**120,750**	**200,000**	**100,000**	**200,000**	**-**	**3,121,472**	**-**	**-**	**-**	**22,997,500**

Table UW7-4. City of Fort Lauderdale
Utility Wide Additional CUSMP Projects - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	UW2	UW2-5	GT LOHMEYER WWTP SCADA IMPROVEMENTS	Upgrade/Improve SCADA Systems	Refer to CUSMP Section UW2-6 and Table UW2-5 for justification and cost breakdown.			-	-	2,475,000	-	2,475,000	540,000	740,000	740,000	
451	UW3	UW3-19	GTL CITY ELECTRICAL UPGRADE PROJECTS	Perform Electrical Maintenance Testing; Replace Service Point 1 -4.16kV Switchgear; 4.16kV feeders to Cryogenic Bldg; Generator Building Unit Substation; add 5kV load break switch for portable generator connection; Motor Control Centers Rehabilitation.	Age/Reliability		-	2,490,321	158,000	-	4,250,000	6,898,321	-	-	500,000	
451	UW3	UW3-20	GTL R&R ELECTRICAL PROJECTS	Unit Substations R&R and future Service Point 1-3 4.16 kV feeder replacement.	Age/Reliability		-	-	1,717,042	1,717,043	1,717,043	5,151,128	2,575,562	2,575,563	-	-
451	UW3	UW3-21	GTL ELECTRICAL STUDIES AND TESTING	Update Plant Electrical Documents; Commission Study of Grounding and Surge Protective System and Lightning Protection System. Perform Electrical Maintenance Testing (Arc Flash).	Safety/Code		-	155,000	-	-	203,535	358,535	203,535	203,535	203,535	
451	UW3	UW3-22	GTL LIGHTNING PROTECTION	Make improvements to lightning protection and grounding/bonding system based on surveys/testing.	Safety/Reliability		-	100,000	100,000	100,000	100,000	400,000	-	-	-	
451	UW3	UW3-23	GTL ELECTRICAL REPLACEMENTS (2015-2020)	Replace medium voltage solid state reduced voltage starters for Effluent Pumps; Replace control instrumentation and power wire for SPS No.1 and Clarifiers 1,2 and 3; Replace control instrumentation and power wire for Chlorine Building; Rehabilitate Scum Pump, Plant Drain, Sanitary Lift Station with new electrical and control and other preventative maintenance.	Age/Reliability		-	450,000	900,000	700,000	1,848,975	3,898,975	-	1,500,000	-	-
451	UW3	UW3-24	GTL ELECTRICAL REPLACEMENTS (2021-2035)	Replace control instrumentation and power wire for SPS No.2 and Clarifiers 4,5, 6 and 7; Replace control instrumentation and power wire for Sludge Holding Tanks; Replace medium voltage feeders and other preventative maintenance.	Age/Reliability		-	-	-	-	-	-	4,848,975	348,975	348,975	
451	UW3	UW3-25	GTL VFD R&R	Replace 480V Variable Frequency Drives.	Age/Reliability		-	-	-	-	-	-	400,000	-	400,000	
451	UW3	UW3-26	GTL LOCAL GENERATOR CONNECTIONS	Apply 5KV Fused Disconnect Switch to Feeder 2F5 in SWGR5203; Apply 480V generator connection switchboard to USS_5311 or USS_5312 in Sludge Pump Station No.3; Apply 480V generator connection switchboard to USS_5307 or USS_5308 in Effluent Pump Station.	Age/Reliability		-	-	-	-	-	-	900,000	-	-	
451	UW3	UW3-27	GTL INJECTION WELL ELECTRICAL STUDIES AND TESTING	Perform Short Circuit Device Coordination and Arc Flash Study; Perform Electrical Maintenance Testing; Perform a survey of plant grounding and bonding system including lightning protection. Generate accurate as-built one line diagrams of the entire wellfield. Generate accurate plan drawings of the well field to depict locations of direct buried power, signal and control wiring, as well as, FPL facilities contained in the well field.	Safety/Code		-	115,000	100,000	-	-	215,000	120,000	120,000	140,000	-
451	UW3	UW3-28	GTL INJECTION WELL ELECTRICAL REPLACEMENTS (2017-2021)	Replace electrical panels, disconnect switches, raceways and wiring at Injection Wells 1 and 2. Replace in-ground power, control and signal raceway and wiring from Well Control House to Wells 1,2,3,and 5 including new in-ground pull boxes; Perform site lighting replacement for Injection Well Field site including Wells, roadway and control building exterior.	Age/Reliability/Safety		-	350,000	600,000	300,000	-	1,250,000	-	-	-	-
451	UW3	UW3-29	GTL INJECTION WELL ELECTRICAL REPLACEMENTS (2021-2025)	Replace electrical panels, disconnect switches, raceways and wiring at Injection Wells 3 and 5.Perform electrical systems rehabilitation of the Well Control Building including new utility service disconnect, 480V motor control center, 240V motor control center, circuit breaker panelboards, lighting transformers, lighting, receptacles and other electrical appurtenances. Add generator connection means and manual transfer switch to facilitate portable emergency generator connection if utility power is lost for an extended period of time.	Safety/Code		-	-	-	-	-	-	1,300,000	-	350,000	-
451	UW3	UW3-30	GTL INJECTION WELL ELECTRICAL REPLACEMENTS (2026-2030)	Replace electrical panels, disconnect switches, raceways and wiring at Injection Well 4. Replace in ground power, control and signal raceway and wiring from Well Control House to Well 4 including new in ground pull boxes.	Safety/Reliability		-	-	-	-	-	-	-	500,000	-	
Totals						**-**	**-**	**3,660,321**	**3,575,042**	**5,292,043**	**8,119,553**	**20,646,959**	**10,888,072**	**5,988,073**	**2,682,510**	**-**

Table UW7-5. City of Fort Lauderdale
Utility Wide Additional CUSMP Projects - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	UW2	UW2-1	FIVEASH WTP SCADA IMPROVEMENTS	Upgrade/Improve SCADA Systems	Refer to CUSMP Section UW2-2 and Table UW2-1 for justification and cost breakdown.			-	-	2,660,000	-	2,660,000	3,540,000	990,000	990,000	
454	UW2	UW2-2	PROSPECT WELL FIELD SCADA IMPROVEMENTS	Upgrade/Improve SCADA Systems	Refer to CUSMP Section UW2-3 and Table UW2-2 for justification and cost breakdown.			-	-	-	476,000	476,000	806,000	178,500	178,500	
454	UW2	UW2-3	PEELE-DIXIE MEMBRANE WTP SCADA IMPROVEMENTS	Upgrade/Improve SCADA Systems	Refer to CUSMP Section UW2-4 and Table UW2-3 for justification and cost breakdown.			-	-	2,560,000	-	2,560,000	240,000	1,240,000	1,240,000	
454	UW2	UW2-4	DIXIE WELL FIELD SCADA IMPROVEMENTS	Upgrade/Improve SCADA Systems	Refer to CUSMP Section UW2-5 and Table UW2-4 for justification and cost breakdown.			-	-	-	20,000	20,000	460,000	160,000	160,000	
454	UW2	UW2-6	TRANSMISSION & COLLECTION SCADA IMPROVEMENTS	Upgrade/Improve SCADA Systems	Refer to CUSMP Section UW2-7 and Table UW2-6 for justification and cost breakdown.			-	-	-	-	-	3,470,000	740,000	740,000	
454	UW2	UW2-7	UTILITIES WIDE AREA NETWORK SCADA IMPROVEMENTS	Upgrade/Improve SCADA Systems	Refer to CUSMP Section UW2-8 and Table UW2-7 for justification and cost breakdown.			-	-	-	7,669,090	7,669,090	4,726,229	4,334,425	4,334,425	
454	UW3	UW3-01	FA WTP ELECTRICAL STUDIES AND TESTING	Perform Short Circuit Device Coordination and Arc Flash Study; Perform Electrical Maintenance Testing.	Safety/Code		-	350,000	110,000	100,000	100,000	660,000	310,000	310,000	310,000	
454	UW3	UW3-02	FA ELECTRICAL SYSTEM REPLACEMENTS (2015-2020)	Replace medium voltage fused service disconnect switches; Replace medium voltage MCC_5201 and MCC_5202; Replace PNL_5602 (LPHS-3); Replace XFMR5501 and XFMR 5502; Replace MCC_5504 and MCC_5503; Replace MCC_5311; add second feed; incorporate/eliminate MCC_5313; Replace/Convert MCC_5614 to 480V and dedicated to HYD_2103; Replace/Convert MCC_5615 to 480V and dedicate to HYD_2104; Replace SWBD5616; Replace XFMR 5612; Replace PNL 5630; Replace General Circuit Breaker Panelboards, transformers, and branch circuits; Replace Surface Wash Pump 1 starter; Replace 2 HSP starters with VFDs; Convert 240V motors to 480V and re-feed; Replace MSTR3202 (Backwash Pump 2).	Age/Reliability		-	1,896,500	1,656,500	1,656,500	1,655,500	6,865,000	-	-	-	
454	UW3	UW3-03	FA ELECTRICAL SYSTEM REPLACEMENTS (2021-2025)	Replace General Circuit Breaker Panelboards; Replace MCC 5301; Separate HYD_2101 and HYD_2102 onto separate MCC's.	Age/Reliability		-	-	-	-	-	-	1,360,000	-	-	-
454	UW3	UW3-04	FA ELECTRICAL SYSTEM REPLACEMENTS (2026-2030)	Replace MCC_5203, perform Short Circuit Device Coordination and Arc Flash Study, perform Electrical Maintenance Testing.	Age/Reliability		-	-	-	-	-	-	-	610,000	-	-
454	UW3	UW3-05	FA ELECTRICAL SYSTEM REPLACEMENTS (2031-2035)	Replace Aqua Ammonia Building power system, perform Short Circuit Device Coordination and Arc Flash Study, perform Electrical Maintenance Testing.	Age/Reliability		-	-	-	-	-	-	-	-	890,000	
454	UW3	UW3-06	PD ELECTRICAL STUDIES AND TESTING	Update Short Circuit Device Coordination and Arc Flash Study; Perform Electrical Maintenance Testing.	Safety/Code		-	210,000	-	-	-	210,000	190,000	380,000	-	
454	UW3	UW3-07	PD SURGE PROTECTION UPGRADES	Replace/Retrofit existing panel boards with integral surge protective devices to external mounted units connected through a branch circuit breaker.	Safety/Reliability		-	25,000	25,000	25,000	25,000	100,000	-	-	-	
454	UW3	UW3-08	PD UPS REPLACEMENTS	Replace UPS_5701and UPS 5702 with new units and appropriate battery capacity.	Age/Reliability		-	-	-	-	-	-	60,000	-	-	
454	UW3	UW3-09	PD HIGH SERVICE PUMP, MEMBRANE FEED PUMP AND DISTRIBUTION PUMP VFD R&R	Replace variable frequency drives for High Service Distribution Pumps P___6201 and P___6202; Membrane Feed Pumps P___2501, P___2502, P___2503 and P___2504; Concentrate Booster Pumps P___7401, P___7402, P___7403.	Age/Reliability		-	-	-	-	-	-	-	500,000	-	-
454	UW3	UW3-10	PROSPECT WELLFIELD ELECTRICAL STUDIES AND TESTING	Perform Short Circuit Device Coordination and Arc Flash Study; Perform Electrical Maintenance Testing; Generate Accurate As-Built One Line Drawings and plans of the entire wellfield.	Safety/Code		-	185,000	-	-	-	185,000	115,000	230,000	115,000	
454	UW3	UW3-11	PROSPECT WELLFIELD BONDING AND GROUNDING TESTING AND LIGHTING PROTECTION	Perform Bonding and Grounding survey and testing; Add lightning protection to generator buildings.	Safety/Code		-	60,000	-	-	-	60,000	-	-	-	-
454	UW3	UW3-12	PROSPECT WELLFIELD GENERATOR EMISSIONS IMPROVEMENT	Address the EPA emissions non-compliance of the 500 kW emergency diesel generator in the Western Generator Building as soon as possible by either adding a diesel oxidation catalyst to the unit or replacing the generator with an emissions compliant unit.	Regulations		-	500,000	-	-	-	500,000	-	-	-	
454	UW3	UW3-13	PROSPECT WELLFIELD UNDERGROUND FEEDER REPLACEMENT	Replace underground feeder conductors to Wells PW-44 and PW-46.	Age/Reliability		-	-	150,000	-	-	150,000	-	-	-	

Table UW7-5. City of Fort Lauderdale
Utility Wide Additional CUSMP Projects - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	UW3	UW3-14	PROSPECT WELLFIELD WELL HOUSE EQUIPMENT REPLACEMENT (2015-2020)	Perform electrical systems rehabilitation at wells PW_25, PW_26, PW_27 and PW_28, and wells PW_30 through PW_34, including new well control houses, electrical systems equipment and controls. Replace starters with reduced voltage starters for wells PW-36 through PW-49.	Age/Reliability/Safety		-	600,000	600,000	600,000	600,000	2,400,000	-	-	-	
454	UW3	UW3-15	PROSPECT WELLFIELD WELL HOUSE EQUIPMENT REPLACEMENT (2021-2025)	Perform electrical systems rehabilitation at wells PW_36 through PW-49 including new well control houses, electrical systems equipment and controls.	Age/Reliability/Safety		-	-	-	-	-	-	2,100,000	420,000	-	
454	UW3	UW3-16	PROSPECT WELLFIELD WELL HOUSE EQUIPMENT REPLACEMENT (2031-3035)	Renew the electrical equipment in well houses PW-50, PW-51, PW-52, PW-53 and PW-54.	Age/Reliability		-	-	-	-	-	-	-	50,000	200,000	
454	UW3	UW3-17	PROSPECT WELLFIELD UNDERGROUND FEEDER REPLACEMENT	Replace underground feeder conductors to PW_36 through PW_43, PW_45, PW_47 and PW_49 in underground raceway with pull boxes approximately every 500 feet.	Age/Reliability/Safety		-	-	-	-	-	-	600,000	-	-	
454	UW3	UW3-18	PROSPECT WELLFIELD DIESEL EMERGENCY GENERATOR BUILDING ELECTRICAL REPLACEMENT (2026-2030)	Renew/Rehabilitate Western Generator Building including main breaker, automatic transfer switch, motor control center, lighting transformer, circuit breaker panel board, emergency diesel generator, wiring and raceways.	Age/Reliability		-	-	-	-	-	-	-	1,200,000	-	
454	UW3	UW3-31	PD DIXIE WELLFIELD ELECTRICAL STUDIES AND TESTING	Perform Short Circuit Device Coordination and Arc Flash Study; Perform Electrical Maintenance Testing.	Safety/Reliability		-	150,000	-	-	-	150,000	120,000	240,000	120,000	
454	UW3	UW3-32	PD DIXIE WELLFIELD ELECTRICAL R&R	Replace solid state reduce voltage starters and well control panels at Wells 27, 28, 29, 30, 31, 32, 33, and 34.	Age/Reliability		-	-	-	-	-	-	-	-	500,000	
454	UW3	UW3-33	PD DIXIE WELLFIELD GENERATOR EMISSIONS IMPROVEMENT	Address the EPA emissions non-compliance of the 500 kW emergency diesel generator in the Western Generator Building as soon as possible by either adding a diesel oxidation catalyst to the unit or replacing the generator with an emissions compliant unit.	Regulations		-	100,000	-	-	-	100,000	-	-	-	
454	UW4	UW4-1	FA FILTRATION SYSTEM MANUAL CONTROLS	Provide local switches/push buttons for manual control of filtration system pumps and valves.	Safety/Reliability		-	-	278,600	-	-	278,600	-	-	-	
454	UW4	UW4-2	PD PUMPING SYSTEMS MANUAL CONTROLS	Provide local switches/push buttons for manual control of transfer pumps and high service pumps.	Safety/Reliability		-	-	70,200	-	-	70,200	-	-	-	
454	UW5	UW5-1	TRANSFER OF EXISTING DATA AND COLLECTION OF NEW DATA	Assets need to be tagged and inventoried for GTL WWTP, Peele Dixie WTP, Fiveash WTP, and stormwater assets.	This is a 2016 Master Plan recommendation. The purpose of this project is to collect additional asset data in order to maintain assets such as WTPs, the WWTP, wastewater collection, transmission, and stormwater. This is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	150,000	75,000	50,000	275,000	25,000	-	-	
454	UW5	UW5-2	PURCHASE ASSET MANAGEMENT SOFTWARE (AMS)	This project includes the capital costs of software purchase including, purchase of the license, software, hardware, additional staffing, and all related work.	This is a 2016 Master Plan recommendation. The purpose of this project is to purchase an AMS that the City can used to employ preventative maintenance, inventory, and other important actions. This is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	125,000	25,000	25,000	175,000	125,000	125,000	125,000	
454	UW5	UW5-3	IMPLEMENTATION OF ASSET MANAGEMENT SOFTWARE AND TRAINING OF STAFF	This project includes transfer and verification of the existing data into the AMS database, and development of report templates and other default settings. Field, office, and administrative personnel will learn to use the AMS.	This is a 2016 Master Plan recommendation. The purpose of this project is to prepare staff for the use of AMS. This is part of the "Infrastructure Renewal" Strategic Initiative.		-	-		175,000	-	175,000	-	-	-	
454	UW6	P90012	CONDUCT A COMPREHENSIVE STUDY ON THE IMPACT OF SEA LEVEL RISE	Investigate the impact of sea level rise, the affect it will have on the city, and methods to minimize that affect.	This is a 2016 CUS Master Plan recommendation. Improved sustainability and identify methods to combat sea level rise.		-	-	-	-	500,000	500,000	-	500,000	500,000	-
Totals						-	-	4,076,500	3,165,300	7,876,500	11,120,590	26,238,890	18,247,229	12,207,925	10,402,925	-

WA1 External Planning Issues

1.1 Introduction

External planning issues exist that could impact the City of Fort Lauderdale's (City's) ability to sustain a sufficient, reliable source of water supply. External issues including the pace of economic and population growth, pending and predicted regulatory changes, regional water supply issues, salt intrusion into the aquifer inland, sea level rise and other pertinent influences can alter the course of the City's future water supply picture. This section provides a description of the status of external issues and their potential effect on the City's water system planning.

Regional water supply issues will include the implementation status of the Lower East Coast Water Supply Plan including potential effects on the City's water supply. The City's Upper Floridan Aquifer (UFA) test wells provided technical insight for planning of future brackish water supply treated with low pressure reverse osmosis (LPRO) including well production rates and expected present and future water quality of the UFA wells. Pertinent findings and probable effects to the City projected by the South Florida Water Management District (SFWMD) Floridan Aquifer study will also be discussed.

1.2 Economic and Population Growth

Economic and population growth, coupled with unit (per capita) water demand, will drive the City's future water supply needs. Water usage can correlate with the state of the economy, as demonstrated in the recession starting around 2007, during which per capita water demands reduced significantly. Despite an improving economy in recent years, the City's per capita water demands have continued to decrease due to City conservation efforts and potentially higher density redevelopment, while increasing population has offset this reduced unit consumption. Redevelopment activity is increasing as evidenced by the number of significant projects planned for Downtown and the Alliance Beach area. Based on the updated potable water demand forecasts that factored in redevelopment activity, presented in section WA2, the City's future water supply appears sustainable assuming the City's water use permits and aquifer quality and productivity are maintained.

1.3 Regional Water Supply Issues

Continually evolving regulatory initiatives, population growth resulting in increased future potable water demands, and unique hydrogeology are challenges facing water supply planners in southeast Florida. South Florida previously relied on only water supply from the Biscayne Aquifer using various types of lime softening techniques. As growth exceeds the capacity of the Biscayne Aquifer, South Florida utilities are turning to alternative water supplies including the Upper Floridan Aquifer and surface water to meet future needs. Regional water supply planning today is increasing the focus on sustaining or improving existing sources of water, diversifying to more secure and less vulnerable supplies and compliance with new potable water treatment standards as described below.

1.3.1 Lower East Coast Water Supply Plan

The SFWMD created the Lower East Coast Water Supply Plan (LEC Plan) in May of 2000 to ensure adequate water supply needs were met for urban areas, agricultural lands, and natural systems throughout Southeast Florida. The LEC Plan presented estimates of the southeast region's water needs, and proposed concepts and ideas to meet those needs.

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The 2000 LEC Plan was updated in 2013 in accordance with legislative mandates to further safeguard water supplies for both human and environmental needs through 2030. The 2013 LEC Plan will be updated every five (5) years, and requires local governments to prepare and adopt a ten (10) Year Water Supply Facilities Work Plan into their comprehensive plans. The City's requisite 10-year Water Supply Facilities Work Plan (Water Supply Plan) was completed in November 2014.

Important components of the Water Supply Plan, relevant to the 2013 LEC Plan, are population and water demand projections for 2035. These include an estimated 2035 population of 267,196 and a raw water unit demand of 176 gallons per capita per day (gpcd). The resulting 2035 average annual raw water withdrawal from the Biscayne Aquifer is forecast to be 47.0 million gallons per day (MGD) which is significantly less than the annual allocation of 52.55 MGD authorized by the City's existing Water Use Permit (WUP). The maximum monthly raw water demand (1.14 times the average demand) of 53.6 MGD is also significantly less than the maximum month Biscayne WUP allocation of 59.90 MGD. Additionally, the 2035 maximum day finished water daily demand forecast of 57.65 MGD is within the existing permitted treatment capacity (Fiveash and Peele-Dixie Water Treatment Plants [WTP]) of 82 MGD (permitted design capacity; Fiveash WTP – 70 MGD, Peele-Dixie WTP – 12 MGD). The 57.65 MGD demand is also within the actual effective treatment capacity of the system, which is 67 MGD (actual treatment capacity; Fiveash WTP – 55 MGD, Peele-Dixie WTP – 12 MGD). Based on this comparison of available water supply with the 20 year forecast, the City could accommodate an upside variance of 5.5 MGD of average daily demand, or approximately 30,000 people, in the 20 year forecasts.

The revised population and demand projections described in the 2014 10-Year Water Supply Facilities Work Plan and confirmed in this Comprehensive Utilities Master Plan (CUSMP) have important implications regarding the need for and/or timing of plans to construct a low pressure reverse osmosis (LPRO) treatment facility for brackish water withdrawals from the Upper Floridan Aquifer (UFA). In the 2013 LEC Plan (Update) and the City's previous Master Plan, a 6 MGD LPRO facility with a 2030 completion date and estimated capital cost of $22.9 million is identified as a City Water Supply Project. It is acknowledged in the Update, however, that based on current demand projections the LPRO facility may not be needed during the applicable 20-year planning horizon. It may be advisable for the City to continue with planning and funding for this project to diversify its water supply. The Biscayne Aquifer has historically been susceptible to saltwater intrusion and contamination; hence, redundancy in water supply may provide benefits to the City in the future. However, the City's 2014 Annual Saltwater Intrusion Groundwater Monitoring Report has not found significant increase in salinity at any of the monitoring well locations to date. Therefore, the capital and operational dollars may be more efficiently expended to protect, sustain, and treat the Biscayne Aquifer for such projects as rehabilitating the old Peele-Dixie lime softening process.

Two UFA test production wells were constructed at the Peele-Dixie facility in 2007. They are open-hole wells completed to approximately 1,200 feet below land surface (ft. BLS), with casing extended to approximately 1,000 ft. BLS. The City's WUP includes an allocation from the UFA which, based on comparison of total allocations with Biscayne Aquifer limitations, implies an annual UFA allocation of approximately 8.6 MGD on average and approximately 10 MGD on a maximum monthly basis. The WUP identifies the two existing UFA wells along with six proposed wells at Peele-Dixie and four proposed UFA wells at the Prospect Wellfield.

Various groundwater modeling analyses were performed previously for the City to evaluate potential issues associated with possible future UFA wellfields. Analyses included basic analytical modeling typically used to support UFA wellfield allocation requests for WUP

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applications. They also involved variable-density numerical modeling using the SEAWAT code developed by the United States Geological Survey (USGS). Several versions of regional SEAWAT models of the Floridan Aquifer System (FAS) in southeast Florida have also been developed and applied by the SFWMD. The SEAWAT models facilitate evaluation of potential water quality change over time in response to UFA withdrawals.

The various modeling results suggest that UFA wellfields can be successfully constructed to provide raw water for an LPRO facility. All the previously applied models, however, suffer from a severe lack of important data about hydraulic properties and water quality distributions within the FAS, especially at the level of detail required for sufficiently accurate predictions about future conditions. Consequently, model predictions regarding whether UFA wellfield operations may cause significant changes in water quality over time are highly uncertain. Such water quality changes can result in costly modifications in wellfield and treatment plant design and operations, as have been demonstrated through case histories of operations at existing UFA wellfields in south Florida.

Due to uncertainties associated with model predictions of UFA wellfield operations, it is imperative that well locations, pumping rates, and wellfield operating plans are developed that minimize the potential for significant water quality changes over time. Wellfield planning must consider maximizing well spacing so that water quality concerns in one well are not mirrored in adjacent wells of close proximity. Individual well production rates must also consider aquifer characteristics.

The City is also a contributing member to the Broward Water Partnership Conservation Program, whose goal is to save 30 MGD of water throughout the County. The extent of the City's commitment toward helping achieve this goal is evidenced in their commitment to reduce their finished water unit water demand consistently to 170 gpcd for the 2035 planning horizon. The City also has a partnership with the Broward County Mobile Irrigation Service to promote irrigation water conservation as well.

1.3.2 Water Resources Availability

In February 2007, the SFWMD implemented to the Regional Water Availability (RWA) Rule in order to conserve the Florida Everglades water supply. Cities needing new sources for water supplies are now required to use alternative sources. Alternative sources include the Upper Floridan Aquifer for brackish water supply, reclaimed wastewater and stormwater for irrigation to supplant potable water sources, as well as surface water and seawater for desalination. The SFWMD RWA Rule approved the City of Fort Lauderdale’s WUP withdrawal capacity for the Biscayne Aquifer, set at 52.55 MGD on an annual average day basis. Although the 2014 10-Year Water Supply Facilities Work Plan and this 20-year CUSMP indicate that the City is not expected to exceed the WUP within the 20-year planning horizon, future demands above the WUP limit beyond 2035 could be met with additional conservation methods, LPRO on the brackish upper Floridan Aquifer or other alternative water sources such as the C-51 Water Reservoir Project.

The C-51 Reservoir Project is a former 950-acre rock quarry, refitted as a 46,000 acre/foot storage reservoir located just North of Twenty Mile Bend, Florida. Utilizing and reclaiming the former quarry reduces the impact on the environment and saves on construction costs. The location of the C-51 Reservoir is just west of the existing L-8 reservoir and combined will create a 75,000 acre/foot storage facility. The C-51 basin catches stormwater and is proposed to create a freshwater basin which can then be used to supplement the region’s water supply. Through a phased approach, the C-51 would produce a raw potable water supply of 35 MGD in

Phase I, 120 MGD in Phase II and 185 MGD in Phase III, to be divided among utilities in Palm Beach and Broward Counties.

The C-51 reservoir project began in 2006 when seven South Florida utilities began investigating a collaborative regional approach to find alternative water supplies. This approach involved a two part feasibility study that was performed in 2008 and 2010. In 2013, a finance and governing committee met to recommend cost studies, and in June 2014 the SFWMD met to negotiate regulatory aspects of the project. A summary of proposed costs for this project are listed in **Table WA1-1**. Unit cost for the C-51 project area is estimated at $1.15 per 1,000 gallons for raw potable water supply (not including treatment or City-specific transmission).

Table WA1-1. Summary of Proposed Cost from C-51 Reservoir Project*

Reservoir and Related Infrastructure (Using Palm Beach Aggregates Estimate)	
(1) C-51 reservoir construction and property	
(3) Southern Boulevard conveyance crossing	
(4) S5AE pump station (between C-51 and L-8 conveyance crossing)	
(5) L-8 canal conveyance crossing	
(6) C-51 reservoir conveyance canal and inflow structure	
(7) C-51 reservoir inflow and water supply pump station	
Sub Total	**$695.0 million**
C-51 Canal Improvements SFWMD	
(2) S155A pump station	$ 25.0 million
Broward County Canal Improvements	
(8) Broward County 298 district improvements	$ 2.3 million
LWDD Improvements	
(9) LWDD improvements	$ 33.3 million
Total	**$ 755.6 million**

*Proposed cost from “C-51 Reservoir – Preliminary Design and Cost Estimate – Final Report”

The City also has an existing agreement with Broward County for the C-12 and C-13 interconnect project; an alternative water supply project associated with the C-12 and C-13 canals intended to recharge the Peele-Dixie wellfield. The C-12/13 Project is currently funded; however, additional funds will be necessary because Broward County is adjusting the construction method and route. The County's plan is expected to be finalized in December of 2015 and should cost the City approximately $1,000,000.

1.3.3 Comprehensive Everglades Restoration Plan

The Comprehensive Everglades Restoration Plan (CERP) was created in 1999 by the collaborative efforts of the SFWMD and the Army Corp of Engineers (ACOE). The goal of the CERP is to protect and rehabilitate south Florida’s ecosystem while providing adequate water supply and flood protection for the region.

Restoration planning efforts identified projects that will aid in the CERP efforts and help to achieve its environmental goals. The 2010 report to Congress stated “In the past five years, three projects were authorized in the Water Resources Development Act of 2007: Indian River Lagoon South, Picayune Strand Restoration and Site 1 Impoundment. The authorization of these projects has allowed the agencies involved in the CERP to begin construction on features that provide needed momentum toward the restoration of the Everglades." The Site 1 impoundment is of the nearest proximity and will capture excess discharge from the Intracoastal Waterway to be used as groundwater recharge, and reduce demand on the Loxahatchee Wildlife Refuge. Additionally, the Lake Belt In-Ground Reservoir Technology Pilot is currently underway in Dade County. Palm Beach and Broward Counties' reservoirs are conceptually designed for above-ground storage of stormwater for environmental and water supply deliveries. The pilot plan includes an initial design evaluation of underground seepage barriers to prevent seepage losses due to high aquifer transmissivity and aquifer water quality impact from stored water. In concept, the seepage barriers will allow drawdown of the reservoirs during the dry season without significant drawdown impact to the aquifer.

1.3.4 Saltwater Intrusion

The City's water supply source, the Biscayne Aquifer, is a shallow, surficial aquifer characterized by highly porous, transmissive limestone karst geology. Coastal saltwater intrusion of the Biscayne Aquifer has occurred in eastern parts of Broward County. The advancement of the saltwater intrusion front (saline interface), typically characterized by the estimated location of the 250 mg/L chloride isochlor, is mapped by local governments in the region, the USGS, and the SFWMD.

The saline interface corresponds to a region within the saturated subsurface where groundwater concentrations increase relatively rapidly from freshwater values to those typical of seawater. Understanding where the saline interface occurs in relation to a municipal wellfield is critical in preventing significant salinity increases that may result in restriction or abandonment of wells. The City proactively manages potential influence from saltwater intrusion risk via wellfield pumping optimization, relocation of wells towards the west, abandonment of eastern wells, and the collection of data from 10 saltwater monitoring wells constructed in 2002.

The USGS/SFWMD efforts produce 5-year estimates of the position of the saltwater interface in Broward County for the surficial aquifer system (SAS), which includes the Biscayne Aquifer. These estimates help with evaluating the threat of saline intrusion to impact water supply wellfields located near the coast, including Fort Lauderdale's Dixie and Prospect wellfields. SFWMD's most recent (Spring 2014) estimate of the saline interface in Broward County indicated a location more than 2 miles east of the Prospect wellfield, and more than 2 miles southeast of the Dixie wellfield. Comparing the 2014 interface location with SFWMD's 2009 estimate suggests a relatively stable saline interface near the Prospect wellfield, but shows the saline interface now approximately 650 feet inland of the 2009 location southeast of the Dixie wellfield. It should be noted that the estimated saline interface location nearest to the Dixie wellfield (to the south in the vicinity of the G-54 Control Structure) has apparently not moved between 2009 and 2014 according to the SFWMD estimates.

While a small advancement has occurred over the last 5 years, the City's monitoring has yielded no evidence of saltwater intrusion into the City's existing Dixie and Prospect Wellfields. The City plans to continue its current saltwater intrusion data collection efforts and support Broward County efforts to minimize salt intrusion risk for sea level rise scenarios anticipated over the next several decades. The City is participating in the development of a Saltwater Intrusion Modeling project with Broward County and the USGS, projected for completion in 2015. Preliminary City findings to date suggest little or no impact to the City's existing SAS wellfields in response to projected sea level rise for the next 50 years.

1.4 Water Quality Regulations

Existing and future water quality regulations will impact water supply planning. While the City is in compliance with existing water quality regulations, planned improvements to the Fiveash WTP should be reviewed to promote compliance with potential, new water quality regulations.

1.4.1 Existing Regulations

The U.S. Environmental Protection Agency's (EPA) governs national water quality regulations. In 1974 congress passed the Safe Drinking Water Act (SDWA) which established national standards for water quality. The State of Florida has primacy for water quality regulations in Florida and governed legislation in Florida Statutes sections 403.850 - 403.864. The statutes follow the SDWA and other national rules with additional state regulations. These regulations are defined in the Florida Administrative Code (F.A.C.) as described below:

- **CHAPTER 62-550, F.A.C., Drinking Water Standards, Monitoring, and Reporting** – Adopts EPA rules for produced water, sets maximum contaminant limits on finished water, sets monitoring requirements and frequencies water systems must adhere to when testing for contamination, requires surveillance, record keeping, and reporting required of water systems, and creates forms and instructions for laboratories to use when reporting chemical monitoring results.
- **CHAPTER 62-555, F.A.C., Permitting and Construction of Public Water Systems** – Creates Construction, operation, and maintenance standards for public water systems, sets rules governing general permits for water systems, sets rules governing construction permits for water systems, creates treatment and monitoring requirements for water systems which use surface water, and creates forms and instructions for water systems to use.
- **CHAPTER 62-560, F.A.C., Requirements for Public Water Systems that are out of Compliance** - Adopts EPA rules on the actions a water system must take when it is not in compliance with the established standards, sets provisions governing variances, exemptions, and waivers, and sets best available technology and treatment techniques for use by water systems that are out of compliance.
- **CHAPTER 62-550.800, F.A.C., Control of Lead and Copper** - Creates in-home tap sampling requirements for large, medium, and small systems, sets source water and water quality parameters sampling, creates lead and copper action levels Corrosion Control Treatment, and requires public education and notification.

1.4.2 Future Regulations

The EPA reviews the SDWA every 6 years with a new renewal due in 2016. New contaminants of emerging concern (CECs) are placed on a Contaminant Candidate List (CCL). EPA is currently working on CCL-4. Specific concerns that may result in future water quality regulations are summarized in **Table WA1-2**.

Table WA1-2. Future Water Quality Regulations

Rule or Contaminant	Description	Applicability to City	Potential Strategies to Address
Strontium	May reduce bone density during children's bone development, preliminary positive regulatory determination made in 2014, final rule expected by 2019 or 2020.	City anticipated to be within limits	Monitor
Algal Toxins	EPA issuing health advisory for microcystin in summer 2015, carried forward onto the draft CCL-4 (draft CCL-4 published in February 2015).	Not currently applicable to City but would apply for C-51 Reservoir or other surface water supply	Prevention, treatment
Climate Adaptation Implementation Plans	Draft plans available on EPA website, public responses out in 2015.	Applicable	Climate adaptation initiatives completed, ongoing and part of this Master Plan
Revised Total Coliform Rule	Guidance Manual Interim Final on EPA website, increased assessments and source identification for total coliform and E. coli occurrences; compliance due by April 2016.	Applicable	Well maintenance, wellfield protection, 4-log compiance
Emerging Contaminants	Chemicals or materials characterized by a perceived, potential, or real threat to human health or the environment including: o Endocrine-disrupting compounds o Pharmaceuticals and personal care products o Perchlorate o Unregulated DBPs (e.g., NDMA) o Fluorinated and brominated compounds	Applicable	Monitor and address when and as needed
Chlorate and Nitrosamines	EPA has decided to include these disinfection byproducts in its third Six-Year review that is scheduled to be released in 2016	Applicable	Upgrade Fiveash treatment and switch to free chlorine disinfectant
Lead and Copper Rule Regulatory Revisions	EPA proposal expected in September 2015 with final expected in March 2017	Applicable	Potential lime treatment reinstatement and blending at Peele Dixie

These future regulations could have a significant impact on the City, especially the nitrogen related disinfection by-products since the City utilizes ammonia-nitrogen to form chloramines. If found harmful and subsequently regulated, the City as well as other utilities using chloramine disinfection, may be required to provide additional treatment and revise disinfection practices away from chloramines. Levels of strontium historically analyzed in the City's water are 250 part per billion (ppb) at the Fiveash WTP and 45 ppb at Peele-Dixie WTP; well within the currently projected 4,000 ppb limit. Therefore, strontium should not be a future concern to the City. While the City's existing groundwater supply does not have issues with algae; future implementation of the C-51 Reservoir or potential migration into the Biscayne Aquifer from percolating canals and ponds could create issues associated with algal blooms and cyanotoxins.

1.5 Climate Change Impact

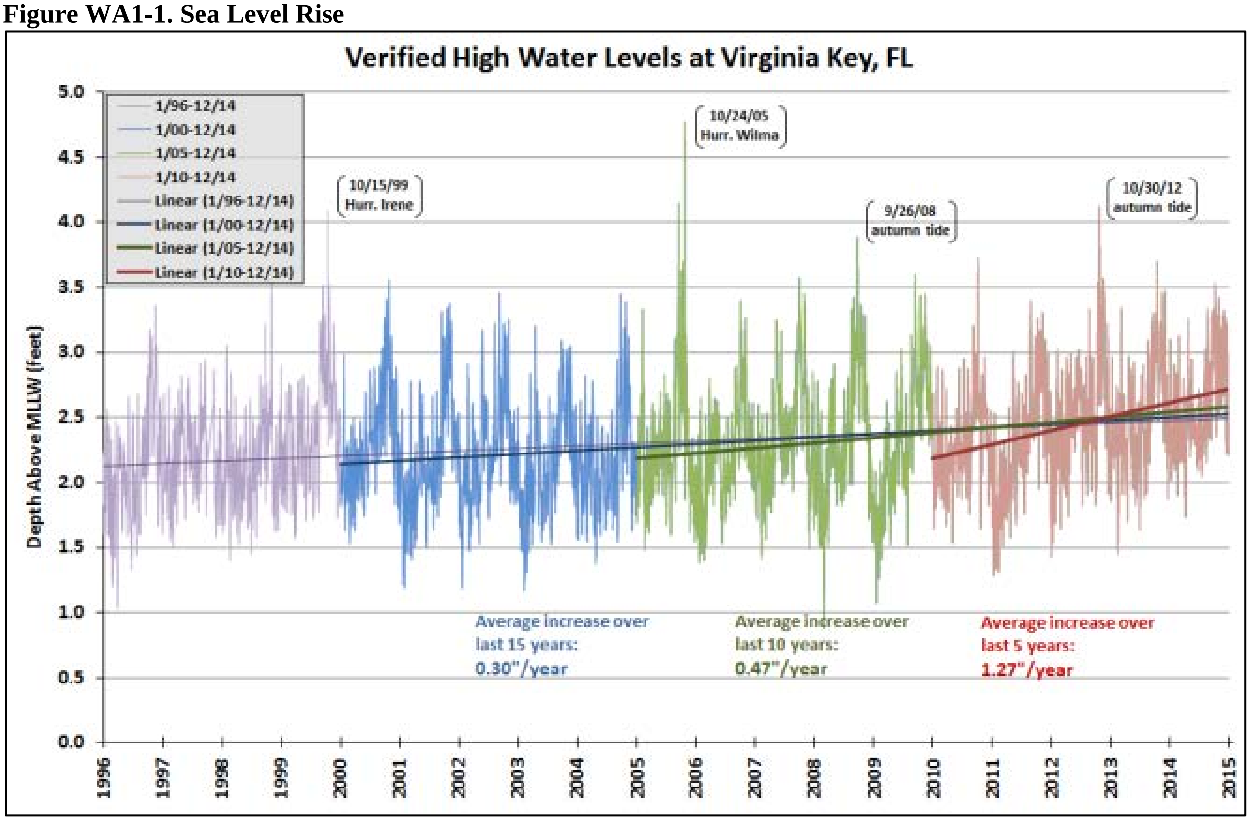
The City's Sustainability Division is closely following predictions for climate change in coastal Florida. In the past 19 years since the University of Miami commenced measurements, the sea level around Miami has risen 3.7 inches (McNoldy, 2015) as shown in **Figure WA1-1**. As sea level rise accelerates (1.27 inches in the last 5 years), ocean levels will rise an additional 5 inches in the next 20 years. Climate Central 2014 projects a main range of local sea level rise from 0.6-1.3 feet by 2050, and 1.7-4.7 feet by 2100, at Key West. The City also utilizes a similar chart to track sea level rise that is available in its latest Vision Plan.

The City has made climate change adaptation a goal of its strategic planning and closely follows adaptation strategies (including the draft Climate Adaptation Implementation Plans available through EPA) and participates in regional initiatives including membership in the Southeast Florida Regional Climate Change Compact.

The Southeast Florida Regional Climate Change Compact's purpose is to collectively create a more resilient infrastructure in south Florida. The Compact is a collaborative effort entered into by Palm Beach, Broward, Miami-Dade, and Monroe Counties in January 2010. The goal of this collaboration is to create a unified plan to prepare for the effects of Climate Change, specifically with regard to rising sea-levels and greenhouse gas emissions. As part of the Regional Climate Action Plan, 110 recommendations were compiled, with 18 of these recommendations being specific to "Water Supply, Management, and Infrastructure."

The recommendations' primary focus centers on sea level rise, salt water intrusion, extreme weather conditions, and infrastructure development. Improvements to both water and wastewater infrastructure will be needed to address these issues, not only to minimize climate impacts to the City, but to reduce the City's effects on the environment.

Figure WA1-1. Sea Level Rise



Source: Rosenstiel School of Marine & Atmospheric Science/University of Miami, 2015

In efforts to move forward with the goals set forth in the Regional Climate Action Plan and address the recommendations, the City is implementing changes. Over $3,000,000 annually is being invested by the City to line gravity collection pipes and reduce I/I. Planning is underway to harden water and wastewater utilities and further prepare for the coming, predicted climatic conditions. As mentioned, Broward County is currently working with the USGS to develop and apply a model for the County that can evaluate potential risks to Fort Lauderdale as well as other coastal wellfields. Additionally, Fort Lauderdale’s continued saline intrusion monitoring program was recently upgraded and provides key data regarding current and future risks of intrusion from sea level rise. The CUS Master Plan Team recommends a more detailed study in the next five years be added to the Community Investment Plan (CIP) to further define the impacts of climate change as presented in **Section WA7**.

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WA2 Potable Water Demand Forecast

With the advent of its Centennial in 2011, the City of Fort Lauderdale furthered progressive planning efforts with conception of the 2013 “vision for the future” (Fast Forward Fort Lauderdale 2035) and a strategic plan (Press Play Fort Lauderdale 2018) to facilitate implementation of the vision. These strategic planning efforts along with the City of Fort Lauderdale Urban Design & Planning Division’s ongoing programs and an improving economy have revived redevelopment in the City. As of January 2015, there were 12 ongoing or planned redevelopment projects in the Central Beach area and 30 projects in the Downtown area. The potable water demand forecast drives capacity related capital needs to meet the projected growth and help the City’s water utility achieve the lofty goals set by the Vision and Strategic Plan.

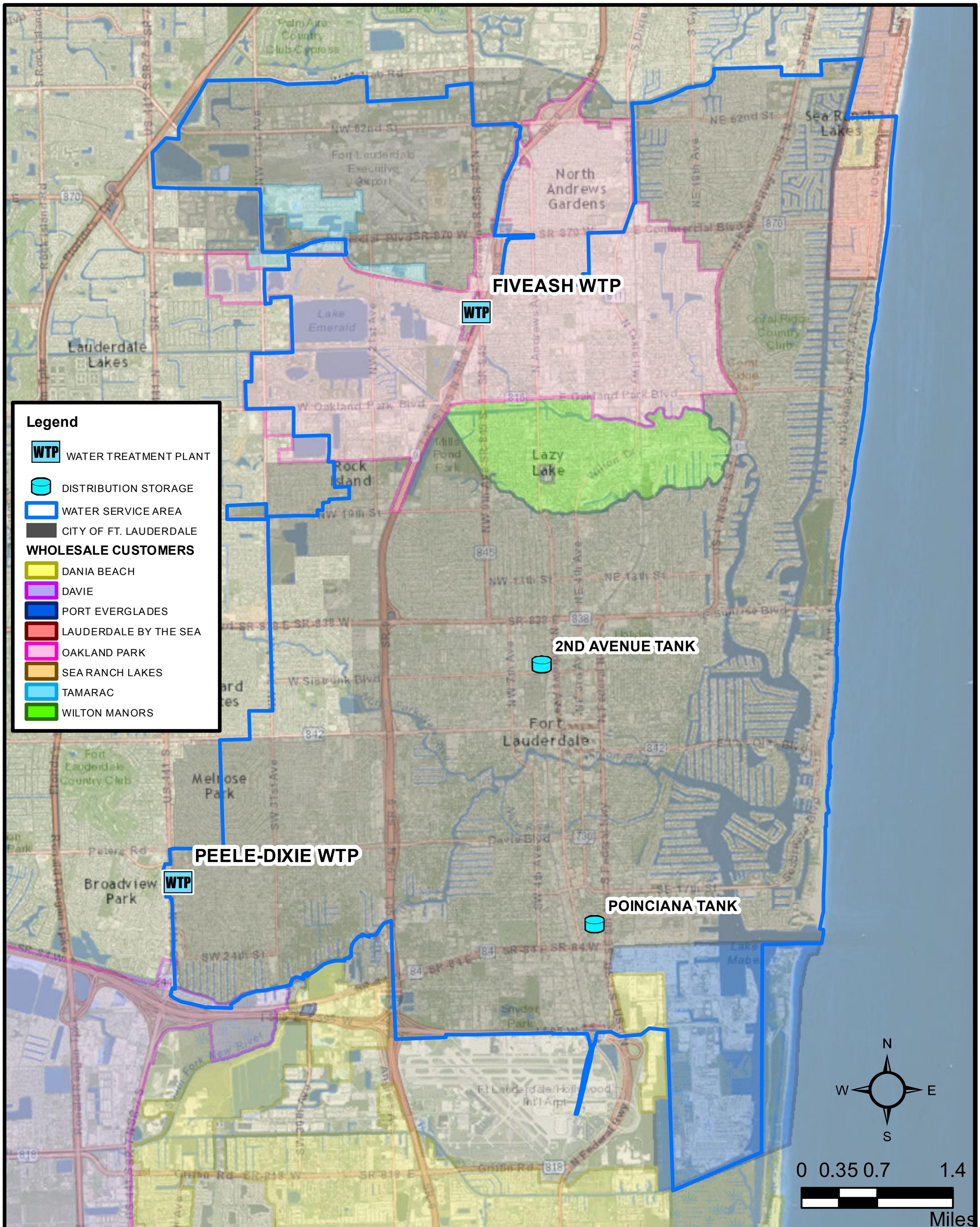
2.1 Water Service Area

The utility’s potable water service area encompasses a total area of 43 square miles and is the largest distribution system in Broward County. The City’s system serves a population of over 225,000, approximately 12% of Broward’s total population, including both retail and wholesale customers. The retail customers include the City of Fort Lauderdale, Roosevelt Gardens, Franklin Park, Washington Park, and Boulevard Gardens’ communities of unincorporated Broward County, which the City anticipates to incorporate in the future. Other retail customers include Lazy Lake, and a portion of Lauderdale-by-the-Sea. The City has wholesale agreements with the Town of Davie and the Cities of Oakland Park, Tamarac (east of 34th Avenue), and Wilton Manors as well as Port Everglades. **Figure WA2-1** illustrates the water service area.

2.2 Population Forecast

The City’s water demand forecast comprises current, baseline demand conditions and population growth projections through year 2035. The population projections were compiled by Broward County Planning and Redevelopment Division (Broward County Planning) using the Traffic Analysis Zones and Municipal Forecasts Update (2014) populations from the University of Florida’s Bureau of Economic and Business Research (BEBR) “Detailed Population Projections by Age, Sex, Race, and Hispanic Origin, for Florida and Its Counties, 2015-2040, With Estimates for All Races” (2014). **Table WA2-1** and **Figure WA2-2** illustrate the historical and forecasted population for the City’s water service area from 2015 to 2035. Note that the populations listed below are permanent. The gross per capita water use calculation, consistent with previous City water forecasting, accounts for the City’s tourist and other non-permanent population, estimated by City planning documents as 5% and 6% of the total population, respectively.

Section WA2 accepted May 6, 2016.



CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WATER SERVICE AREA

FIGURE WA2-1

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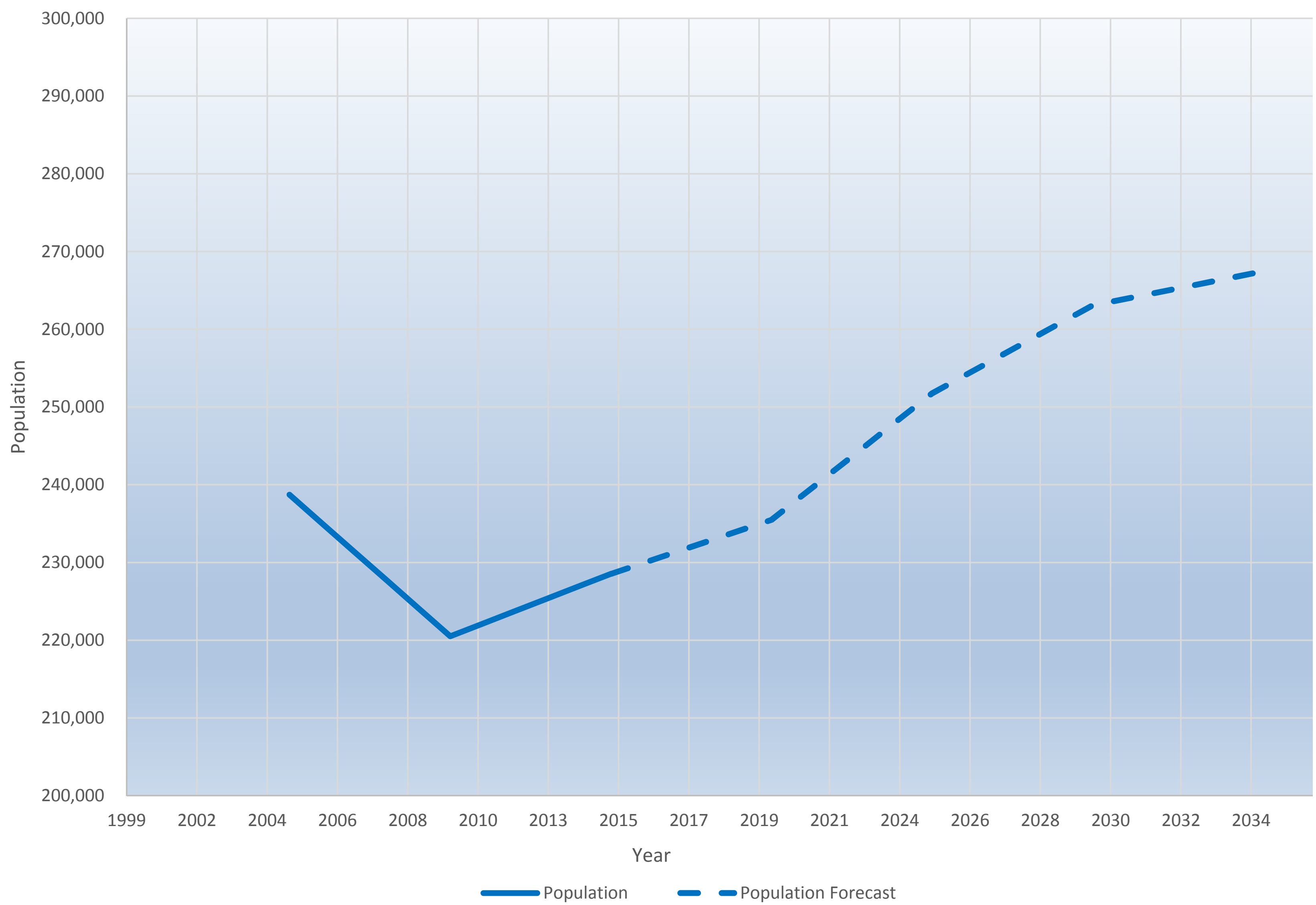
Table WA2-1. Historical and Forecasted Water Service Area Population

Location	2005[1]	2010[1]	2015[2]	2020[2]	2025[2]	2030[2]	2035[2]
Fort Lauderdale	--	162,715	169,094	174,316	189,166	198,394	201,880
Lauderdale-by-the Sea	--	3,463	3,841	4,009	3,960	3,922	3,894
Sea Ranch Lakes	--	663	703	720	709	704	697
Unincorporated Broward County	--	6,745	6,265	6,652	7,005	7,297	7,414
Davie	--	525	528	530	527	534	585
Lauderdale Lakes	--	374	381	383	378	386	386
Lauderhill	--	2,923	2,890	2,881	2,840	2,927	2,969
Lazy Lake	--	25	26	26	26	26	26
North Lauderdale	--	345	349	352	1,060	1,291	1,403
Oakland Park	--	29,851	30,706	31,718	32,257	33,477	33,825
Tamarac	--	1,497	2,152	2,162	2,137	2,179	2,188
Wilton Manors	--	11,374	11,611	11,740	11,693	11,931	11,929
Total	**238,725**	**220,500**	**228,546**	**235,489**	**251,758**	**263,068**	**267,196**

[1] 2005 and 2010 historical population estimates from the City of Fort Lauderdale Urban Design & Planning Division.

[2] 2015 to 2035 population forecast compiled by the City of Fort Lauderdale Urban Design & Planning Division including information from the 2014 Traffic Analysis Zones and Municipal Forecasts Update (Broward County Planning and Redevelopment Division) and the "Detailed Population Projections by Age, Sex, Race, and Hispanic Origin, for Florida and Its Counties, 2015-2040, With Estimates for 2012 All Races" (University of Florida's Bureau of Economic and Business Research (BEBR)).

Figure WA2-2. Service Area Population Forecast



Section WA2 accepted May 6, 2016.

2.3 Historical Demands

In 2014, the average annual daily demand (AADD) for potable water pumped into the City's distribution system (defined as "finished" water or demand) was approximately 37.5 MGD as tabulated in **Table WA2-2** and graphically depicted in **Figure WA2-3**. Over the past 7 years (2008 to 2014), and as shown in **Figure WA2-3**, the 12-month moving average finished AADD has decreased steadily to current levels due to factors including economic recession and the City's successful water conservation efforts. Reduced service area population and the economic slowdown were likely primary factors decreasing water consumption from 2005 to 2010. With the population increasing from 2010 to 2014, the finished water demand continued to decrease likely due to the City's diligent water conservation efforts including changes in building codes for new construction.

The City also tracks raw and finished water unit (per capita) demands by dividing total (gross) demands by the total permanent population. The City's gross unit finished water demand has historically ranged from 167 to 213 gallons per capita per day (gpcd) and, in year 2014, was below the 170 gpcd goal set by the City in its Sustainability Action Plan. Note that the total finished water demand includes demands from permanent population as well as commercial, transient or non-permanent and tourist populations; hence the gross unit water demand accounts for the community as a whole understanding that the divisor is only permanent population. This method for calculating unit water demands is consistent with the South Florida Water Management District (SFWMD) understanding that gross unit water demands can vary depending on the commercial and non-permanent population components of a community.

2.4 Demand Forecast

The City's water demand forecast consists of current, baseline demand conditions added to population growth projections through year 2035. Water demands are categorized as finished or raw, and as annual average daily, maximum daily and peak hourly. Demands forecasts apply to annual average (latest 15 years) rainfall with a discussion of the effect of varying precipitation (both rainfall extremes and drought) on the City's finished water demands. The City will continue to track the gross unit (per capita) water demand to determine if the recently achieved 170 gpcd is sustainable or a product of higher than average rainfall and vacancy conditions. The CUS Master Plan Team does not recommend alteration of the future gross unit water demand-gpcd for this Master Plan until the City can evaluate weather variability with actual data.

2.4.1 Annual Average Finished Daily Demand

In 2014, the City's finished average annual daily demand (AADD), representing the total treated water volume that is sent to the distribution system over a year divided by 365 days, was approximately 37.5 MGD (**Table WA2-2**). The CUS Master Plan team considered finished AADD to be "gross" as it consists of the total volume of water that is demanded by not only the City of Fort Lauderdale service area but also by its retail and wholesale customers. The finished gross AADD contains non-revenue water that includes accounted-for and unaccounted-for distribution system flows and losses (e.g., leaks, pipe breaks and system flushing).

Table WA2-2. Water Service Area Water Demand Forecast

Year	Population[1,2]	Raw AADD (MGD)	Raw Per Capita (gpcd)	Finished AADD[3] (MGD)	Finished Per Capita[4] (gpcd)	Finished MDD (MGD)
2005	238,725	48.2	202	47.8	200	56.3
2006	235,080	50.4	214	50.1	213	63.1
2007	231,435	43.4	187	43.1	186	53.6
2008	227,790	43.6	192	42.8	188	56.4
2009	224,145	44.6	199	43.6	195	54.4
2010	220,500	41.9	190	40.6	184	49.5
2011	222,109	41.4	186	40.3	181	50.3
2012	223,718	39.6	177	38.3	171	48.1
2013	225,328	39.2	174	37.7	167	49.7
2014	226,937	39.3	173	37.5	165	49.4
2015	228,546	42.5	186	41.4	181	53.8
2020	235,489	42.6	181	41.7	177	54.2
2025	251,758	44.8	178	43.3	172	56.3
2030	263,068	46.3	176	44.7	170	58.1
2035	267,196	47.0	176	45.4	170	59.1

[1] 2005 to 2013 Population based on the 10-Year Water Supply Facilities Work Plan - 2014 Update

[2] 2014 Population forecasted using a linear regression from years 2010 to 2013 during economic recovery

[3] Finished AADD projected from 2015 to 2035 based on estimated population and per capita consumption

[4] Finished AADD gpcd for the years 2028 through 2035 is assumed to be 170 gallons per person per day

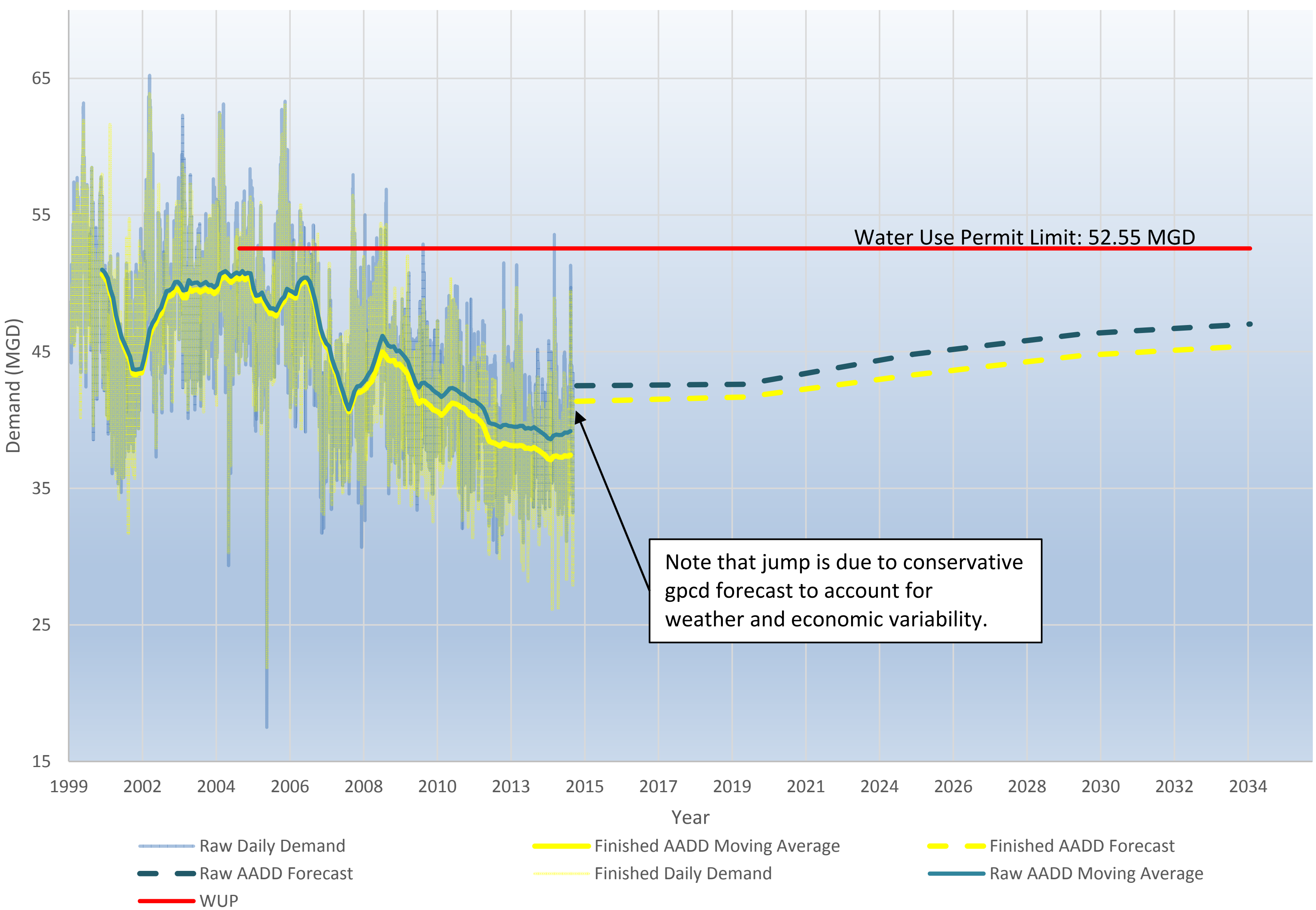
As a component of the gross average annual daily demand, the wholesale customers water demand is approximately 25% of the overall, finished AADD. **Table WA2-3** summarizes the demand forecast for the wholesale customers, City of Oakland Park, City of Wilton Manors, Port Everglades, Oakland Forest, City of Tamarac, and other wholesale users.

Table WA2-3. Wholesale Water Demand Forecast, MGD

Year	City of Oakland Park	City of Wilton Manors	Port Everglades	Oakland Forest	City of Tamarac	Broward County WW Services	FDOT – Toll Booth (<0.01 MGD)	Total
2005	4.01	1.6	1.31	0.5	0.19	0.0007	0.0005	7.61
2010	4.29	1.7	1.68	0.55	0.2	0.0012	0.0005	8.42
2015	4.73	1.82	2.14	0.6	0.21	0.0019	0.0005	9.5
2020	5.19	1.94	2.73	0.63	0.22	0.0031	0.0005	10.72
2025	5.62	2.04	3.49	0.66	0.23	0.0049	0.0005	12.04

Figure WA2-3 shows that the finished AADD decreased steadily from 2007 to 2014 to current levels due to factors such as the "Great Recession" in 2007 and the City's water conservation efforts. Reduced service area population and the economic downturn is likely the reason for decreased water consumption from 2005 to 2010.

Figure WA2-3. Potable Water Average Daily Demand (ADD) Forecast



Section WA2 accepted May 6, 2016.

Although the population increased from 2010 to 2013, the water demand continued to decrease; likely due to the City's water conservation efforts, more efficient new construction codes and higher density redevelopment as noted earlier. New construction water conservation codes include water efficient construction and more multi-family housing (uses less water per capita than single-family homes). The City's water demand per capita is currently below 170 gallons per capita per day (gpcd), which was the Sustainability Action Plan goal. For the water demand forecast, the CUS Master Plan Team assumed the finished water demand in the year 2028 to be 170 gpcd based upon the City's goal and Consumptive Use Permit. The CUS Master Plan Team also assumed that the finished water per capita demands for the years 2028 through the 2035 would remain constant at 170 gallons per person per day. As noted in the previous section, the CUS Master Planning Team calculated net gpcd unit demand with finished AADD and permanent residential population, understanding that the demand includes commercial, transient or non-permanent populations and tourist population components.

2.4.2 Treatment Efficiency

Treatment efficiency, defined as well production versus finished water production, varies with the treatment technology utilized. The treatment efficiency for the Fiveash WTP, which uses lime softening technology, is roughly 99 to 97 percent of the raw water pumped. Fiveash treatment losses discharge to the wastewater system in small quantities. The treatment loss for the Peele-Dixie WTP, which uses nanofiltration softening technology, is roughly 15 percent of the raw water pumped in the form of concentrate reject from the membrane process. Overall, for both facilities total treatment efficiency is approximately 95 percent. The treatment losses are discharged to the wastewater system for the Fiveash WTP and down a 3,000 foot deep injection well for the Peele-Dixie WTP. A small portion of the Fiveash WTP water pumps with spent lime sludge to the sludge lagoons where the surrounding wellfield effectively recovers some water: however, the treatment efficiency calculations conservatively assume this water is not recovered. **Table WA2-4** summarizes the historical overall treatment loss in the system, which prior to 2008 included only lime softening.

Section WA2 accepted May 6, 2016.

Table WA2-4. Treatment Efficiency

Year	Population[1,2]	Raw AADD (MGD)	Finished AADD (MGD)[3]	Finished Peele-Dixie (MGD)	Finished Fiveash (MGD)	Dixie Wellfield	Prospect Wellfield	Treatment Efficiency Peele-Dixie	Treatment Efficiency Fiveash	Total Treatment Efficiency
2005	238,725	48.2	47.8	7.6	40.2	7.6	40.6	99%	99%	99%
2006	235,080	50.4	50.1	7.4	42.7	7.4	43.0	99%	99%	99%
2007	231,435	43.4	43.1	7.3	35.8	7.3	36.1	99%	99%	99%
2008	227,790	43.6	42.8	5.7	37.1	6.4	37.2	89%	99%	98%
2009	224,145	44.6	43.6	4.0	39.6	4.8	39.8	84%	99%	98%
2010	220,500	41.9	40.6	6.4	34.2	7.5	34.4	86%	99%	97%
2011	222,109	41.4	40.3	5.9	34.4	6.9	34.6	86%	99%	97%
2012	223,718	39.6	38.3	5.7	32.5	6.7	32.9	85%	99%	96%
2013	225,328	39.2	37.7	5.8	31.9	6.9	32.3	85%	99%	96%
2014	226,937	39.3	37.5	6.9	30.6	8.1	31.1	85%	98%	95%
2015	228,546	42.5	41.4	4.5	36.9	5.3	37.2	85%	99%	97%
2020	235,489	42.6	41.7	3.0	38.7	3.5	39.1	85%	99%	98%
2025	251,758	44.8	43.3	6.5	36.8	7.6	37.2	85%	99%	97%
2030	263,068	46.3	44.7	7.0	37.7	8.2	38.1	85%	99%	97%
2035	267,196	47.0	45.4	7.0	38.4	8.2	38.8	85%	99%	97%

[1] 2005 to 2013 Population based on the 10-Year Water Supply Facilities Work Plan - 2014 Update

[2] 2014 Population forecasted using a linear regression from years 2010 to 2013 during economic recovery

[3] Finished AADD projected from 2015 to 2035 based on estimated population and per capita water consumption

2.4.3 Maximum Daily Demand

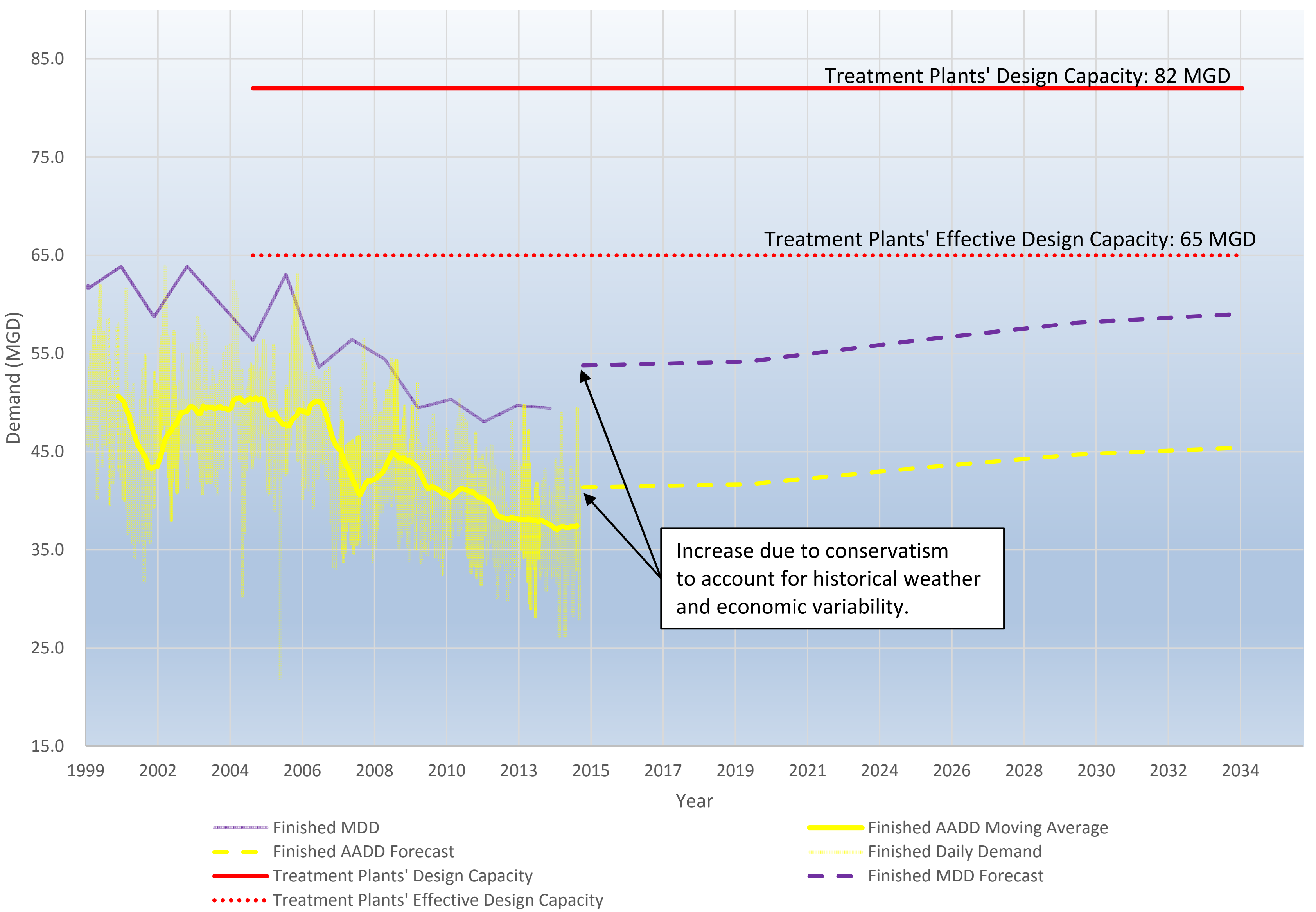
Maximum daily demand (MDD) is defined as the highest daily demand for a given year and is used to size water treatment plant production capacity. The City's current Consumptive Water Use Permit (WUP) has limits for average annual and maximum monthly withdrawals, but does not have a maximum daily limit. The CUS Master Plan Team reviewed WTP flow Reports from January 1, 2005 to November 30, 2014 for the Fiveash and Peele-Dixie Water Treatment Facilities to determine the (MDD) peaking factor. For the water distribution system, the MDD factor averaged 1.26 over the ten year period with a peak value of 1.32 in years 2008, 2013, and 2014. Additionally, the 99th and 95th percentile calculated MDDs were 1.22 and 1.15, respectively, over the ten years as summarized in **Table WA2-5**. To provide a planning level of conservatism and account for uncertainties such as City's current flow metering tolerances, the CUS Master Plan Team recommends a system-wide MDD factor of 1.3 for water production and distribution system planning. **Figure WA2-4** shows the resulting MDD forecast compared to historical MDD data and treatment plants' design capacities.

Table WA2-5. Maximum Daily Demand Forecast

Year	Finished AADD[1] (MGD)	Finished MDD[2] (MGD)	MDD 99% (MGD)	MDD 95% (MGD)	MDD Factor	MDD Factor 99 Percentile	MDD Factor 95 Percentile
2005	47.8	56.3	55.9	54.9	1.18	1.17	1.15
2006	50.1	63.1	61.4	58.6	1.26	1.23	1.17
2007	43.1	53.6	52.1	50.4	1.24	1.21	1.17
2008	42.8	56.4	55.4	50.0	1.32	1.29	1.17
2009	43.6	54.4	53.8	51.1	1.25	1.23	1.17
2010	40.6	49.5	47.8	45.6	1.22	1.18	1.12
2011	40.3	50.3	48.3	46.9	1.25	1.20	1.16
2012	38.3	48.1	46.0	43.4	1.26	1.20	1.14
2013	37.7	49.7	44.6	42.9	1.32	1.18	1.14
2014	37.5	49.4	47.8	42.9	1.32	1.28	1.14
2015	41.4	53.8	50.3	47.7	1.30	1.22	1.15
2020	41.7	54.2	50.7	48.1	1.30	1.22	1.15
2025	43.3	56.3	52.7	49.9	1.30	1.22	1.15
2030	44.7	58.1	54.4	51.6	1.30	1.22	1.15
2035	45.4	59.1	55.3	52.4	1.30	1.22	1.15

[1] Finished AADD projected from 2015 to 2035 based on estimated population and per capita water consumption
[2] 2015 to 2035 MDD calculated using MDD factor multiplied by forecasted finished AADD

Figure WA2-4. Potable Water Maximum Daily Demand (MDD) Forecast



Section WA2 accepted May 6, 2016.

2.4.4 Peak Hourly Demand

Peak hourly demand applies to high service pumping, storage, and distribution capacity requirements. As with MDD, the City's current WUP does not include a peak hourly limit. The City's peak hour demand factor derives from the City's Fiveash and Peele-Dixie WTPs' historical hourly water demands. Historically, the peak hour factor has varied been between 1.9 and 2.2 at both WTPs. The CUS Master Plan Team selected and used a system wide maximum day demand factor of 2.2 for distribution system planning considering the historical data and accounting for inherent tolerances associated with the City's current flow metering systems.

2.4.5 High Rainfall Year Demand and Drought Year Demand

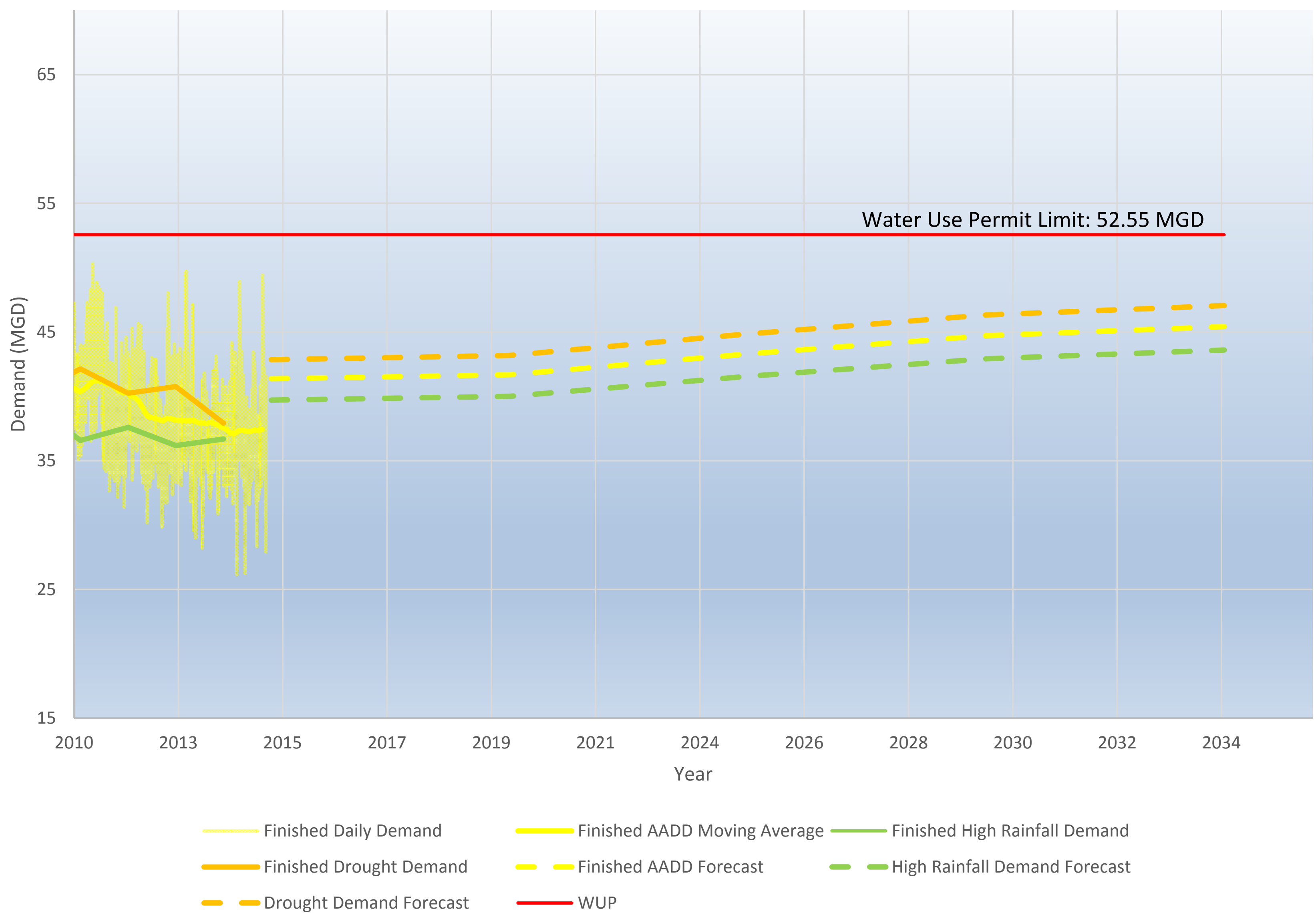
Rainfall and drought scenarios change the amount of water usage due to increased and decreased landscape irrigation. With climate change, more extreme weather (heavy precipitation and extended droughts are expected. **Figure WA2-5** and **Table WA2-6** illustrate the demand changes during high rainfall and "drought" events and annual minimum rainfall compared to the finished AADD. Drought events considered equate to a one in ten year drought event. **Table WA2-6** illustrates that the City's demand during drought conditions will require approximately 2 MGD more finished water than an average rainfall year. The City has ample permitted water supplies to address future drought events over the 20-year planning horizon. Additionally, as the City densifies drought tolerance will improve due to lower irrigation per capita. Conversely, with climate change, more extreme weather (heavy precipitation as well as extended droughts) are expected. The City is considering additional measures, the C-12 and C-13 Interconnects for example, to take advantage of high ground water when available to help provide adequate water supply in an extended drought as occurred in 2011.

Table WA2-6. High Rainfall and Drought Year Demands

Year	Finished Daily Demand - High Rainfall MGD	Finished AADD MGD	Finished Daily Demand - Minimum Rainfall (Drought) MGD
2010	39.4	40.6	40.1
2011	36.6	40.3	42.1
2012	37.6	38.3	40.3
2013	36.2	37.7	40.8
2014	36.7	37.5	37.9
2015	37.3	38.9	40.3
2020	38.4	40.0	41.5
2025	41.1	42.8	44.3
2030	42.9	44.7	46.3
2035	43.6	45.4	47.1

Note: Average high annual rainfall event = 13 inches. Average minimum annual rainfall event = 1 inch.

Figure WA2-5. High Rainfall and Drought Demand Projections



Section WA2 accepted May 6, 2016.

2.5 Water Demand Forecast Conclusions

The CUS Master Plan team drew the following conclusions based on the potable water demand forecast, the City of Fort Lauderdale:

a. Has sufficient water supplies to meet 2035 planning period demands, considering a one in ten year drought conditions.
b. Does not require alternative water supplies, like the Upper Floridan Aquifer and C-51 Reservoir, over the next 20 years and the City should only consider these sources for quality, efficiency, risk minimization, reliability or redundancy reasons.
c. Has not experienced significant advancements in the Biscayne Aquifer saline interface nor are such advancements predicted for the 20-year planning period, however, the City should continue to monitor in cooperation with Broward County and SFWMD.
d. Should closely monitor the unit potable water demands over the next few years to evaluate further potential reductions in the per capita target level of water consumption. This will enhance the sustainability of the Biscayne Aquifer and avoid the high costs associated with developing new alternative supplies.
e. Continue to protect and minimize the vulnerability of the City's water supply from saltwater intrusion, treatment plant disruption, wellfield contamination, raw water line breaks, etc.

Section WA2 accepted May 6, 2016.

WA3.A Hydraulic Modeling Software Comparison

3.A.1 Introduction

The City of Fort Lauderdale is updating its planning tools for its Comprehensive Utilities Strategic Master Plan and is considering the selection of modeling software to perform hydraulic analysis of its potable water distribution and wastewater collection systems in a cost efficient manner. The purpose of this section of the CUS Master Plan is to provide information on the two leading commercially-available hydraulic modeling software packages, WaterGEMS a product of Bentley Systems, Inc. and InfoWater® a product of Innovyze, Inc. considered by Reiss Engineering as capable of meeting the City of Fort Lauderdale's needs to hydraulically model its potable water distribution and wastewater collection systems.

3.A.2 Comparison

Table WA3.A-1 provides a comparison of WaterGEMS and InfoWater® hydraulic modeling software. The table compares general information, alternatives management, fire flow capabilities, data transfer capabilities, database capabilities, other capabilities and add-on modules of the two softwares. The "other capabilities" of the modeling softwares were ranked from one to three in usefulness with one being the least useful and three being the most useful for the City.

3.A.3 Cost

Hydraulic modeling software licenses are scaled based on number of pipes. The City's water model has over 36,000 pipes; therefore, an "unlimited" pipe license would be required. The cost of WaterGEMS with unlimited pipes is approximately $23,000 plus approximately $5,000 annually for license support. The cost of InfoWater® with unlimited pipes is approximately $17,000 plus approximately $3,000 for license support. It is anticipated that the City would require one (1) to three (3) modeling software licenses. At a minimum, the Engineering Division will use the model for capital planning and problem identification and solving. The additional two licenses could be used by the Utilities Division to identify, check and solve operational problems and try "what if" type repair scenarios and by the Sustainable Development Department to check water and sewer capacity availability for new development applications. Similar utilities have between one (1) and three (3) modeling software licenses for analogous uses. The City has an outdated license with Innovyze; Innovyze stated that a discount might be available to reinstate the former license to current status and provide the necessary upgrades to InfoWater®.

Section WA3.A accepted February 2, 2016.

Table WA3.A-1. Hydraulic Modeling Software Comparison

Item	WaterGEMS	InfoWater®
General Information		
Vendor	Bentley Systems, Incorporated	Innovyze
Calculation Engine	Modified EPANET	Modified EPANET
Licensing	Standalone/server	Standalone/server
Platform	Standalone/ArcGIS (license required)	ArcGIS (license required) standalone version: H20Net
Documentation	Yes	Yes
Diagnostic Reporting	Yes	Yes
Water Quality Analysis	Yes	Yes
Support	Yes	Yes
Alternatives Management		
Scenario Management	Yes	Yes
Scenario Inheritance	Yes	Yes
Input Alternatives	Yes	Yes
Alternatives Inheritance	Yes	Yes
Sub-setting of Model	Yes, Topology w/ queries	Yes, Facility sets w/queries
Scenario Comparison	Input	Input and Output
Scenario Manager/Results Active Link	Yes	Yes
Fire Flow Capabilities		
Multiple fire flow locations	Yes	Yes
Variable fire flow rates in a single simulation	Yes	Yes
Visual fire flow pipe results	No	Yes
Subset range searching	Yes	Yes
Data Transfer Capabilities		
ODBC Capability	Import/Export	Import/Export
EPANet	Import/Export V1/V2	Import/Export V2
Other Model Formats	Import, Cybernet 2, Kypipe 3	H2ONet, H2OMap
Shape files	Import/Export	Import/Export
Other Import Formats (WaterGems and InfoWater®)	Geodatabases, AutoCAD/DXF, MS Access, MSExcel, dBase, Delimited Text	
Database Capabilities		
Add new attributes	Yes	Yes
Sorting ascending/descending	Yes	Yes
SQL statements to calculate or set values	Yes	Yes
Search and find	Yes	Yes

Section WA3.A accepted February 2, 2016.

Item	WaterGEMS	InfoWater®
Summary Statistics	Yes	Yes
Group Editing	Yes	Yes
Copy – Paste	Yes	Yes
Default Value Prototypes	Yes	Yes
Map Editing		
Redraw existing pipes	Yes	Yes
Change entity type once drawn (Morphing requires less time to be completed)	Yes (morph)	Yes (delete, recreate)
Adjust pipes at relocated nodes	Yes	Yes
Annotation and Labeling	Extensive Capability using ArcGIS	Extensive capability using ArcGIS
Quality Assurance/Quality Control		
Tracing	Yes	Yes
Tolerance settings for node insertion	Yes	Yes
Identify nodes with only one pipe connected	Yes	Yes
Nodes in Close Proximity to Unsplit Pipes	Yes	Yes
Input Data Verification	Yes	Yes
ID Elements with Errors (post hydraulic analysis)	Yes	Yes
Ability to identify overlaying pipes/nodes	Yes	Yes
Ability to clean out and archive bad data	No	Yes
Output Review		
Min/Max/Ave Results	Yes	Yes
Customizable Reports	Yes	Yes
Graph Format	Yes	Yes
Full Results Query Capability	Yes	Yes
Show pipe and node results simultaneously	Yes (all at once)	No (one at a time)
Contouring Ability	Yes	Yes
Video type controls	Yes	Yes
Demand Allocation		
Module Available	Yes (Load Builder)	Yes (Demand Allocator)
Customer Meter Data	Yes	Yes
Area based demand	Yes	Yes
Population based demand	Yes	Yes
Model Calibration		

Section WA3.A accepted February 2, 2016.

Item	WaterGEMS	InfoWater®
Available	Separate Module (Darwin Calculator) with suite license	Separate Module (Calibrator) with suite license
Genetic Algorithm Engine	Yes	Yes
Skeletonization		
Skeletonization Module	Yes	Yes
Pipe Removal Based on Attribute(s)	Yes	Yes
Dead-end Removal	Yes	Yes
Series Pipe Merging	Yes	Yes
Parallel Pipe Merging	Yes	Yes
Reallocated Demands	Yes	Yes
Other Capabilities*		
Undo Function (2)	Partial, w/ editor interface	Two step for deleted elements only
Variable Frequency Drives (3)	Yes (same pump or use battery)	Yes
Report Quality Graphics (3)	Extensive using ArcGIS functionality	Extensive using ArcGIS functionality
Pump/Valve Element Type (3)	Point	Point
SCADA Interface (2)	Separate Module (ScadaConnect)	Yes (already in package)
Pipeline Costing Tool (2)	Yes	Yes
Engineering Tables Provided (1)	Yes	Yes
Hydraulic Calculator (2)	No	Yes
Reference Formats (2)	SHP, Coverage, DWG, DXF, DGN, Geodatabase, TIF, MrSID	DGN, DWG, DXF, SHP, MI, AI Coverages, TIF, Geodatabases
Ability to thematically map reference files (3)	Extensive using ArcGIS functionality	Extensive using ArcGIS functionality
Model Coordinate Transformation (2)	Extensive using ArcGIS functionality	Extensive using ArcGIS functionality
TIN overlay capability (2)	Extensive using ArcGIS functionality	Extensive using ArcGIS functionality
Use GRID or other DEM/DTM for elevation data (3)	Extensive using ArcGIS functionality	Extensive using ArcGIS functionality
Vulnerability Assessment (3)	Separate Module (WaterSafe)	Separate Module (Protector)
Genetic Algorithm for Pump Improvements (3)	No	Yes
Genetic Algorithm for Pipe Improvements (3)	Separate Module (Darwin Designer)	Separate Module (Designer)
Add-on Modules		
Automated Calibration	Yes (Darwin Calibrator)	Yes (Calibrator)
Demand Allocation	Yes (Load Builder)	Yes (Demand Allocator)
Skeletonization	Yes (Skelebrator)	Yes (Skeletonizer)
Vulnerability Assessment	Yes (WaterSAFE)	Yes (Protector)

Section WA3.A accepted February 2, 2016.

Item	WaterGEMS	InfoWater®
Pump Operation/Energy Analysis	Yes	Yes
Water Quality Calibration	No	Yes (Water Quality Calibrator)
Pipe Optimization	Yes (Darwin Designer)	Yes (Designer)
SCADA Interface	Yes (ScadaConnect)	Yes
Unidirectional Flushing	Yes (Flushing Simulation)	Yes (InfoWater® UDF)
SCADA Connection	Yes (SCADAConnect)	Yes (SCADAWatch)
Asset Management and Capital Planning	Limited	Yes, CapPlan

* Numbers listed beside items under *Other Capabilities* heading denote the usefulness of the item, one (1) being least useful and three (3) the most useful.

3.A.4 Conclusions

As displayed by the comparison table, the functionality of Water GEMS and InfoWater® are very similar and both would likely meet the City's hydraulic modeling needs. InfoWater® is more cost effective, especially considering the City's outdated license. InfoWater® does have a more robust uni-directional flushing (UDF) design module and the City has made UDF a priority to clean its water distribution pipes and improve delivered water quality to its customers. InfoWater® is also significantly more cost effective, especially if a discount/credit is given for the City's former license. The CUS Master Plan team recommends the City upgrade its former InfoWater® license to one (1) to three (3) current licenses, based on the cost savings as well as the supplementary benefits of water quality calibration and the more robust UDF design module. If the City selects InfoWater® for water and wastewater pressure hydraulic modeling, Innovyze has a product called InfoSWMM® to handle gravity flow models for stormwater and wastewater collection.

Demand allocation is considered the essential add-on module for hydraulic models' update. The add-on modules recommended for consideration by the City include automated calibration, vulnerability assessment, pump operation/energy analysis, water quality calibration, SCADA interface and unidirectional flushing. The Engineering Division, Utilities Division, and Department of Sustainable Development could potentially use the add-ons to help with the optimization of the water/wastewater distribution system, and to update and maintain the models.

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WA4 Potable Water Distribution Hydraulic Evaluation

This hydraulic evaluation of the City of Fort Lauderdale’s (City) potable water distribution system evaluates existing and future capacity needs. The Comprehensive Utility Strategic (CUS) Master Plan Team constructed a new City potable water distribution hydraulic model (Water Model) with demands, infrastructure and operation protocol to support the hydraulic evaluation. The City requested that the master plan team construct new models from the City's GIS utility atlases, rather than updating the skeletonized "backbone" models created in prior master plans. The hydraulic evaluation’s goal is to continue to maintain the level of potable water service to the City’s customers now and in the future. The hydraulic analysis consists of capacity and fire flow analyses. The CUS Master Plan Team identified and converted capacity needs into recommendations for future capital improvements projects.

4.1 Existing Facilities

The City maintains and operates a potable water system consisting of the following three main components: 1. Two water treatment plants (WTPs): Fiveash WTP and the Peele-Dixie WTP; 2. Two remote storage and repump facilities: Poinciana Park Water Tank & Pump Station and the Northwest 2nd Avenue Water Tank & Pump Station; 3. Approximately 750 miles of distribution pipeline. **Figure WA4-1** illustrates the existing potable water system. The City withdraws groundwater from the surficial Biscayne Aquifer from two active wellfields, the Dixie Wellfield (serving Peele-Dixie WTP) and the Prospect Wellfield (serving Fiveash WTP). The WTPs treat the raw groundwater to meet all water quality regulations and pump the finished water through the City’s distribution system to its customers either directly or via the remote storage and repump facilities.

4.2 Distribution Level of Service Criteria

The Fiveash and Peele-Dixie high service pumps deliver water through 750 miles of distribution system pipelines. The performance of the distribution system relates directly to providing sufficient service to the City’s water customers. The City’s ability to provide adequate flows and pressures to customers was defined as service. The CUS Master Plan Team evaluated the distribution system based on hydraulic and fire protection standards described in **Table WA4-1** and **Table WA4-2**. **Table WA4-2** specifically provides fire flow quantities and duration for land use subtypes. Corresponding land use subtype coverage for Fort Lauderdale is presented in **Figure WA4-2**.

Section WA4 accepted December 19, 2016.

Table WA4-1. Water System Hydraulic Standards

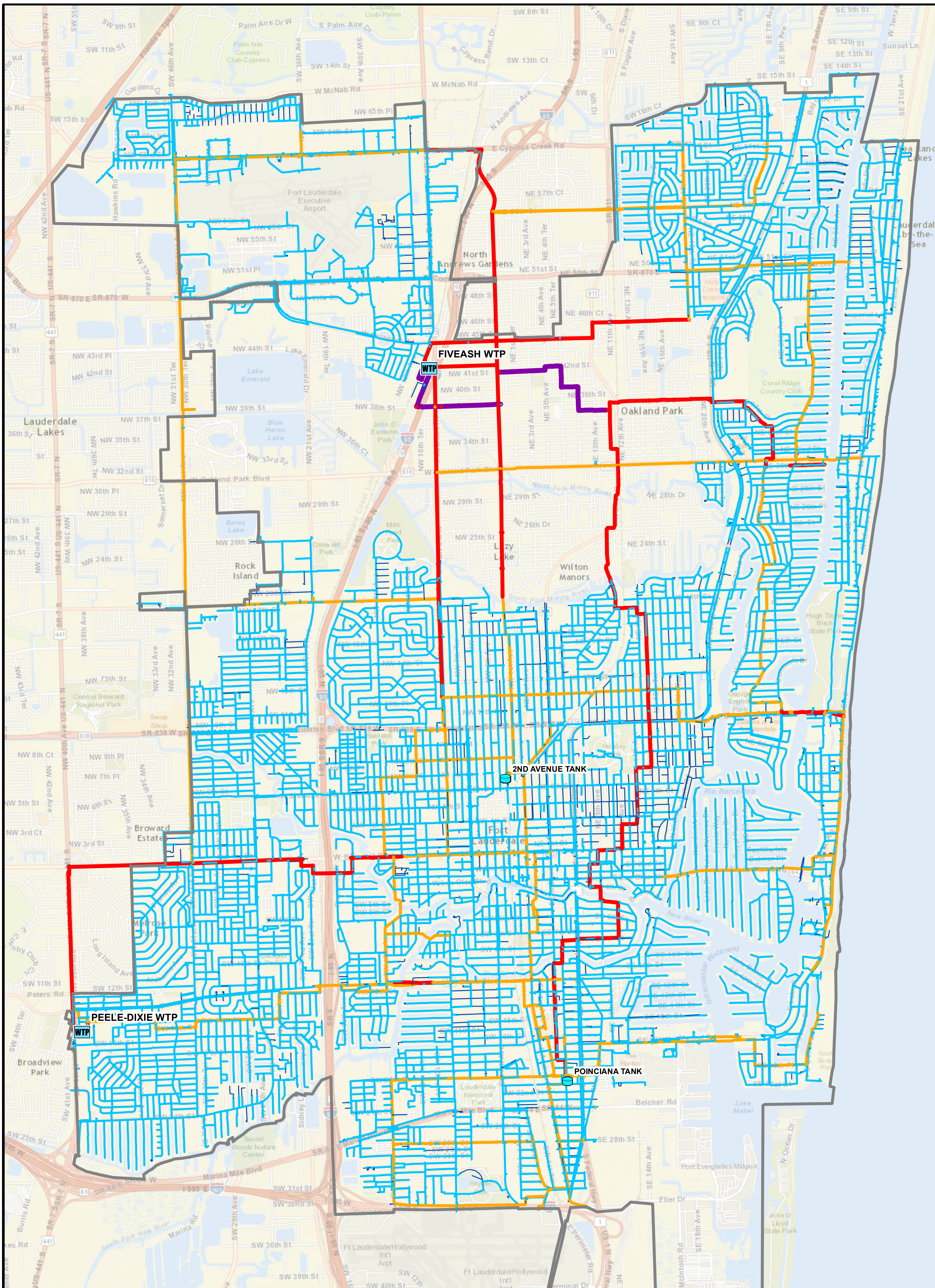
Parameter	Standard	Description
Maximum Velocity	5 fps	Non-Fire Flow Scenarios
Maximum Head Loss for Pipe Dia. < 16-inch	10' / 1000'	Non-Fire Flow Scenarios
Maximum Head Loss for Pipe Dia. > 16-inch	3' / 1000'	Non-Fire Flow Scenarios
Maximum Distribution Pressure	90 psi	All Scenarios
Minimum Distribution Pressure	40 psi	Non-Fire Flow Scenarios
	30 psi	Residential Maximum Day Demand + Fire Flow
		Commercial Maximum Day Demand + Fire Flow

Sources: 2012 Edition of the 10 State Standards Recommended Standards for Water Works, adjusted from 2007 Water Master Plan Update and City Engineering guidance.

Table WA4-2. Fire Flow Protection Standards

Land Use	Fire Flow (gpm)	Duration (hours)
Industrial	Up to 5,000	4
Shopping Centers	3,500 to 5,000	4
Multi-Story Residential/ Commercial	3,500 to 5,000	4
Business Districts	2,000 to 3,000	3
Residential	500 to 1,500	2

Source: 2007 Water Master Plan Update, City of Fort Lauderdale



Legend

DISTRIBUTION STORAGE	
WTP — WATER TREATMENT PLANT	
WATER SERVICE AREA	

Pipe Diameter

- < 6 inch
- 6 - 12 inch
- 16 - 24 inch
- 30 - 42 inch
- 48 - 60 inch

N
W E
S

0 0.5 1
Miles

CITY OF FT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
Pipe Diameters

FIGURE WA4-1

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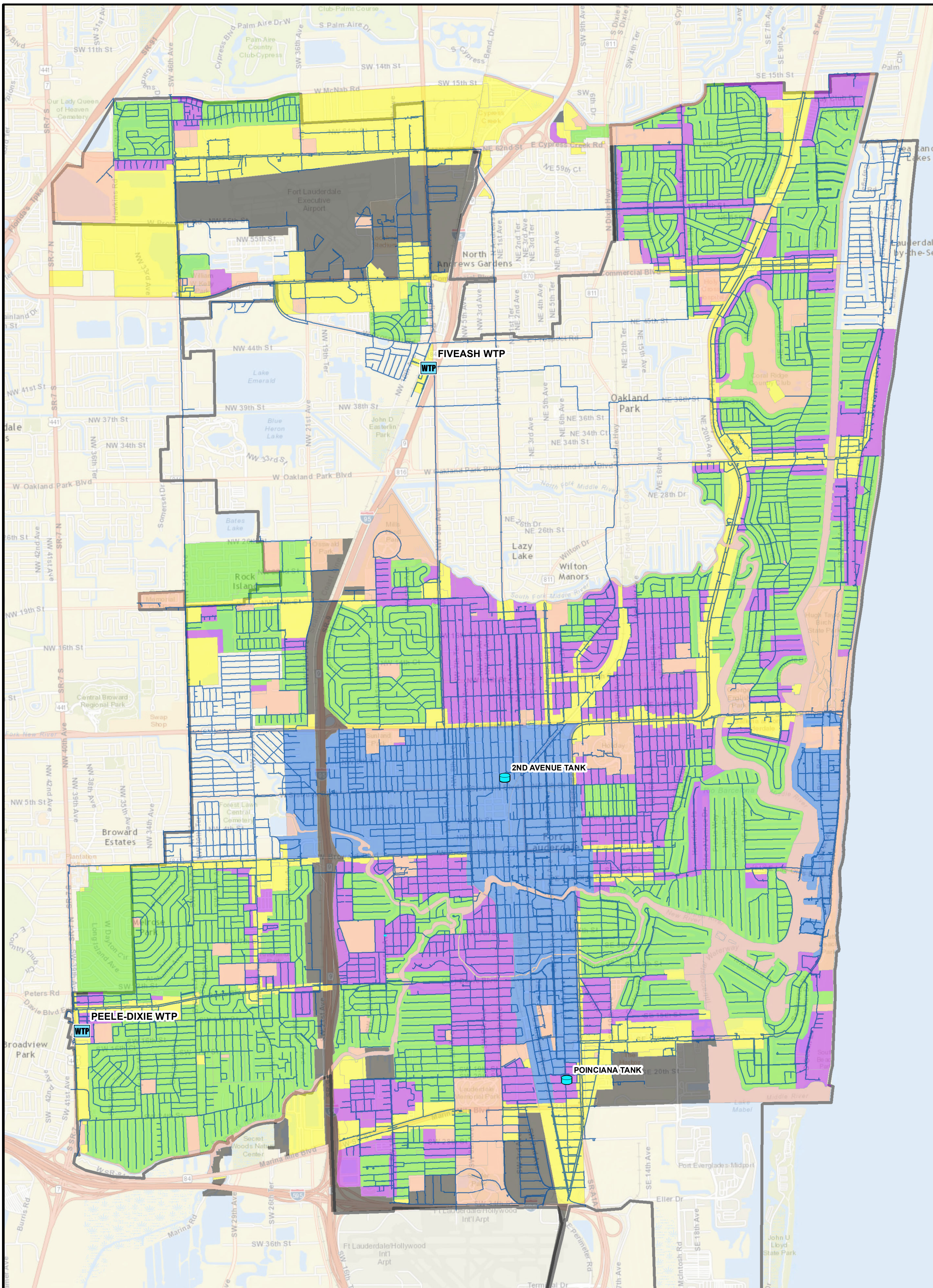

N
W E
S

Legend

DISTRIBUTION STORAGE
WTP WATER TREATMENT PLANT
DISTRIBUTION PIPE

Future Land Use

- ACTVITY CENTER
- COMMERCIAL
- PARK/COMMUNITY CENTER
- MULTI-STORY RESIDENTIAL
- INDUSTRIAL
- RESIDENTIAL
- WATER SERVICE AREA

RE

CITY OF FT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
Future Land Use

FIGURE WA4-2

G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA-4\Figure X.x Future Land Use.mxd

4.3 Capacity Analysis

The CUS Master Plan Team evaluated the distribution system by comparing Water Model simulation output to service standards presented in **Table WA4-1**. The Water Model evaluated calendar year 2015 (2015) and future distribution parameters (pressure, velocity, etc.) to identify areas of the distribution system not meeting service standards. The hydraulic model runs showed that 2015 and future simulated pressures were within the City's acceptable ranges for the existing 2015 scenarios. However, 2015 and future simulations identified areas with velocities outside of the established hydraulic criteria around both WTPs and in minor piping intersections. Water Model year scenarios for years 2020, 2025, and 2035 showed similar results. **Figures WA4-3, WA-4, WA-6,** and **WA-8** illustrate hydraulic model pressure and velocity output for distribution system peak hour demands (PHD) with existing infrastructure and no improvements for years 2015, 2020, 2025, and 2035.

Improvements from the City's existing CIP and new master plan projects added to the hydraulic model resolved the hydraulic criteria issues. **Figures WA4-5, WA-7,** and **WA-9** illustrate hydraulic model pressure and velocity output for distribution system PHD with existing infrastructure plus the corresponding CIP projects, highlighted in the figures, for the years 2020, 2025, and 2035. The improvements resolved year 2020 model PHD velocity and pressures issues as well as 2025 and 2035 hydraulic issues. The CUS Master Plan Team recommends the following improvements with phasing:

- Capacity-Increase Pipe Projects in the City's Current 5-Year CIP
- Central New River Water Main River Crossings (in City's 5-Year CIP) - abandon approximately 200 feet of the 16-inch SE 1st Street Crossing and replace with a 16-inch crossing and abandon ~400 feet of the SW 7th Avenue Crossing and replace with a 12-inch.
- Watermain Improvements Area 1 (0-5 Year) - Bring the 54-inch water main on 38th Street back into service, add ~400 feet of 30-inch discharge from the Peel-Dixie high service pumps to the old west existing 30-inch discharge, and upsize ~100 feet of 36 and 30-inch from the 42-inch reducer to the intersection of NE 37th Street and NE 11th Avenue with 42–inch.
- Watermain Improvements Area 2 (5-10 Year)- Upsize ~100 feet of the 6-inch from the 6x6x12 tee to 36x30x6 tee to 12-inch at the intersection of SE 12th Avenue and E Broward Boulevard, upsize ~100 feet of 8-inch from the 16x8x8 tee to the 16x8x6 tee with a 16-inch water main at the intersection of Middle Street and SW 14th Avenue, and upsize ~50 feet of 6-inch from the 6x6x10 tee to the 6x10x10 tee with a 10-inch water main at the intersection of Commercial Boulevard to Bougainvillea Drive.

Piping surrounding both the Fiveash and Peele-Dixie WTPs experience high velocities during the 2015 PHD scenario. To alleviate the capacity issues around the Fiveash WTP, the CUS Master Plan Team recommends that the City return the 54-inch ductile iron water main on 38th Street to service; this requires the City's Engineering team or a consultant to develop an FDEP acceptable strategy to flush the pipe. To alleviate capacity issues around the Peele-Dixie WTP, the CUS Master Plan Team recommends that the City install an additional 30-inch discharge line from the WTP pump discharge header to the "old" 30–inch discharge on the west side of the plant. The new Peele-Dixie WTP connection will alleviate local capacity issues and better utilize existing infrastructure versus intrusively replacing water mains in the adjacent neighborhoods.

Section WA4 accepted December 19, 2016.

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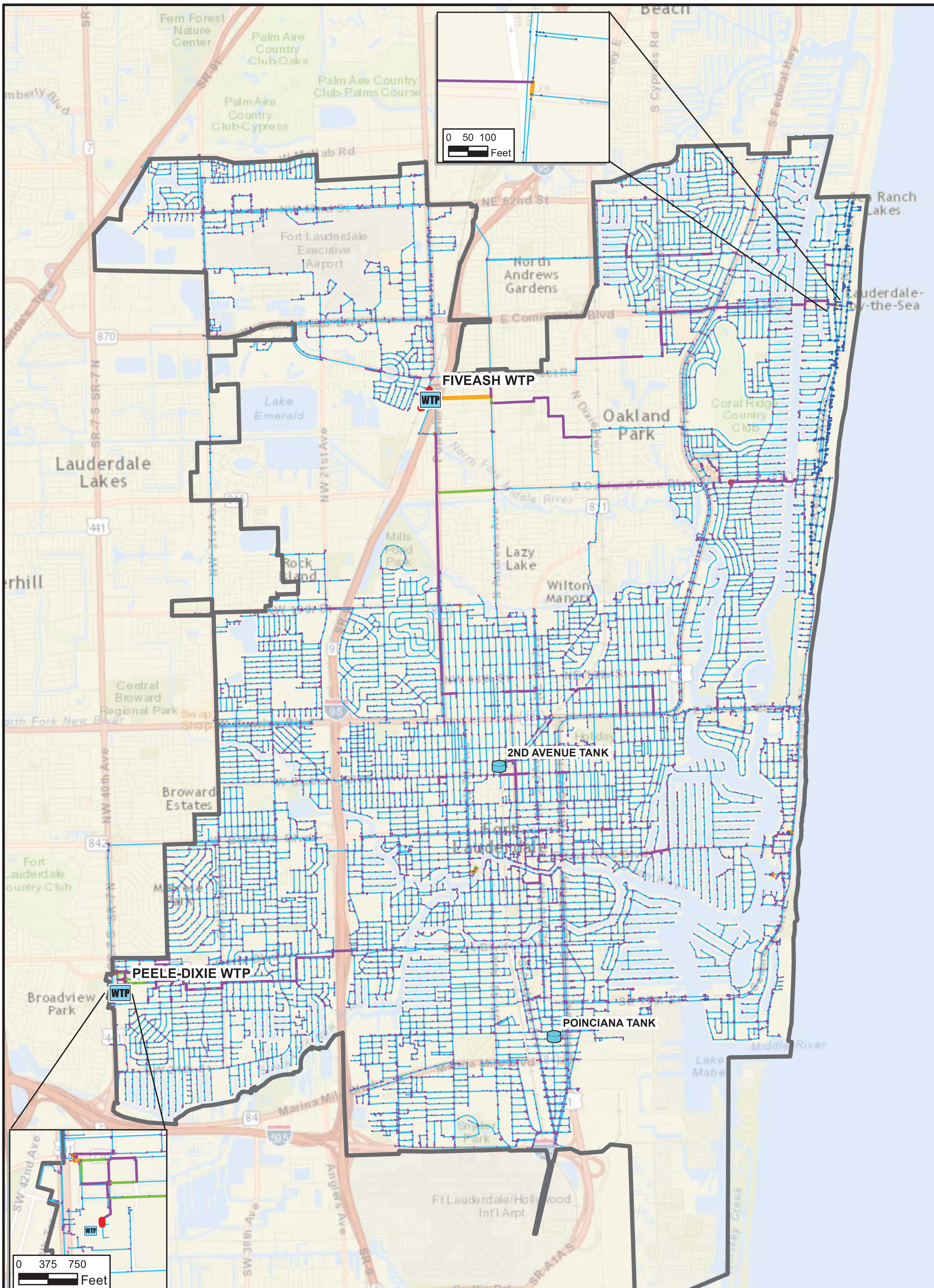

LEGEND

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Miles

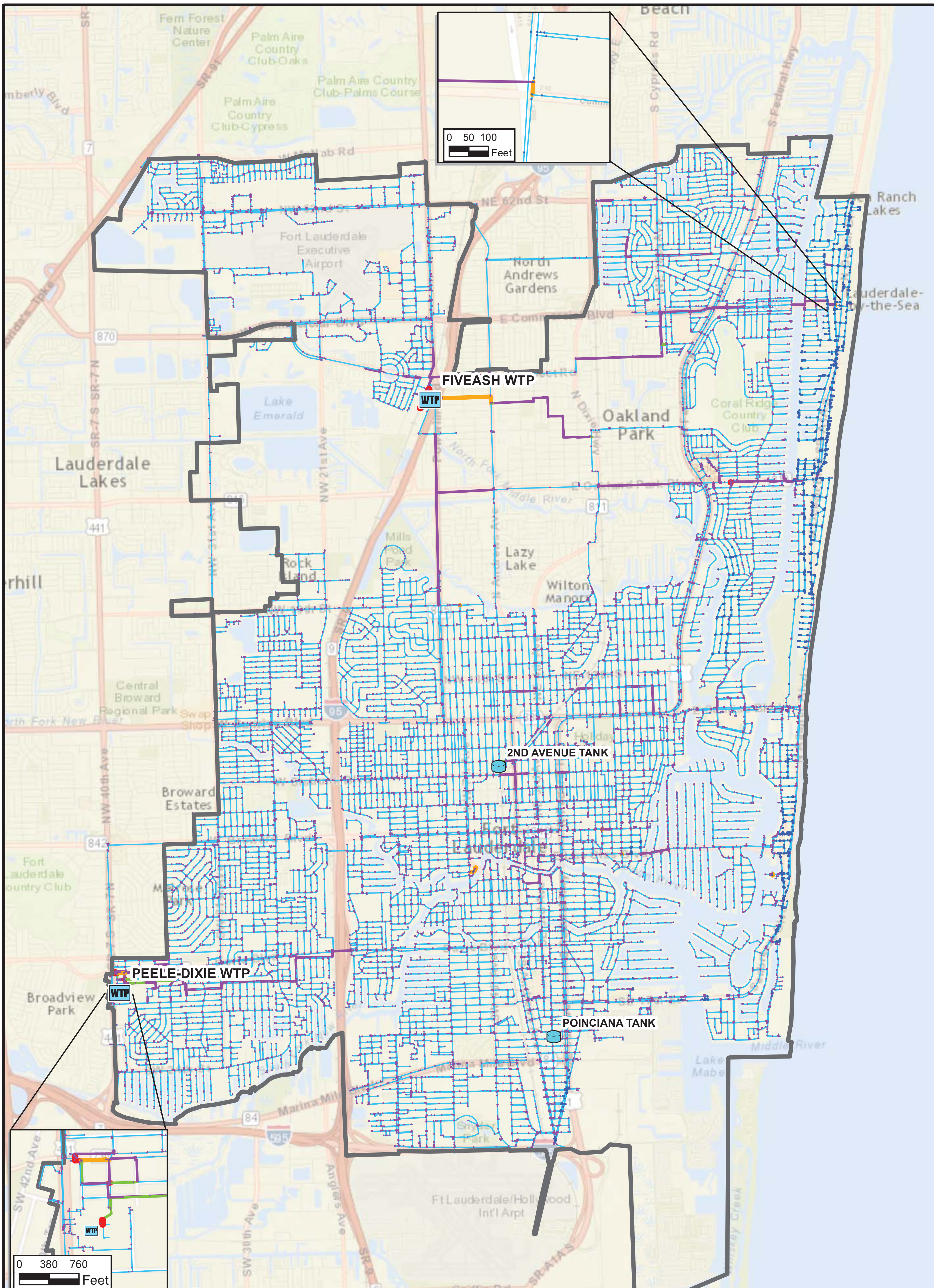
DISTRIBUTION STORAGE
WATER TREATMENT PLANT
WATER SERVICE AREA

PRESSURE	VELOCITY
< 20 PSI	< 2.5 ft/s
20 - 40 PSI	2.5 - 5.0 ft/s
40 - 50 PSI	5.0 - 7.5 ft/s
50 - 60 PSI	7.5 - 10 ft/s
> 60 PSI	> 10 ft/s

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2015 PEAK HOUR DEMAND (NO IMPROVEMENTS)

FIGURE WA4-3

G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA-4\WA4-3 2015 PHD.mxd



LEGEND

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0 0.25 0.5 1
Miles

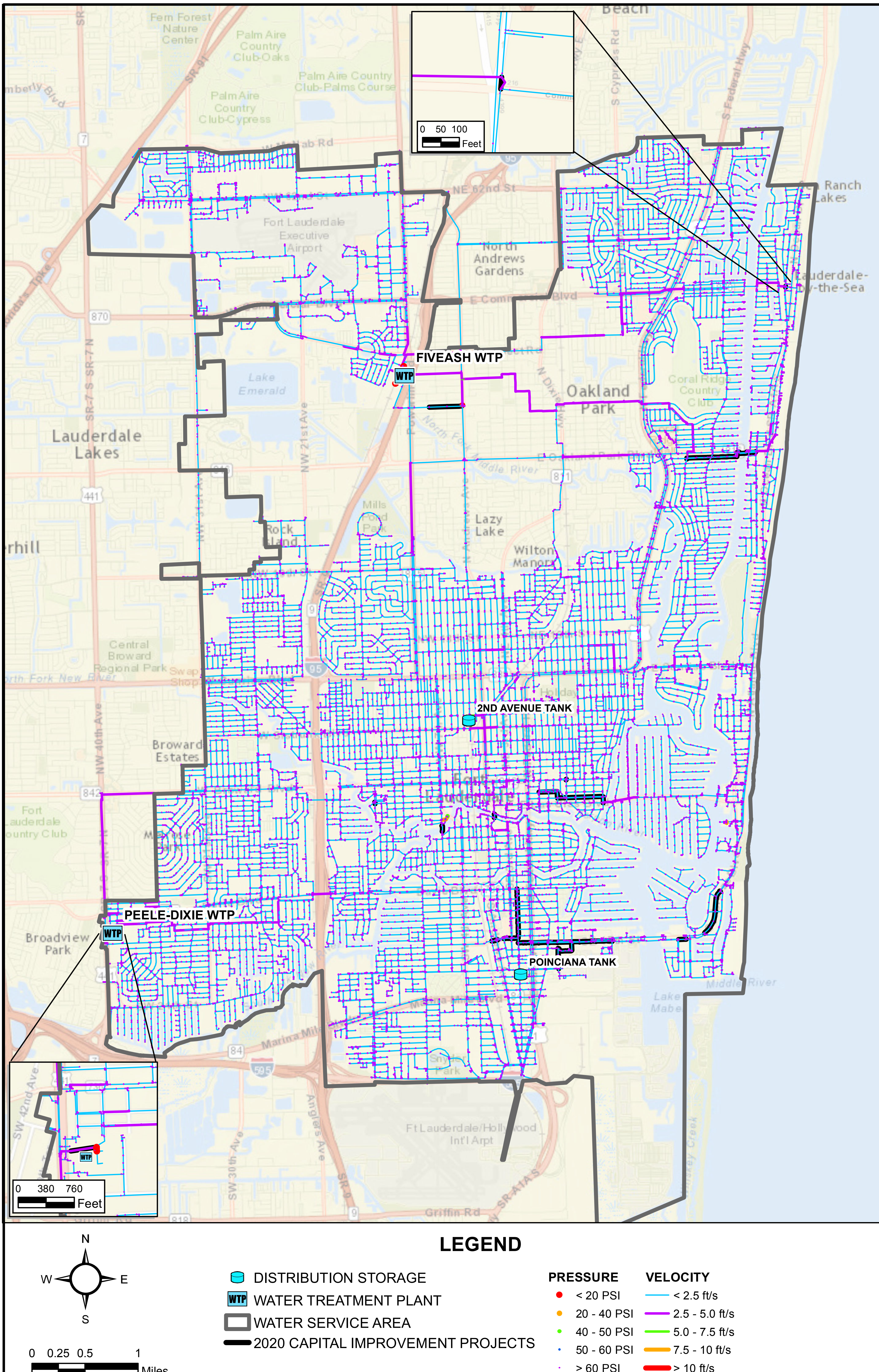
DISTRIBUTION STORAGE
WATER TREATMENT PLANT
WATER SERVICE AREA

PRESSURE	VELOCITY
< 20 PSI	< 2.5 ft/s
20 - 40 PSI	2.5 - 5.0 ft/s
40 - 50 PSI	5.0 - 7.5 ft/s
50 - 60 PSI	7.5 - 10 ft/s
> 60 PSI	> 10 ft/s

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2020 PEAK HOUR DEMAND (NO IMPROVEMENTS)

FIGURE WA4-4

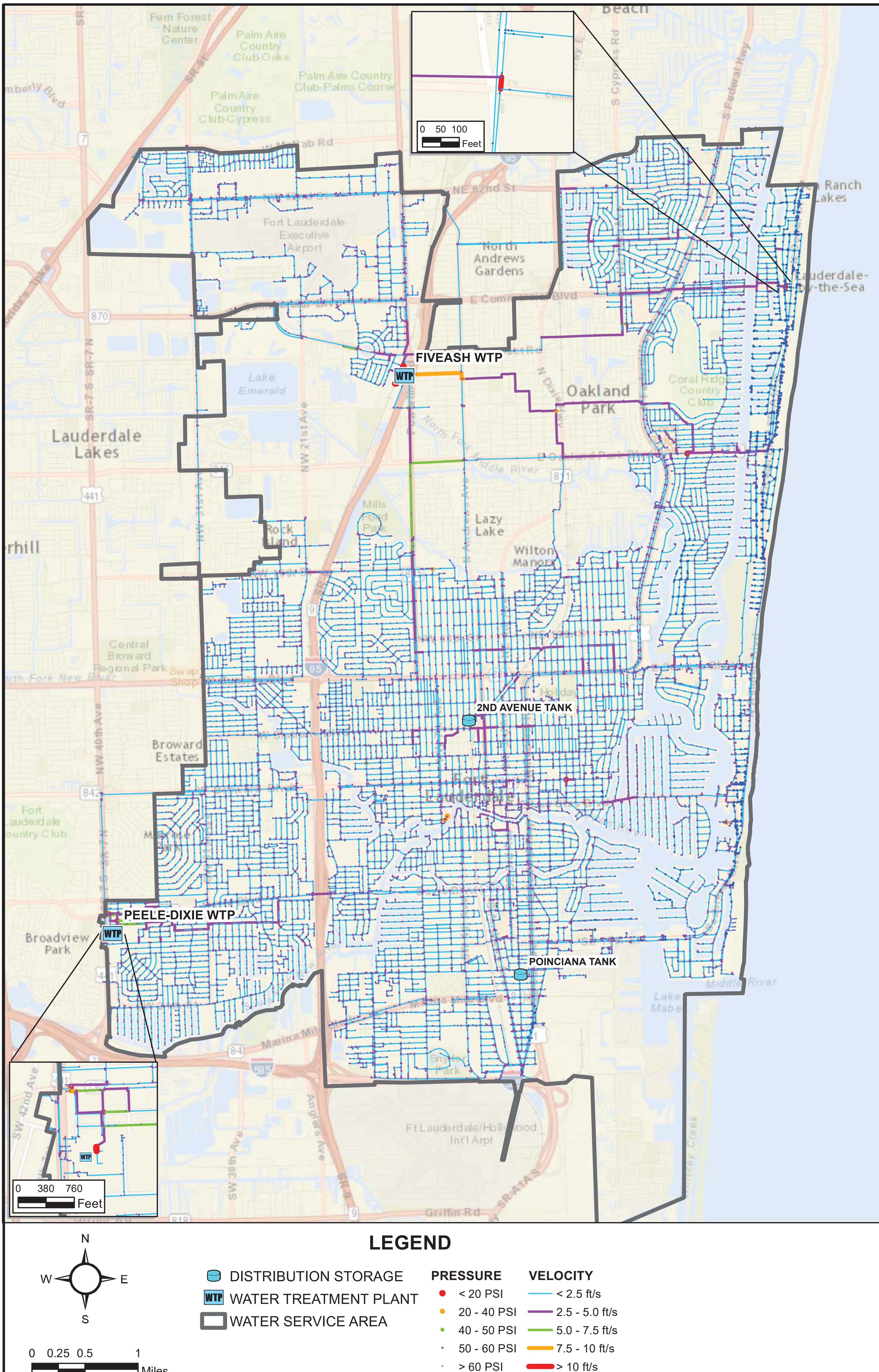
G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA-4\WA4-4 2020 PHD.mxd



CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2020 PEAK HOUR DEMAND (WITH IMPROVEMENTS)

FIGURE WA4-5

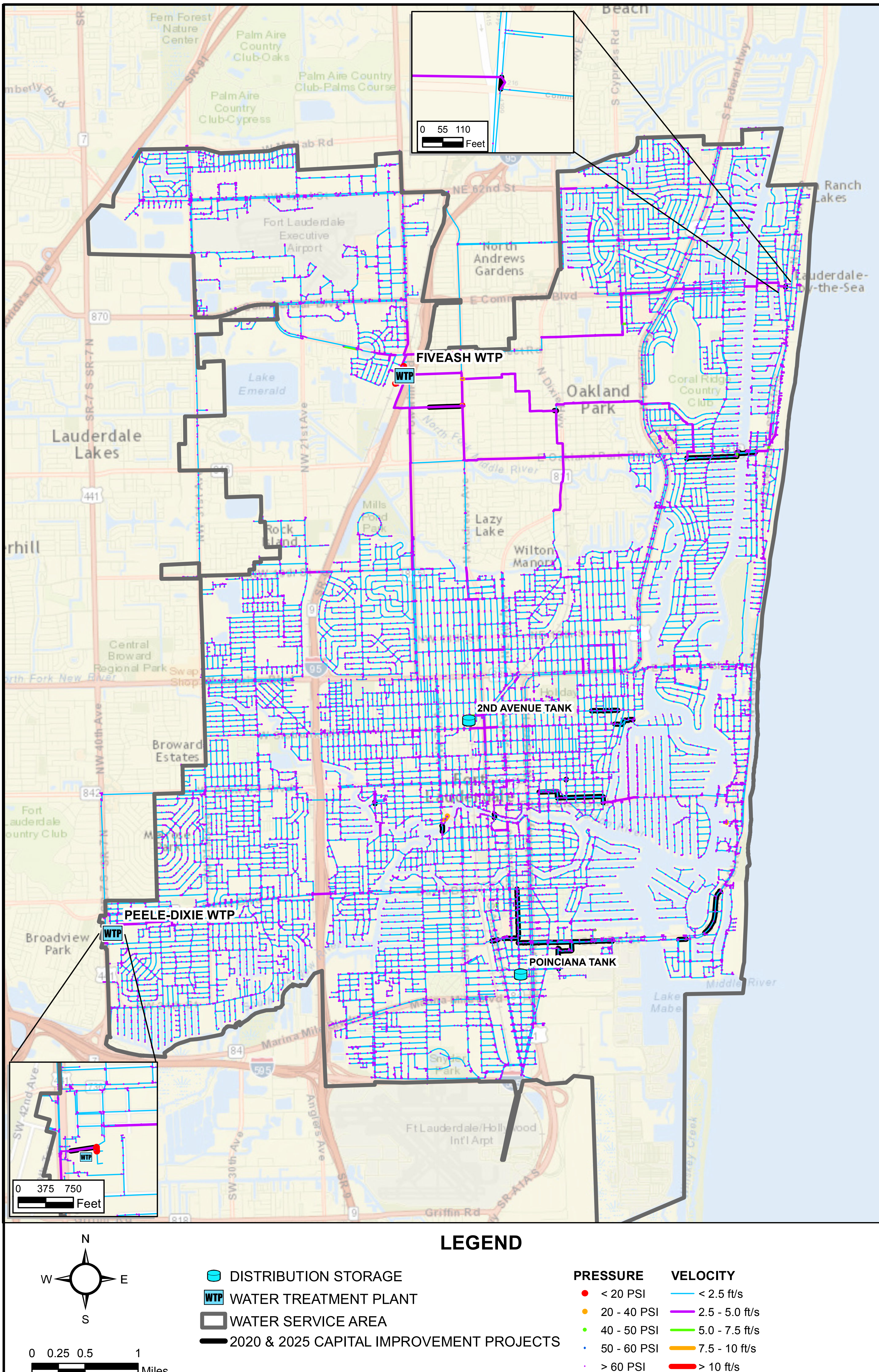
G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\PW\WA-4\WA4-5 2020 PHD CIP.mxd



CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2025 PEAK HOUR DEMAND (NO IMPROVEMENTS)

FIGURE WA4-6

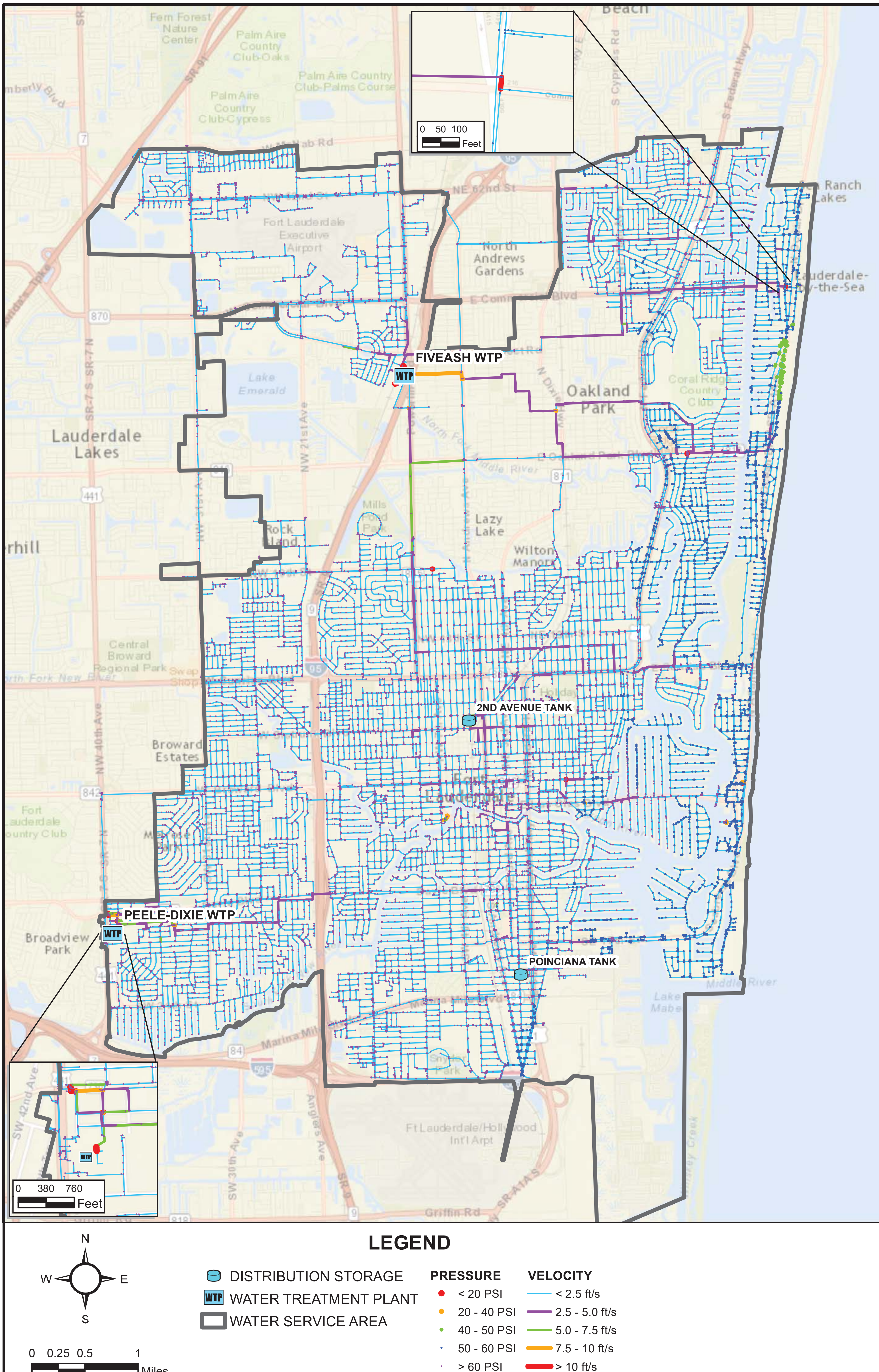
G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA-4\WA4-6 2025 PHD.mxd



CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2025 PEAK HOUR DEMAND (WITH IMPROVEMENTS)

FIGURE WA4-7

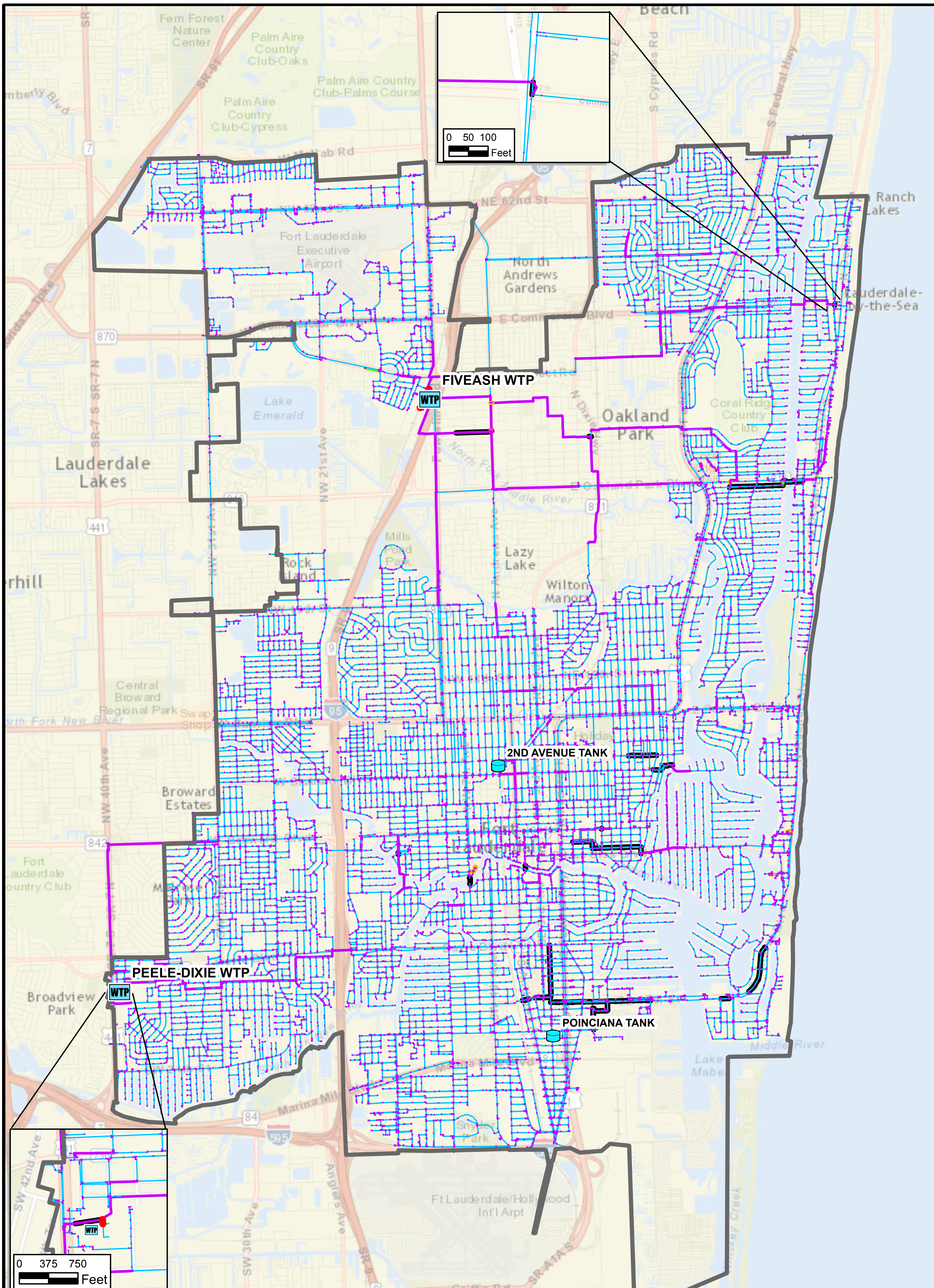
G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\PW\WA-4\WA4-7 2025 PHD CIP.mxd



CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2035 PEAK HOUR DEMAND (NO IMPROVEMENTS)

FIGURE WA4-8

G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA-4\WA4-8 2035 PHD.mxd



LEGEND

DISTRIBUTION STORAGE
WATER TREATMENT PLANT
WATER SERVICE AREA
CAPITAL IMPROVEMENT PROJECTS

PRESSURE
- < 20 PSI
- 20 - 40 PSI
- 40 - 50 PSI
- 50 - 60 PSI
- > 60 PSI

VELOCITY
- < 2.5 ft/s
- 2.5 - 5.0 ft/s
- 5.0 - 7.5 ft/s
- 7.5 - 10 ft/s
- > 10 ft/s

N E S W

0 0.25 0.5 1 Miles

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2035 PEAK HOUR DEMAND (WITH IMPROVEMENTS)

FIGURE WA4-9

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\PW\WA-4\WA4-9 2035 PHD CIP.mxd

The new Peele Dixie main increases redundancy and reliability to supply potable water to the City's customers. Year 2015 Water Model runs indicate high velocities near the 2nd Avenue Storage and Repump Station during peak hour demand. Future Water Model runs indicate that the velocities will increase over time and should be addressed if the 2nd Avenue facility remains in service at its current location.

An area just south of the Performing Arts Center in the middle of the service area experiences lower pressures due to a significant demand located on smaller diameter piping. City engineering staff, now trained on operating the Water Model, should review the area to ensure the demand is located on the proper pipe/node and adjust the demand allocation as necessary. If the Water Model continues to predict the lower pressures, field check the area and consider looping or replacing the piping to alleviate the issue.

4.4 Harbor Beach Pressure Issue

For several years and possibly since the last master plan the City has been experiencing low pressures in the Harbor Beach area during peak demand periods. The CUSMP team compared SCADA recorded pressures in the area with model predicted values and identified a discrepancy. The CUSMP team recommended additional, localized field testing and City crews capably executed. Three rounds of additional pressure recorder and hydrant testing were performed by the City. Based on the final valve isolation test it was unequivocally determined that the 16-inch main coming south on A1A (Fort Lauderdale Beach Boulevard/Seabreeze Boulevard) is somehow disconnected north of Holiday Drive/Harbor Drive. It was field confirmed that the 12-inch main on the SE 17th Street Causeway is solely supplying the area. The other 16-inch main crossing the SE 17th Street Causeway does not connect to the 6-inch service main in Harbor Beach by design.

Having performed the critical field testing City distribution crews thoroughly understand the situation and are planning on further action to identify the cause of the A1A 16-inch main disconnection. Upon reconnection, the CUS Master Plan Team recommends uni-directionally flushing the 16-inch main to remove years of sediment buildup. Once reconnected, the hydraulic model can again be compared to new field results to confirm performance. The CUSMP team also recommends connecting the 16-inch main (crossing SE 17th Street Causeway) to the 6" Harbor Beach service pipe on Seabreeze Boulevard for redundancy in the Harbor Beach area at one of the several opportunities.

4.5 Fire Flow Analysis

4.5.1 Hydrant Flow Test Verification

The City has over 6,000 fire hydrants and performs routine hydrant testing and maintenance to determine the readiness of the hydrants to provide water during fire emergencies. A hydrant's secondary use is to test the hydraulic capabilities of the distribution system. During routine testing and maintenance, the City's maintenance contractor recorded key hydraulic parameters at each hydrant, such as static pressure, residual pressures and flow. The CUSMP team paired hydrant test parameters with the Water Model output to compare and assess hydrant flows and pressures. An emitter coefficient adjusted the Water Model output for minor hydrant head losses. The City provided the field test data, including all of the hydrant test locations. Fifty locations were selected and compared to Water Model output. **Table WA4-3** and **Figure WA4-10** exhibit the fifty selected hydrant test locations.

Section WA4 accepted December 19, 2016.

Table WA4-3 exhibits that the static pressure Water Model simulated output versus field measured data matched within plus or minus 10 percent for most hydrants, which suggests that the Hazen-Williams “C factors” are accurate. Though the static pressure is within a reasonable range of accuracy, the residual pressures have some significant discrepancies. The majority of the large negative (Water Model < Field) percent difference (yellow highlight) discrepancies are on long dead end stretches through small diameter pipelines. For several test hydrant locations the flow recorded in the field suggests that either these pipes are different diameter or the flow was recorded incorrectly. Additionally, the large positive (Field < Water Model) percent difference (red highlight) discrepancies suggest that there could be a closed valve, inaccurate pipe diameter recorded, inaccurate surrounding pipe connections, reduction of pipe diameter due to mineral scaling, or flow was recorded incorrectly. The CUS Master Plan Team suggests that the City further investigate the major discrepancies.

4.5.2 Fire Flow Evaluation

The CUS Master Plan Team evaluated fire flow for the 2015 maximum day demand (MDD) conditions with remote storage and pump stations discharging. The fire flow evaluation was run on the hydrant nodes and evaluated on available flow at 20-psi (available flow). Available flow is the flow that the distribution system is hydraulically capable of transmitting to the selected node at 20-psi without considering individual hydrants or minor hydrant losses. Comparing the land use to the available flow at nodes throughout the Water Model, the CUSMP team identified and further evaluated several critical nodes. **Figure WA4-11** illustrates the available flow at each node. Available flows less than 500 gpm were determined to be on hydrants in the Water Model assigned to 2–inch distribution lines using GIS and atlas maps. The City verified that these hydrants are not fed by 2-inch distribution pipe and it is recommended that the City update the GIS hydrant and/or water distribution map accordingly and apply changes to the Water Model.

Table WA4-3. Fire Hydrant Flow Comparison (Field to Model)

Hydrant Number	Model Junction ID	Field Static Pressure (psi)	Model Static Pressure (psi)	Static Pressure % Difference	Field Residual Pressure (psi)	* Model Residual Pressure @ Field Fire Flow (psi)	Residual Pressure % Difference	Field Fire Flow (gpm)
8920	FIREHYDRANTASMB2959	70	74	6%	55	57	3%	1350
5985	DEADENDFIREHYDRANTASMB1246	70	72	3%	60	-143	-338%	1300
10490	DEADENDFIREHYDRANTASMB1576	70	73	4%	55	-39	-171%	1250
7703	DEADENDFIREHYDRANTASMB1665	75	73	-2%	50	-40	-179%	1190
8156	DEADENDFIREHYDRANTASMB187	75	69	-8%	60	55	-9%	1300
9904	DEADENDFIREHYDRANTASMB2779	70	74	6%	40	-61	-254%	1060
5632	DEADENDFIREHYDRANTASMB340	75	74	-1%	65	68	4%	1350
1145	DEADENDFIREHYDRANTASMB3776	75	75	-1%	60	40	-34%	1300
9844	DEADENDFIREHYDRANTASMB4240	70	72	4%	55	-66	-219%	1250
1215	DEADENDFIREHYDRANTASMB4509	70	73	5%	50	28	-44%	1190
9729	DEADENDFIREHYDRANTASMB4841	70	72	3%	60	-75	-225%	1300
7603	DEADENDFIREHYDRANTASMB4867	70	71	2%	60	29	-51%	1300
10623	DEADENDFIREHYDRANTASMB5173	75	71	-5%	15	59	293%	650
0	DEADENDFIREHYDRANTASMB5307	75	75	-1%	65	54	-17%	1350
2842	DEADENDFIREHYDRANTASMB5597	75	74	-2%	50	23	-55%	1190
1240	DEADENDFIREHYDRANTASMB5842	70	74	6%	50	60	20%	1190
2389	FIRE_SERVICE416	70	71	2%	60	62	4%	1300
2617	FIRE_SERVICE920	80	74	-8%	70	76	9%	1405
5180	FIREHYDRANTASMB1094	75	76	1%	65	55	-15%	1350
9175	FIREHYDRANTASMB1100	70	74	6%	50	36	-28%	1190
1220	FIREHYDRANTASMB1180	70	70	-1%	60	65	9%	1300
2329	FIREHYDRANTASMB1337	70	69	-2%	60	67	11%	1300
2962	FIREHYDRANTASMB1487	75	76	2%	45	66	47%	1130
2453	FIREHYDRANTASMB1509	70	72	3%	65	56	-14%	1350
2918	FIREHYDRANTASMB2263	75	74	-1%	45	67	48%	1130
6000	FIREHYDRANTASMB2332	75	73	-3%	60	17	-72%	1300
2429	FIREHYDRANTASMB2394	65	73	12%	55	57	4%	1250
2270	FIREHYDRANTASMB240	65	71	9%	55	51	-6%	1250
1623	FIREHYDRANTASMB2438	75	74	-2%	40	62	54%	1060
8512	FIREHYDRANTASMB2440	75	75	-1%	65	57	-12%	1350
1629	FIREHYDRANTASMB2845	75	72	-3%	60	64	7%	1300
1714	FIREHYDRANTASMB3365	80	74	-7%	40	73	83%	1060
9331	FIREHYDRANTASMB3497	70	73	4%	60	63	5%	1300
8392	FIREHYDRANTASMB3679	65	72	10%	55	54	-2%	1250
10447	FIREHYDRANTASMB3918	80	73	-8%	60	76	27%	1300
7455	FIREHYDRANTASMB4396	75	75	0%	65	69	6%	1350
9535	FIREHYDRANTASMB4433	65	74	13%	60	37	-39%	1300
5978	FIREHYDRANTASMB4606	80	73	-8%	50	65	30%	1190
7117	FIREHYDRANTASMB4644	80	72	-11%	25	51	105%	840
1453	FIREHYDRANTASMB4942	70	75	7%	50	65	30%	1150
4693	FIREHYDRANTASMB4942	80	75	-6%	65	74	14%	1350
9194	FIREHYDRANTASMB5435	75	73	-2%	60	50	-17%	1300
9606	FIREHYDRANTASMB5472	65	73	12%	60	57	-5%	1300
1696	FIREHYDRANTASMB5850	75	73	-2%	60	62	3%	1300
1188	DEADENDFIREHYDRANTASMB1120	70	72	3%	55	15	-74%	1250
9402	FIREHYDRANTASMB5878	75	72	-4%	65	70	8%	1350
4907	FIREHYDRANTASMB6014	75	76	1%	65	72	11%	1350
10277	FIREHYDRANTASMB679	75	73	-3%	60	-124	-307%	1300
1698	FIREHYDRANTASMB690	70	74	6%	55	62	13%	1250
9948	DEADENDFIREHYDRANTASMB4574	75	74	-2%	60	27	-54%	1060

* Model residual pressures were adjusted by the difference in field to model static pressures.
(Model Residual Pressure at Field FF)x(1-Static Pressure % Difference)

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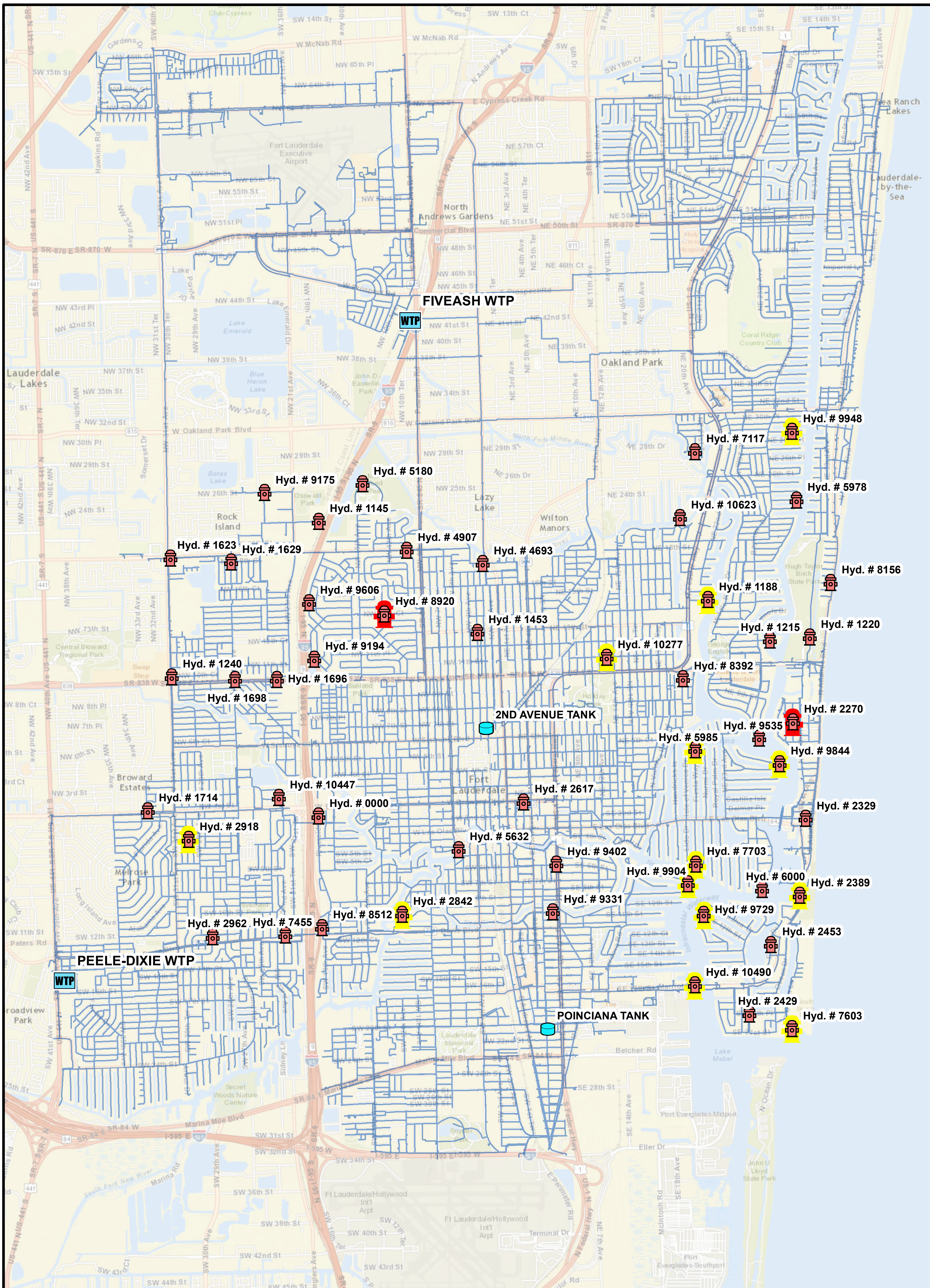

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Miles

Legend

- Model Residual Pressures within 50% of Field
- DISTRIBUTION STORAGE
- WTP WATER TREATMENT PLANT
- DISTRIBUTION PIPE

Model Residual Pressures > 50% of Field

Model Residual Pressures > -50% of Field

RE

CITY OF FT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
50 Selected Hydrants for Verification

FIGURE WA4-10

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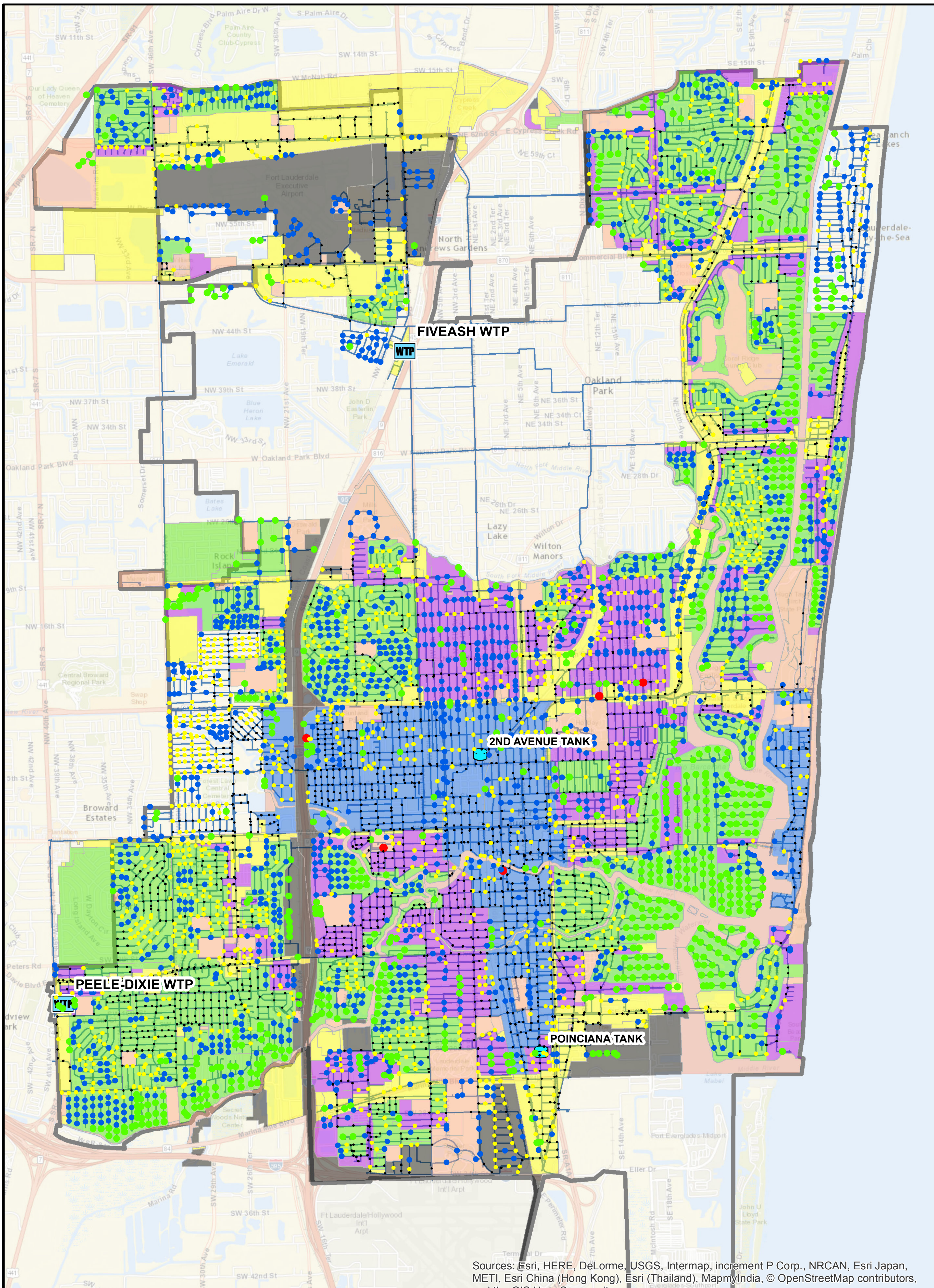

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Miles

Legend

DISTRIBUTION STORAGE
WTP WATER TREATMENT PLANT
DISTRIBUTION PIPE
WATER SERVICE AREA

AVAILABLE FLOW (@ 20 PSI)

- < 500 gpm
- 500 - 2000 gpm
- 2000 - 3500 gpm
- 3500 - 5000 gpm
- > 5000 gpm

Future Land Use

- ACTVITY CENTER
- COMMERCIAL
- PARK/COMMUNITY CENTER
- MULTI-STORY RESIDENTIAL
- INDUSTRIAL
- RESIDENTIAL

RE

CITY OF FT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
Available Fireflow

FIGURE WA4-11

G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA-4\Figure X.x Fireflow.mxd

4.6 Potable Water Distribution Hydraulic Evaluation Summary

The CUS Master Plan Team drew the following conclusions based on the hydraulic evaluation:

- Engineering tools, including the hydraulic and water quality model (Water Model), developed as part of this CUS Master Plan, are now available to the City for planning, operating and troubleshooting the potable water distribution system.
- Water Model scenarios were developed and adjusted to the City's unique operating conditions to evaluate capacity level of service in the potable water distribution system.
- The hydraulic evaluations identified necessary improvements within the potable water distribution system to meet the City's standard level of service.
- The hydraulic evaluation concluded that the City's potable water distribution system has sufficient capacity to meet existing demands; minor transmission improvements were identified to extend capacity into the future as illustrated in **Figure WA4-12**.
- The identified system upgrades are advisable in order to effectively plan for future needs and growth in the service area while working to improve level and reliability of service to the customer.
- **Table WA4-4** displays estimated unit capital costs for pipelines.
- **Figure WA4-12** illustrates potable water distribution capacity related Community Investment Plan (CIP) projects identified in the hydraulic evaluation.
- The City should investigate the significant discrepancies in Water Model versus Field fire hydrant tests identified in the hydraulic evaluation and build/maintain a fire hydrant flow database for asset management purposes.

Potable Water Distribution Community Investment Plan

With projected growth, development, and redevelopment, including changes to building codes for new construction in the City's service area, the Water Model results indicate that areas of lower pressure are projected to occur in locations along the beach. Descriptions of the identified Community Investment Plan (CIP) projects to improve the level of service in these areas are summarized in **Section WA7-Water CIP** to be completed between the years 2015 and 2035 based on system demand growth.

The CUS Master Plan Team identified unit costs to estimate construction costs. Unit pipe costs are dependent on the pipe diameter, route conflicts and method of construction. **Table WA4-4** illustrates the estimated unit cost of various pipe diameters used to estimate the potable water pipe capital cost. Unit capital costs include construction items (such as furnish and install pipe, valves, fittings, other appurtenances), utility conflict resolution, overhead, and profit. Non-construction costs including land acquisition, legal, administrative, design, permitting, field oversight and contingency convert construction costs to capital project costs.

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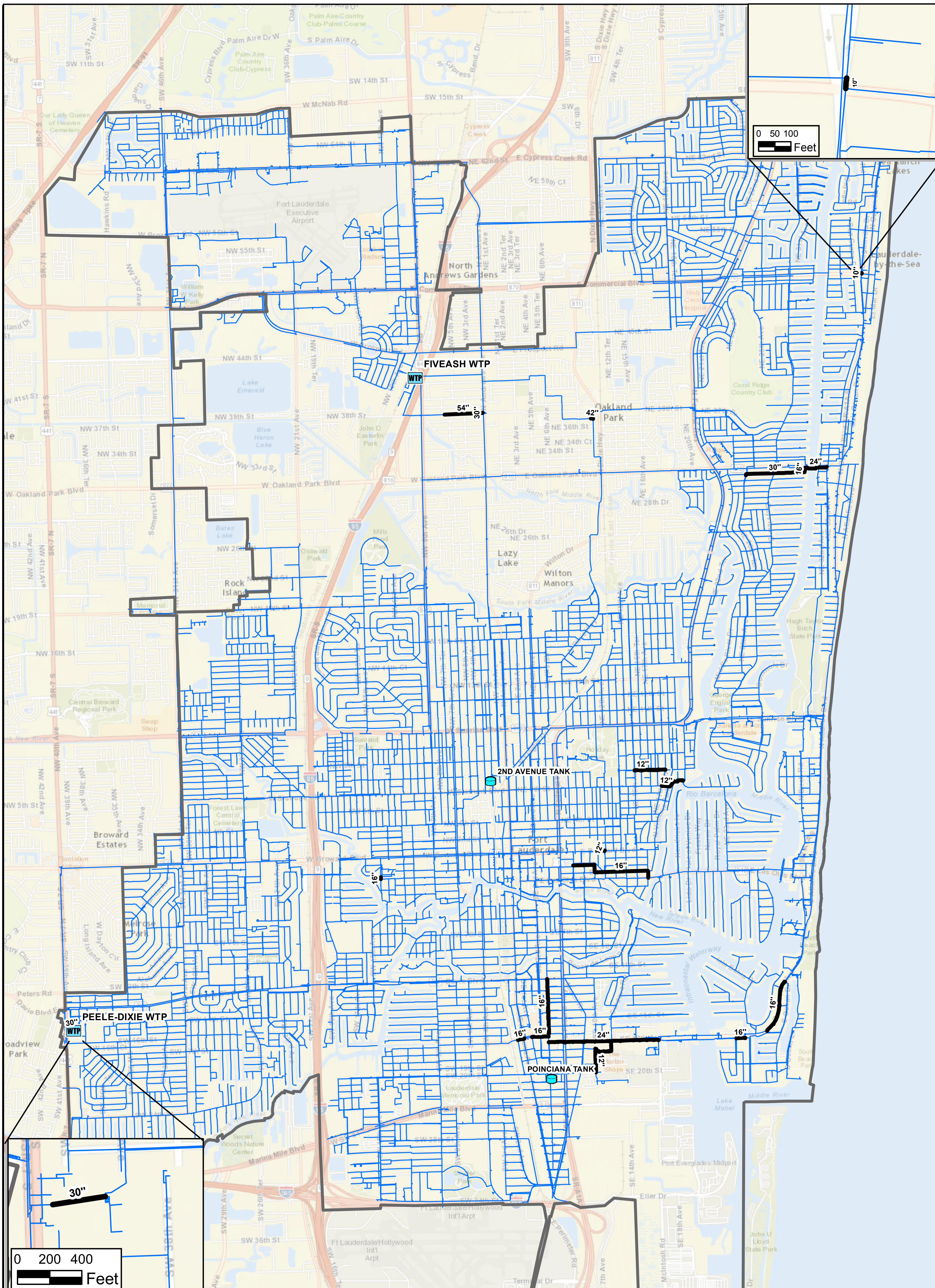

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Miles

Legend

- DISTRIBUTION STORAGE
- WTP WATER TREATMENT PLANT
- CAPITAL IMPROVEMENT PROJECTS
- WATER SERVICE AREA
- PIPELINE

CITY OF FT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
Capital Improvement Projects

FIGURE WA4-12

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Table WA4-4. Pipe Unit Capital Costs

Pipe Diameter (inch)	Unit Capital Cost[1] ($/LF)
10	$280
12	$290
16	$360
20	$380
24	$430
30	$520
36	$640
42	$780
48	$920
54	$1,100
64	$1,520

[1]Capital cost estimates derived from bid prices for similar projects, City of Tampa unit pipe construction contract prices, Toho Water Authority's Cypress Lake Water Transmission Project, and the SJRWMD's Cost Estimating and Economic Criteria for District Water Supply Plan document. Capital costs include construction costs and non-construction costs including 20% for administrative, engineering and legal costs, 25% for contingency and 10% for program management costs.

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WA5.A Water Treatment Plant Evaluation

5.A.1 Water Quality Goals

The City operates two water treatment plants (WTPs), the Charles W. Fiveash WTP and the Walter E. Peele-Dixie WTP. The Fiveash WTP is the largest, providing a 2014 annual average daily flow of approximately 31 MGD, and a maximum daily flow of 43 MGD. The Peele-Dixie WTP is a smaller, newer facility with an annual average daily flow of approximately 8 MGD, and a maximum daily flow of 12 MGD. The Peele-Dixie WTP was originally constructed in 1926 and converted from a lime softening plant to a nanofiltration plant in 2008. Each facility has been evaluated with respect to their ability to meet the City's current and future needs for water quality, efficiency, reliability and sustainability. **Table WA5.A-1** summarizes both WTP's effluent water quality, the City's water quality goals, and the Safe Drinking Water Act (SDWA) Drinking Water Standards.

Table WA5.A-1. WTP Effluent Quality, Goals, and SDWA Drinking Water Standards.

Parameter	Units	Goal	Fiveash Effluent Water Quality (2014)	Peele-Dixie Effluent Water Quality (2014)	Primary Drinking Water Standards	Secondary Drinking Water Standards
Total Hardness	mg/L as CaCO3	50 - 120	77.3	17.4	NS	NS
Sodium	mg/L	< 50	36.5	<50	160	NS
Total Dissolved Solids (TDS)	mg/L	< 500	<500	<500	NS	500
Iron	mg/L	< 0.3	0.02	0.10	NS	0.3
Manganese	mg/L	< 0.05	ND	<0.05	NS	0.05
Fluoride	mg/L	< 0.7	0.58	0.6	4.0	2.0
Sulfate	mg/L	< 200	ND	<200	NS	250
Chloride	mg/L	<100	66.5	16.7	NS	250
Color	Pt-Co	< 8	15.2	1.9	NS	15
Turbidity	NTU	< 1	0.16	0.16	NS	NS
Alkalinity	mg/L as CaCO3	> 40	60.7	54.1	NS	NS
H2S	mg/L	< 0.1	<0.1	<0.1	NS	NS
pH	Units	8.0 – 8.5*	9.19	9.0	NS	6.5-8.5
TTHM	mg/L	< 0.06	0.064	0.064	0.08	NS
HAA_5	mg/L	< 0.04	0.0318	0.0318	0.06	NS
Free Ammonia	mg/L	<0.2	<0.5	<0.5	NS	NS
Corrosivity	-----	Non Corrosive	Non Corrosive	Non Corrosive	NS	Non Corrosive
LSI	units	> 0.2	>0.3	0.3	NS	NS

Notes:

*Operating above range will require compliance with F.A.C 62-550.520 Secondary Contaminants Monitoring Requirements: (1) Analysis to determine compliance with Rule 62-550.320, F.A.C., shall be conducted by all community water systems and shall be repeated once each compliance period. Lime softening facilities may operate above 8.5 but less than or equal to 9.0 pH units without Department approval, and may operate

above 9.0, but less than or equal to 10.0 pH units upon approval by the Department of a written demonstration by the water system that operating at the higher pH will not cause the treatment plant to suffer operational failures, that minimum disinfectant levels can be maintained throughout the distribution system, and that the system can remain in compliance with the lead and copper and microbiological provisions of Chapters 62-550 and 62-555, F.A.C.ND = No Data or not required to be monitored continually.
NS = No Standard for groundwater systems.
NM = Not measured, assumed ND based on chlorine addition

5.A.2 Water Demand

The City of Fort Lauderdale's Urban Design & Planning Division forecasts a 2035 potable water service population of 267,196 as discussed in **Section WA2.** Applying the raw water unit demand of 176 gallons (170 finished water divided by treatment efficiency) per capita per day (gpcd). The resulting 2035 average annual raw water withdrawal from the Biscayne Aquifer is forecast to be 47.0 million gallons per day (MGD) which is within the annual allocation of 52.55 MGD authorized by the City's existing Water Use Permit (WUP). The 2035 maximum monthly raw water demand (1.14 times the average demand) of 53.6 MGD is also within the maximum month Biscayne WUP allocation of 59.90 MGD. Similarly, the 2035 maximum day finished water daily demand forecast of 57.65 MGD is within the existing water treatment plants' (WTP) permitted and effective finished water capacities as follows:

- Fiveash WTP = 70 MGD permitted, 55 MGD effective finished water capacity
- Peele-Dixie WTP = 12 MGD permitted, 12 MGD effective finished water capacity
- Total WTP = 82 MGD permitted, 67 MGD effective finished water capacity

Note that effective capacity is a longer term feasible capacity at which the WTP more effectively operates. Based on the comparison of available Biscayne Aquifer supply with the 20 year population/demand forecast, the City could accommodate an upside variance of 5.5 MGD (52.55 – 47.0 MGD) of raw average daily demand, or approximately 30,000 people, in the 20 year forecast assuming the per capita rate of water use remains the same.

5.A.3 Regulatory Requirements

The U.S. Environmental Protection Agency (EPA) governs national water quality regulations. In 1974 congress passed the SDWA which established national standards for water quality (as illustrated in **Table WA5.A-1**). The State of Florida has primacy for water quality regulations in Florida and governed legislation in Florida Statutes sections 403.850 - 403.864. The statutes follow the SDWA and other national rules with additional state regulations. These regulations are defined in the Florida Administrative Code (F.A.C.) as described in **Section WA1**.

The EPA reviews the SDWA every 6 years with a new renewal due in 2016. New contaminants of emerging concern (CECs) are placed on a Contaminant Candidate List (CCL). EPA is currently working on CCL-4. Specific concerns that may result in future water quality regulations are summarized in **Table WA5.A-2**.

Table WA5.A-2. Future Water Quality Regulations

Rule or Contaminant	Description	Applicability to City	Potential Strategies to Address
Strontium	May reduce bone density during children's bone development, preliminary positive regulatory determination made in 2014, final rule expected by 2019 or 2020.	City anticipated to be within limits	Monitor
Algal Toxins	EPA issuing health advisory for microcystin in summer 2015, carried forward onto the draft CCL-4 (draft CCL-4 published in February 2015).	Not currently applicable to City but would apply for C-51 Reservoir or other surface water supply	Prevention, treatment
Climate Adaptation Implementation Plans	Draft plans available on EPA website, public responses out in 2015.	Applicable	Climate adaptation initiatives completed, ongoing and part of this Master Plan
Revised Total Coliform Rule	Guidance Manual Interim Final on EPA website, increased assessments and source identification for total coliform and E. coli occurrences; compliance due by April 2016.	Applicable	Well maintenance, wellfield protection, 4-log compiance
Emerging Contaminants	Chemicals or materials characterized by a perceived, potential, or real threat to human health or the environment including: o Endocrine-disrupting compounds o Pharmaceuticals and personal care products o Perchlorate o Unregulated DBPs (e.g., NDMA) o Fluorinated and brominated compounds	Applicable	Monitor and address when and as needed
Chlorate and Nitrosamines	EPA has decided to include these disinfection byproducts in its third Six-Year review that is scheduled to be released in 2016	Applicable	Upgrade Fiveash treatment and switch to free chlorine disinfectant
Lead and Copper Rule Regulatory Revisions	EPA proposal expected in September 2015 with final expected in March 2017	Applicable	Potential lime treatment reinstatement and blending at Peele Dixie

5.A.4 Fiveash WTP Evaluation and Recommendations:

The City's largest water treatment plant is the Charles W. Fiveash WTP, with a design capacity of 70 million gallons per day (MGD). The plant is located in northwest Fort Lauderdale and draws its raw water from the Prospect Wellfield, which is fed from the surficial Biscayne Aquifer. Operations staff have noted that treating more than 55 MGD through the lime softening process shows a significant increase in finished water turbidity and decreased color removal. Therefore, the Fiveash WTP currently has a reduced, effective capacity of approximately 55 MGD. Over the past 10 years, the Fiveash WTP has experienced a steady decline in average daily demands (AADD) and maximum daily demands (MDD). The AADD has decreased from approximately 40 MGD in 2005 down to 31 MGD in 2014 (measured as wellfield treated flows), while the MDD has decreased from 50 MGD to 43 MGD over the same time period.

Much of the equipment for the lime softening system is at the end of its useful life. Spare lime softening treatment unit capacity is not available, thus limiting preventive maintenance to short-term corrective measures. **Section WA8** includes a complete delineation and schedule of anticipated equipment renewal and replacement for the Fiveash WTP. The Fiveash WTP Reliability Upgrades and Disinfection System Replacement (Reliability Upgrade) Project is on-going to replace several key mechanical items and automate the controls of key plant processes. Phases II and III of the Reliability Upgrade Project are under design and will be distributed for bid in the near future. The Fiveash WTP produces safe, reliable potable water. However, there are issues with the finished water quality that the CUSMP recommends resolving as discussed below. The CUSMP recommendations are summarized in a 20-year Community Investment Plan (CIP) included in **Section WA8.**

5.A.4.1 Color Removal Investigation

The Fiveash WTP color is higher than the EPA Secondary Drinking Water Standard range of 15 platinum-cobalt scale color units (Pt-Co). The high color causes water quality complaints from residents and visitors to the City, and is currently a major concern. The target water quality goal for color is 5-10 Pt-Co color units. The Fiveash WTP maintains an average finished water color of approximately 15 Pt-Co, exceeding the water quality goal and causing aesthetic issues and complaints. The City's record of distribution system complaints shows that the color has reached as high as 40 Pt-Co. The CUSMP Team has identified and examined several current, well-known, and effective color removal options for the Fiveash WTP including:

- Enhanced lime softening at a higher pH
- Enhanced lime softening and coagulation with additional chemicals
- Ozone and enhanced lime softening at a higher pH
- Granular activated carbon (GAC) following lime softening
- Ozone and granular activated carbon (GAC) following lime softening
- Nanofiltration
- Nanofiltation in parallel with lime softening
- Ion Exchange and lime softening
- Oxidation (ozone or hydrogen peroxide), UV, and lime softening

Depending on the desired finished water color level, the following treatment strategies should be implemented:

- To achieve a finished water color level between 15-20 Pt-Co, enhanced softening and coagulation treatment is required.
- To achieve a finished water color level between 10-15 Pt-Co, either ozone, UV, or hydrogen peroxide, followed by enhanced softening and coagulation treatment, is required.
- To achieve a finished water color level of 8 Pt-Co or less, either ozone with GAC, nanofiltration, or ion exchange with lime softening is required.

The CUS Master Plan Team recommends conducting a pilot study of GAC to gather the appropriate effectiveness and design criteria. This treatment strategy provides the greatest benefit at the lowest potential cost, and could potentially be incorporated into the existing treatment process.

5.A.4.2 Storage and High Service Pumping Modifications

Currently, Fiveash WTP high service pumps pull from seven interconnected clearwells and the finished water storage tanks to pump finished water to the distribution system. The CUS Master Plan Team recommends eliminating direct withdrawal from the clearwells to prevent short-circuiting and better control finished water quality. This modification allows the high service pumps to pull solely from the finished water storage tanks.

The CUS Master Plan Team recommends modifying the existing piping system such that the water from the filters gravity flows into the clearwells, then is transferred by pumps into the ground storage tanks. A common header from the ground storage tanks feeds the high service pumps that discharge finished water into the distribution system. The common header allows better and more consistent control of the Fiveash WTP finished water and minimize finished ammonia levels. The piping modifications require the modification of GST No. 1 to include at least one baffle wall and a new outlet pipe to tie in to the high service pump suction header with the remaining two GSTs.

This process flow modification will allow for more stable disinfectant residuals, optimized process control, and a reduction in stagnant water, water age, and disinfection by-products. The optimized process control allows for the monitoring of the disinfectant residual and the flow rates through the clearwells and ground storage tanks. When combined, the City can potentially achieve a 4-log virus inactivation credit in accordance with FDEP regulation; providing a significant benefit to the City by reducing the potential for boil water notices.

5.A.4.3 Aeration Basin Upgrades

In order to reduce energy costs and provide higher oxygen transfer efficiency and sulfide removal, the CUS Master Plan Team suggests several upgrades to the current aeration basin system. These basins allow for the removal of excess carbon dioxide and other objectionable gases by passing large quantities of air through the water. The addition of several upgrades will increase the efficiency of these aerators.

The existing blower is close to reaching the end of its useful life. Replacing the current blower and the diffusion apparatus system with a more efficient (turbo) blower and diffuser system (fine bubble) will reduce energy costs through increased air transfer efficiency.

The two aeration basins are separated through slide gates. The slide gates are corroded and need to be replaced. In addition, the operators (stems, wheels, gears) are also in need of replacement. The existing configuration and condition of gates and operators precludes the isolation of one aeration basin. The CUS Master Plan Team recommends replacing the isolation gates and operators for each of the two (2) aeration chambers, including the addition of motorized operators.

5.A.4.4 Chemical Treatment System Upgrade

The existing chlorine system is planned for replacement under the Reliability Upgrade Project between 2016-2019. The CUS Master Plan Team recommends that the City reassess the chlorine injection system in order to obtain 4-log virus inactivation and obtain certification from FDEP. A positive total coliform or E. coli bacteria sample from one well is enough to trigger the response including boil water notifications for the entire WTP service area. For the Fiveash WTP notifications span three quarters of the entire service area. However, if 4-log virus inactivation is achieved through water treatment, then no other action is required from the utility. While positive total coliform or E. coli bacteria occurs infrequently, shallow aquifers such as the Biscayne are more vulnerable and the City experienced an occurrence in 2016.

The Fiveash WTP currently injects chlorine and ammonia in the recarbonation basins prior to the filters. Modifications to disinfection practices, such as a free chlorine residual in the finished water storage tanks, can help achieve 4-log virus inactivation but must be balanced against disinfection byproduct (DBP) formation and rule compliance. A more detailed discussion, along with other alternatives for achieving 4-log virus inactivation credit, is depicted in **Section WA5.B.2.4-5**.

5.A.4.5 Final Summary of Fiveash Water Treatment Plant Options

The CUS Master Plan Team developed three (3) options to improve the Fiveash WTP. The options vary based on treatment processes provided and costs to implement.

Option 1: Repair/Replace the Current Fiveash WTP
Option 1 for the Fiveash WTP entails continuing to rehab and repair/replace the current lime softening system. Much of the equipment for the lime softening system is at the end of its useful life. Spare lime softening treatment unit capacity is not available, thus limiting preventive maintenance to short-term corrective measures. As shown in **Section WA8**, the Repair & Replacement (R&R) costs of the Fiveash WTP over the next five years are well over $100,000,000, with an additional $30,000,000 every 5-years through 2035. This alternative will not improve the water color quality of the Fiveash WTP. The Fiveash WTP produces an average finished water color in excess of 15 Pt-Co, exceeding the water quality goal of 5-10 Pt-Co and causing aesthetic issues and complaints. Continuing to produce water with the existing method and current infrastructure will continue status-quo water quality results.

Option 2: Implement Color Removal Process to Existing Fiveash WTP
Option 2 for the Fiveash WTP involves upgrading the existing plant to include an efficient color removal process. Based on **Section WA5.B**, the CUS Master Plan Team recommends conducting a GAC pilot study to gather the appropriate effectiveness/efficiency and design criteria. The GAC treatment strategy (Option 2A) provides the desired benefit at the lowest potential cost, and could potentially be incorporated into the existing treatment process. This treatment alternative will allow the Fiveash WTP to produce finished water with a color quality parameter 8 Pt-Co or less. The feasibility of GAC is recommended to be confirmed by pilot testing**.** Options 2B (new ozone + softening + GAC) is included in case the GAC process alone is infeasible due to rapid consumption by the raw water total organic carbon concentrations.

Option 3: Implement New WTP at Fiveash
Based on **Section WA5.B.5**, the cost to improve the current Fiveash WTP system exceeds $75,000,000. With an additional $30,000,000 being spent on the Reliability Upgrade Project, the Fiveash WTP will require approximately $100,000,000 to maintain over the next five years. With the current Fiveash WTP being over 60 years old, building a new, innovative water treatment plant may be the best option for the City. Once an ideal treatment method is determined based on the recommended pilot testing, costs for a new WTP can be refined and compared to the $100,000,000 renovation costs. The advantages of building a new water treatment plant are significant versus renovating the old Fiveash WTP. A new, innovative and robust water treatment plant will produce improved water quality, greater reliability, easier operation, and lower maintenance costs. Option 3A and 3B are brand new WTPs with varying processes, Option 3C includes partial use of the existing Fiveash WTP lime softening facilities coupled with a smaller, new membrane WTP to blend finished water and minimize cost.

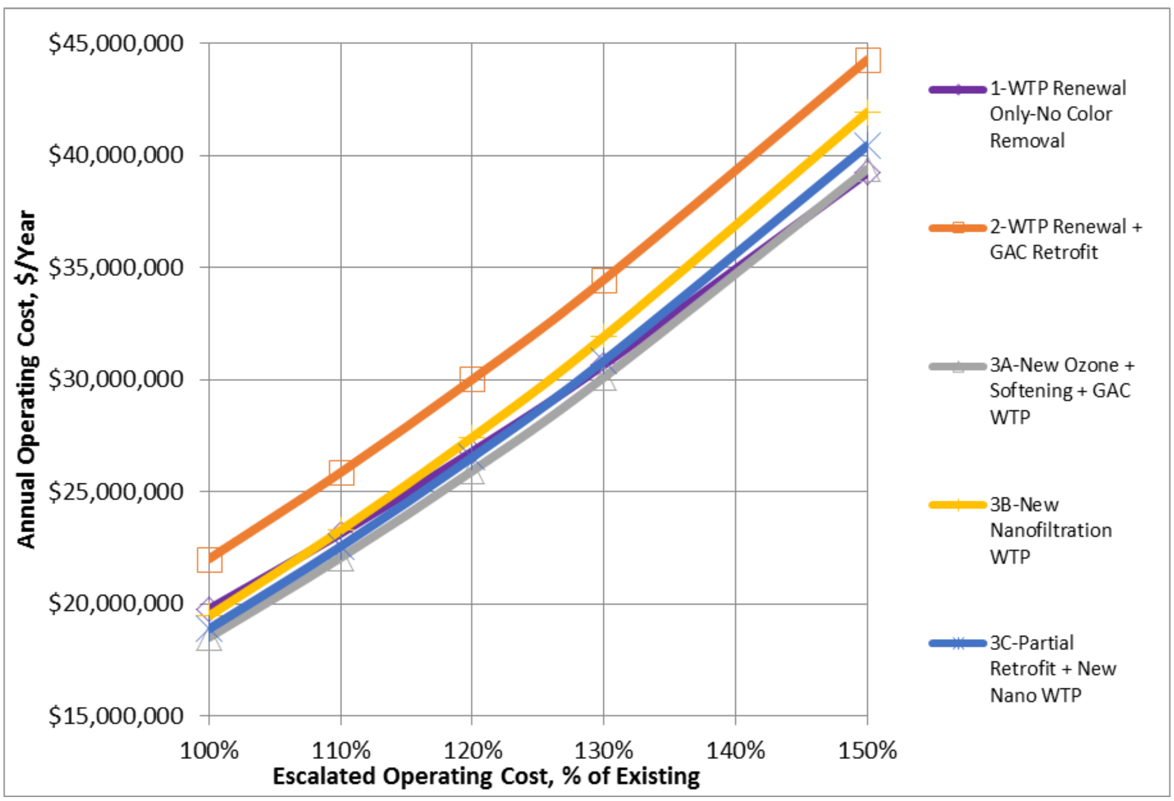
A life cycle cost analysis is summarized in **Table WA5.A-3**.

Table WA5.A-3. Water Treatment Plant Improvement Summary

	Category	WTP Renewal Only-No Color Removal Option 1	WTP Renewal + GAC Retrofit Option 2	New Ozone + Softening + GAC WTP Option 3A	New Nanofiltration WTP Option 3B	Partial Retrofit + New Nano WTP Option 3C
Design Flow	Average Daily Demand, MGD	40	40	40	40	40
	Maximum Daily Demand, MGD	60	60	60	60	60
Construction and Capital Cost	Total Material and Construction Cost	$80,000,000	$104,000,000	$180,000,000	$180,000,000	$129,000,000
	Engineering, Adminstrative, Legal (20%)	$16,000,000	$20,800,000	$36,000,000	$36,000,000	$25,800,000
	Contingency (25%)	$20,000,000	$26,000,000	$45,000,000	$45,000,000	$32,250,000
	Program Managment (10%)	$8,000,000	$10,400,000	$18,000,000	$18,000,000	$12,900,000
	Total Capital Cost	**$124,000,000**	**$161,200,000**	**$279,000,000**	**$279,000,000**	**$199,950,000**
Annual Oparating Cost	Average Actual Flow Treated, MGD	28	28	28	28	28
	Residuals Disposal, $/Year	$1,000,000	$1,000,000	$1,000,000	$500,000	$750,000
	O&M Costs, $/Year	$12,775,000	$15,015,000	$15,515,000	$16,975,000	$16,147,600
	Annual Rehabilitation, $/Year	$6,000,000	$6,000,000	$2,000,000	$2,000,000	$2,000,000
	Total Operating Cost, $/year	**$19,775,000**	**$22,015,000**	**$18,515,000**	**$19,475,000**	**$18,897,600**
	Capital Equivalent Annual Cost, $/Year	$9,950,000	$12,935,000	$22,388,000	$22,388,000	$16,045,000
	Total Annual Cost, $/Year	***$29,725,000***	***$34,950,000***	***$40,903,000***	***$41,863,000***	***$34,943,000***

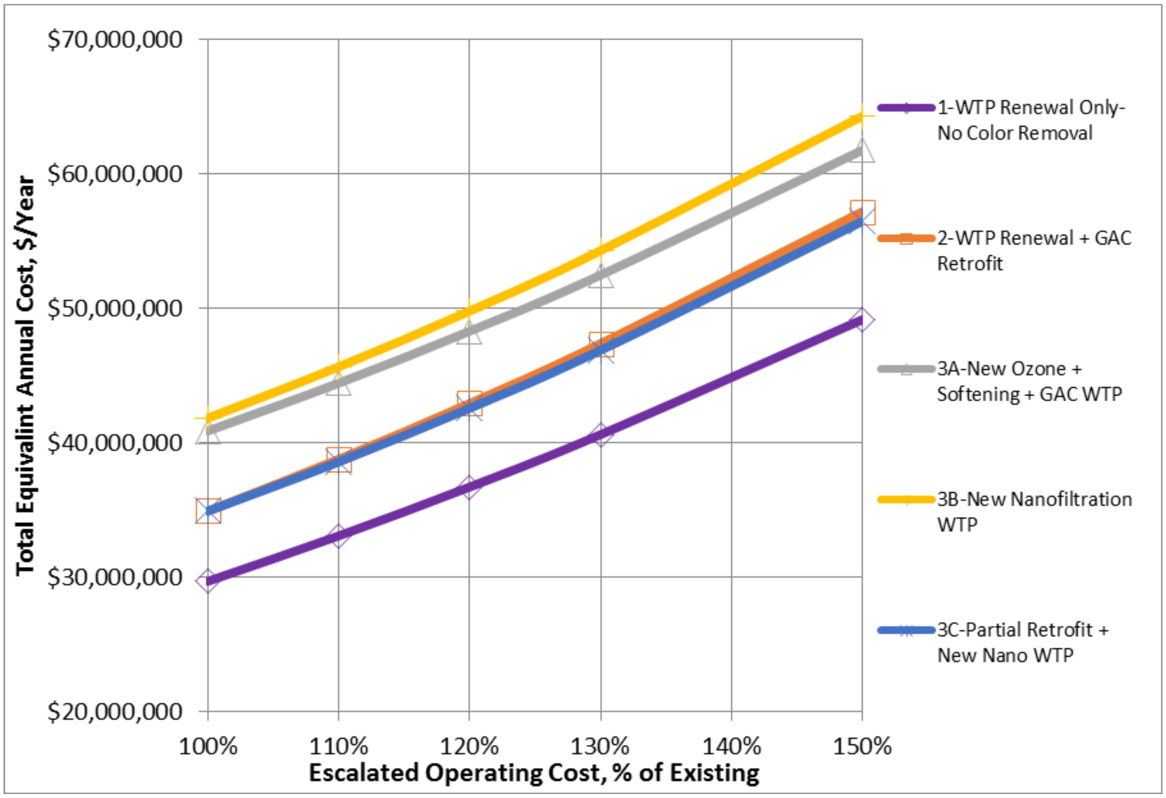
Note: Capital and operating costs estimated based on best available information and should be verified by pilot testing.

Figure WA5.A-1. Fiveash WTP Improvement Options-Annual Operating Costs



Section WA5A accepted January 11, 2017.

Figure WA5.A-2. Fiveash WTP Improvement Options-Equivalent Annual Costs



5.A.5 Peele-Dixie WTP Evaluation and Recommendations:

The City operates the Walter E. Peele-Dixie Water Treatment Plant (WTP), providing drinking water to the southern portion of the City's service area. The Peele-Dixie WTP was originally constructed in 1926 as a lime softening plant. In 2008, the City built a new nanofiltration plant on site, and shut down the lime softening facility. The lime softening plant is not in use and Section WA5D evaluates the City's options for reactivating or decommissioning the old lime softening plant. The Peele-Dixie WTP maintains a Florida Department of Environmental Protection (FDEP) permitted treatment capacity of 12 MGD. The Peele-Dixie WTP is designed to allow for an expansion of an additional 6 MGD of membrane treatment skids. Raw water to the Peele-Dixie WTP is pumped from the Dixie Wellfield, which had a new wellfield constructed in 2008 and a new 30-inch raw water main constructed in 2012. The Peele-Dixie WTP uses a hybrid Reverse Osmosis/Nanofiltration (RO/NF) system to treat Biscayne aquifer raw water. For calendar year 2014, the Peele-Dixie WTP treated an annual average day of 8.1 MGD of groundwater, producing 6.9 MGD of finished water. The plant recovers 85% water as permeate, while the remaining 15% concentrate water is disposed of in an underground deep injection well. The Peele Dixie WTP does have issues operating at full design capacity due to iron fouling; City operations staff is working on alternatives to maximize operating capacity.

Much of the equipment and mechanical items at the Peele-Dixie WTP are in good condition, as the plant was constructed in 2008. **Section WA8** includes a complete delineation and schedule of anticipated equipment renewal and replacement for the Peele-Dixie WTP. The treatment at the Peele-Dixie WTP consists of sulfuric acid and antiscalant addition as pre-treatment prior to cartridge filtration and nanofiltration treatment. The membrane permeate is chlorinated, pH adjusted, and treated with corrosion inhibitor prior to being directed to the degasifiers. After the degasifiers, the water feeds into a single clearwell with partial interior baffle walls. In the clearwells, chlorine, ammonia, fluoride, and corrosion inhibitor are added prior to the final pH adjustment using caustic. From the clearwells, the water is pumped to the ground storage tanks. After the ground storage the water can be polished with additional chlorine and ammonia before being distributed into the water distribution system via the high service pumps.

Based upon the Peele-Dixie WTP evaluation, improvements and investigations are recommended in order to ensure a reliable water quality that meets primary and secondary drinking water standards. In addition, these improvements, including membrane replacement and chemical day tank replacement, will reduce energy consumption and enhance operability and safety. Peele-Dixie WTP recommendations are summarized in a 20-year Community Investment Plan (CIP) Table included in **Section WA5C.**

5.A.5.1 Peele-Dixie Lime Softening Plant Rehabilitation Investigation

Prior to the implementation of the reverse osmosis/nanofiltration system, the City used a conventional lime softening process with granular media filtration to treat water at the Peele-Dixie WTP. This original lime softening water treatment plant was in service for 82 years and was taken out of service in 2008 following startup of the new membrane plant.

Recommissioning the Peele-Dixie Lime Softening Plant was evaluated. The benefits of recommissioning would produce a less corrosive and more stable finished water by blending higher alkalinity water with the membrane treated water. Recommissioning the lime softening plant may also allow the raw water to be drawn from the original, deeper wells in the Peele-Dixie Wellfield. Recommissioning could offset the expansion of the membrane system to potentially reduce operating costs and aid with WUP compliance. The City abandoned all but four of the original wells in accordance with SFWMD and FDEP rules (filled with grout, cut and capped at 5 feet below ground). Two of the remaining wells were transferred to the golf course for use as irrigation wells and two were demolished and await abandonment. The old lime plant could be fed with new Peele-Dixie wells.

However, the old Peele-Dixie Lime Plant is in dilapidated condition, and the equipment is outdated and would require total replacement. The tanks would need thorough structural inspections and likely require rehabilitation. The tanks are also outdated by newer, more efficient style tanks. Reconstruction of the lime plant would cost in excess of $30,000,000, nearly the cost of a brand new similar sized lime softening facility, and would require significant annual repair and replacement following. Therefore, the CUSMP Team recommends the old Peele-Dixie lime plant be permanently decommissioned or repurposed for revenue generation. **Section WA5.D** discusses further the requirements for rehabilitating the old lime-softening facility.

5.A.5.2 Chemical Storage Area Investigation

During the Peele-Dixie WTP site visit the CUSMP Team interviewed City operational staff who relayed that the storage-and-feed system for the sodium hydroxide and sulfuric acid does not store ample chemical supply to sustain the treatment process for 24 hours and some of the larger tanks cannot receive full shipment loads. In order to reduce staffing operation costs to refill the "day" tanks twice a day, the CUSMP Team recommends additional storage should be added to the current storage-and-feed system. The installation of additional storage can be incorporated into the expansion of the membrane treatment system or performed independently.

The CUSMP Team observed that the chemical storage tanks were installed initially, followed by the construction of the secondary containment system and building structure. As a result, if one of the tanks needs to be removed or replaced, or if there is a need to install an additional tank, there will be little space and poor accessibility. In addition, the antiscalant and corrosion inhibitor bulk chemical tanks do not allow for a full-load delivery of chemicals. Less than full truckloads are charged as full truckloads by the delivery companies, resulting in costly, inefficient chemical purchases. To avert both issues, the CUSMP Team recommends investigating the installation of separate roll-up, over-head doors or possibly multiple, smaller tanks.

At each of the chemical storage and pumping areas, there is a significant step-down adjacent to the entrance of the buildings. This poses a safety concern, and the CUSMP Team recommends the installation of grating to create a level, flat surface without a step-down to prevent workplace accidents and still provide necessary containment.

5.A.5.3 Pumping Area Investigation

Three out of the five high service pumps that distribute finished water from the ground storage tanks to the service area currently do not have VFDs. VFDs would allow pumps to increase or decrease speed to match system flow and pressure variances, resulting in improved distribution system operations. The CUSMP Team recommends installing VFDs on high service pumps 3, 4, and 5, which will inevitably produce lower operating costs, less maintenance, and lower energy costs. The VFDs are most likely going to be larger than the soft start devices currently installed. Space is at a premium (non-existent) in the chemical building electrical room. There was no additional space for expansion included in the construction of the electric room. Location of VFDs to be determined in the design phase. Regarding the outside pump area, installing a shelter over the high service pumps would help decrease wear due to weather and sunlight, lightning damage and operation and maintenance during inclement weather.

5.A.5.4 Operations and Maintenance Workshop

Currently, there is not a “workshop,” or available space, for the operations and maintenance (O&M) staff to perform repairs and operate machinery. Including a separate space will allow for a proper, permitted area for the operations staff to perform repairs on the equipment as needed, and potentially reduce costs by not having to hire outside staff to perform the repairs. Based upon current conditions, the CUSMP Team suggests investigating the conversion of the 2nd floor into a permitted area for a maintenance workshop. In order to use the 2nd floor area as a maintenance workshop, either the passenger elevator will have to be retrofitted into a freight elevator, or there will be a need for an additional freight elevator. In addition, a means will be necessary to move heavy parts to and from the elevator. This could be a winch crane with platform truck or a bridge crane. These options and the existing building’s capacity to handle increased floor loadings for the added weight of heavy motors and equipment will be evaluated during final design. Alternatively, a new facility could be constructed on the plant property, maybe near the old lime building.

5.A.5.5 Post-Treatment Water Stabilization

The CUS Master Plan Team recommends implementing post-treatment stabilization of the treated water. Currently, a chemical corrosion inhibitor is introduced into the water to prevent corrosion of equipment, tanks, and the distribution system. The efficacy of this was investigated in 2011 and the results were published in “Peele-Dixie Water Treatment Plant Corrosion Study Results”, March 2011. The 180-day test shows that the corrosion inhibitor is performing adequately, however, long-term impacts are not known. Post-stabilization of the water, beyond the existing corrosion inhibitor, should be explored to potentially include the removal of the corrosion inhibitor.

The CUS Master Plan Team recommends performing more detailed process engineering and pilot testing to confirm the viability of the Peele-Dixie WTP Biscayne aquifer membrane replacement to effectively post stabilize the finished water. As the membrane replacement is scheduled and budgeted for February 2017, this option could be the least cost capital and operationally if viable. Should the Biscayne Aquifer membrane replacement not fully meet the Peele-Dixie WTP finished water quality goals, the CUS Master Plan Team recommends pursuing Stabilization Option 2 (see Section WA5.D) of adding carbon dioxide and calcite treatment to accomplish post-stabilization and corrosion abatement. The design should account for the future total flow of 18 MGD. The CUS Master Plan Team recommends two phase construction, with the first phase to match the existing 12 MGD plant capacity.

5.A.6 Water Treatment Plant Climate Change Mitigation Measures:

As discussed in detail in **Section WA11**, risks to the City's water supply system associated with potential climate change and sea level rise include the following:

- Saline intrusion risk to the City's Biscayne Aquifer wellfields, the magnitude of risk dependent primarily on the rate of sea level rise. The Dixie wellfield's close location seaward of the G-54 Control Structure appears more vulnerable than the Prospect Wellfield;
- Restricted stormwater gravity discharge through the SFWMD Control Structures during extreme high tides and/or major storm events. Limited discharge would promote wellfield flooding that may cause impaired water quality due to surface water infiltration into improperly sealed production wells. This is less of a potential issue at the Dixie Wellfield compared to the condition of the wells at the Prospect Wellfield. Seven of the eight wells in the Dixie Wellfield are located on elevated concrete structures approximately four feet above the ground surface;
- As mentioned in **Section WA10**, operation of the C12/C13 interconnect may facilitate enhanced discharge of regional system flows to tide. This will lower water table elevations in the area, which will reduce potential flooding associated with extreme climatic events;
- Increased water demand, in particular for irrigation, due to higher evapotranspiration (ET) rates in combination with reduced rainfall. Demand increases significantly greater than that currently estimated for 2035 could require request for additional allocation sooner than currently authorized in the City's WUP, however, climate change projections regarding future precipitation trends are uncertain;
- Hurricanes damaging water supply facilities;
- Fortunately, the Peele-Dixie WTP uses membrane treatment which can effectively decrease the low levels of salt that could possibly impact the wellfield after a catastrophic storm surge or tidal flooding event.

Measures the City can take to address impacts to the water supply system due to potential climate change and sea level rise include the following:

- Review findings of the USGS/Broward County variable density modeling study. Combine modeling results with ongoing monitoring to apply existing model to perform simulations specific to City wellfield operations (Estimated modeling costs = $75,000 - $100,000);

- Perform subsurface investigation and if needed install additional monitoring well(s), typically 4-inch diameter, south of the Dixie wellfield (Estimated costs = $150,000 - $200,000 per well);
- Assess and implement as needed production well improvements to prevent potential surface water infiltration in the event of flooding events (Estimated costs = $230,000 per well for wellhead replacement; $450,000 per well for total well replacement - see **Section WA.5.A.7** for details).
- Monitor customer per capita usage annually to compare with long-term reduction goals and 2035 demand estimates. Evaluate need for additional water allocations if long-term demands increase significantly above current estimates; and plan and implement further hurricane hardening measures for water supply facilities;
- Implement conservation methods that reduce per capita usage below the planned 170 gallons per date rate.

5.A.7 Existing Biscayne Aquifer Capacity

The City currently operates two Biscayne Aquifer wellfields to provide water for their WTPs. These include the Prospect wellfield, which consists of 29 active wells and supplies raw water to the Fiveash Lime Softening WTP, and the Dixie wellfield, which consists of 8 active wells, and supplies water to the Peele-Dixie Membrane WTP. **Figures WA5.A-3** and **Figures WA5.A-4** present the locations and identification of production wells for these two wellfields.

Table WA5.A-4 and **Figures WA5.A-5 through WA5.A-17** provide summaries of recent pumping rates for individual wells and wellfields. These include data from January 2013 through July 2015. Figures presenting pumpage data include total and individual wellfield summaries, as well as individual well values. Pumping rates correspond to reported monthly total withdrawals, expressed as average daily values in million gallons per day (MGD). Data presented in **Table WA5.A-4** include the average and maximum values for each well and wellfield (expressed in MGD), as well as the relative ranking of each well per wellfield, from highest to lowest reported pumpages. Separate rankings correspond to recent average and maximum withdrawals.

Figures WA5.A-5 through WA5.A-7 present comparisons of recent (Jan-2013 to Jul-2015) total and individual wellfield withdrawals compared to allocations authorized by the City's WUP. Maximum total withdrawals from both wellfields indicate the ability to produce approximately 102.5 MGD, which substantially exceeds the maximum equivalent of 52.55 MGD authorized by the WUP. For the Prospect wellfield, maximum withdrawals of about 84 MGD exceed their WUP allocation of 49.5 MGD, while the 18.5 MGD maximum withdrawn from the Dixie wellfield exceeds the WUP allocation of 15 MGD. Overall, the historical pumpage data demonstrate that the City's existing Biscayne Aquifer wellfields can provide sufficient raw water to meet future demand for the next 20 years, which corresponds to this master planning horizon. Well capacity higher than the withdrawal limitation indicates that the city has sufficient capacity in the wellfields to allow for various wells to be taken out of service for maintenance and repairs.

5.A.8 Field Inspection of Biscayne Aquifer Wellfields

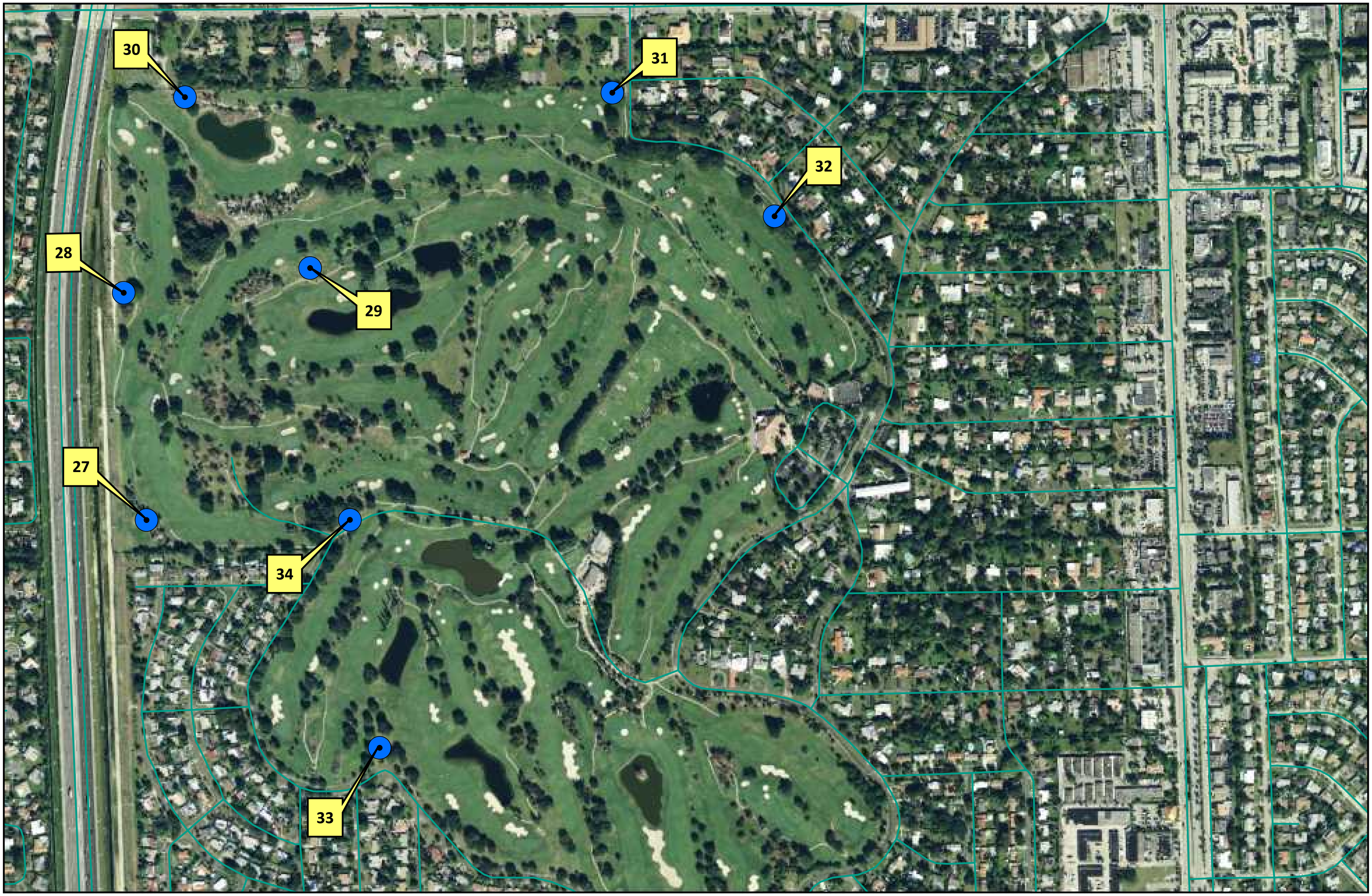
The CUSMP Team including hydrogeologic expert JLA Geosciences Inc. (JLA) performed a visual evaluation of each Biscayne Aquifer production well facility on September 17, 2015 to identify failed or deficient components and recommend improvements or enhancements to restore or improve individual well facilities and reliability. City staff participated in the field inspection along with CUSMP Team members. A summary of observations made during the inspection follows, along with recommendations for future activities the City may wish to consider to promote optimal individual well and overall wellfield performance.

Table WA5.A-4
Ft. Lauderdale Biscayne Aquifer Wellfields

Dixie Wellfield	Well #		2013-15 Maximum Month	Max Month Rank	2013-15 Average Month	Avg Month Rank	Well depth	Cased depth
			MGD		MGD		ft BLS	ft BLS
	28		2.67	1	1.66	2	125	100
	33		2.59	2	1.75	1	120	90
	31		2.58	3	1.48	4	120	90
	30		2.44	4	1.21	5	120	90
	34		2.43	5	1.08	6	120	90
	29		2.40	6	1.57	3	120	90
	27		1.89	7	0.73	7	120	90
	32		1.48	8	0.09	8	120	90
		Dixie Total	**--**		**9.56**			
		WUP Allocation	**15.00**		**15.00**			
Prospect Wellfield	**Well #**							
	34		4.76	1	1.39	7	90	75
	36		4.23	2	1.52	6	99	81
	28		4.13	3	1.53	5	116	81
	44		3.88	4	1.58	4	90	68
	45		3.76	5	2.14	1	120	100
	52		3.68	6	0.32	28	120	100
	33		3.55	7	1.72	3	101	80
	35		3.28	8	1.75	2	96	70
	32		3.27	9	0.98	14	103	82
	43		3.07	10	1.15	10	90	66
	42		2.95	11	0.88	16	91	82
	26		2.95	12	0.85	17	144	105
	39		2.93	13	1.02	13	98	82
	47		2.91	14	1.29	8	120	100
	53		2.90	15	0.52	24	120	100
	49		2.88	16	0.95	15	N/A	N/A
	30		2.83	17	1.06	11	109	90
	38		2.75	18	1.19	9	102	82
	25		2.71	19	0.81	18	150	112
	37		2.65	20	1.04	12	98	82
	31		2.49	21	0.62	22	100	80
	50		2.45	22	0.60	23	120	100
	51		2.42	23	0.47	26	120	100
	27		2.12	24	0.73	20	103	100
	48		2.03	25	0.63	21	N/A	N/A
	46		2.00	26	0.81	19	120	100
	40		1.89	27	0.50	25	90	62
	41		1.45	28	0.32	27	95	82
	54		1.03	29	0.06	29	120	100
		Prospect Total	**--**		**28.46**			
		WUP Allocation	**49.50**		**43.43**			
		Biscayne Total	**--**		**38.02**			
		WUP Allocation	**64.50**		**58.43**			

Prospect Biscayne Wellfield

Figure WA5.A-3



0 250 500 1,000 1,500 2,000
Feet

N

Production Well

Well #

Dixie Biscayne Wellfield

Figure WA5.A-4

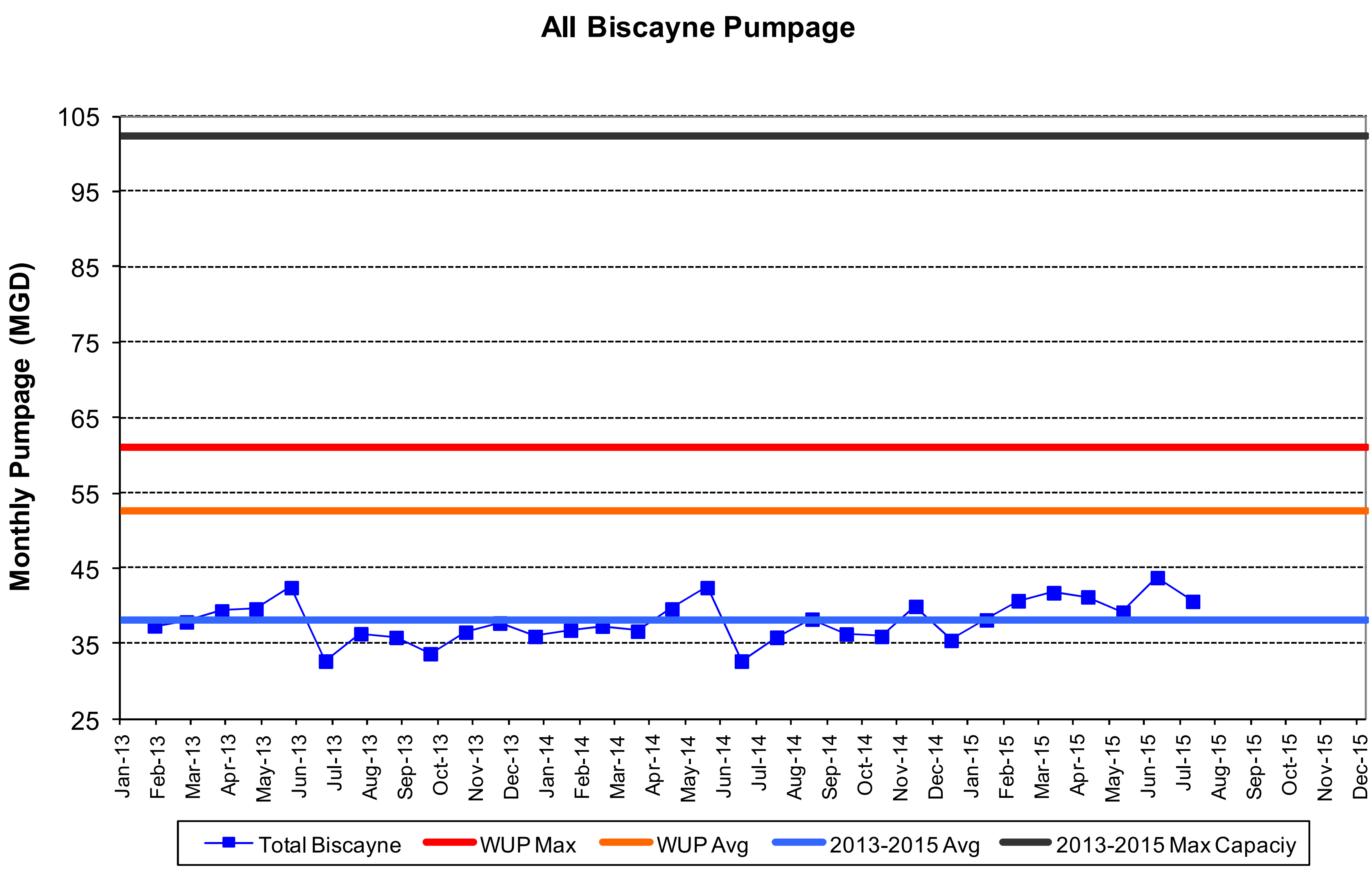
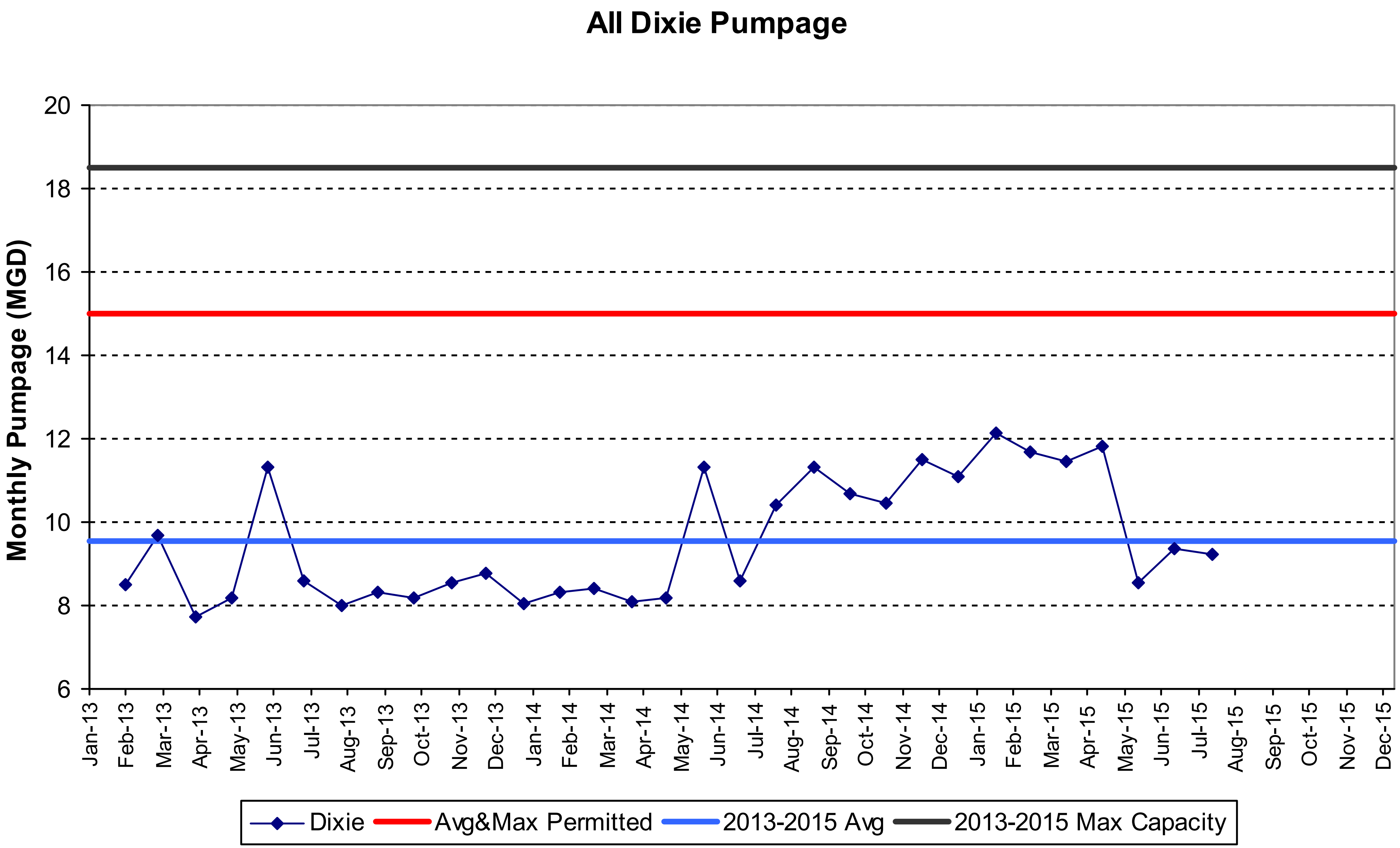


Figure WA5.A-5



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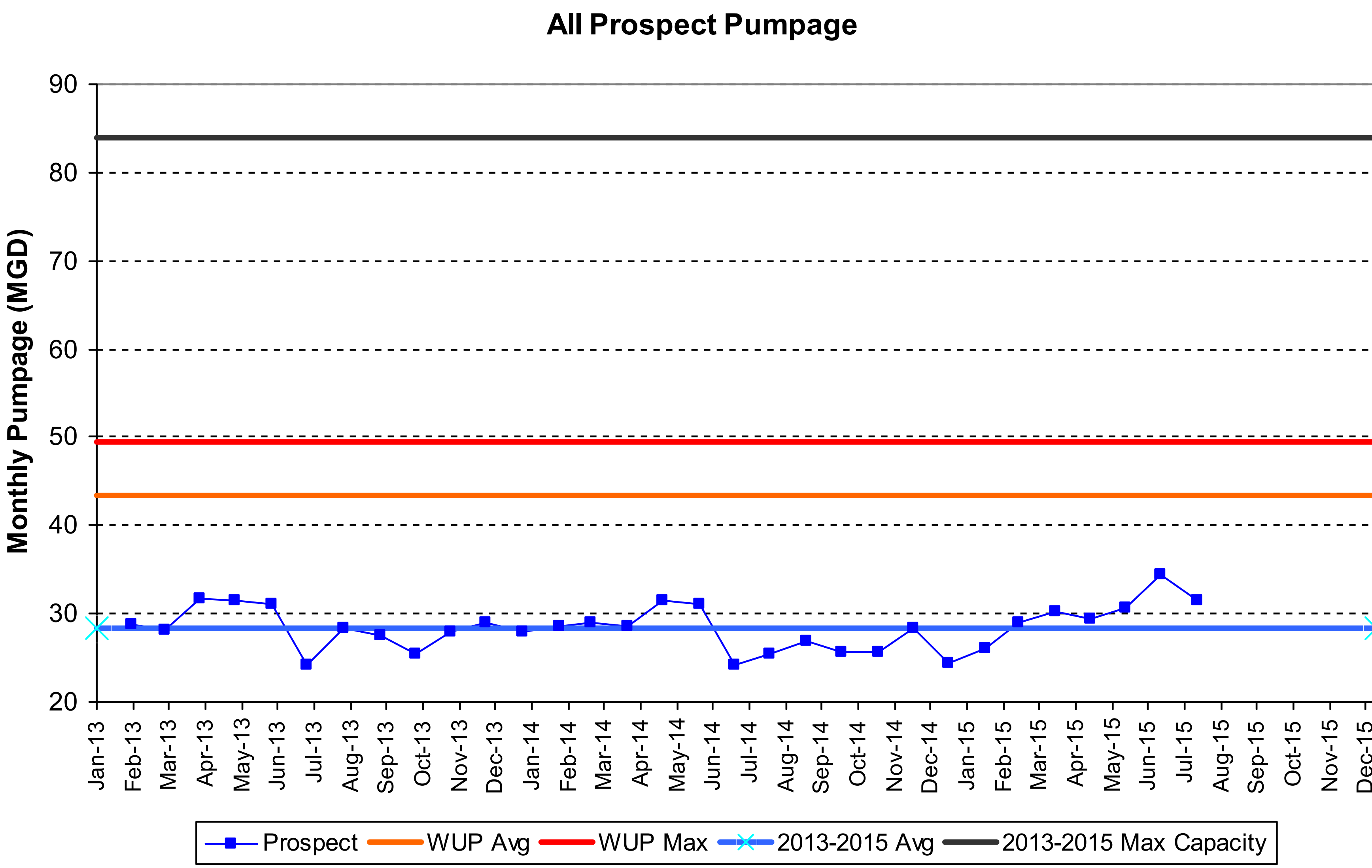
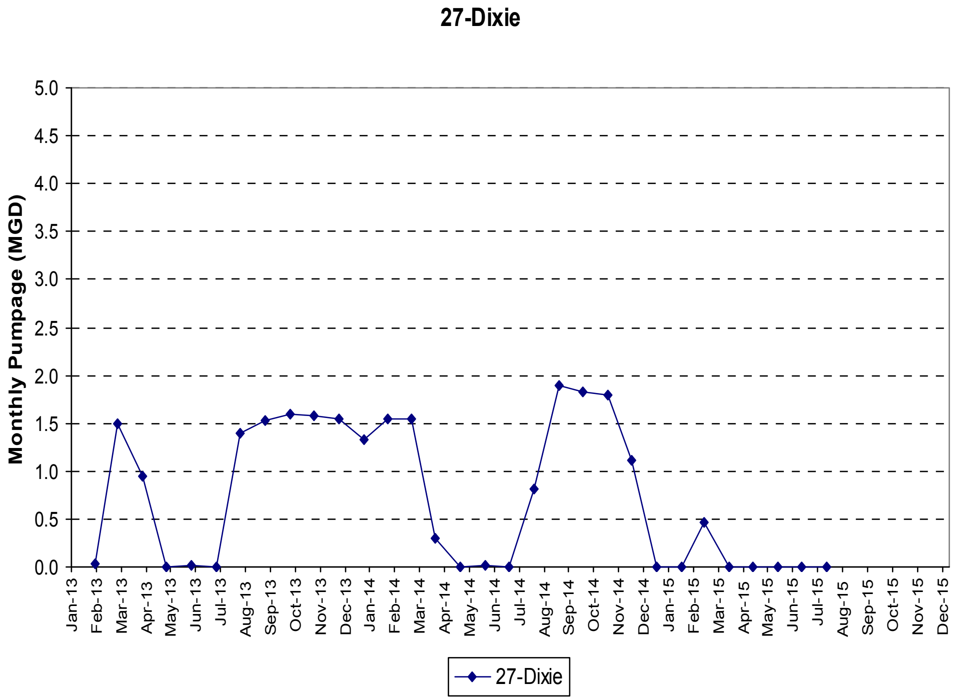
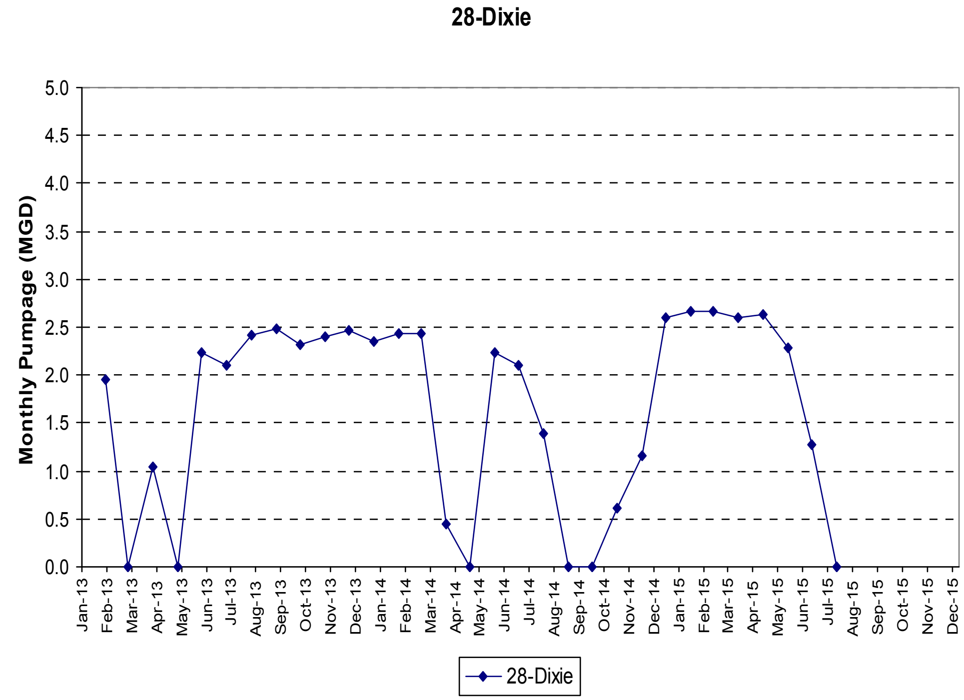
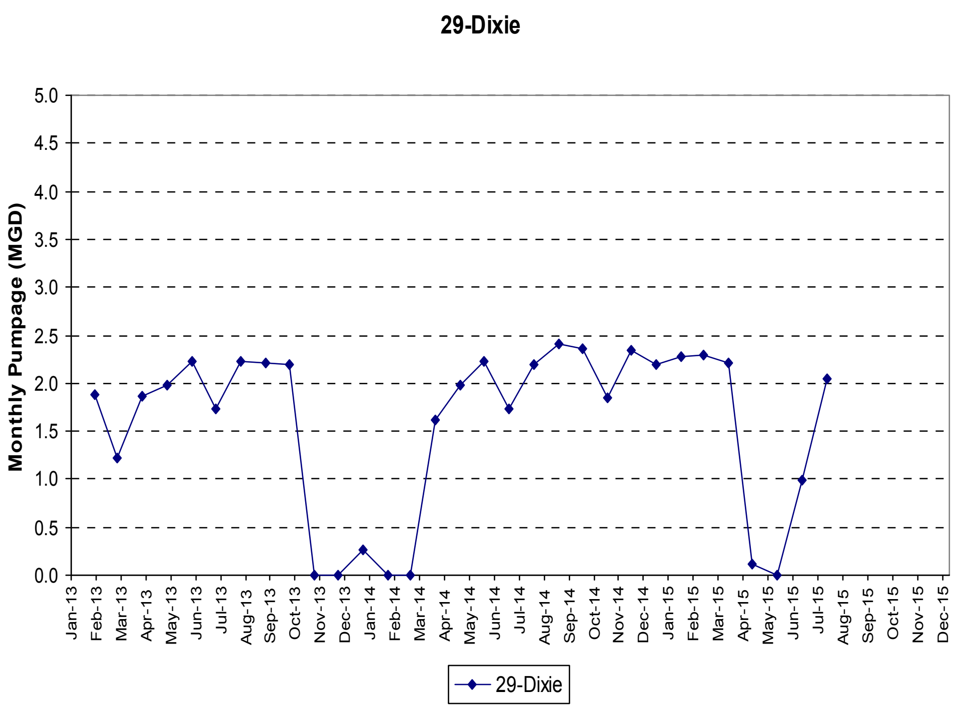
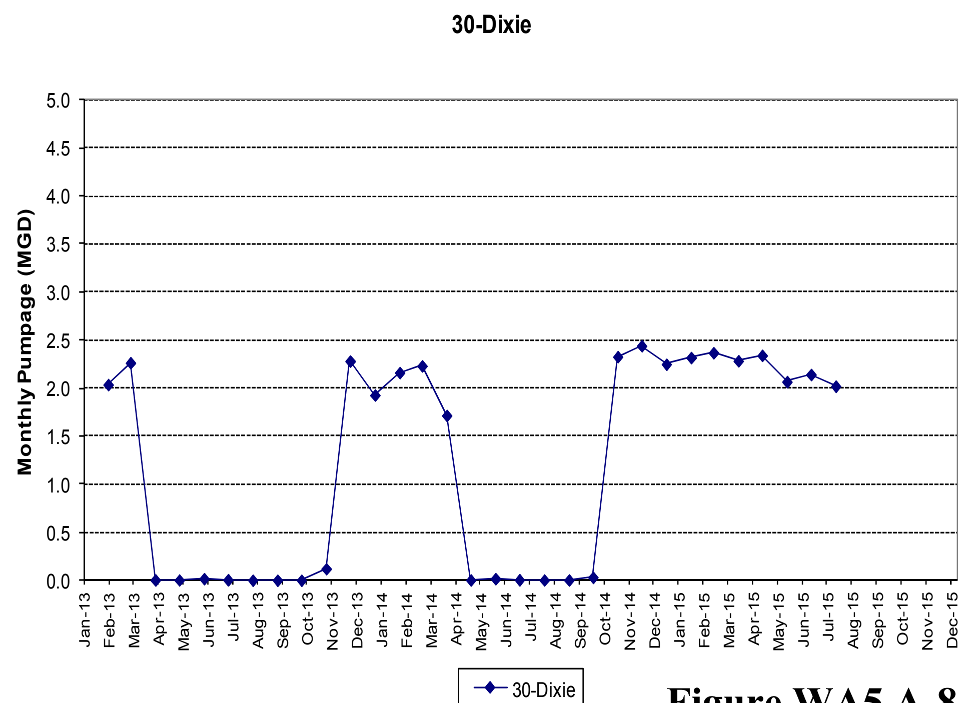


Figure WA5.A-7









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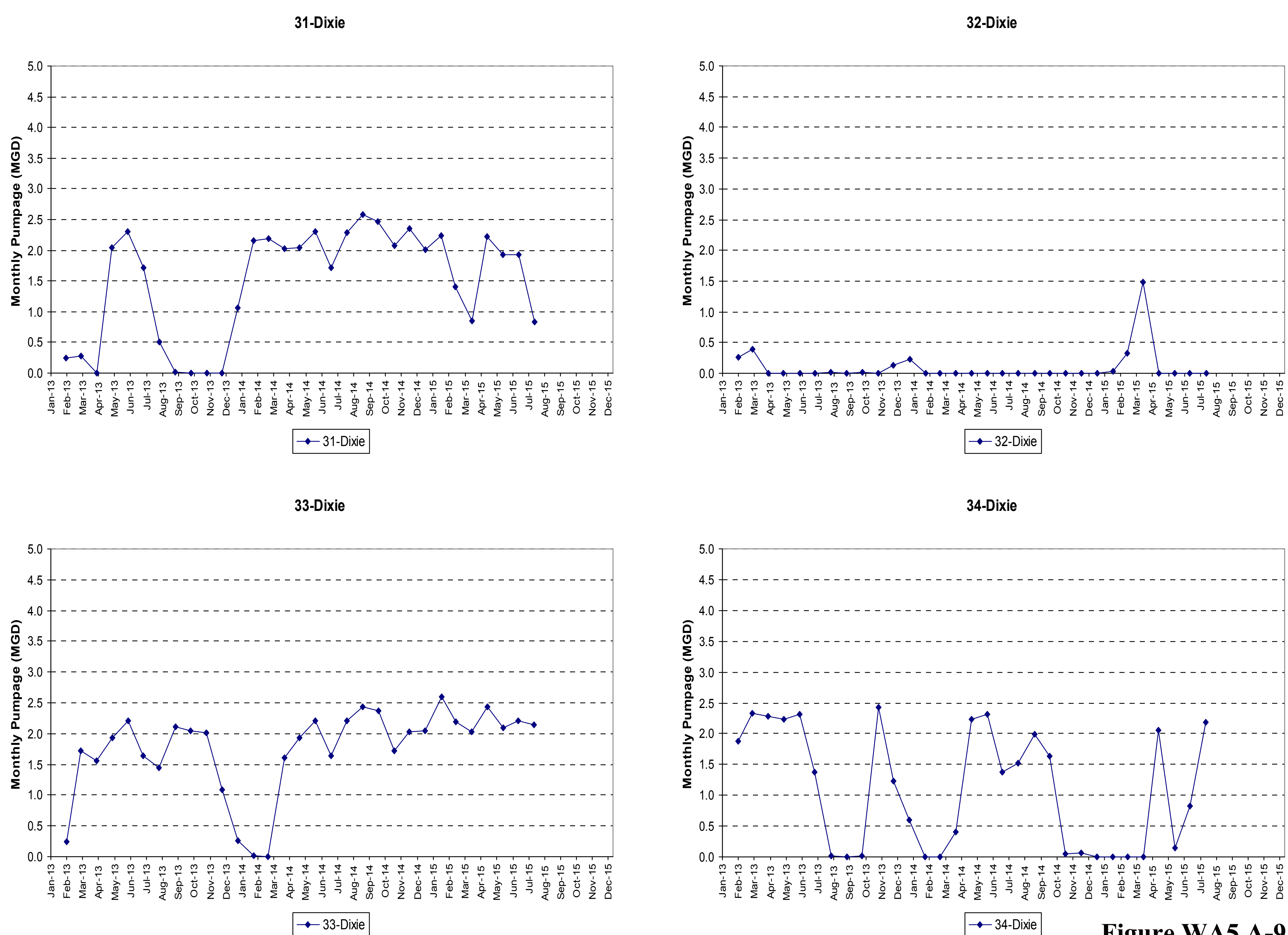

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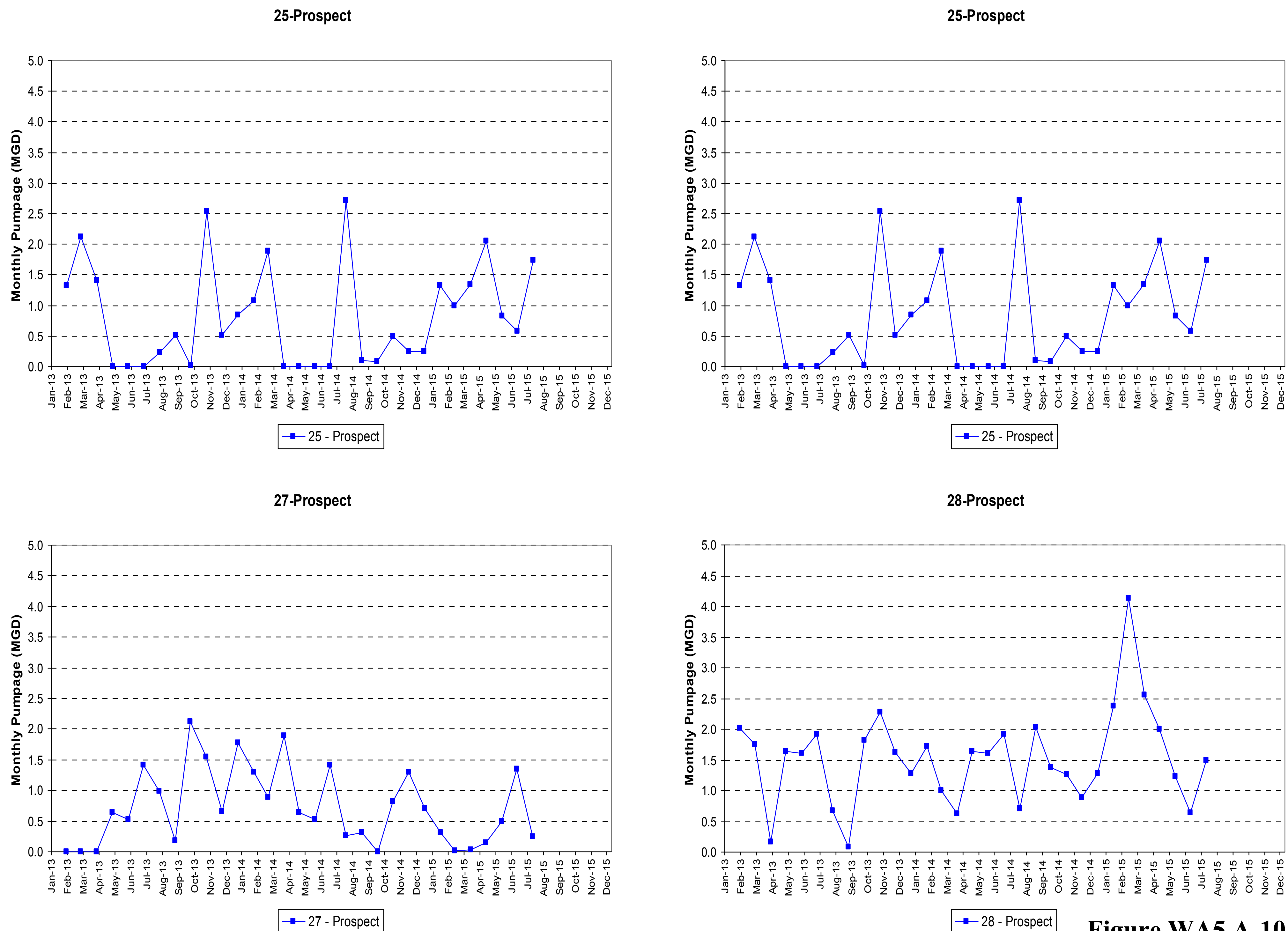
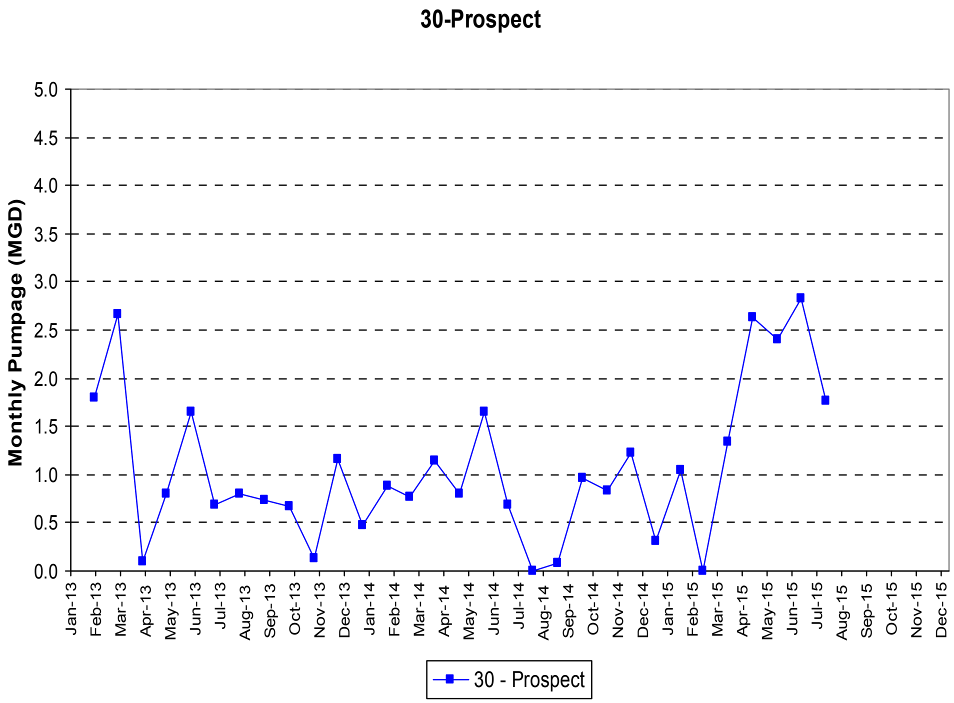
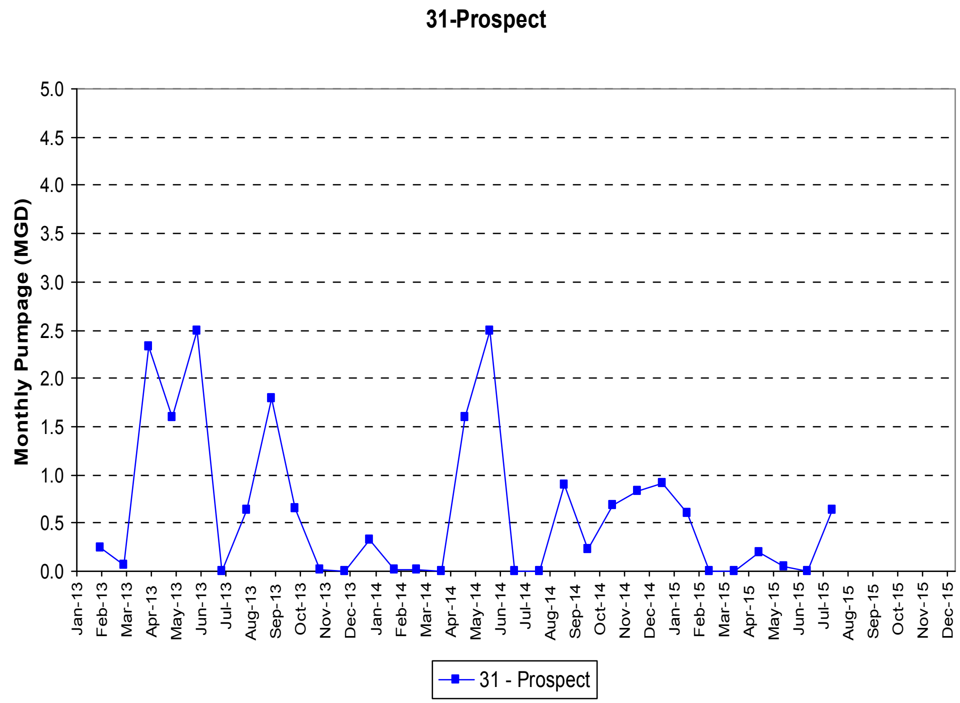
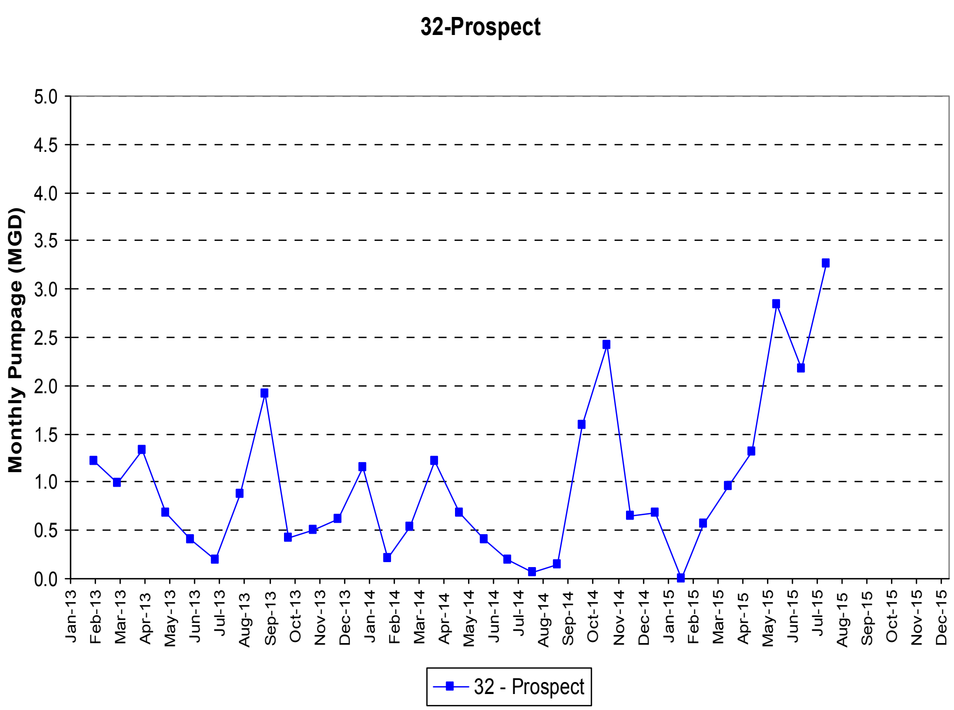


Figure WA5.A-10







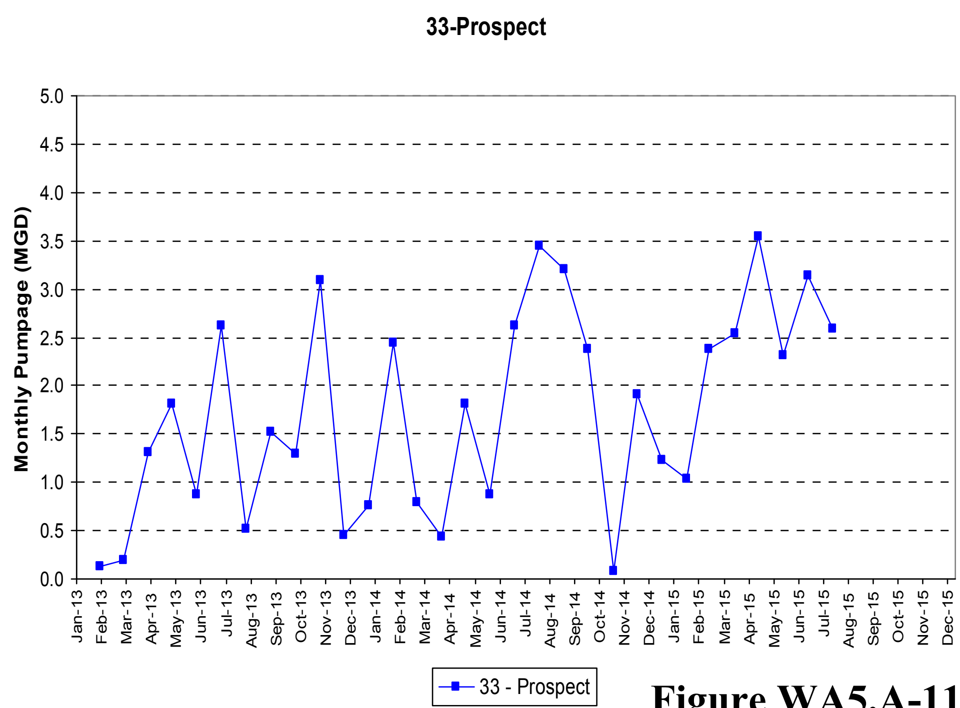
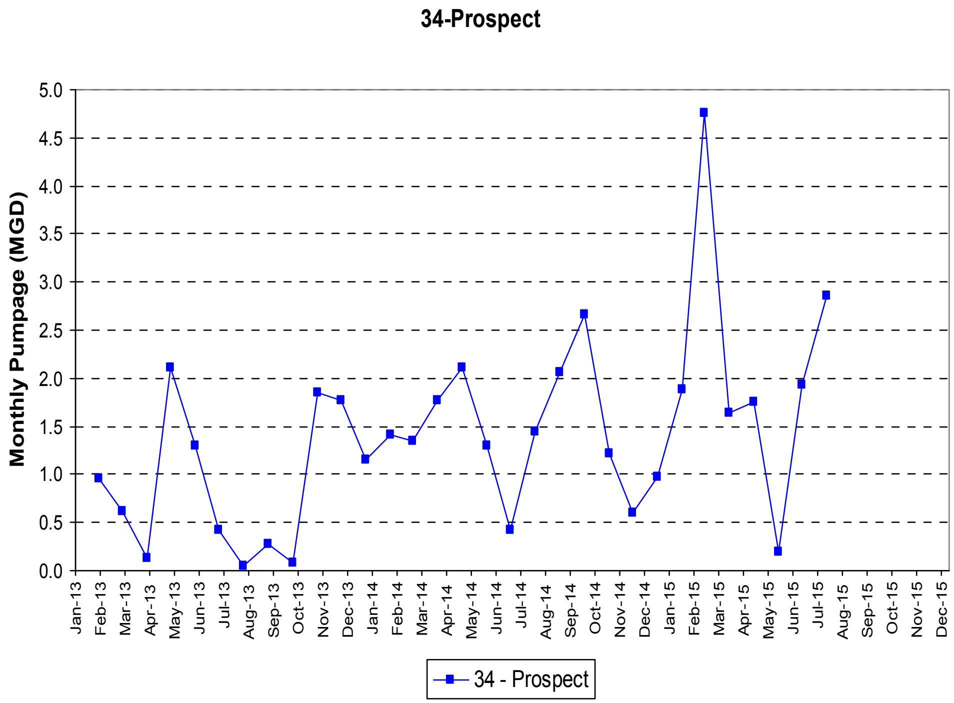
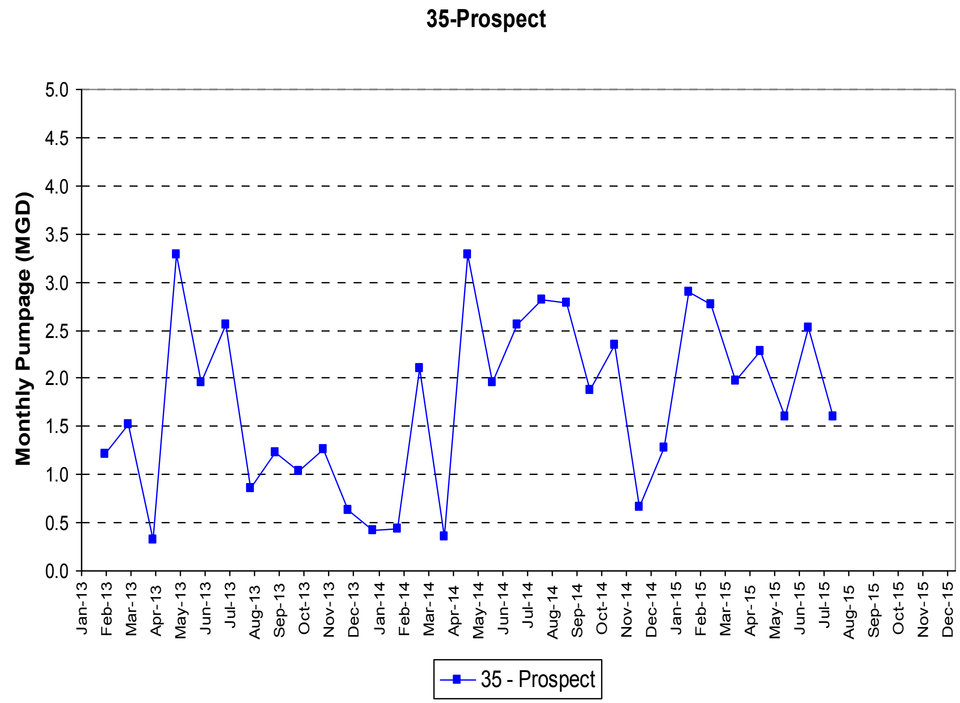
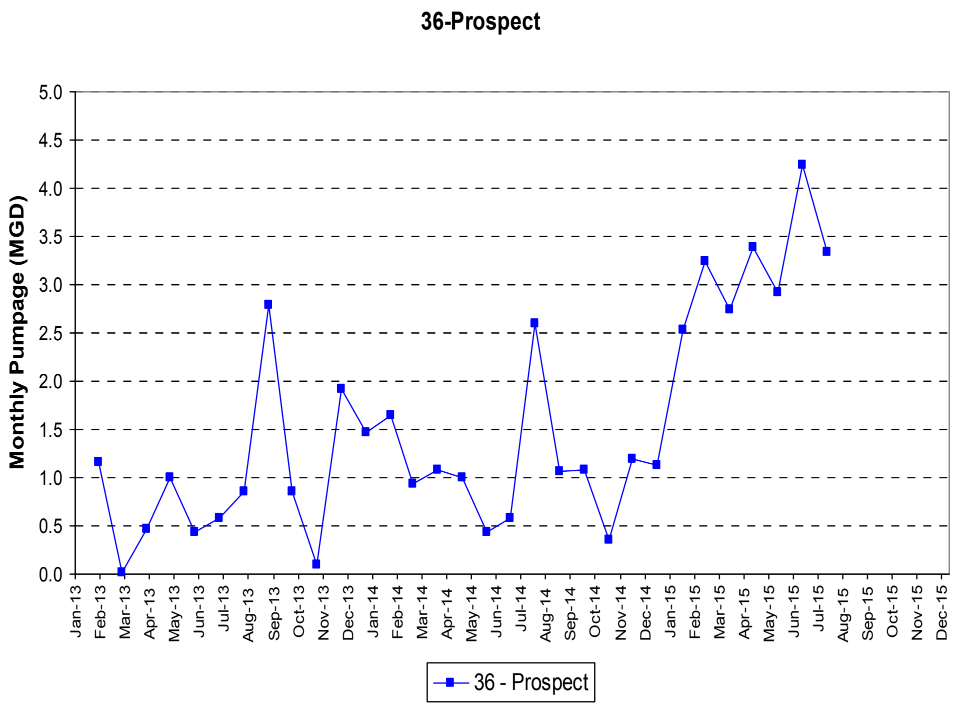


Figure WA5.A-11







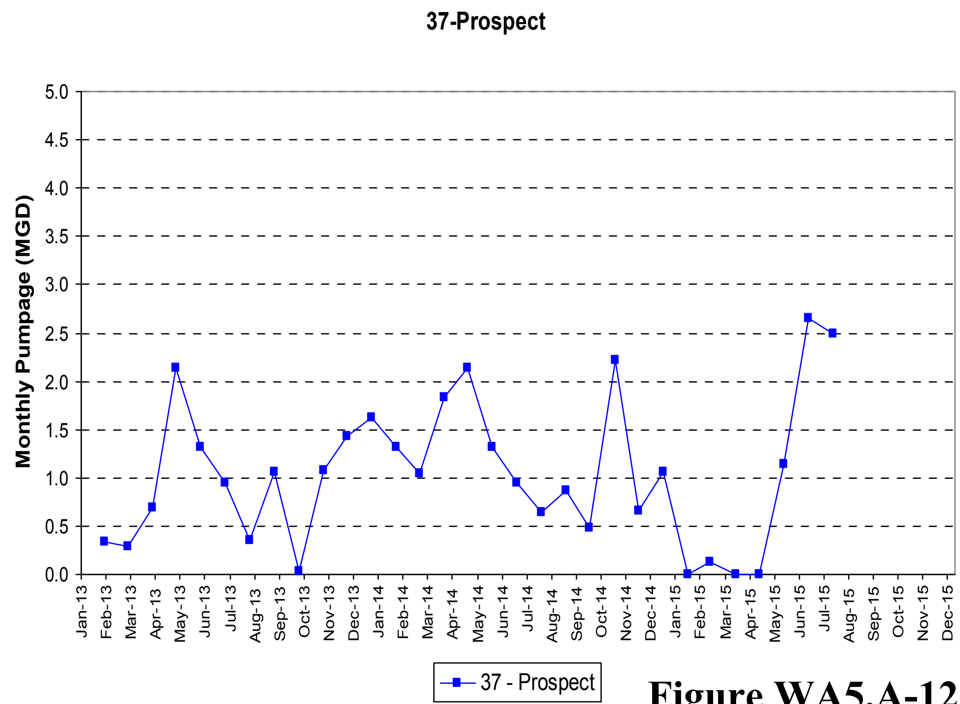
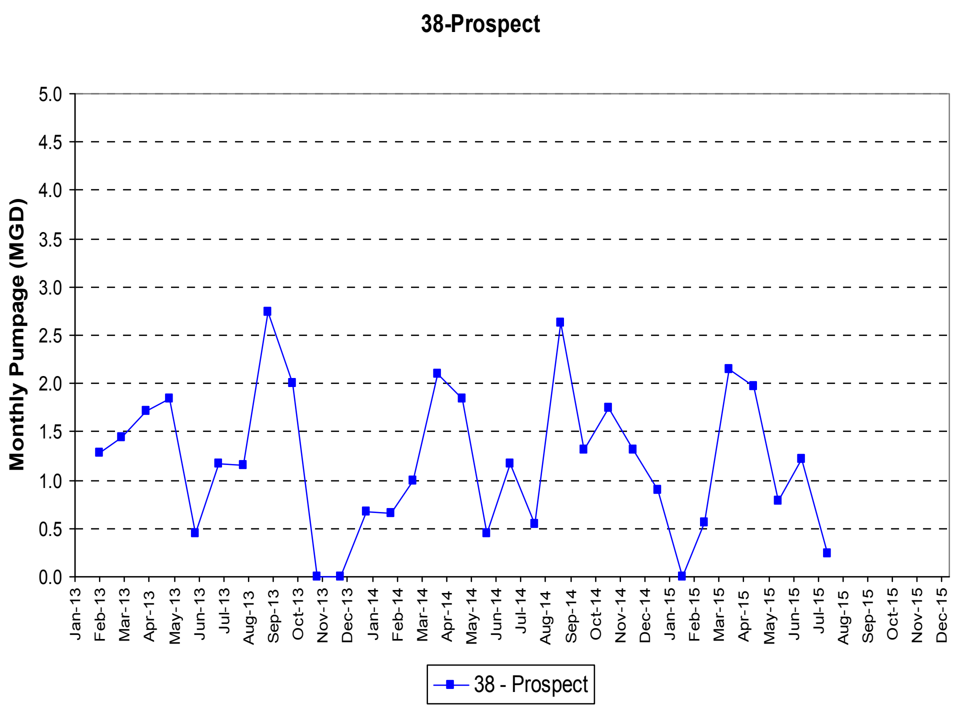
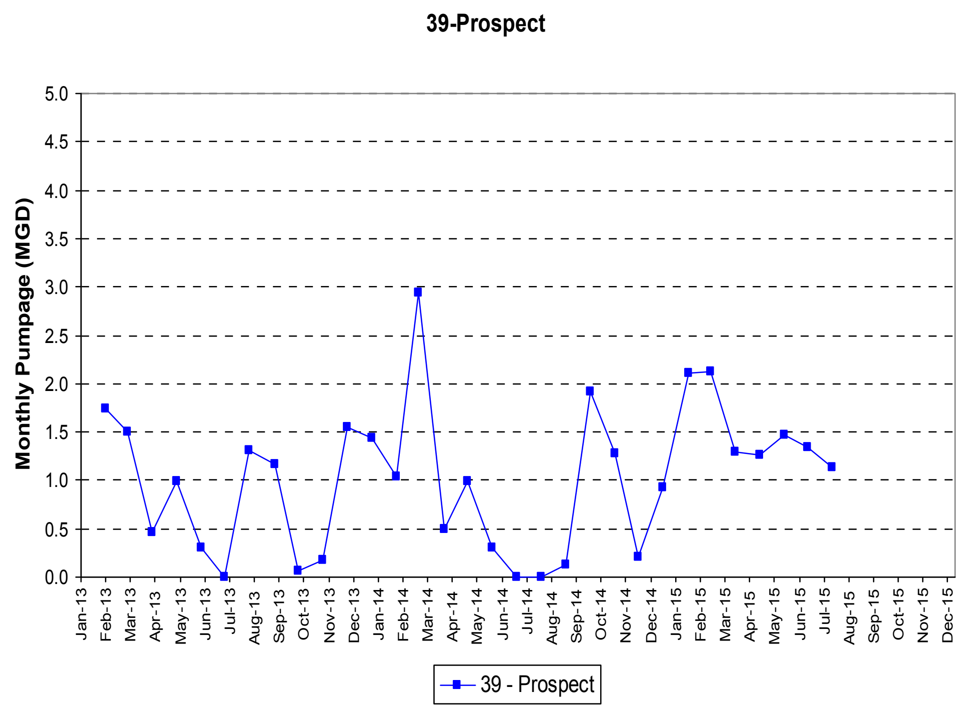
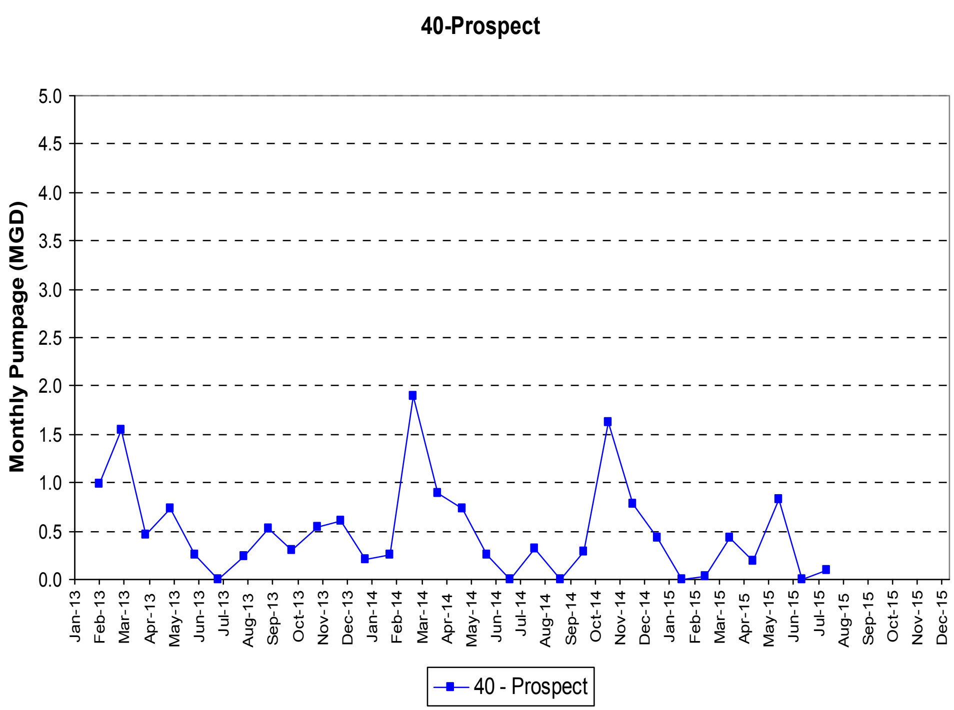


Figure WA5.A-12







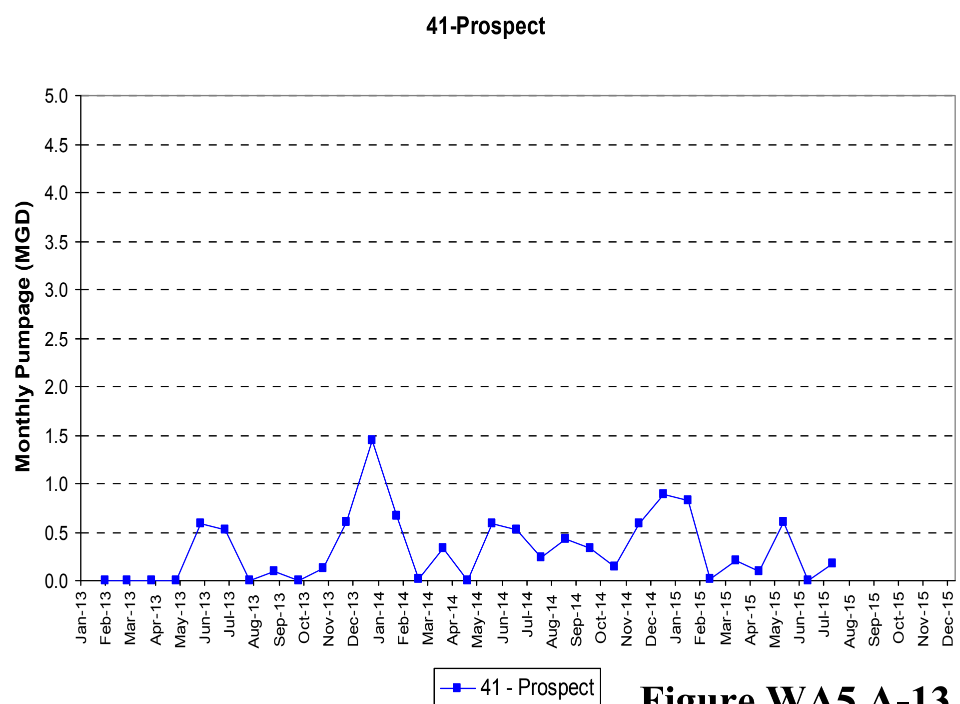


Figure WA5.A-13

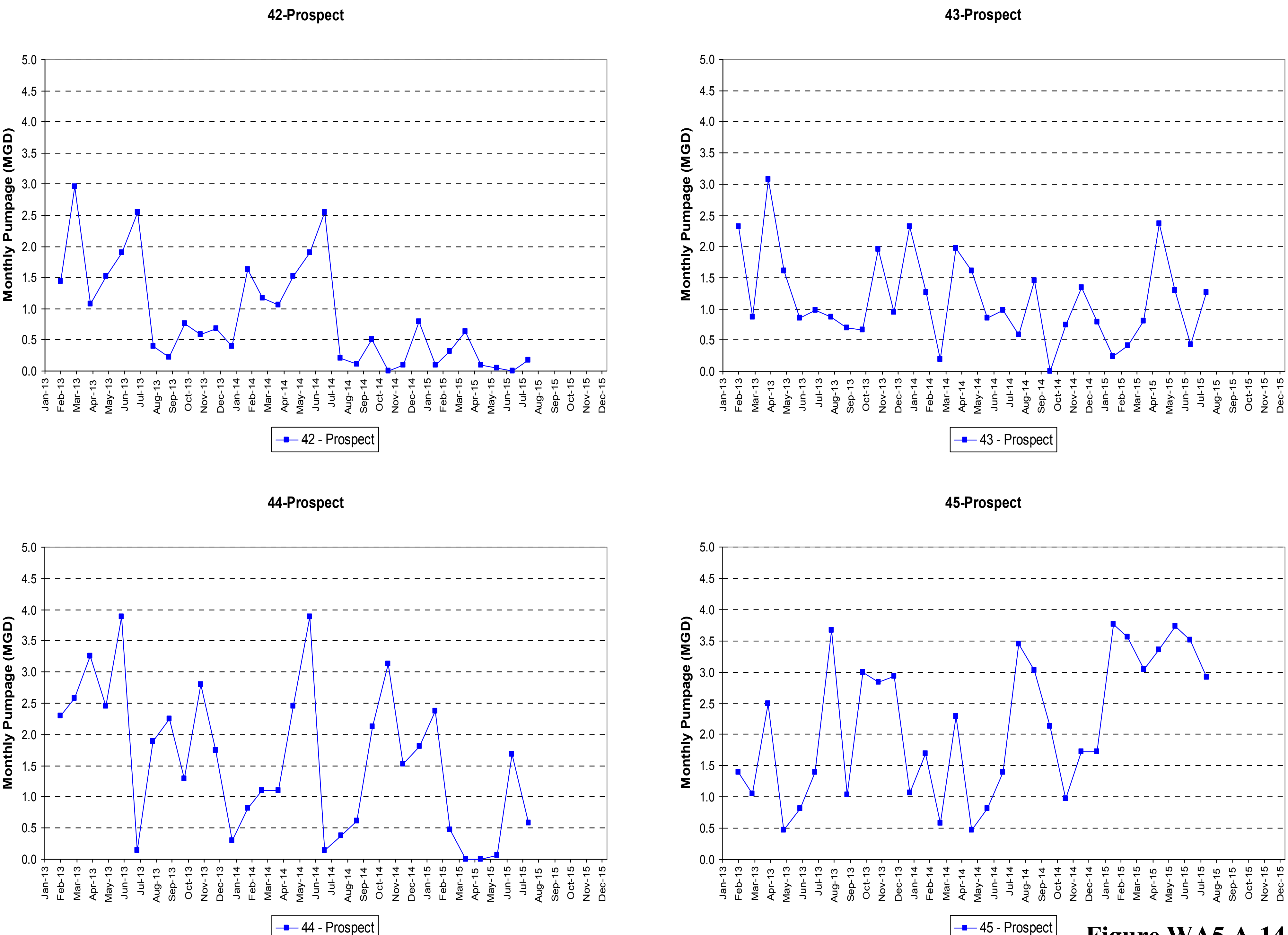


Figure WA5.A-14

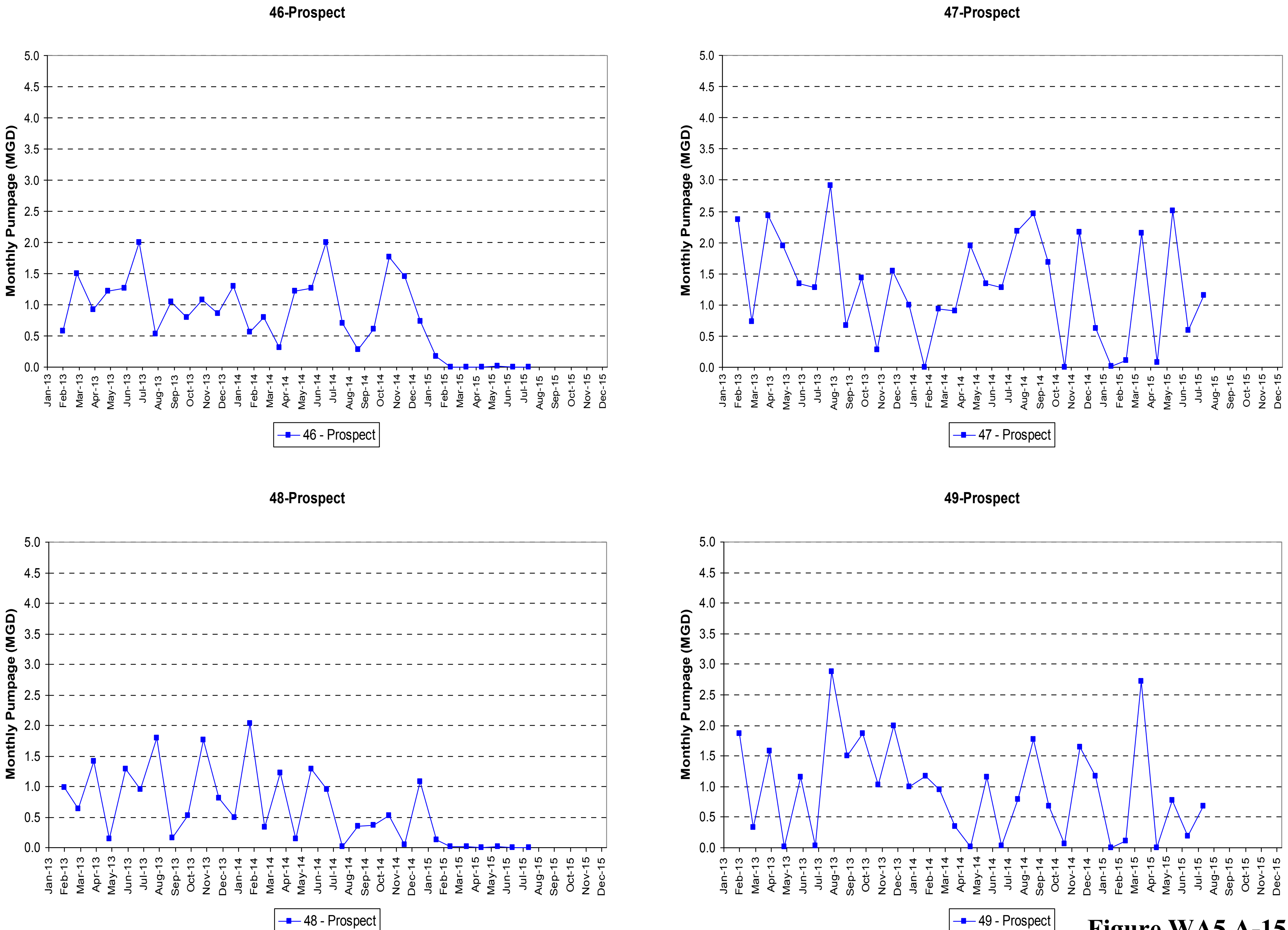
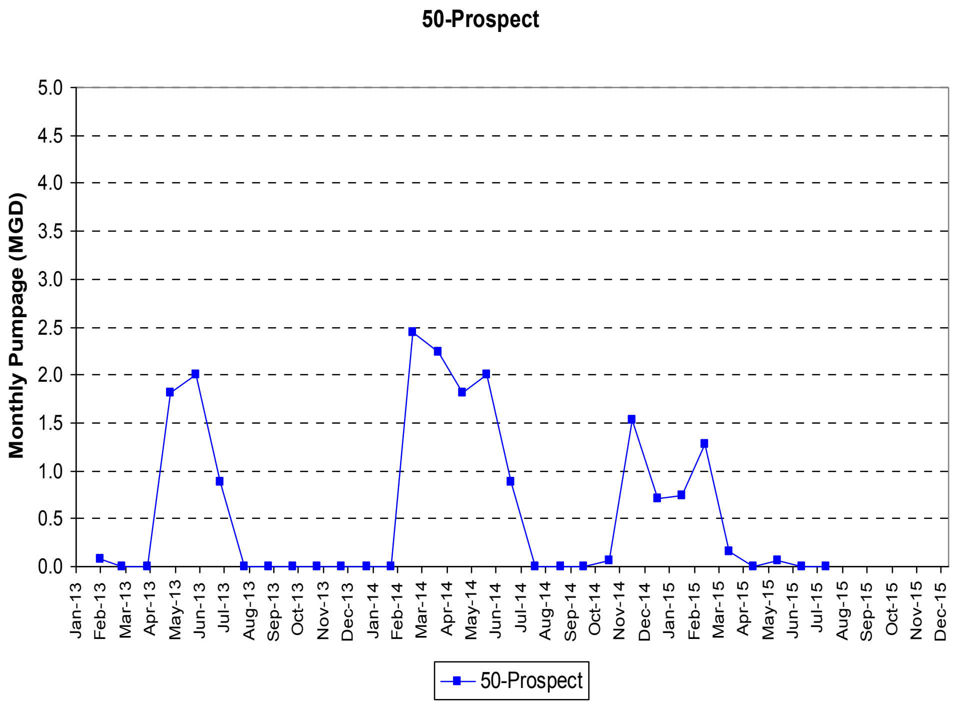
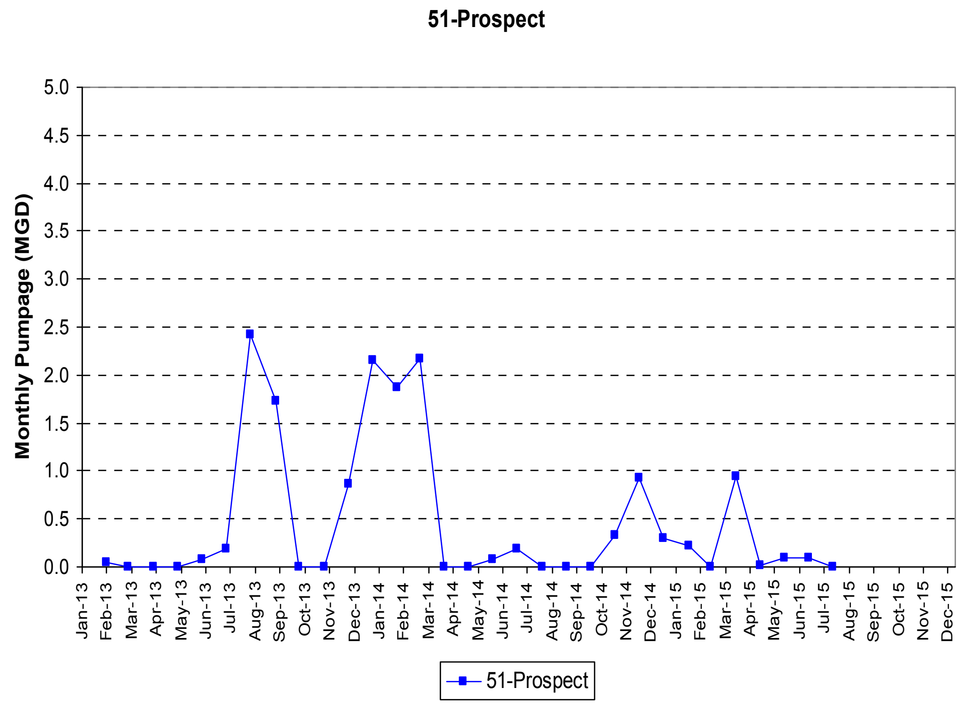


Figure WA5.A-15





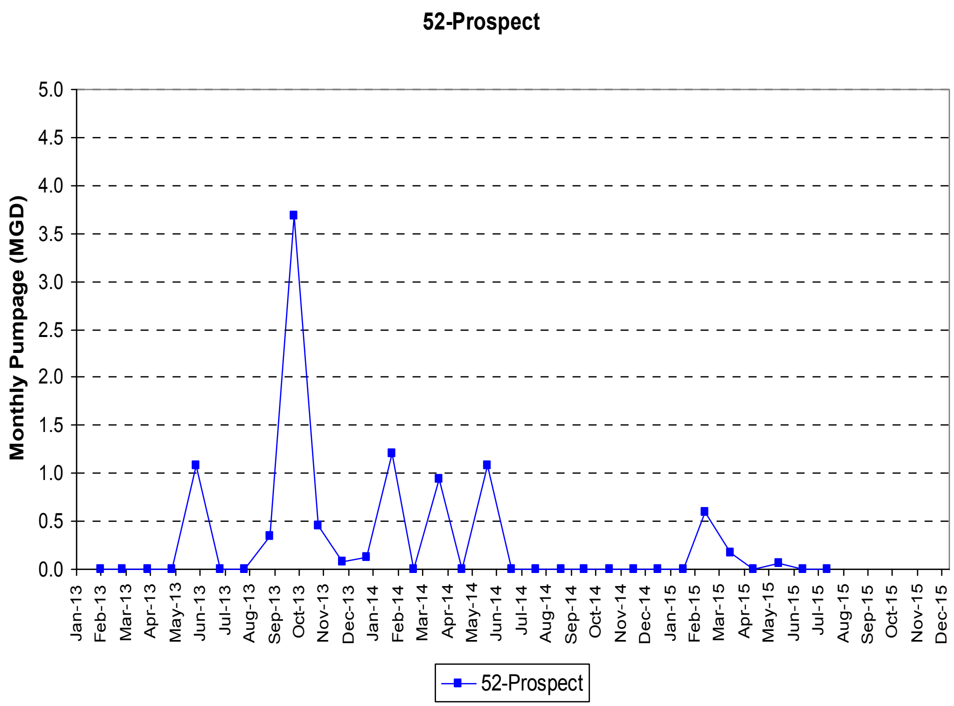
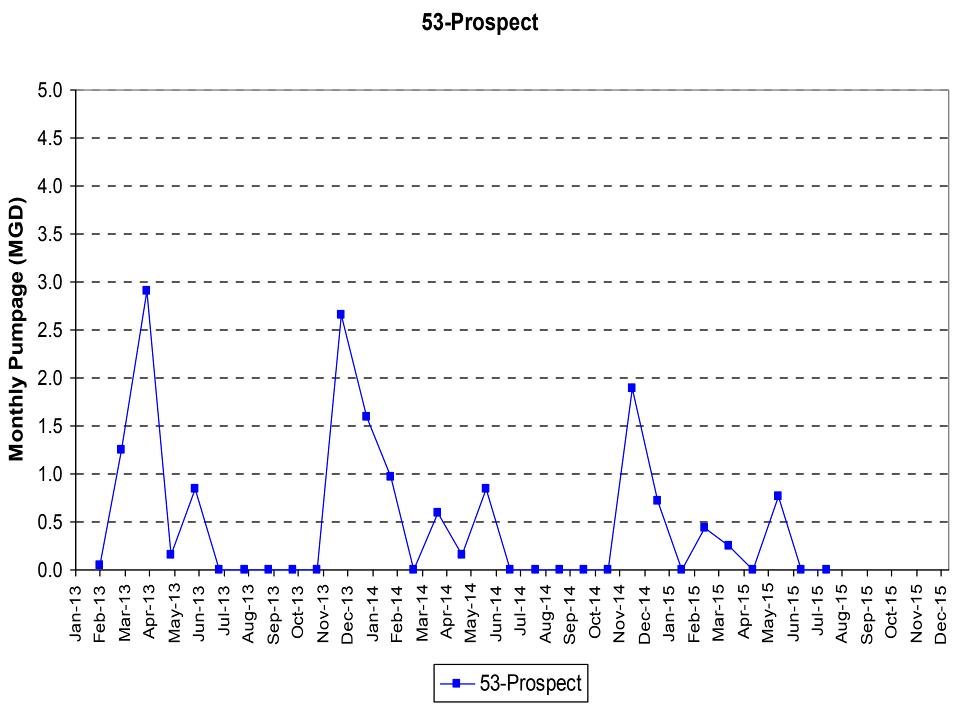


Figure WA5.A-16



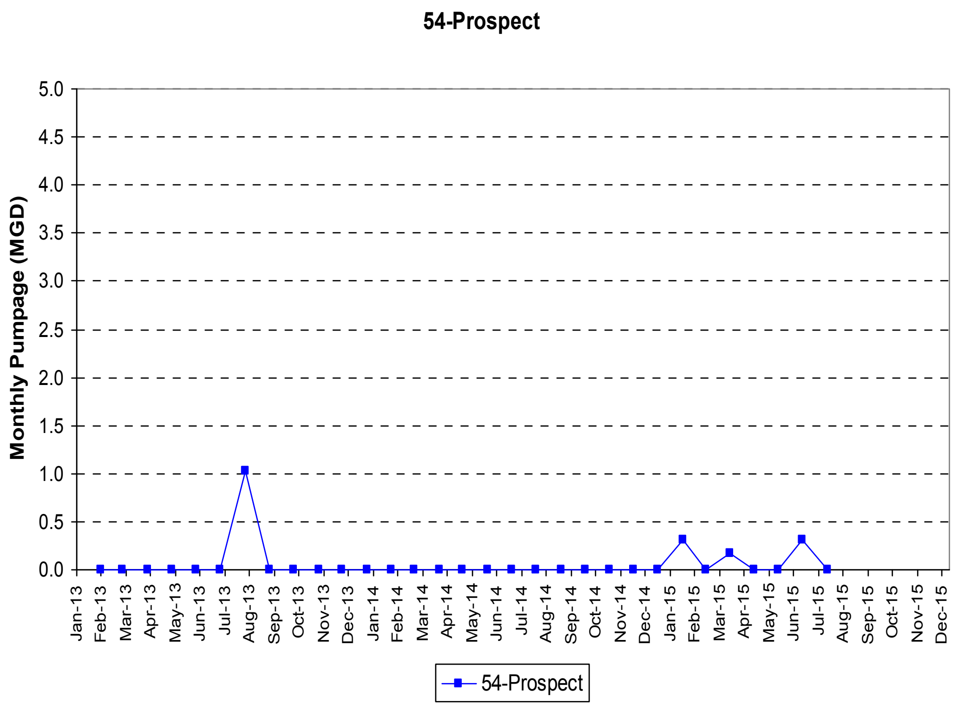


Figure WA5.A-17

5.A.8.1 Field Observations

Prospect Wellfield (Fiveash WTP):
Observations from the September 17, 2015 wellfield site investigation for the Prospect Wellfield are summarized below:

- The wellhead pressure gauge is missing or not working at wells 35, 34, 49, and 28.
- The vertical turbine pump shaft packing is leaking at wells 45, 26, 34 33, 35, 51.
- The wellhead check valve is leaking at wells 25, 33, 35.
- The concrete well pad is cracked at wells 41, 27, 26, 34, 32, 35.
- Well 41, the electrical conduit to the vertical turbine pump is not sealed at the pad.
- Well 39, the steel mesh on the air release line is separated from the pipe.
- Wellhead/water main pressure ranged between 6 psi (Well 53) and 29 psi (Well 26).
- The digital water level displays were operational at wells 53, 52, 54, 27, 26, 33, 35, 51.
- The digital water level displays were not operational at all other Prospect Wells.
- The local pressure transducer/digital water level display readings varied widely including some out of range values.
- The water level pressure transducers are strapped to the vertical turbine column pipe and not installed into stilling wells.
- Flowmeters and digital flowmeter displays appear to be in good condition and operational at all 29 well sites.
- Wellhead and discharge piping at all 29 well sites exhibit varying degrees of rusting.
- Heavy rusting and pitting of the well casing is seen at wells 37, 36, 46, 41, 28, 42, 27, 25, 26, 34, 33, 30.
- Moderate rusting and pitting of the well casing is seen at wells 40, 31, 49, 35, 51.
- Minor rusting and pitting of the well casing is seen at wells 45, 47, 48, 53, 52, 50, 54, 44, 32.
- City staff have reconditioned the exposed steel casing at wells 38, 39, 44. Reconditioning included wrapping and welding the existing well casing to a new steel outer casing and the top flange to support the pump and motor. The base of the new steel casing does not touch the concrete pad, but was sealed with hydraulic cement at wells 38 and 39 to prevent moisture from getting between the original steel well casing and new steel sleeve.
- All well pumps are 100 horsepower (hp), 3 stage vertical turbine pumps.
- Pump performance curves for Prospect Wellfield vertical turbine pumps and water level/drawdown data from the individual wells are not available for review.

Dixie Wellfield (Peele-Dixie WTP):
Observations from the September 17, 2015 wellfield site investigation for the Dixie Wellfield are summarized below:

- Well 28, wellhead pressure gauge not working.
- Well 32, has leaking flow control valve.
- Wellhead/water main pressure ranged between 65 psi (Well 30) and 84 psi (Well 31).
- Water level pressure transducer display at well 31 is not operational.
- Water level pressure transducer readings were highly varied.
    - Static water levels ranged between -68.85-feet (Well 30) and 2.95-feet (Well 28).
    - Pumping water levels ranged between -62.89-feet (Well 34) and 15.88-feet (Well 33).
- The water level pressure transducers are installed into stilling wells.

- The wellhead and discharge piping at all 8 well sites has minor paint chipping and visible rust.
- All eight (8) Dixie WF production wells are equipped with submersible pumps. Wells 28, 29, 30, 31, 32, 33 and 34 have 100 hp pumps and well 27 has a 75 hp pump.
- Dixie Wellfield submersible well pumps were performing sufficiently and the City maintains pump performance curves for each.

5.A.8.2 Summary and Recommendations

5.A.8.2.1 Maintenance

Many of the observations made during the September 17, 2015 wellfield site visit can be addressed by City staff on a continual basis. Currently, City maintenance staff replace gauges, address leaking wellhead fittings and valves, perform pump maintenance and removal, and replace water level data loggers as needed. City maintenance staff should continue to perform their scheduled facility maintenance. In addition to the City's current maintenance schedule, it is recommended these additional items are addressed:

Prospect Wellfield (Fiveash WTP):

1. Install and routinely replace the desiccant dryer cartridges on ALL level transducers.
2. Replace the data logger pressure transducers that are no longer working.
3. Replace nonfunctional water level displays.
4. Install vertical water level ports, with 1-inch PVC drop tubing in the annulus in all wells for pressure transducer data logger installation. This will minimize damage to data loggers, provide for more accurate water level data, and facilitate easy maintenance.
5. Re-establish all level transmitters depths to well pad and confirm elevations with the SCADA system reading at the Fiveash WTP.

Dixie Wellfield (Peele-Dixie WTP):

1. Install vertical water level ports, with 1-inch PVC tubing dropped in the annulus in all wells for measuring manual water levels.
2. Install and routinely replace the desiccant dryer cartridges on ALL level transducers.
3. Replace the data logger pressure transducers that are no longer working.
4. Replace nonfunctional water level displays.
5. Re-establish all level transmitters depths to well pad and confirm elevations with the SCADA system reading at the Peele-Dixie WTP.

5.A.8.2.2 Improvements:

The eight Dixie Wellfield production wells that supply the Peele-Dixie Membrane WTP were constructed in the early 2000's out of corrosion resistant PVC well casing. The twenty-nine production wells at the Prospect Wellfield that supply the Fiveash lime softening WTP were constructed between 1969 and 1999 out of steel well casing.

Based upon the September 2015 wellfield site visit, it appears the Prospect Wellfield wells are in greater need of infrastructure improvements than the Dixie Wellfield wells due to well ages, wellhead designs, and out of service equipment. A breakdown of the Prospect Wellfield and Dixie Wellfield well ages is summarized below:

5.A.8.2.3 Newer Wells (less than 20 years old)

Of the 37 in service production wells, all eight of the Dixie Wellfield wells are less than 20 years old while only seven of the twenty-nine Prospect Wellfield production wells (48, 49, 50, 51, 52, 53, and 54) were constructed within the last 20 years. All Dixie production wells consist of 24-inch diameter PVC casing with open-hole completion. The Prospect production wells consist of 18-inch diameter steel well casings. Over time, steel casing tends to corrode, whereas PVC casing is essentially inert, with life expectancy of PVC wells on the order of fifty years. Absence of corrosion in PVC-cased wells makes them preferable for membrane filtration WTPs.

5.A.8.2.4 Intermediate Age Wells (20-30 years old)

Five of the Prospect (43, 44, 45, 46, 47) production wells, constructed between 27 and 30 years ago, consist of corrosion-prone steel casings.

5.A.8.2.5 Older Wells (30-46 years old)

Seventeen of the Prospect production wells (25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, and 42) range in age between 35 and 46 years. Well failure in older wells is typically due to failure of the casing and/or the cement seal, which causes sand and silt production. Leaky casings may also contribute to undesirable chemical and biological characteristics of the produced water. Steel well casings are dissolved by corrosion over time depending on the corrosiveness of the water and oxygen introduced by the well pumping system. A steel cased well can have a life expectancy of 50 years; however, steel wells that are in the 20 to 30-year age frequently need to be replaced due to casing and/or cementing failures.

5.A.8.2.6 Wellheads

The visible part of the well includes the surface casing, wellhead, piping, electrical conduits, control panels, telemetry communications tower, and security fencing. Wellheads at the Dixie Wellfield, constructed within the past 20 years, appeared in better condition than Prospect wellheads. Dixie wells include durable control panel enclosures, and modern well pump control equipment. While these materials come at a somewhat higher cost, they contribute to the greater well reliability. These materials are typically specified for wells that feed membrane WTPs.

Most Prospect wellheads are outdated, consisting solely of the final steel well casing and flange, which is attached to and supports the vertical turbine well pumps. The typical Prospect wellhead design places the pump weight and stress directly onto the well casing, which promotes corrosion where exposed to the atmosphere. City maintenance personnel have patched and reinforced the aboveground wellhead/well casing at wells 38, 39, and 44 due to excessive corrosion. As older wells are repaired, reconstructed, and if necessary replaced, the wellheads also need to be upgraded consistent with a standard wellhead design.

5.A.8.2.7 Wellfield Testing Plan

In addition to the physical state of the aboveground equipment at each well site, the City monitors individual well performance with a recently installed SCADA historian that tracks water levels. The City now has the monitoring equipment to perform a comprehensive wellfield testing program at both the Dixie and Prospect Wellfields and plans to evaluate individual pump and well performance.

Comprehensive Wellfield Testing includes:

- pump performance testing with respect to wire-to-water efficiency;
- comparison of field performance with certified pump curve data for each well pump & motor to evaluate potential discrepancies;

- SCADA system data evaluation, involving comparison with manual water level measurements from each well during testing, which include pumping and static water levels, and specific capacity calculations;
- field water quality testing; and
- visual observations during routine operations.

Comprehensive wellfield testing including video surveys will identify underperforming wells that may need rehabilitation in both wellfields, and for the Prospect Wellfield, will identify and prioritize the replacement of older wells. Water quality varies from well to well and wells producing higher color water should be replaced first. A hydrogeologic survey/evaluation of the wellfield is necessary to identify areas of higher water quality (lower color).

5.A.8.2.8 Well Replacement Plan

Following wellfield testing and prioritizing and targeting wells for either rehabilitation or replacement, City staff can design and implement a strategic and comprehensive capital expenditure budget. Based on the results of recommended comprehensive testing, it is anticipated to consist of the following:

1. Wells that are 30 years old or older (wells 25, 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44) should be properly abandoned. Four wells should be replaced per year at a cost of approximately $450,000 per replacement well facility (2015 dollars). Construction of replacement wells should commence in 2017 and be completed by 2022.

2. Prospect wells less than 30 years old (10 wells) should be replaced at a rate of two per year beginning 2022. Specific wells to be replaced will depend upon age and results of performance testing. The specific replacement/rehabilitation approach will be site specific and may include: over drilling the existing well; replacement at a nearby location or installation of a non-ferrous liner. For budgeting the cost of $450,000 (2015 dollars) per well per year is recommended.

5.A.8.2.9 Well Rehabilitation

Well maintenance budgeting should include additional funding for:

- well rehabilitation work on wells that are greater than 30 years old (prior to replacement);
- maintaining pumps and motors; and
- replacement of mechanical and electrical components before failure renders the well facility inoperable.

Estimated costs for well rehabilitation are approximately $148,000 per year ($4,000/year per well).

5.A.8.2.10 Planning Level Cost Estimate

Planning level cost estimates of the proposed wellfield testing, well replacement schedule, and well rehabilitations are summarized below in **Table WA5.A-5**.

Table WA5.A-5. Planning Level Cost Estimates, Well Replacement Schedule, and Well Rehabilitations

Item	Priority	Cost Estimate	Year
Comprehensive Wellfield Testing for twenty-nine Biscayne Aquifer wells located in the Prospect Wellfield.	**HIGH**	**$58,000**	**2016**
Comprehensive Wellfield Testing for eight Biscayne Aquifer wells located in the Dixie Wellfield.	**HIGH**	**$16,000**	**2016**
Replacement of Wells >30 yr. Old. (4/Yr.)	**HIGH**	**$1,800,000**	**2017-2022**
Replacement of Wells <30 yr. Old (2/Yr.)	**LOW**	**$900,000**	**2023-2026**
Well Rehabilitation	**HIGH**	**$148,000**	**2016-2026**
Total		**$2,922,000 Per Year**	

5.A.9 Saline Intrusion Monitoring

The City monitors potential influence from saltwater intrusion in the Biscayne Aquifer by collecting data from 10 saltwater monitoring wells. **Figure WA5.A-18** depicts locations and identifications of these wells with respect to City wellfields, along with the May 2014 estimated location of the saline interface. Completion depths for the wells range between 200 and 270 feet below land surface (ft BLS). All wells contain casing to only five ft BLS, which enables conductivity profiling to be performed throughout the entire thickness of the aquifer penetrated by each well. **Figures WA5.A-19 through WA5.A-21** present monthly conductivity profiling results from 2013.

Saline water is considered by SFWMD and Broward County Environmental Protection Department to equate to a conductivity of approximately 1,200 micromhos per centimeter (µmhos/cm), which corresponds to an estimated dissolved chloride concentration of 250 milligrams per liter (mg/L). Accordingly, water quality results for monitoring wells MW-1 through MW-5A, and MW-7A can be considered to represent fresh water throughout the entire sampling intervals. Rapid conductivity increases to values in excess of 4,000 µmhos/cm apparent in wells MW-6A, MW-8A, and MW-9 document the location of the saline interface, consistent with the estimated 2014 location depicted in **Figure WA5.A-18**.

Conductivity profiling results for MW-10C, located within the Dixie wellfield, indicate freshwater occurs throughout the subsurface to at least 220 ft. BLS. This well represents the third different monitoring well sampled at this location during 2013. The City abandoned well MW-10A in February and constructed replacement well MW-10B in March. Faulty construction of MW-10B led to abandonment and replacement with MW-10C in July.

Results for January sampling of MW-10A indicated a conductivity of almost 2,500 µmhos/cm at 240 feet BLS. Sampling of MW-10C revealed a conductivity of 1,066 µmhos/cm at 240 feet BLS in July, but values ranging from 583 µmhos/cm in August to 693 µmhos/cm in November. These results, combined with data for nearby MW-6A and the estimated 2014 saline interface location, suggest the "toe" of the saline wedge may exist beneath the Dixie wellfield. While such saline water occurs approximately 100 feet below the production zone of the Dixie wellfield, its occurrence suggests an enhanced vulnerability to saline intrusion depending on future operations and conditions.

Section WA5A accepted January 11, 2017.

Combining historical and future monitoring of MW-10C and nearby wells, with groundwater model simulations developed specifically to address potential conditions near the Dixie wellfield, would be a prudent exercise for evaluating the vulnerability of the Dixie wellfield to saline intrusion. The most efficient approach for this evaluation would be to use the variable density groundwater model recently constructed by the USGS and Broward County. Pending results of future monitoring/modeling, it may be appropriate to install additional monitoring well(s). The most likely location for an additional saline monitoring well based on existing conditions would be to the south of the Dixie wellfield, between MW-10C and MC-6A.

In the event that future saline intrusion impacted the Dixie wellfield's ability to provide suitable raw water for the Peele-Dixie WTP, it appears that the Prospect Wellfield has sufficient capacity to provide enough water for the City to meet their 2035 demand. The current estimate of 59.1 MGD for 2035 max day finished water demand is below the reported 70 MGD design capacity of the Fiveash WTP. City staff indicated, however, that the Fiveash WTP capacity may be limited to 55 MGD. While 2013-2015 pumpage data indicate the Prospect wellfield can provide about 84 MGD, implementation of repair, maintenance, and improvements to the existing production wells as recommended above would help ensure that sufficient raw water is available to meet City demand in the event Peele-Dixie facilities became inoperable. Alternatively, the membrane process at Peele-Dixie can be modified to mitigate some of the impacts from salt water intrusion.

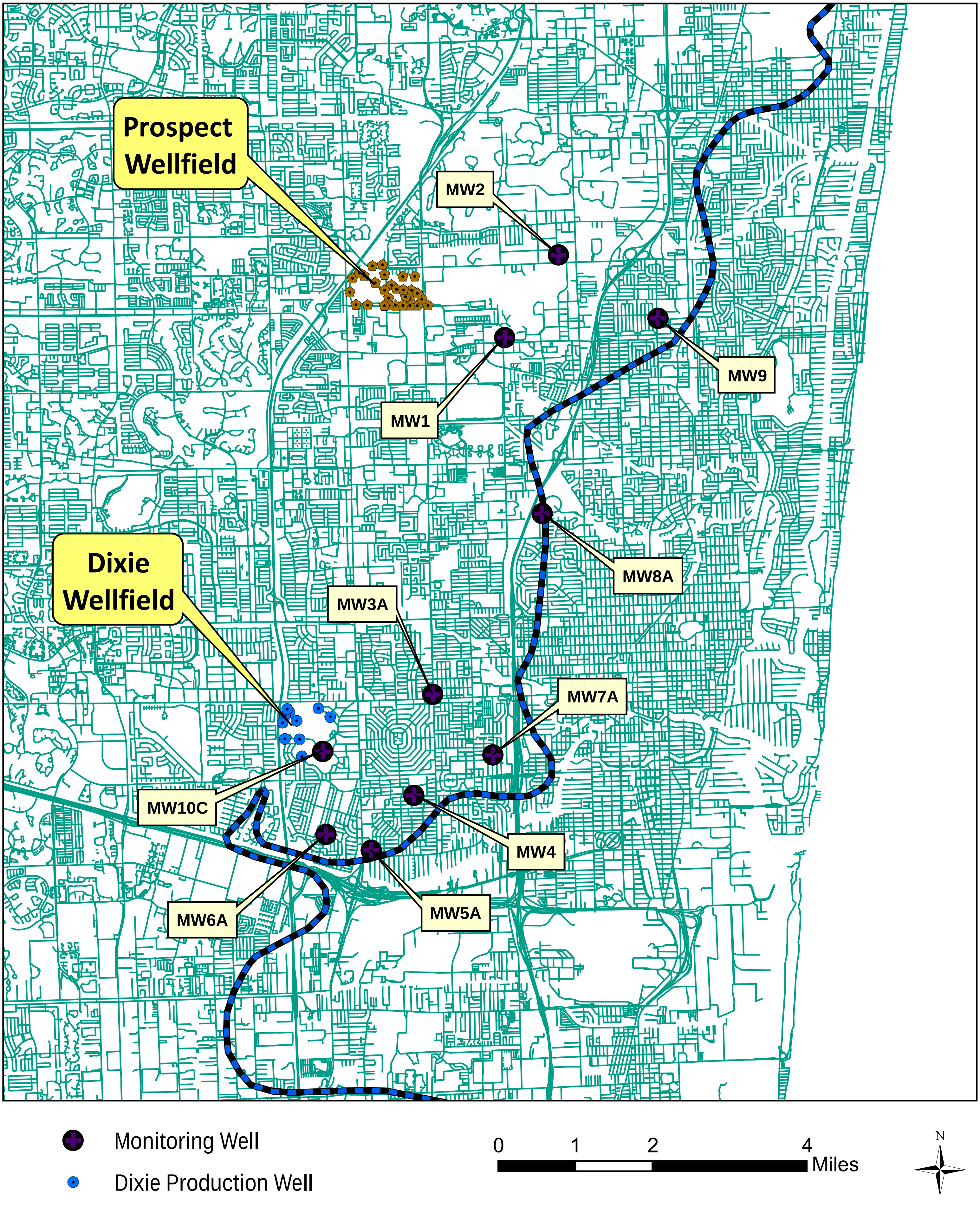
Historical pumping and saline intrusion monitoring data indicate little, if any, potential for adverse impacts from movement of the salt water front, particularly in the near term (years to a decade or more). Significant uncertainty exists, however, regarding the potential for long term adverse impacts from saline intrusion. The primary source of uncertainty reflects difficulty in projecting rates of sea level rise. As described above, a prudent approach to assess the potential for long term impacts from saline intrusion includes a combination of ongoing monitoring and variable density groundwater modeling. Pending the outcome of ongoing monitoring and the modeling analysis, it may be recommended to perform subsurface testing and construct additional monitoring wells. Accordingly, recommended improvements to City operations pertaining to saline intrusion, along with associated planning level costs, include the following:

- Short term - Continued monitoring coupled with variable density modeling simulations of City wellfield conditions (Estimated modeling costs = $75,000 - $100,000)
- Long term - Test well profiling and installation of additional saline monitoring well (Estimated costs = $150,000 - $200,000 per well).

Additional information pertaining to these recommended projects are included in the Community Investment Plan (CIP) presented in **Section WA7-Water CIP**.

5.A.10 Water System Electrical Improvements

For a complete analysis of the water system's electrical, instrumentation and control needs, please refer to **Section UW3** of the CUS Master Plan.



Saline Monitoring Wells

Figure WA5.A-18

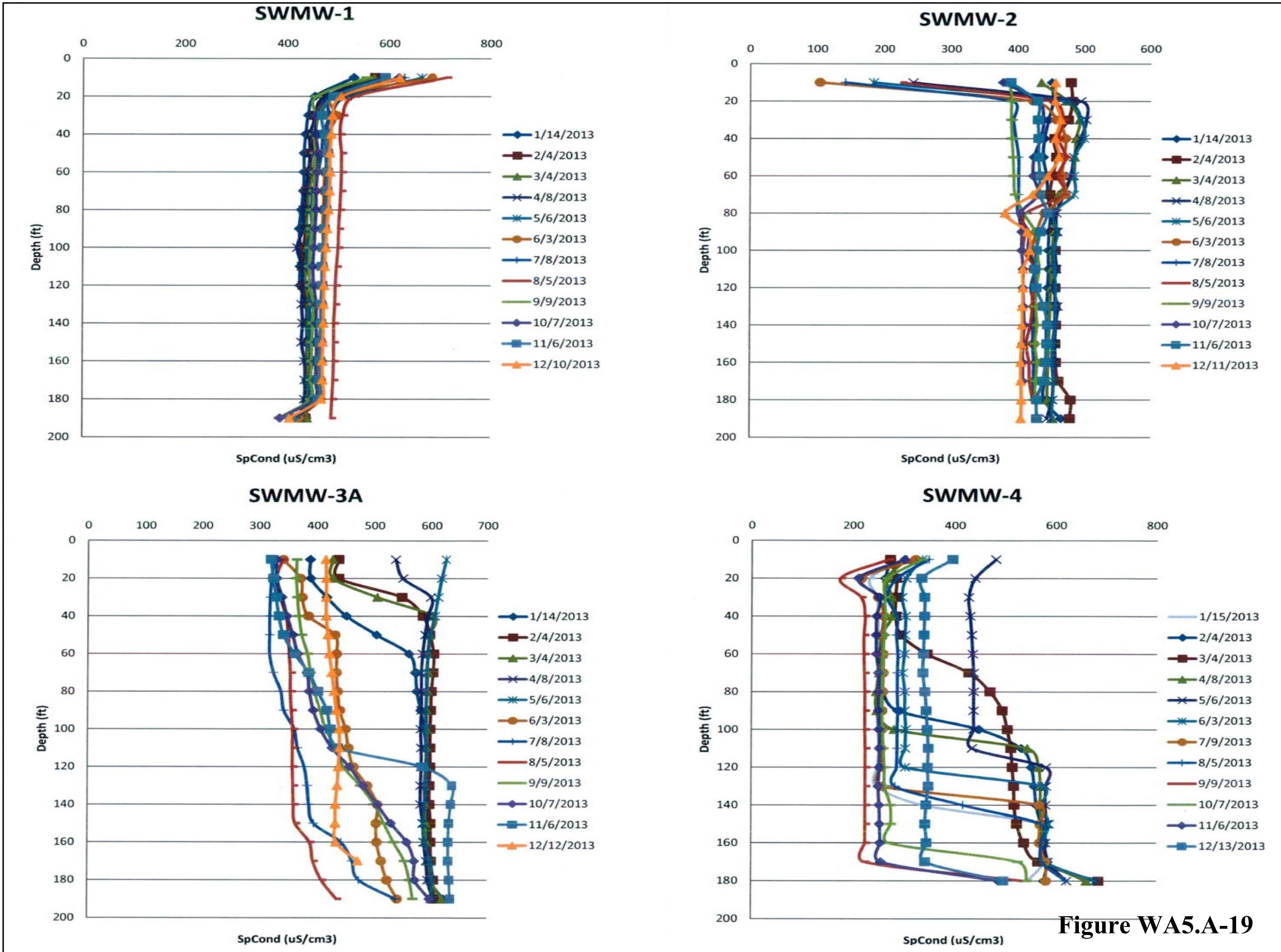


Figure WA5.A-19

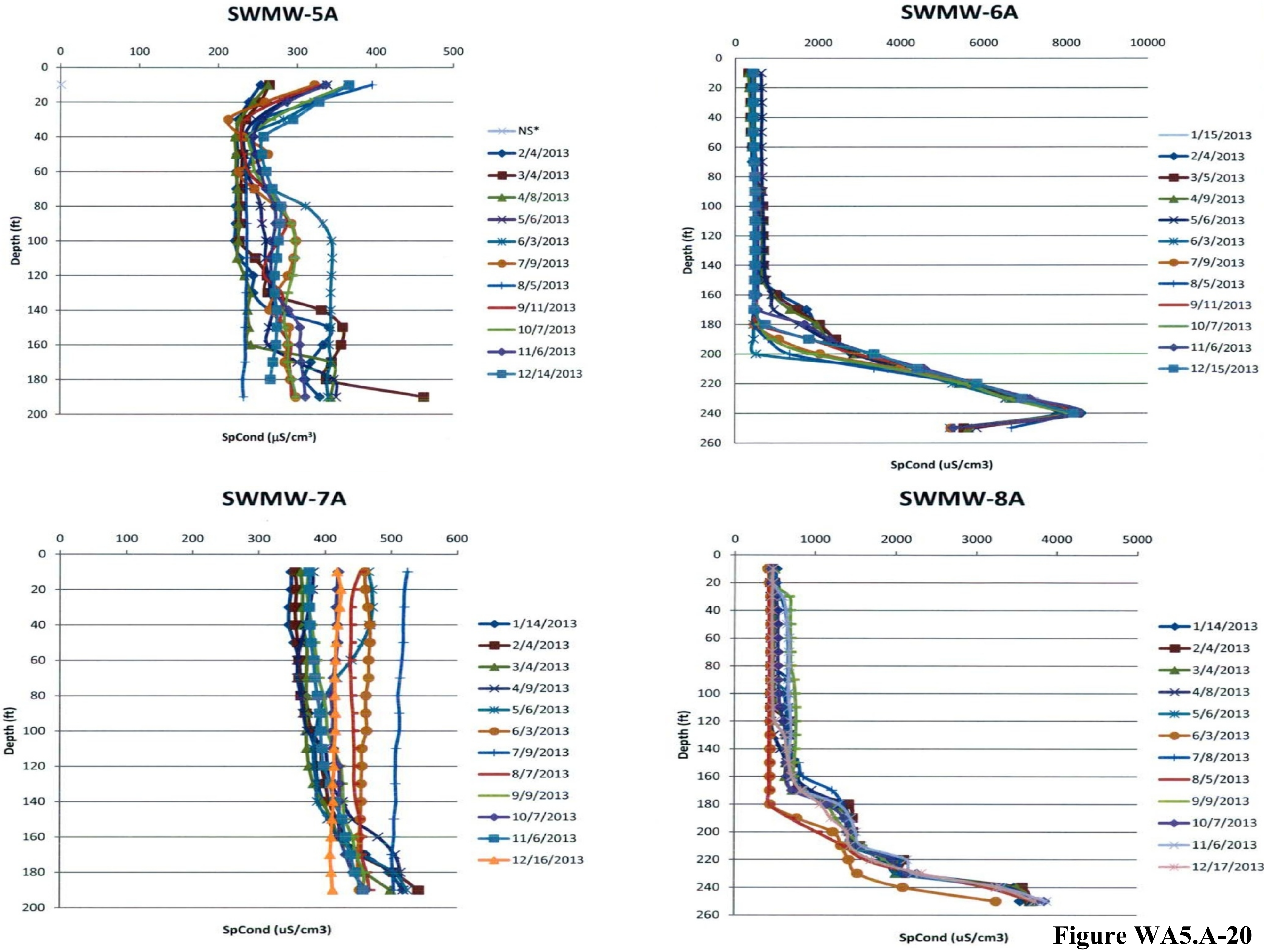
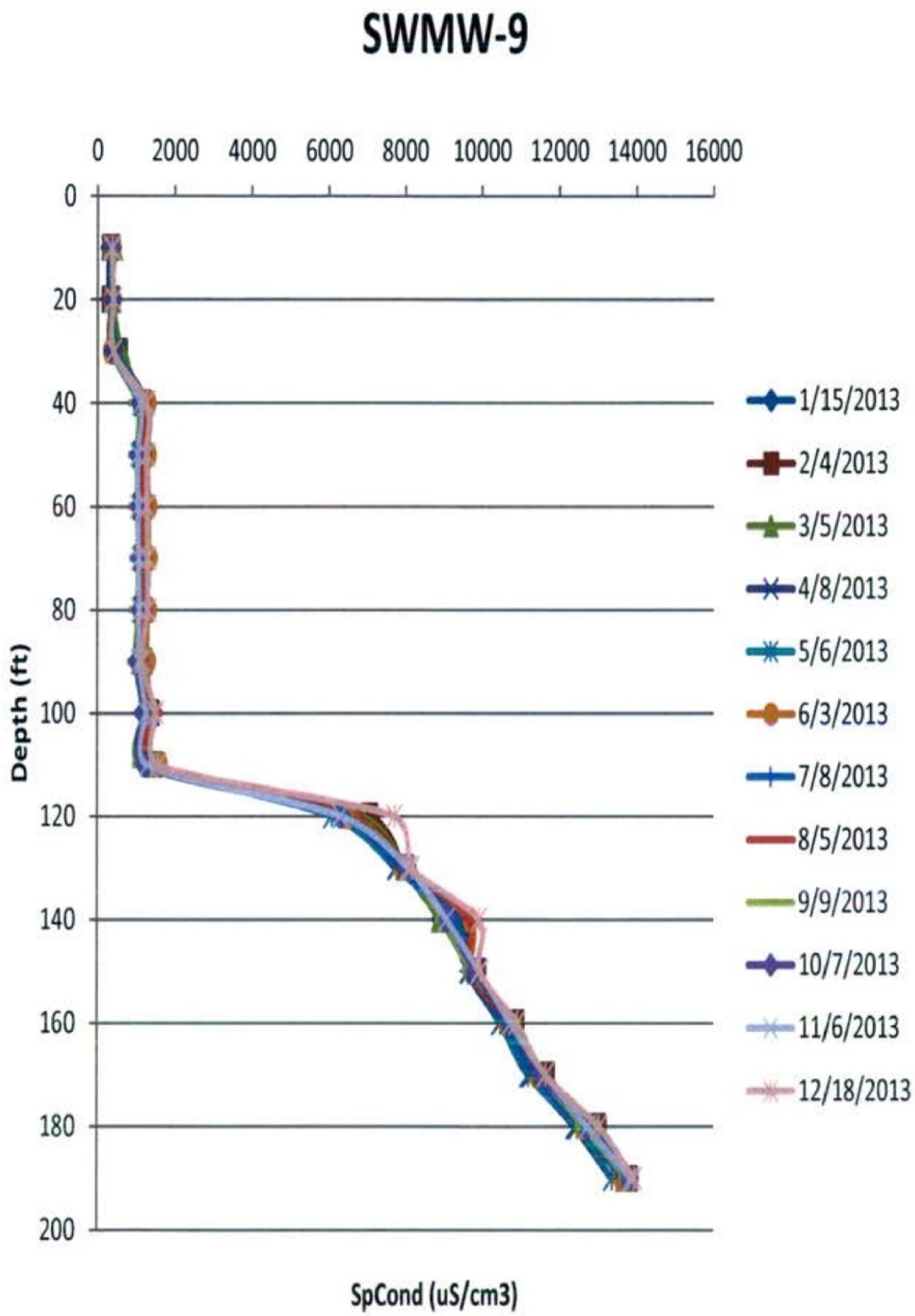


Figure WA5.A-20



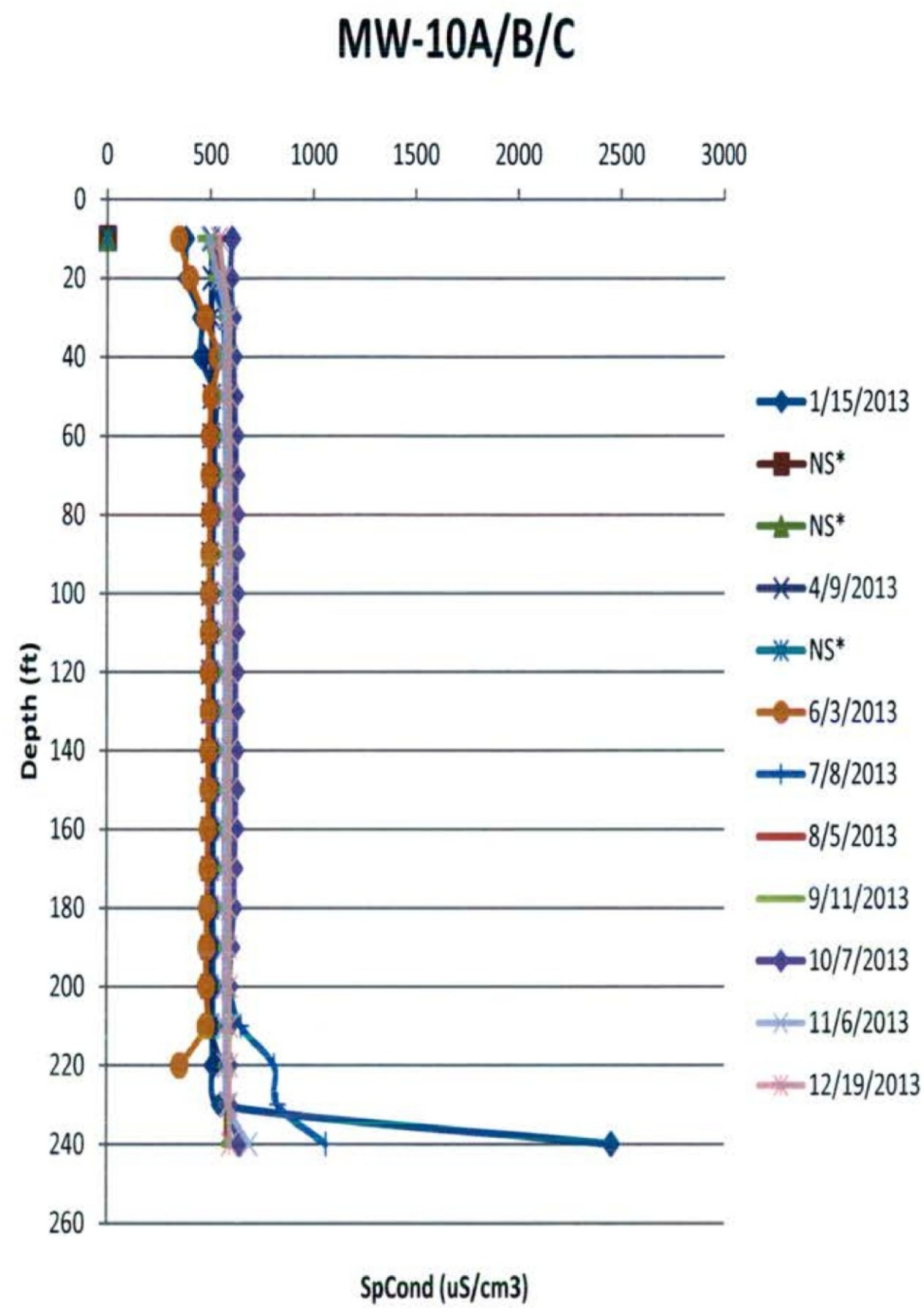
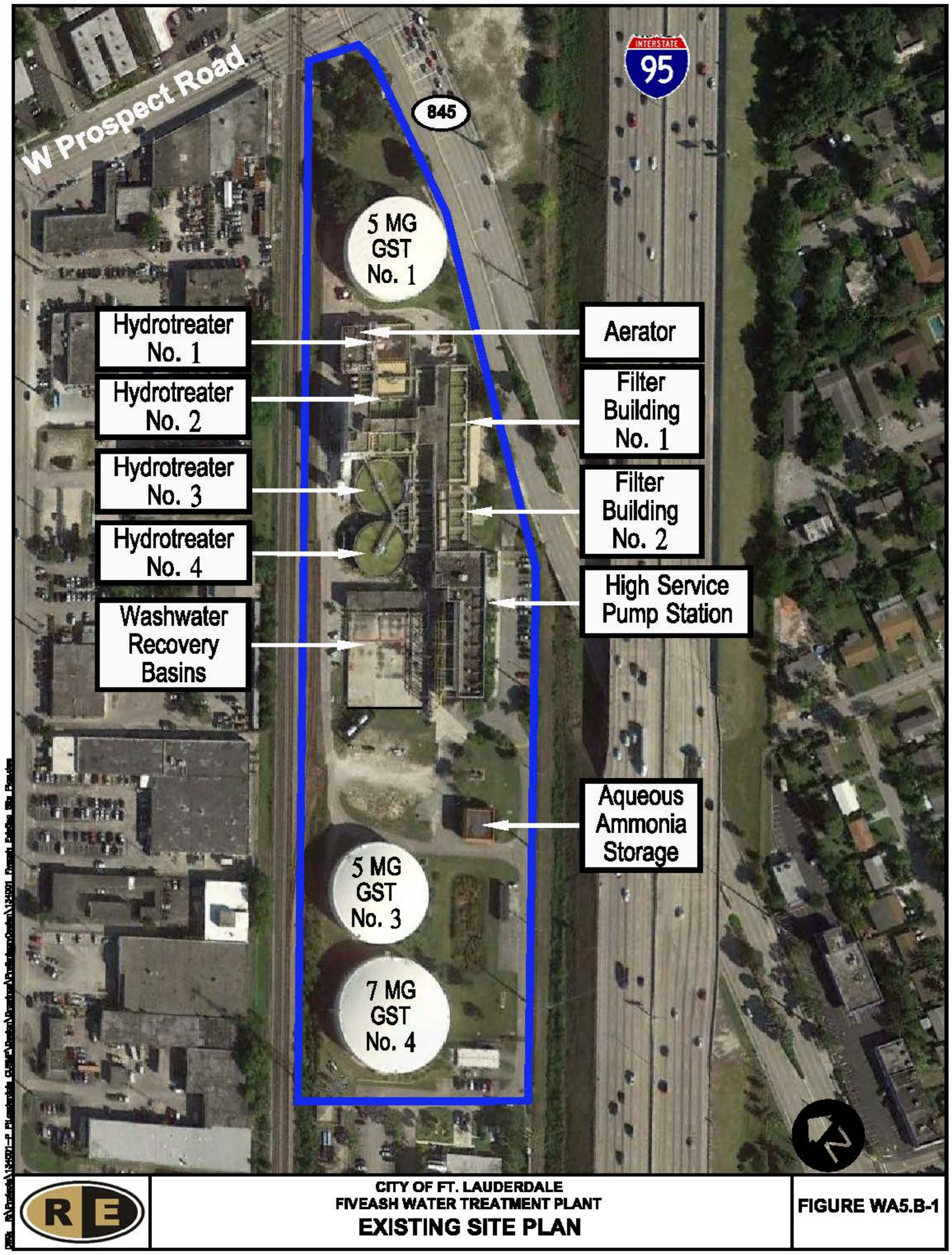


Figure WA5.A-21

WA5.B Fiveash Water Treatment Plant Process Evaluation

The City's largest water treatment plant (WTP) is the Charles W. Fiveash WTP, with a design treatment capacity of 70 MGD. Combined with Peele-Dixie WTP's 12 MGD capacity, the two WTPs can easily meet the City's current and future water demands. The plant is located in northwest Fort Lauderdale and was originally constructed in 1950. The facility has undergone various expansions in subsequent years, and **Figure WA5.B-1** depicts the existing facility site plan. The source water is from the Prospect Wellfield, fed from the surficial Biscayne Aquifer.

Figure WA5.B-1. Fiveash Water Treatment Existing Site Plan



Section WA5B accepted January 19, 2017.

A prior report, "Fiveash WTP Filtration and Aeration Treatment Evaluations," Montgomery Watson, September 1996, indicated that the plant had a reduced capacity of 60 MGD due to hydraulic restrictions. That report stated that removing the hydraulic limitations, the aeration basins, would enable higher treatment flow rates. In addition, the Operations staff noted that the finished water quality decreases with increasing flows. Treating more than 55 MGD through the lime softening process shows a significant increase in finished water turbidity and decreased color removal. Therefore, the Fiveash WTP currently has a reduced, effective capacity of approximately 55 MGD.

Much of the equipment and mechanical items for the lime softening system are at the end of their useful life. Spare lime softening treatment unit capacity is not available, thus limiting preventive maintenance to short-term corrective measures. A Fiveash WTP “Reliability Upgrades” is on-going to replace several key mechanical items and automate the controls of key plant processes. Phases II and III of the Reliability Upgrades are under design and will be distributed for bid in the near future. The Reliability Upgrades project has been under design for twelve years. The first design task order was approved in early 2004. Along the way, the project has been adjusted to keep up with current goals. Most recently, the project was adjusted to switch to the control system standard recommended by the CUSMP team. The CUSMP Team recommends the City check the Fiveash WTP Reliability Upgrades project to ensure that sodium hypochlorite is fully compatible with the Fiveash WTP treatment process and will not exacerbate the filter scaling issue.

The Fiveash WTP produces safe, reliable potable water, but there are issues with the finished water quality that the City would like to have resolved. The color and pH are higher than the EPA Secondary Drinking Water Standard range of 15 platinum-cobalt scale color units (Pt-Co) and 6.5 – 8.5 (upper limit of 10.0 allowed with written approval from the Florida Department of Environmental Protection (FDEP)/Broward County Department of Health per FAC 62-550.520(1)) standard units (SU), respectively. The yellow-tinted color causes water quality complaints from residents and visitors to the City.

The Fiveash WTP utilizes conventional lime softening, with a target pH of 9.0 - 9.5, followed by filtration. Polymers are added for turbidity removal and to assist in color removal. Chlorine and ammonia are added and combined to form chloramines for primary and secondary, residual disinfection. Over the past 10 years, the Fiveash WTP has experienced a steady decline in average daily demands (AADD) and maximum daily demands (MDD). The AADD has decreased from approximately 40 MGD in 2005 down to 31 MGD in 2014 (measured as wellfield treated flows), while the MDD has decreased from 50 MGD to 43 MGD over the same time period. The daily **Table WA5.B-1** lists the wellfield flows as displayed in **Figure WA5.B-2**. **Figure WA5.B-2** illustrates a possible weak correlation between water demand and annual rainfall over the last 5 years. Landscape irrigation demands are expected to be higher during lower rainfall years. Rainfall has bounced around the approximate 62 inch per year average over the last five years. The City’s water demand was low on the high rainfall years but did not show significant reaction to changes in the annual other than staying on the same, inverse trend. Other demand factors at work include the City's water conservation efforts, economic factors and urbanization. A generalized plant process schematic is illustrated in **Figure WA5.B-3**.

Table WA5.B-1. Fiveash WTP Wellfield Flows

Year	AADD (MGD)	MDD (MGD)	Rainfall (Inches)
2005	40.55	50.53	53.0
2006	43.02	55.39	48.5
2007	36.07	48.26	63.0
2008	37.21	50.66	52.0
2009	39.83	51.17	52.8
2010	34.39	43.74	59.8
2011	34.56	42.8	53.9
2012	32.9	41	77.9
2013	32.32	48.13	65.2
2014	31.15	43.08	66.0

Figure WA5.B-2. Fiveash WTP Wellfield Flows

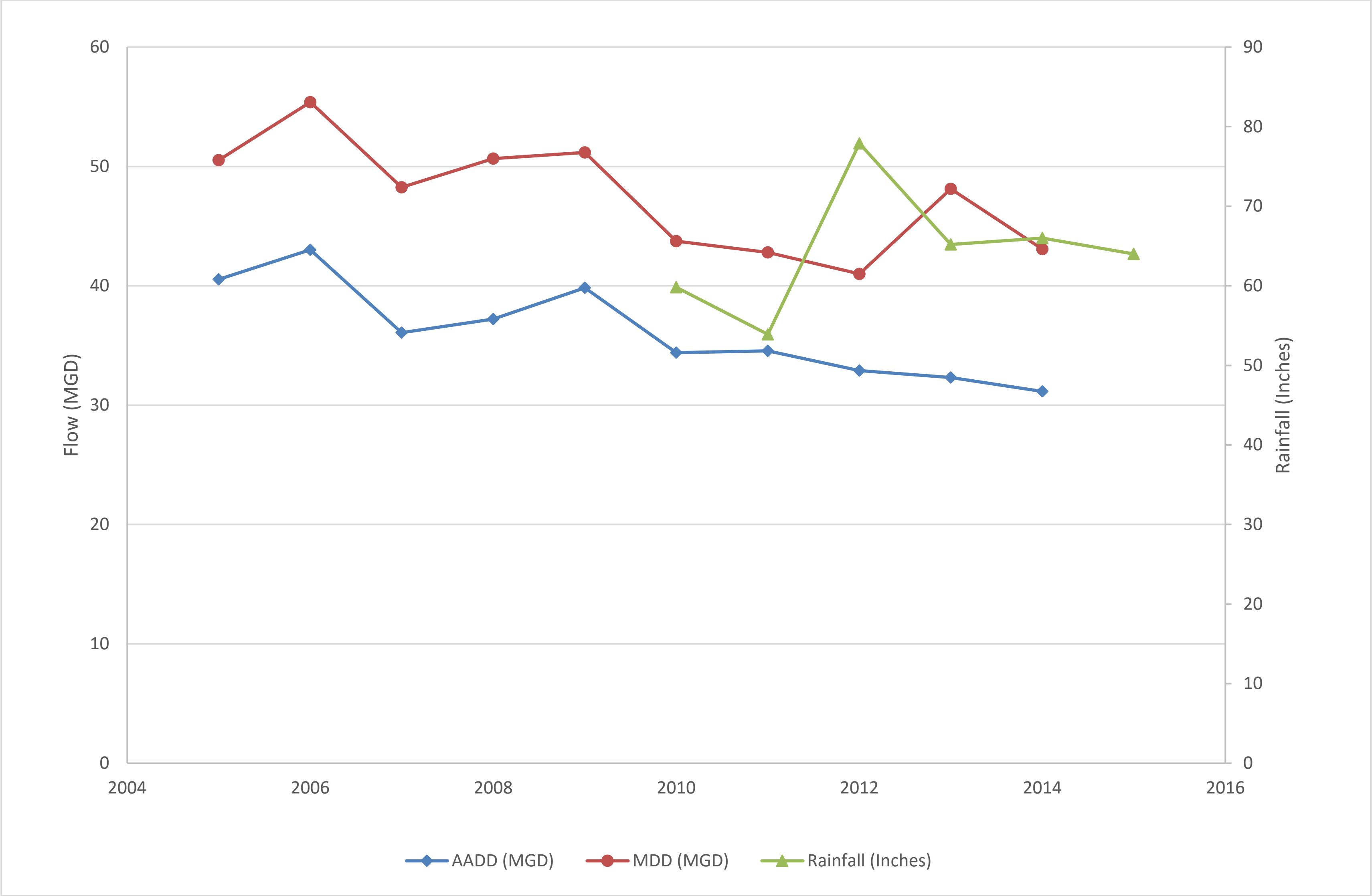


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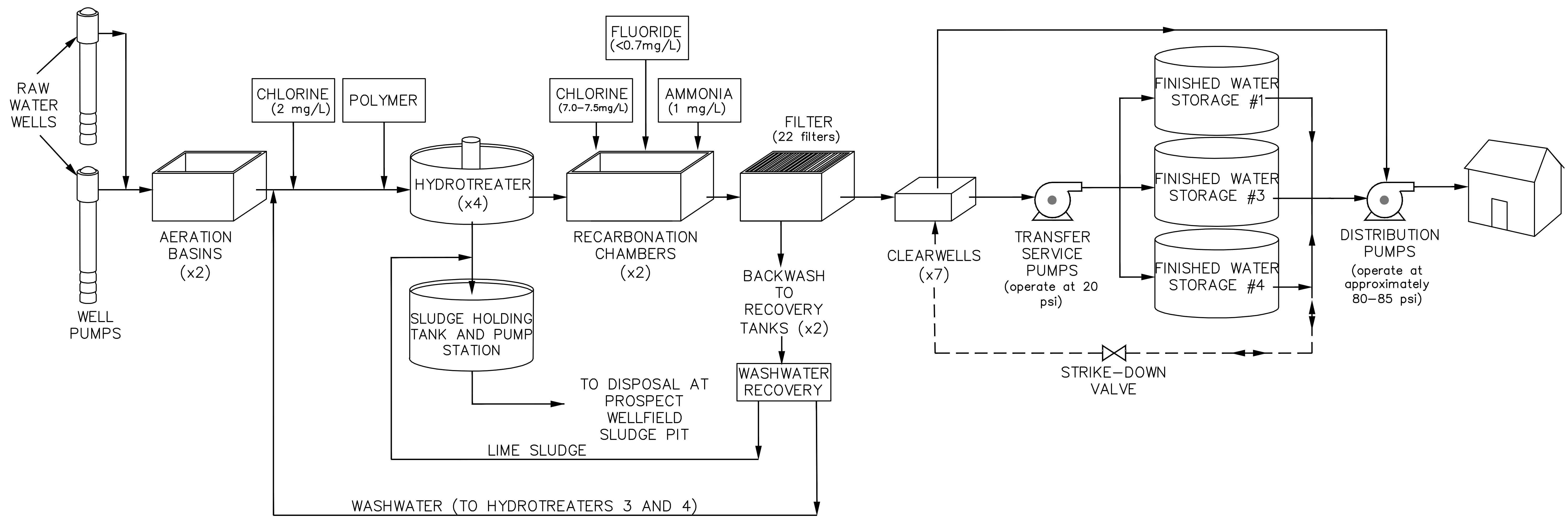
Figure WA5.B-3 Fiveash WTP Process Flow Diagram



CITY OF FT. LAUDERDALE
FIVEASH WATER TREATMENT PLANT
PROCESS FLOW DIAGRAM

FIGURE WA5.B-3

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5.B.1 Existing Conditions

5.B.1.1 Raw Water Wells

Raw water to the Fiveash WTP was previously supplied from groundwater wells that surround Prospect Lake and wells that surround the Fort Lauderdale Executive Airport. The wells at the Executive Airport were abandoned in 1999 due to contamination. However, Production Well #35 is still in use and is within the Fort Lauderdale Executive Airport fence line. The raw water supplied to the Fiveash WTP is pumped from wells around Prospect Lake, which is known as the Prospect Wellfield. The old abandoned wells at the Executive Airport site are located directly east of the Prospect Wellfield.

The Prospect Wellfield maintains twenty-nine (29) active production wells that were constructed from 1969 through 2006. The wells have pumping capacities of approximately 3 MGD each, which equates to a total wellfield capacity of approximately 87 MGD. The Water Use Permit (WUP) allows up to 43.43 MGD AADD and 49.5 MGD maximum month to be withdrawn from the Prospect Wellfield.

5.B.1.2 Aeration Basins

The Prospect Wellfield well pumps deliver raw water from the active production wells into one (1) basin with two (2) aeration chambers. The Prospect Wellfield raw water contains high concentrations of carbon dioxide. These aeration basins remove excess carbon dioxide and other objectionable gases by passing large quantities of air through the water. Air diffusers located at the bottom of the aeration basins constantly produce coarse air bubbles that pass through the water and carry off the most volatile of the taste- and odor-causing organics (including H_2S).

5.B.1.3 Lime Softening

There are four (4) hydrotreaters that receive water from the aeration basins and treat for dissolved minerals (calcium and magnesium), or hardness. On average, at least three (3) of the hydrotreaters are routinely in operation, while the last hydrotreater is used solely during peak flow hours and for redundancy. Lime ($Ca(OH)_2$) slurry is distributed to each hydrotreater, and is slowly mixed (0.264-1.06 revolutions per minute) with the raw water using four (4) wall baffles spaced at 90°. Prior to lime softening, the influent is dosed with polymer to aid in turbidity and color removal. Adding hydrated lime to the raw water raises the pH to a target of 9-9.5 and allows for the precipitation of calcium carbonate ($CaCO_3$) and magnesium hydroxide ($Mg(OH)_2$). These compounds adhere to one another and precipitate out as floc. Flocculation allows for the settlement and collection of the solids using sludge drain pipes located at the bottom of the hydrotreaters. The sludge drain pipes carry the solids into the sludge holding tank before it is disposed at the Prospect Wellfield sludge disposal lagoon.

The lime system does not function properly and cannot be accurately dosed to the plant's flow. "Bridging" of lime in the hoppers above the slakers frequently decreases or interrupts flow into the slakers. The slakers require near constant attention to assure that the slaked lime is flowing to the treatment units. Furthermore, open troughs deliver the slaked lime to the treatment process by gravity flow. Each slaker is connected to a dedicated treatment unit, so the whole train goes down if one piece of equipment has to be shut down.

The slakers were installed in 2007 and there was a substitution for the specified equipment. Automatic weighing slakers were specified that could indicate when lime was not dropping from the hoppers in the correct amounts; the existing slakers do not have that capability.

5.B.1.4 Chemical Injection and Filtration

An initial dose of free chlorine (2.0 mg/L) is applied to the water leaving the aeration process to control bacterial growth in downstream processes. The primary disinfectant chloramine dose is accomplished by adding free chlorine (7.0-7.5 mg/L) at the front of the recarbonation basins and ammonia (1 mg/L) near the end of the recarbonation basins. Ammonia combines with the free chlorine to form chloramines (NH_2Cl, $NHCl_2$, and NCl_3) and primarily monochloramine (NH_2Cl). Chloramines, as the primary disinfectant, inactivate pathogens in the water. Chloramines, as a secondary or residual disinfectant, prevent pathogen regrowth in the distribution piping and in customer plumbing. High organic carbon content in the raw water precludes the use of the stronger disinfectant, free chlorine, to comply with EPA's Disinfection Byproduct (DBP) Rule. Chloramine disinfection does form other, currently unregulated chlorinated nitrogen compounds that are being investigated and considered by the EPA for future regulation. Fluoride (target of < 0.7 mg/L) is also added in one (1) of two (2) recarbonation basins.

Recarbonation, or the injection of carbon dioxide (CO_2), is typically used to reduce the pH and reintroduce carbonate into the system for water stability. Currently, the recarbonation process is not in use and the recarbonation tanks are used for chemical addition and mixing. The recarbonation basins can be used for pH adjustment downward by installing the CO_2 generation, storage and feed systems as is required for the enhanced lime softening alternative discussed herein. Adjusting the pH downward must be balanced against increasing nitrification reaction rates in the distribution system as high pH is a proven nitrification mitigation strategy.

After chemical addition, the water discharges through one (1) of twenty-two (22) sand/anthracite gravity filters. The gravity filters remove particles and floc not settled out by gravity in the preceding hydrotreaters. Filter backwash is transported to the washwater diversion structure, where it is decanted and the liquid stream returned to Hydrotreaters 3 and 4. The concentrated sludge is transferred to the sludge holding tank, pumped to the Prospect Wellfield sludge disposal lagoon with lime sludge, dried and ultimately disposed of offsite via contract hauling.

5.B.1.5 Clearwell and Transfer Pumps

The filter effluent discharges into one (1) of seven (7) underground clearwells. After the addition of ammonia, the total chloramine target residual concentration is approximately 3.5 mg/L. The treated water flows through the clearwells prior to being transferred to one of the ground storage tanks using transfer pumps or the filtered water can take a shortcut and get pumped out into the distribution system by the high service pumps. The shortcut can contribute to decreased water quality and should be eliminated. The transfer pumps operate at a discharge pressure of approximately 20 psi. The clearwells are connected through gated openings in the walls between clearwell cells and 60-inch diameter transfer pipes.

5.B.1.6 Ground Storage Tanks and High Service Pumping

There are three (3) ground storage tanks on-site. GST No. 1 has a capacity of 5 million gallons (MG) and is located on the north side of the property. GSTs No. 3 and 4 have a capacity of 5 MG and 7 MG, respectively, and are located on the south side of the property. In 2008, Ground Storage Tank (GST) No. 2 reached the end of its useful life and was taken out of service and demolished.

The Fiveash WTP has three banks of high service pumps. HSP 4 and HSP 5 are at the north end of the site, HSP 6-11 are located inside the High Service Pump Station No. 2 (diesel house), and HSP 12-16 are located outside, to the west of the diesel house. Only the pumps in the diesel house can pull from the transfer pipe connected to GSTs 3 and 4. The other two banks of HSPs will require some means of isolation from the clearwells and connection to the GSTs.

Currently, the Fiveash WTP high service pumps pull from both the clearwells (x7) and the ground storage tanks to pump finished water to the distribution system. These high service pumps operate at a target pressure of approximately 80-85 psi. The ground storage tank discharge pipes also have strike-down valves that, when the water level in the clearwells reaches a certain low point, allow for water to leave the ground storage tank by gravity and recirculate back in to the clearwells. There are no flow meters or capabilities to prevent this from occurring, so there is currently no way to monitor or control the less than ideal circulation patterns. Short-circuiting causes process and control reliability issues, as well as an increase in DBP formation and instability of the chloramine residual. **Figure WA5.B-3** illustrates this storage-pumping system.

The CUS Master Plan Team recommends that this final process be revised to prevent short-circuiting, and eliminate the high service pumps pulling treated water directly from the clearwells. This modification allows the high service pumps to pull solely from the finished water storage tanks. **Section WA5.B.2.2** further explains how this process can be improved.

5.B.2 Fiveash Water Treatment Plant Recommended Improvements

Based upon the Fiveash WTP evaluation, improvements and investigations are recommended in order to ensure a reliable water quality that meets primary and secondary drinking water standards. **Table WA5.B-2** summarizes proposed water quality goals used in this evaluation**.** Improvements were focused on enhancing operations, reducing maintenance events, and optimizing energy efficiency.

5.B.2.1 Color Removal and Virus Inactivation Process Investigation

The color of the water is a major concern for the City. The target water quality goal for color is 5-10 Pt-Co color units. The Fiveash WTP maintains an average finished water color of approximately 15 Pt-Co, exceeding the water quality goal and causing aesthetic issues and complaints. The City's record of distribution system complaints shows that the color has reached as high as 40 Pt-Co. The CUSMP intends to investigate color removal options for process improvements at the facility, as well as replace old, deteriorated pipes that can contribute to the color.

The City contracted a consultant to evaluate methods for color reduction, which was captured in the "Fiveash WTP Filtration and Aeration Treatment Evaluations" (Montgomery Watson, 1996). A bench-scale evaluation was performed, including jar testing, for color reduction by optimizing the lime softening process. This report concluded that color removal could be enhanced through the addition of a color-targeting polymer at a pH of 10.6-10.8, by additional lime, or increasing the pH using caustic. If additional lime is used, the pH of the settled water would need to be reduced to 8.0-8.5 (to prevent filter cementation).

The CUS (Comprehensive Utility Strategic) Master Plan Team has identified and examined several current, well-known, and effective color removal options for the Fiveash WTP.

Table WA5.B-2. Proposed Finished Water Quality Goals

Parameter	Units	Goal	Fiveash Effluent Water Quality (2014)	Primary Drinking Water Standards	Secondary Drinking Water Standards
Total Hardness	mg/L as CaCO3	50 - 120	77.3	NS	NS
Sodium	mg/L	< 50	36.5	160	NS
Total Dissolved Solids (TDS)	mg/L	< 500	ND	NS	500
Iron	mg/L	< 0.3	0.02	NS	0.3
Manganese	mg/L	< 0.05	ND	NS	0.05
Fluoride	mg/L	< 0.7	0.58	4.0	2.0
Sulfate	mg/L	< 200	ND	NS	250
Chloride	mg/L	<100	66.5	NS	250
Color	Pt-Co	< 8	15.2	NS	15
Turbidity	NTU	< 1	0.16	NS	NS
Alkalinity	mg/L as CaCO3	> 40	60.7	NS	NS
H2S	mg/L	< 0.1	ND	NS	NS
pH	Units	8.0 – 9.0*	9.19	NS	6.5-8.5
Parameter	**Units**	**Goal**	**Fiveash Effluent Water Quality (2014)**	**Primary Drinking Water Standards**	**Secondary Drinking Water Standards**
TTHM	mg/L	< 0.06	0.064	0.08	NS
HAA_5	mg/L	< 0.04	0.0318	0.06	NS
Free Ammonia	mg/L	< 0.2	ND	NS	NS
Corrosivity	-----	Non Corrosive	ND	NS	Non-corrosive
LSI	units	> 0.2	ND	NS	NS

Notes:

ND = No Data or not required to be monitored continually
NS = No Standard for groundwater systems
* Upper limit of 9.0 allowed with written approval from the FDEP/Broward County Department of Health

Color removal options include:

- Enhanced lime softening at a higher pH
- Coagulation and enhanced lime softening with additional chemicals
- Ozone and enhanced softening
- Ozone and granular activated carbon (GAC) in conjunction with lime softening
- Nanofiltration
- Ion Exchange and lime softening
- Oxidation, UV, and lime softening

Table WA5.B-3 summarizes the results of this color removal investigation.

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Table WA5.B-3. Color Removal Options for Fiveash WTP

Alternative	Description	Color Removal Limit	Convert to Free Chlorine	Capital Cost	Operating Cost/Energy Consumption	Pros	Cons	4-Log Inactivation Credit
Enhanced Softening	Increase hydrated lime dosage to the existing system to remove total organic carbon (TOC) (pH 11-12)	15-20 Pt-Co	No	$	$	•Effective hardness and TOC removal •Reduces turbidity •Removes inorganic compounds •High pH mitigates Nitrification •May use existing system thereby minimizaing capital cost	•Produces high sludge volume •High pH inhibits pathogen removal •Increased chemical costs •Does not meet color goal •Requires acid (CO2) addition to lower pH	Partial. If followed by filtration, 2-log virus inactivation credit is achievable provided specific criteria are met, especially turbidity (<1 NTU). Continuous monitoring required. Additional 2-log virus inactivation credit required through chlorine or chloramines.
Coagulation & Enhanced Softening	Addition of coagulants such as ferric chloride to remove TOC, in addition to enhanced lime softening	15-20 Pt-Co	No	$	$$	•Effective hardness and TOC removal •Reduces turbidity •High pH mitigates Nitrification •May use existing softening system thereby minimizing capital cost	•Produces high sludge volume •High pH inhibits pathogen removal •Increased chemical costs •Requires acid (CO_2) addition to lower pH •Does not meet color goal	Partial. If followed by filtration, 2-log virus inactivation credit is achievable provided specific criteria are met, especially turbidity (<1 NTU). Continuous monitoring required. Additional 2-log virus inactivation credit required through chlorine or chloramines.
Ozone & Enhanced Softening	Incorporate ozonation to facilitate color removal and provide disinfection in combination with enhanced lime softening	10-15 Pt-Co	No	$$	$$	•Effective hardness and TOC removal •Effective disinfectant •Reduces turbidity •High pH mitigates Nitrification •Eliminates aeration •Ozone requires small footprint •May use some of the existing infrastructure thereby minimizing capital cost	•Produces high sludge volume •High pH inhibits pathogen removal •Ozone must be created on-site •pH out-of-compliance requires acid (CO_2) addition •Does not meet color goal •Potential ozone by-products produced	Yes. Ozone can provide 4-log virus inactivation with low doses and low contact times. Lime softening with filtration will provide up to 2-log provided specific monitoring requirements are met (turbidity <1 NTU); however, this is not needed with ozone.
Ozone & Granular Activated Carbon (GAC) & Lime Softening	Incorporate ozonation to facilitate color removal and provide disinfection prior to GAC adsorption/filtration	5 Pt-Co	Yes	$$$	$$	•Effective hardness and TOC removal •Effective disinfectant •Reduces turbidity •Eliminates aeration •Ozone requires small footprint •Do not have to enhance existing softening process	•GAC filters may need to be changed frequently •GAC requires large footprint •Ozone must be created on-site •Still requires softening	Yes. Ozone can provide 4-log virus inactivation with low doses and low contact times.
Granular Activated Carbon (GAC)	Incorporate GAC adsoprtion/filtration	8 Pt-Co	Yes	$$	$$	•Effective hardness and TOC removal •Reduces turbidity •Do not have to enhance existing softening process	•GAC filters may need to be changed frequently •GAC requires large footprint •Still requires softening	No. GAC does not provide a virus inactivation credit, however, it will allow the conversion to free chlorine which requires a lower CT to achieve 4-log virus inactivation credit.
Nanofiltration/ Reverse Osmosis	Using a membrane separation process to remove TOC and hardness	5 Pt-Co	Yes	$$$	$$	•Effective hardness and TOC removal •Elimination of hydrotreaters, recarbonation basins, & filters •Does not require additional softening	•Iron fouling •Pretreatment required •Requires permeate degasification •Post stabilization required •High energy consumer •Requires concentrate disposal •High percentage of water loss	Partial. 2-log virus inactivation credit is allowed presuming that on-line monitoring and integrity testing is performed with a an average pore size not greater than 0.01 micron; turbidity of the permeate of less than 0.15 NTU. Salt Passage must be less than 25% but more likely required to be less than 5%. Additional 2-log virus inactivation credit required through chlorine or chloramines.
Ion Exchange & Lime Softening	Ion exchange resin used to provide TOC removal	5 Pt-Co	Yes	$$$	$$$	•Effective hardness and TOC removal •Regenerated on-site	•Resin fouling •Regenerant disposal required •Requires additional disinfection •High operating costs over long-term	Partial. Ion Exchange does not provide any credit. Lime softening with filtration can provide up to 2-log virus inactivation credit with specific monitoring requirements (turbidity < 1 NTU). Additional 2-log virus inactivation credit required through chlorine or chloramines.
Oxidation, Ultraviolet (UV), & Lime Softening	Oxidizing agents such as ozone or hydrogen peroxide added with intense UV light exposure	5-15 Pt-Co	No	$$$	$$	•Effective hardness and TOC removal •Does not add to the pollutant load •Effective disinfectant	•Requires low turbidity and high absorbance for effectiveness •Lamp fouling •Lamp maintenance •High Energy Consumer	Yes. Ozone and UV can provide 4-log virus inactivation with low doses and low contact times.

The treatment methods outlined in the table above are discussed in more detail in the following sections.

5.B.2.1.1 Ozone

Ozonation of the raw water, prior to lime softening, is an effective treatment for color removal and the oxidation of organics. Because ozone is more effective in destroying viruses, bacteria, and organics than chlorine, ozone is an ideal selection for disinfection as well. The oxidizing properties of ozone can reduce the concentration of iron, manganese, and sulfur in the water to eliminate taste and odor issues.

Ozone (O_3) must be created on-site and used immediately. Ozone is produced by an ozone generator that uses either dried air (requiring air dryers and compressors) or liquid oxygen (LOX). The LOX system is preferred as it produces a higher percent weight concentration of ozone than the dry air system and is more efficient. Ozone contactors (diffused bubble or in-line injection systems) are used to dissolve ozone in water. Currently, the diffused bubble systems are more common, however, the industry is converting to sidestream injection systems for increased mass transfer efficiency, smaller footprint, and better operational control. Sidestream injection involves splitting off a portion of the main flow into a side stream. Ozone is injected into this side stream and then the side stream is mixed back into the main flow.

Figure WA5.B-4 depicts a simplified diffusion ozone system schematic illustrating the process. The ozone contact basins are typically composed of several enclosed consecutive chambers. In the first chamber, water flows downward against rising bubbles (countercurrent). Additional chambers are added to ensure sufficient contact time between ozone and water.

The footprint for ozonation can be relatively small, allowing for retrofitting the existing Fiveash WTP. Ozone, in combination with lime-softening and chlorination, can inevitably reduce the color down to below 10 Pt-Co. Ozone can be introduced prior to or after lime softening. The existing aeration basins can be converted to ozone contact basins to reduce cost and the impacted site footprint. Additionally, the higher pH of the lime softened water reduces the efficacy of ozone for oxidation, lending to the injection of ozone to occur upstream of the lime softening basins. The drawback to this is that the ozone will not be able to be utilized for 4-log virus inactivation credit. Another drawback of ozone includes the low-level formation of carcinogenic byproducts such as brominated byproducts, aldehydes, ketones, and carboxylic acids. The installation of a post-filtration system may alleviate the formation of these byproducts.

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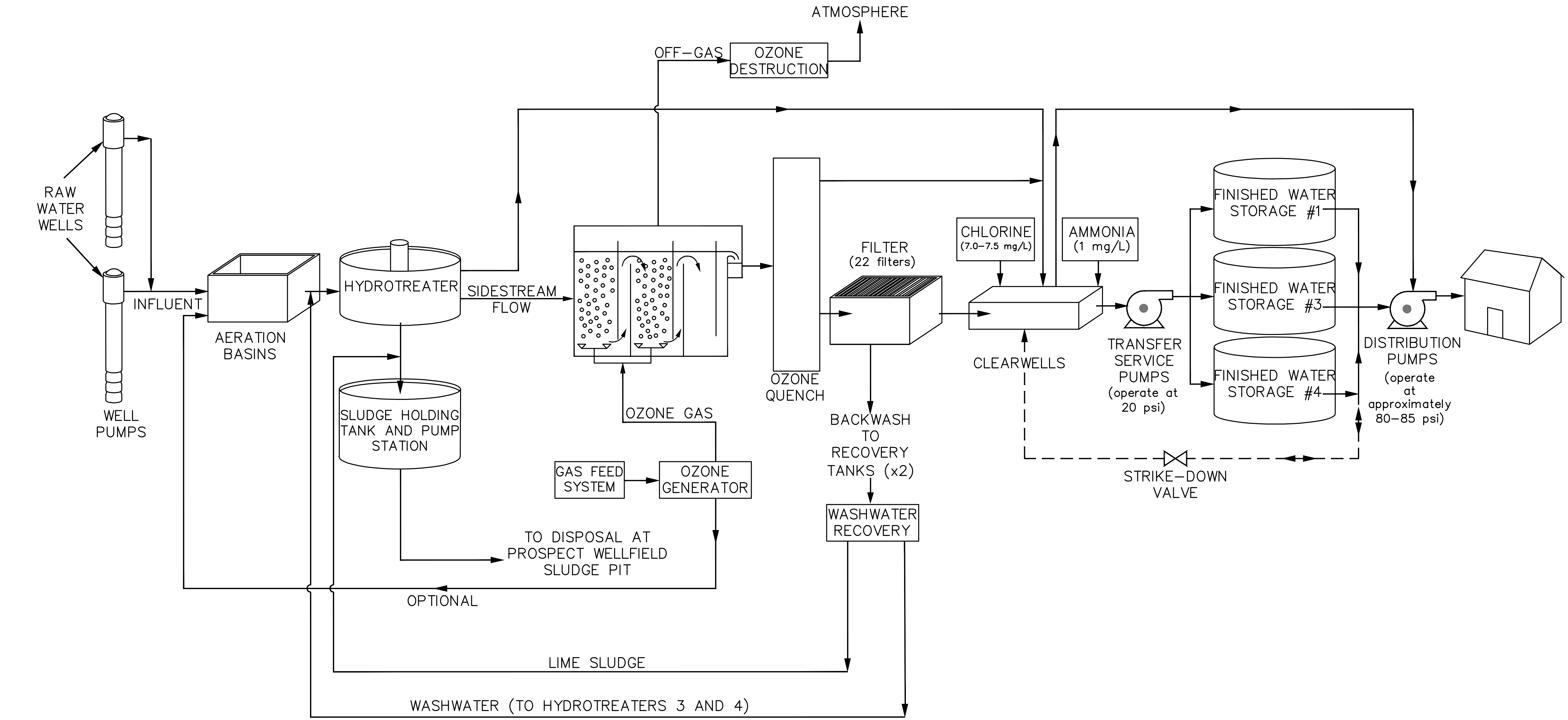
Figure WA5.B-4 Simplified Ozone System Schematic



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CITY OF FT. LAUDERDALE
FIVEASH WATER TREATMENT PLANT
SIMPLIFIED OZONE SYSTEM SCHEMATIC

FIGURE WA5.B-4

5.B.2.1.2 Granular Activated Carbon

Granular activated carbon (GAC) is commonly used to adsorb natural organics, taste, color, odor compounds, and synthetic organic chemicals in drinking water treatment. GAC also reduces the constituents that form trihalomethanes (THMs), haloacetic acids (HAAs), and other byproducts of concern. Activated carbon is an effective adsorbent because it is a highly porous material and provides a large surface area to which contaminants may adsorb. GAC is made from organic materials with high carbon contents such as wood, lignite, coconut husks, and coal. GAC can be used to partially treat the flow and blend the treated water with the non-treated water to optimize treatment and minimize costs. **Figure WA5.B-5** illustrates a simplified GAC system schematic.

Following the lime softening process, the addition of GAC treatment would allow for the successful elimination of color-inducing organics. In addition to dissolved organics removal, the GAC filters provide turbidity reduction, solids removal, and biological stabilization. Placing the GAC filters following the lime softening process reduces the total organic carbon load on the carbon filter media. There are no on-site generation requirements for GAC treatment, so there will not be a difficult by-product disposal issue. However, periodic GAC replacement will require delivery and removal by semi-tractor trailers, resulting in onsite truck traffic. A major benefit of GAC is that it reduces the need and utilization of additional chemical treatment to the drinking water. Therefore, chemical storage, handling, and operations/control complexities are also avoided. GAC units are also operator-friendly due to the simplicity of the system. However, space requirements may be of concern, as Fiveash WTP will need several 12 ft. (minimum) diameter units for sufficient treatment. Fiveash WTP may be able to mitigate this space issue by retrofitting some or all of the existing anthracite/sand filters with GAC material.

Eventually, the ability of GAC to bind and remove chemicals is severely diminished and the GAC needs to be replaced. The useful life of GAC filters is based on raw water contaminant levels and treated water flow. Multiple GAC filters will be required to ensure sufficient organics removal, as well as redundancy. Excessive organics concentrations translate to high GAC “consumption” rates and could render GAC cost prohibitive; pilot testing is recommended to confirm viability. GAC filters are also subject to hydrogen sulfide fouling, and a process for the removal of hydrogen sulfide prior to the GAC filters will need to be implemented using either the existing aeration basins, or an advanced process such as ozone or forced draft aeration.

GAC, in combination with lime softening or ozone, can inevitably reduce the color well below 8 Pt-Co. The “spent” GAC is returned to the manufacturer’s facility where it is recharged and then re-used as GAC, minimizing waste and promoting a “green” process.

With the implementation of GAC at the Fiveash WTP, the City’s distribution system disinfectant could possibly be converted away from chloramines to free chlorine. This transition would improve water quality in the distribution system and allow the City to discontinue the addition of ammonia to the water system. Furthermore, GAC is effective at removing the small quantities of undesirable minerals or contaminants that may be present in trace amounts in the raw water.

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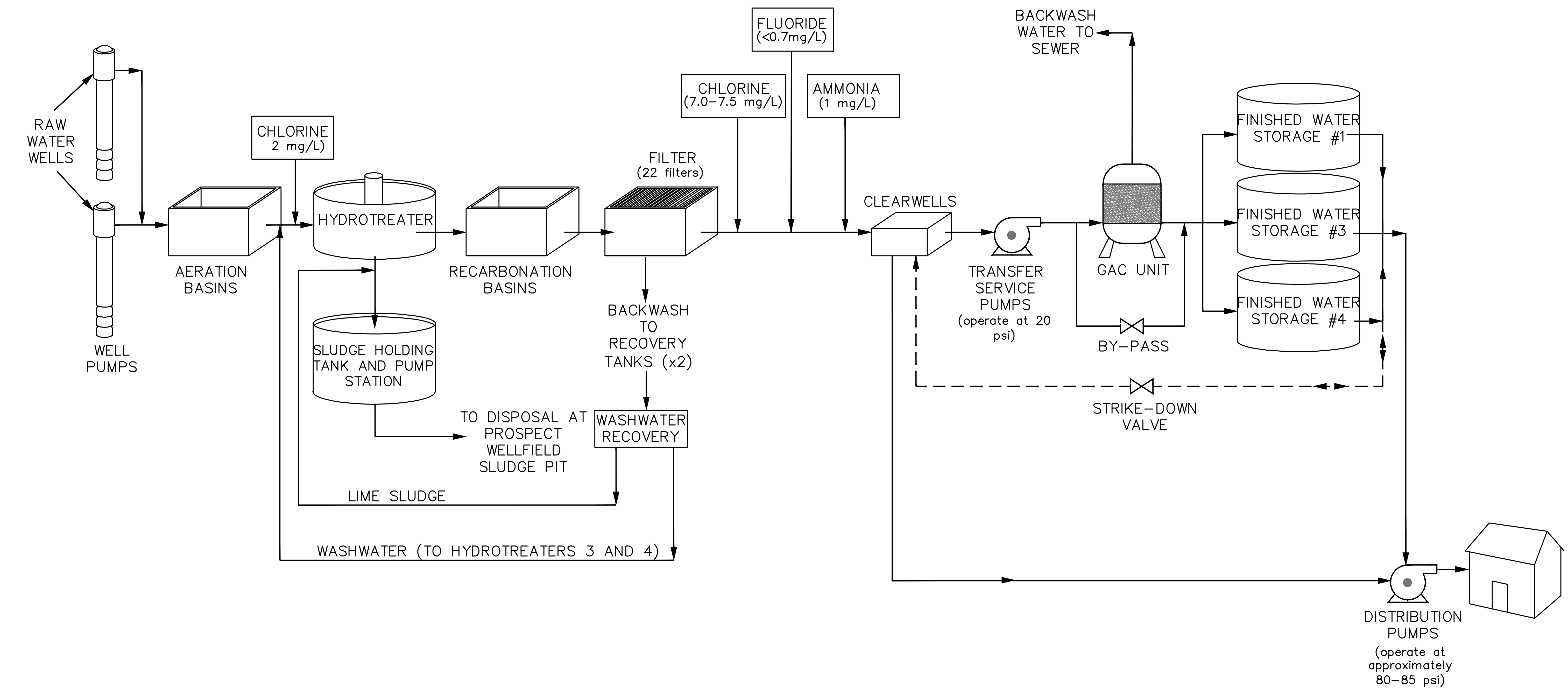
Figure WA5.B-5 Simplified GAC System



CITY OF FT. LAUDERDALE
FIVEASH WATER TREATMENT PLANT
SIMPLIFIED GAC SYSTEM

FIGURE WA5.B-5

5.B.2.1.3 Nanofiltration

Nanofiltration (NF) is a membrane separation process that operates based on the principle of reverse osmosis. The feed pressure forces the water through the membrane against the natural osmotic gradient, thereby increasing the dissolved contaminant on one side of the membrane and increasing the volume of water with lower concentrations of dissolved contaminants on the other (as shown in **Figure WA5.B-6**). As the desired level of removal increases, the feed pressure also generally increases. The membranes are constructed as hollow fibers or thin film composite sheets with thousands of fibers in a single pressure vessel. The fibers are typically 0.5 and 2.00 mm outer diameter.

NF includes three basic flow streams: the feed (influent), permeate (effluent), and concentrate (waste product). A number of membrane elements (typically three to seven) are arranged in pressure vessels. This series of pressure vessels is arranged in stages, wherein the concentrate from the prior stage becomes the feed for the subsequent stage. The permeate from each stage is blended together for the final product stream. The particles that accumulate on the feed side of the membrane must be periodically removed using chemical cleaning. The chemicals required for this unit process include ammonia, corrosion inhibitor, chlorine, sodium hydroxide, and fluoride (see **Figure WA5.B-6**).

NF membranes are typically used for hardness and organics removal, which would make this treatment a suitable color treatment alternative for the Fiveash WTP. Implementing NF at the Fiveash WTP would allow for the elimination of the hydrotreaters, the recarbonation basins, and the filters. Nanofiltration has already proven its adequacy with the City, as it is the primary treatment method used at the Peele-Dixie Water Treatment Plant. The main drawbacks are the capital and operating expense, as well as the percentage of water that remains as concentrate and requires disposal of (which can be highly energy intensive).

The NF system requires permeate degasification, post stabilization treatment, prevention of iron fouling, and concentrate disposal. The post-stabilization could be addressed by potentially blending raw water with the membrane permeate to enhance the minerals and water stability. The disposal of concentrate and the high percentage of water loss as concentrate are also drawbacks of NF. Water loss would reduce the Fiveash WTP effective production capacity by 15%, thus reducing available water addressed in the 10 Year Water Supply Plan. The increase in system pumping head would increase electrical costs moderately, this requiring electrical power reduction in other areas to meet the 2020 20% energy reduction goals.

If the existing Fiveash WTP aquifer storage and recovery (ASR) well is converted to a production well (refer to section 5.B.3.3), then nanofiltration/reverse osmosis could be a suitable treatment option. This would be a relatively small system for a 0.5 MGD well, with little concentrate, that may be able to be delivered to the wastewater system. The first step would be to run a pilot on the system to gather the appropriate effectiveness and design criteria. After a feasibility study with the pilot data a detailed design could be implemented.

The cost of implementing membrane treatment must also be considered in the selection process. Unit cost for water produced by membrane softening of raw water from the Biscayne Aquifer is about five times more expensive than lime softening. Reverse Osmosis treatment of brackish raw water from the Floridan Aquifer is about 10 times more expensive than lime softening of raw water from the Biscayne Aquifer. These relative costs will help to determine the recommended alternative.

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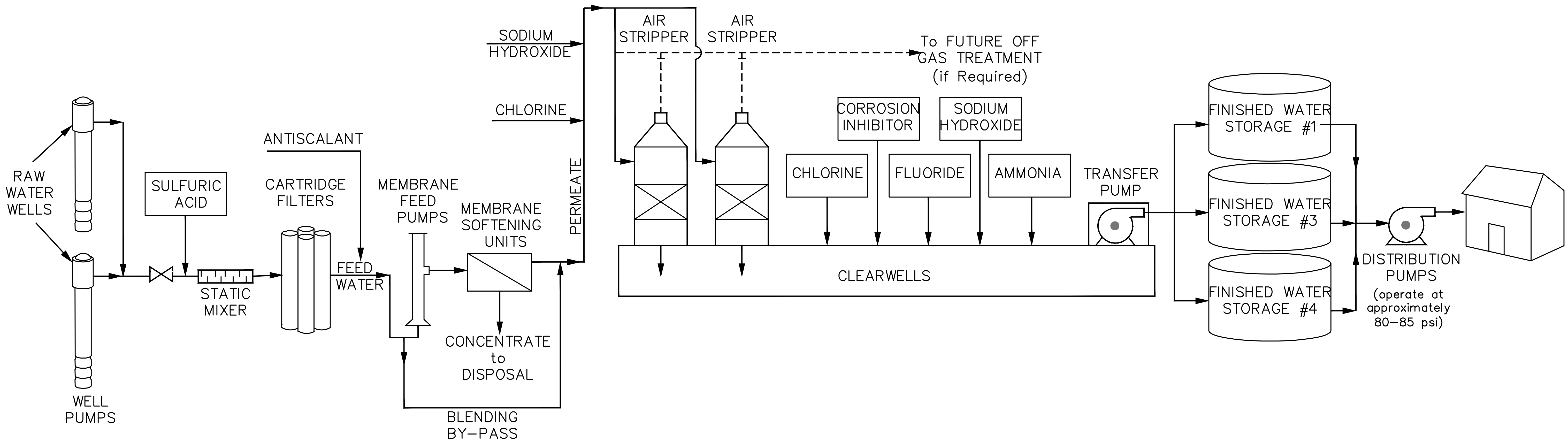
Figure WA5.B-6 Nanofiltration Schematic



CITY OF FT. LAUDERDALE
FIVEASH WATER TREATMENT PLANT
NANOFILTRATION SCHEMATIC

FIGURE WA5.B-6

5.B.2.2 Storage and High Service Pumping Modifications

Currently, Fiveash WTP high service pumps pull from both the clearwells (x7) and the finished water storage tanks before it is circulated into the distribution system. The CUS Master Plan Team recommends that this final process be revised in order to prevent short-circuiting, and eliminate pulling treated water directly from the clearwells. This will allow the high service pumps to pull solely from the finished water storage tanks.

CUS Master Plan Team suggests modifying the existing piping system such that the water from the filters is conveyed into a clearwell, where the transfer pumps will then discharge the treated water into the ground storage tanks. From the ground storage tanks, the treated water will flow to a common header for the high service pumps to circulate water out into the distribution system. By installing a common header, transmission of water out of the plant will be more controlled such that water is effectively distributed to the City. The change would reduce changes in water characteristics resulting from the plant sending out water of varying age. This will also require the modification of GST No. 1 to include at least one baffle wall and a new outlet pipe to tie in to the high service pump suction header with the remaining two GSTs.

The process flow modification will allow for more stable disinfectant residuals, optimized process control, and a reduction in the presence of stagnant water, water age, and disinfection by-products. The optimized process control allows for the monitoring of the disinfectant residual and the flow rates through the clearwells and ground storage tanks. When combined, the City can potentially achieve a 4-log virus inactivation credit according to FDEP regulations.

5.B.2.3 Aeration Basin Upgrades

In order to reduce energy costs and provide a higher oxygen transfer efficiency and sulfide removal, CUS Master Plan Team suggests several upgrades be made to the current aeration basin system. These basins allow for the removal of excess carbon dioxide and other objectionable gases by passing large quantities of air through the water. The addition of several upgrades will increase the efficiency of these aerators.

The existing blower is close to reaching the end of its useful life. Replacing the current blower and the diffusion apparatus system with a more efficient [turbo] blower and diffuser system (fine bubble) will inevitably reduce clogging and reduce energy costs through increased efficiency.

The two aeration basins are separated through slide gates. The slide gates are corroded and need to be replaced. In addition, the operators (stems, wheels, gears) are also in need of replacement. Although repair efforts started in 2014, when one of the aeration basins needs to be taken out of service for repair, the existing condition of gates and operators makes the isolation of one tank unattainable. The CUS Master Plan Team suggests replacing the isolation gates and operators for each of the two (2) aeration basins, and including the addition of motorized operators. The gates and valves to be replaced and upgraded include:

1. Valves on the raw water line
2. Aeration Basin No. 2 - Effluent Gates (8)
3. Aeration Basin No. 1 Effluent Gates (2)
4. Aeration Basin No. 1 and 2 - Outlet Structure Isolation Gate
5. Aeration basin and related structures' drain valves (each basin has a 6-inch gate valve on a flanged wall pipe)

The condition and operational status of the two (2) gates that feed Hydrotreaters 1 and 2 and two (2) gates that feed Hydrotreaters 3 and 4 from the distribution chambers need to be confirmed by WTP staff. In addition, the adjacent chamber that flows to Hydrotreaters 3 and 4 has a 12-inch gate valve that needs to be replaced, while the flow distribution chamber for Hydrotreaters 1 & 2 has a 6-inch gate valve that needs to be replaced.

5.B.2.4 Chemical Treatment System Upgrade

If the City does not select one of the color treatment methods evaluated in Section 5.B.2.1, the CUS Master Plan Team recommends that the existing chlorine injection system at the Fiveash WTP be reassessed. The existing chlorine system is planned for replacement and the fluoride system tank filling will be automated under the Reliability Upgrades and Disinfection System Replacement project between 2016-2019. The City has expressed the desire to achieve 4-log virus inactivation in the treatment system.

The current chemical treatment system injects chlorine gas, fluoride, and ammonia in the recarbonation basins prior to the filters. According to WTP staff, operators manually inject fluoride (at a target rate of < 0.6 mg/L) into the system using metering pumps, and this configuration could result in a possible dosage error. In addition, the detention time for the 4-log virus inactivation using chloramines is substantially greater than with free chlorine. Using automated chlorine and fluoride injection after filtration will provide a stable, free chlorine residual during transfer to the ground storage tanks, allowing for a 4-log virus inactivation credit through the detention time in the clearwells and ground storage tanks. After the ground storage tanks, the water can be treated with ammonia to provide a residual disinfectant of chloramines for the water distribution system. During a more detailed design, the injection locations can be optimized along with a sampling plan to minimize disinfection by-product formation and maintain high water quality standards.

Sodium hypochlorite reacts with water to form hypochlorous acid and sodium hydroxide. Sodium hydroxide is a base and raises the pH of the water. Considering Fiveash WTP effluent can exceed a pH of 9, pH reduction needs to be considered if a sodium hypochlorite disinfection system is installed as part of the Reliability Upgrades and Disinfection System Replacement. pH reduction can be accomplished through recarbonation or acid injection. Acid systems can include weak solutions of hydrochloric or sulfuric acid, citric acid and alum, or acetic acid.

Disinfecting the lime softened water with free chlorine for an extended period of time will promote disinfection by-product formation, specifically, THMs, and HAAs. The high concentration of total organic carbon (TOC) in the water will combine with the free chlorine to form THMs, likely in exceedance of the MCL. The CUSMP Team recommends that a TOC-removal technology be implemented, such as GAC, in order to capitalize on the chemical treatment system improvements. Once a TOC-removal technology is implemented, chlorine will provide 4-log virus inactivation credit. The City can decide to continue with chloramines or pursue the implementation of converting to a free chlorine treatment and distribution system.

Free chlorine versus chloramination depends on the water source type, quality, and the plant treatment process. However, if organics are reduced, free chlorine can be a more cost effective and stronger oxidizing disinfectant, and eliminates the need for adding ammonia. There is also less potential for nitrification within the distribution system.

5.B.2.5 Virus Inactivation Credit

The CUS Master Plan Team recommends that the City implement water treatment to obtain 4-log virus inactivation and obtain certification from FDEP. When bacteriological samples from the wells show the presence of total coliform or E. Coli bacteria, 4-log disinfection is required along with additional well monitoring events and public notification. However, if 4-log virus inactivation is achieved through water treatment, then no other action is required from the utility.

The Fiveash WTP currently injects chlorine and ammonia in the recarbonation basins, prior to filtration, to achieve a chloramine residual of 3.5 mg/L at the outlet of the ground storage tanks. Chlorine is also injected into the aeration basins to assist with achieving the target chloramine residual. After the recommended improvement of addressing the hydraulic flow issues with the WTP, the monitoring and reporting of 4-log virus inactivation should be implemented.

In order to achieve 4-log virus inactivation with the current system, the City could potentially chlorinate using the raw water line about 200-300 feet before the aeration basin and achieve the credit through contact time. In addition, adding chlorine well before the aeration basin would resolve the color issue, while the air stripping would remove the TTHMs.

Other disinfectants, including, free chlorine and ozone are recommended and can also be used to achieve 4-log virus inactivation credit. The existing filters can also be used to meet 4-log virus inactivation credit, providing that specific water quality metrics are met, specifically, turbidity. **Table WA5.B-4** displays the required detention time for various disinfectants, assuming that 2-log inactivation is achieved though filters and the remaining 2-log virus inactivation credit is achieved though chemical disinfectant.

Table WA5.B-4. Residence Time Requirements for 2-log Virus Inactivation Credit

Residual Concentration	Baffling Factor	Ozone	Free Chlorine (pH 6-9)	Free Chlorine (pH 10+)	Chloramines (pH = 8.0)	Chloramines (pH = 9.0)	Chloramines (pH = 11.0)
mg/L	-----	min	min	min	min	min	min
0.2	0.3	4.17	27.5	85	5,917	4,034	767
0.5	0.3	1.67	11.0	34	2,367	1,614	307
1.0	0.3	0.84	5.5	17	1,184	807	15
1.5	0.3	0.56	3.7	11.3	789	538	103
2.0	0.3	0.42	2.8	8.5	59	404	77
3.5	0.3	0.24	1.6	4.9	339	231	44
4.0	0.3	0.21	1.4	4.3	296	202	39

Notes:

Free chlorine CT (pH 6-9, 18.5ºC) = 1.65 mg-min/L

Free chlorine CT (pH 10+, 18.5ºC) = 5.1 mg-min/L

Chloramines CT (pH = 8, 18.5ºC) = 355 mg-min/L

Chloramines CT (pH = 9, 18.5ºC) = 242 mg-min/L

Chloramines CT (pH = 11.0, 18.5ºC) = 46 mg-min/L

Ozone CT (18.5ºC) = 0.25 mg-min/L

Source for CT Values: *Appendix E to the United States Environmental Protection Agency's Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, 1991 (per the "Surface Water Guidance Manual").*

If it is determined that the filters cannot provide sufficient water quality to provide a 2-log virus inactivation credit, different chemicals can be used to treat the water and achieve 4-log virus inactivation (e.g. chloramines, free chlorine, and ozone). **Table WA5.B-5** displays the residence times required for various disinfectants at varying chemical residual concentrations. The cells highlighted orange are the recommended time requirements to achieve residual concentration targets.

Table WA5.B-5. Residence Time Requirements for 4-log Virus Inactivation Credit

Residual Concentration	Baffling Factor	Ozone	Free Chlorine (pH 6-9)	Free Chlorine (pH 10+)	Chloramines (pH = 8.0)	Chloramines (pH = 9.0)	Chloramines (pH = 11.0)
mg/L	-----	min	min	min	min	min	min
0.2	0.3	8.84	55	407	13,667	8,967	1,517
0.5	0.3	3.54	22	163	5,467	3,587	607
1.0	0.3	1.77	11	82	2,734	1,794	304
1.5	0.3	1.18	7.3	55	1,823	1,196	203
2.0	0.3	0.89	5.5	41	1,367	897	152
3.5	0.3	0.51	3.2	24	781	513	87
4.0	0.3	0.45	2.8	21	684	449	76

Notes:

Free chlorine CT (pH 6-9, 18.5ºC) = 3.3 mg-min/L
Free chlorine CT (pH 10+, 18.5ºC) = 24.4 mg-min/L
Chloramines CT (pH = 8, 18.5ºC) = 820 mg-min/L
Chloramines CT (pH = 9, 18.5ºC) = 538 mg-min/L
Chloramines CT (pH = 11.0, 18.5ºC) = 91 mg-min/L
Ozone CT (18.5ºC) = 0.53 mg-min/L

As shown, ozone requires the shortest amount of contact time with the water to provide virus inactivation credit, while chloramines, with a lower pH (+/- 8.0), has the longest contact time requirements. During maximum daily flow conditions (55 MGD) and assuming the tanks remain at least two-thirds full, the existing ground storage tanks provide a residence time of approximately five hours (300 minutes). At the current chloramine residual concentration, 3.5 mg/L, and the current operating conditions (pH ~ 9 SU), the WTP does not retain sufficient residence time for 4-log virus inactivation. The CUS Master Plan Team recommends the City implement the hydraulic improvements and residual monitoring as well as investigate other treatment processes to achieve 4-log virus inactivation credit.

5.B.3 Fiveash WTP Aquifer Storage and Recovery Well System

The City owns an aquifer storage and recovery (ASR) well system at the Fiveash WTP. The ASR system consists of one (1) 16-inch diameter ASR well (ASR-1) completed to a depth of 1,200 feet, one (1) 6-inch diameter, single-zone Floridan Aquifer monitor well completed to a depth of 1,175 feet located approximately 350 feet west of the ASR well, and one (1) 2-inch diameter single-zone Biscayne Aquifer monitor well completed to a depth of 200 feet. The ASR well system was completed in 1998 and was designed to store raw Biscayne Aquifer water from the Prospect Wellfield during low demand periods. Water would then be withdrawn from ASR-1 during periods of high demand.

The open-hole interval (targeted storage zone) of the ASR is completed within the Ocala Limestone. Chloride (Cl) and total dissolved solids (TDS) concentrations within the storage zone were originally about 3,500 milligrams per liter (mg/L) and 7,900 mg/L, respectively. Hydraulic testing of the ASR well can be completed via a step drawdown test as illustrated in **Table WA5.B-6**.

Table WA5.B-6. Hydraulic Testing Results of the ASR Well

Pumping Rate (GPM)	Pumping Rate (MGD)	Drawdown (feet)	Specific Capacity (GPM/ft)
968	1.39	38	25.5
1,377	1.98	60	22.95
1,849	2.66	96	19.25
2,104	3.03	119	17.68

Cycle testing occurred historically on a non-continuous basis between October 1999 and August 2004. Initial testing using raw (untreated) groundwater was in accordance with Florida Department of Environmental Protection (FDEP) Underground Injection Control (UIC) Permit Number 0128340-002-UC (formerly UC-06-296564) issued for a 5-year period in October 1997. FDEP authorized a three year permit extension in October 2003. FDEP granted water quality exemptions in 1998 for color, odor, and iron in the injected water.

Seven recharge/recovery cycles occurred between October 1999 and August 2004. Results of the cycle testing can be depicted in **Table WA5.B-7**.

Table WA5.B-7. Cycle Testing Results of the ASR Well

Cycle	Rate In (MGD)	Volume In (gal)	Rate Out (MGD)	Volume Out (gal)	Percent Recovery
1	1.773	19,499,000	1.040	1,040,000	5.33%
2	1.876	75,036,000	1.555	4,666,000	6.22%
3a	1.969	224,445,000	0	0	13.10%[1]
3b	1.806	413,534,000	1.129	54,193,000	8.49%[1]
4	1.870	56,097,000	0.451	34,262,000	61.08%
5	2.060	61,803,000	0.630	37,178,000	60.16%
6	2.001	240,145,000	0.521	49,999,000	20.82%
7	1.596	193,075,000	0.970	67,883,000	35.16%

[1]Higher recovery for 3a assumes only 3b injected volume; lower recovery assumes 3a+3b injected volumes.

Cycle testing results indicated extremely poor recovery percentages, especially at the targeted higher recovery rates greater than 1 MGD. Improved recovery percentages occurred at the reduced withdrawal rates; however, the percentages were still well below the desired efficiencies for routine ASR operations of 75% to 90%. Poor recoveries evident from the cycle testing were interpreted to lack of overlying aquifer confinement due to the occurrence of an approximately 140-ft thick section of permeable Suwannee Limestone. The absence of a confining layer directly above the storage horizon promotes upward migration of injected fluids, most of which apparently cannot be recovered during the withdrawal phase of ASR cycling, particularly at the desired higher pumping rates. Based on results from the cycle testing, it was concluded that the well as constructed was not viable for routine operations as an ASR facility in light of operational costs and poor recoveries.

The testing that was performed on the ASR system was not significant enough to allow the City to apply for an operating permit for the system. Therefore, the system is currently permitted under a Class V construction permit. The most recently issued FDEP construction permit (no. 128340-006-UC) was issued on March 28, 2013 and expires on March 27, 2018. The permit does not allow operation of the ASR well system, but, instead only allows quarterly injection of one casing volume (approximately 10,000 gallons) of raw water from the Prospect Wellfield to keep the well casing filled with fresh water. This is allowed for maintenance purposes to protect the well casing from corrosion. The City obtained a Water Quality Criteria Exemption (WQCE) in 1998 for color, odor, and iron to allow storage of raw water that did not meet the secondary drinking water standards for these parameters. **Table WA5.B-8** provides a summary of the upper limits for color, odor, and iron that the WQCE allows to be injected via the ASR well.

Table WA5.B-8. WQCE Maximum Allowable Limits

Parameter	Secondary Drinking Water Standard	WQCE Upper Limit
Color	15 SCU	100 SCU
Odor	3 TON	6 TON
Iron	0.3 mg/L	3.0 mg/L

The WQCE remains in place as long as the ASR well system remains permitted under a construction permit. A new WQCE will need to be obtained when the City has completed testing of the ASR well system and an operating permit has been obtained from the FDEP.

The testing performed on the ASR well system took place between 1999 and 2003 and consisted of performing six (6) cycle tests in which varying amounts of water were injected into the ASR well. The water was then recovered from the ASR well until the chloride concentration of the recovered water reached a threshold amount of 250 mg/L, at which point recovery ceased. Cycle testing of the ASR well system ceased in 2003 due to disappointing recovery volumes of stored water.

5.B.3.1 Replacement and Rehabilitation

Once constructed, the subsurface portion of ASR wells and associated monitoring wells typically do not require replacement or rehabilitation. The City currently injects 10,000 gallons of fresh water in the ASR well on a quarterly basis to protect the well casing from corrosion. This maintenance should continue. Inspection of the ASR well system surface equipment (conducted in August 2015) revealed that the surface equipment is well maintained and in very good condition. Surface equipment such as valves, flowmeter, and pressure transducers may need replacement due to exposure to the elements within the next five (5) to ten (10) years.

5.B.3.2 Regulatory Requirements

The ASR well system is permitted in accordance with conditions set forth in Florida Department of Environmental Protection (FDEP) Operating Permit No. 0128340-006-UC and Rule 62-528, Florida Administrative Code (FAC). The permit has an expiration date of March 27, 2018. A construction permit application to renew the existing construction permit must be submitted to the FDEP prior to March 27, 2018 in order to keep the ASR permitted. The permit processing fee (required to be submitted with the permit application) is currently $750 per ASR well, therefore, the permit processing fee to renew the ASR construction permit will be $750. The permit processing time is typically approximately six (6) months. As long as the permit application is submitted prior to the expiration date of the current permit, the ASR system will continue to be subject to the conditions of the existing permit during the period between the current expiration date of the existing permit and the issuance of the permit renewal. **Table WA5.B-9** provides approximate permit application due dates through 2035 and is prepared with the assumption that the City wishes to maintain the ASR well system permit; the permit renewal application is submitted 30 days prior to the permit expiration date and the permitting period is six (6) months.

Table WA5.B-9. Permit Renewal Application Due Dates

Permit Expiration Date	Renewal Application Submittal Date	Renewed Permit Issue Date
March 27, 2018	February 26, 2018	August 27, 2018
August 26, 2023	July 27, 2023	January 29, 2024
January 28, 2029	December 29, 2028	June 29, 2029
June 28, 2034	May 29, 2034	November 29, 2034

Unlike Class I deep injection wells, ASR wells are not required to undergo Mechanical Integrity Testing (MIT). If the City opts to resume testing and operation of the ASR system with raw Biscayne Aquifer water from the Prospect Wellfield, the WQCE would remain in place until the completion of testing. The City would need to apply for a new WQCE when an application for an operating permit has been submitted to the FDEP. The application for a WQCE should be submitted to the FDEP concurrent with the operation permit application and the permitting process would parallel that of the operation permit. The FDEP fee for applying for a WQCE is $6,000 per parameter for which a WQCE is requested. In the case of raw water from the Prospect Wellfield, the fee would total $18,000 each time the WQCE is renewed.

5.B.3.3 ASR System Options for the Future

The current ASR well system permit does not allow testing or operation of the ASR well. The permit only allows injection of approximately 10,000 gallons of water from the Prospect Wellfield on a quarterly basis to protect the well casing from corrosion. There are several options available to the City regarding the use of the ASR well system which include:

- Maintaining the ASR system as-is currently taking place, no operation of the ASR well;
- Resumption of testing of the ASR well system using raw groundwater from the Prospect Wellfield;
- Use of the ASR system for storage and recovery of finished potable water; or
- Conversion of the ASR well to a Floridan Aquifer production well to serve as a source water for a membrane softening or reverse-osmosis water treatment plant in the future.

Each of the options is discussed below along with a cost estimate for implementing the option.

Maintain the ASR Well System in its current use
This option requires no changes to the existing facilities and only requires calibration and maintenance of pressure gauges, pressure transducers and the flowmeter on an annual basis, and exercising the valves on the ASR well surface piping on a quarterly basis. The City is also allowed to fill the well casing (approximately 10,000 gallons) with raw water from the Prospect Wellfield on a quarterly basis. While this option maintains the ASR well system, it does not allow the City to operate the ASR well system. This option must be maintained until another use for the well has been found and implemented (discussed below). It is not recommended once another use for the well has been found and implemented since it requires renewal of the ASR well system permit every five (5) years which requires payment of the permit processing fee as well as paying a consultant to prepare the renewal application.

Resume Testing the ASR Well System with Raw Water
This option has the ASR well system being used for its originally intended purpose which is to inject raw groundwater from the Prospect Wellfield during periods of low demand and pumping the stored water from the well for use during high demand periods on a seasonal basis. Use of the ASR well system in this manner provides protection to the wellfield from over-pumping, which can result in upconing of lower quality water. Use of the ASR well system in this manner also provides protection against drought. The estimated cost of resuming testing of the system with raw water is approximately $40,000 a year. This option is not recommended due to the poor recovery efficiency of injected water during cycle testing.

Resume Testing the ASR Well System with Finished Water
This option is similar to the above option except finished water from the water treatment plant would be injected. Recovered water would need to undergo filtration and disinfection prior to distribution to customers. The estimated cost of resuming testing of the ASR well system with finished water is approximately $100,000 a year. This option is more costly since finished water would be used and is not recommended due to the poor recovery efficiency of the ASR well.

Convert the ASR Well and Floridan Aquifer Monitor Well to a Production Well
This option involves converting the ASR well to a Floridan Aquifer production well. The well would need to be permitted with the South Florida Water Management District. The brackish water (total dissolved solids of the native groundwater is approximately 6,800 mg/L) produced from the well could then be used as a production well for any reverse-osmosis treatment facilities that may be constructed at the site in the future. Water produced from the ASR well would need to undergo pretreatment to address color and iron to protect the membranes from damage. It is recommended that if this option is utilized, that no more than approximately 500,000 gallons per day be pumped from the well to avoid creating upconing of lower quality water which would result in an increase in the total dissolved solids of the water produced from the well. There would be no need to renew the existing FDEP permit for the ASR well system if this option were utilized, but documentation demonstrating that the wells had been converted to production wells would need to be provided to FDEP. The estimated cost for this option is

approximately $3,000 a year to maintain the existing surface facilities. This option is preferred since it preserves the option of using the wells as production wells in the future.

Costs associated with maintaining the ASR well for potential use as a production well should be considered along with current and/or future plans for constructing additional Floridan Aquifer production wells to supply raw water for a low pressure reverse osmosis (LPRO) water treatment system. Two Floridan production wells currently exist near the Peele-Dixie water treatment plant (WTP), and an additional six wells are proposed and permitted according to the CITY's existing Water Use Permit (WUP). Eight (8) proposed Floridan production wells located near the Prospect Biscayne Aquifer wellfield are also included in the existing WUP. Future plans for timing and sizing of a potential Floridan Aquifer wellfield and LPRO WTP will likely impact whether maintaining the ASR well for future use as a Floridan production remains a viable option.

5.B.4 Summary and Recommendations

The Fiveash WTP process control issues impact the finished water quality and stability. The disinfection residual control is difficult to maintain due to the plant process flow not following a single, uniform path. The finished water color is greater than 15 Pt-Co color units causing numerous water quality complaints. Process improvements will need to be implemented in order to provide an aesthetically pleasing finished water to residents and visitors.

The ASR well on-site is not permitted for full use and is only allowed to have 10,000 gallons added to the well to keep the water moving and prevent degradation of the casing. Investigations into other uses for this well while performing the minimum flushing and testing required to maintain the well for future use is recommended.

Plant upgrades and improvements are recommended in order to address the treatment issues. It is recommended that the City investigate and implement a color removal strategy to enhance the aesthetics of the water. Depending on the desired finished water color level, the following treatment strategies should be implemented:

- To achieve a finished water color level between 15-20 Pt-Co enhanced softening and coagulation treatment is required or keep Fiveash WTP running in current manner.
- To achieve a finished water color level between 10-15 Pt-Co ozone, UV, or hydrogen peroxide, followed by enhanced softening and coagulation treatment is required.
- To achieve a finished water color level of 8 Pt-Co or less, then GAC, nanofiltration, or ion exchange with lime softening is required.
- Of note, the color removal process (~$37M) and projected Section WA8-Water R&R ($95M) capital costs are approximately $132M in capital cost at the Fiveash WTP over the next 5 years. A brand new WTP costs approximately $180M to $200M (capital) and would dramatically lower R&R costs going forward. These two options are essentially equivalent on a life cycle basis, with the new WTP option requiring approximately $48M to $68M more in capital costs now.

The CUS Master Plan Team recommends:

- Pilot testing ozone and GAC as the preferred color removal process to confirm cost viability. This treatment strategy potentially provides the greatest benefit at the lowest potential cost, and can be incorporated into the existing treatment process.

- Modifications to the aeration basins to allow for operational control and increase the efficiency of the Fiveash WTP thereby reducing electrical costs. This recommendation will not be needed if ozone is selected to replace the aeration basins.
- Improving the ground storage tanks and clearwells to provide a single flow path for a consistent water and operational control over the disinfection process and water distribution.
- With the current Fiveash WTP being over 60 years old, the City should decide if building a new, innovative water treatment plant is the best option. The decision comes down to spending $132M in capital to rehabilitate and add a color removal process to the existing Fiveash WTP or $180M to $200M to construct a new WTP to dramatically lower annual R&R costs and risk.
- Community Investment Plan (CIP) costs for Fiveash WTP process improvements are provided in **Section WA7-Water CIP**.

WA5.C Peele-Dixie Water Treatment Plant Process Evaluation

5.C.1 Existing Facilities

The City operates the Walter E. Peele-Dixie Water Treatment Plant (WTP), providing drinking water to the southern portion of the City's service area. The Peele-Dixie WTP was originally constructed in 1926 as a lime softening plant. In 2008, the City built a new nanofiltration plant on site, and shut down the lime softening plant. The lime softening plant is not in use and Section WA5D evaluates the City's options for reactivating or decommissioning the old lime softening plant.

The Peele-Dixie WTP maintains a Florida Department of Environmental Protection (FDEP) permitted treatment capacity of 12 MGD. The Peele-Dixie WTP is designed to allow for an expansion for an additional 6 MGD of membrane treatment skids.

Raw water to the Peele-Dixie WTP is pumped from the Dixie Wellfield, which had a new wellfield constructed in 2008 and a new 30-inch raw water main constructed in 2012. **Figure WA5.C-1** presents the layout of the membrane treatment area. The Peele-Dixie WTP uses a hybrid Reverse Osmosis/Nanofiltration (RO/NF) system to treat Biscayne aquifer raw water. For calendar year 2014, the Peele-Dixie WTP treated an annual average day of 8.1 MGD of groundwater, producing 6.9 MGD of finished water. The plant recovers 85% water as permeate, while the remaining 15% concentrate water is disposed of into an underground deep injection well. A simple schematic of the Peele-Dixie WTP Process Design is illustrated in **Figure WA5.C-2**.

The treatment at the Peele-Dixie WTP consists of sulfuric acid and antiscalant addition as pre-treatment prior to cartridge filtration and nanofiltration treatment. The membrane permeate is chlorinated, pH adjusted, and treated with corrosion inhibitor prior to being directed to the degasifiers. After the degasifiers, the water feeds into a single clearwell with partial interior baffle walls. In the clearwell, chlorine, fluoride, and corrosion inhibitor are added prior to the final pH adjustment using caustic. From the clearwell, the water is pumped to the ground storage tanks and ammonia is added to form chloramines. Finished water is delivered from the ground storage tanks into the water distribution system via the high service pumps.

5.C.2 Capacity Evaluation

5.C.2.1 Raw Water Wells

The feed water source for the Peele-Dixie WTP is the Biscayne Aquifer. The aquifer is located in South Florida in parts of Dade, Broward, and Palm Beach Counties. This aquifer underlies an area of approximately 4,000 square miles and is a highly permeable aquifer that consists mainly of limestone, less-permeable sandstone, and sand. The water from the Biscayne aquifer has relatively high calcium and magnesium hardness and low sodium chloride levels. The total dissolved solids (TDS) in the raw water from the Peele-Dixie Wellfield is about 350 to 500 ppm TDS.

In 2008, the City installed eight (8) new raw water wells in the Peele-Dixie Wellfield and abandoned the existing wells. The new well pumps have capacities of approximately 2.5 MGD each, which equates to a total wellfield capacity of approximately 20 MGD per day. The South Florida Water Management District (SFWMD) Water Use Permit (WUP) limits the maximum daily withdrawal to 15 MGD, which is sufficient to produce 12 MGD of finished water through the membrane treatment system. No significant raw water system capacity issues were identified by the CUSMP Team including City operations personnel.

The membrane water treatment plant was designed and constructed with room for future expansion to 18 MGD capacity, by creating 6 MGD from brackish water from the Floridan

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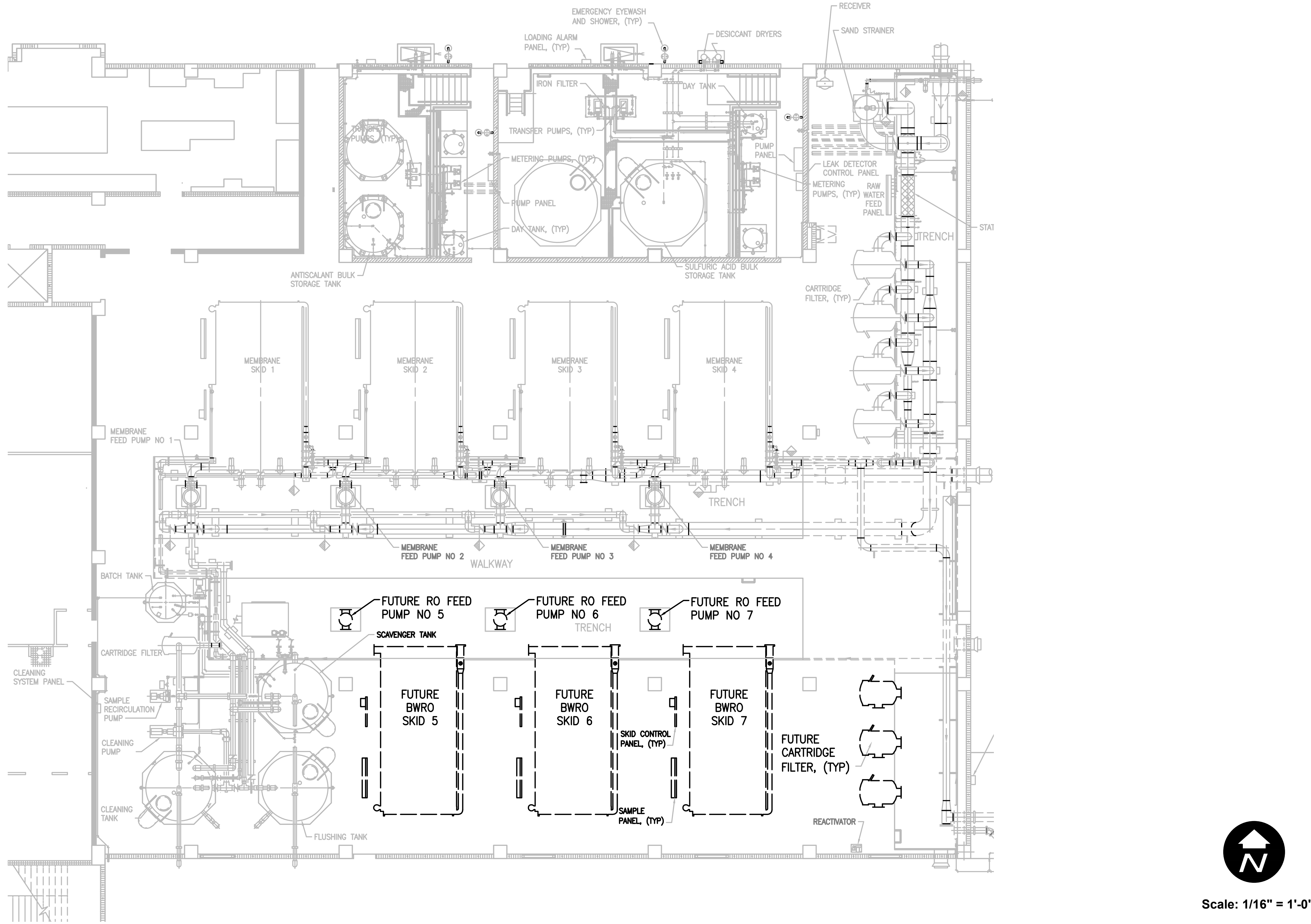

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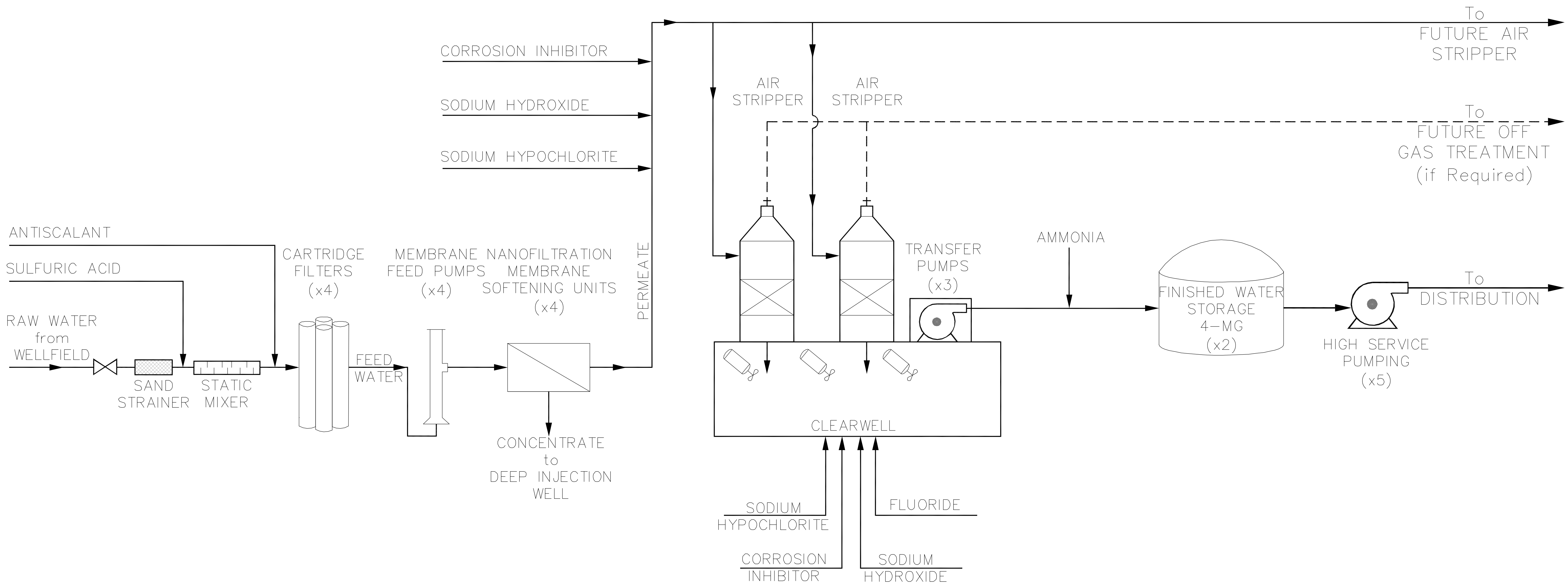
CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
EXISTING BUILDING PLAN

FIGURE WA5.C-1



EXISTING NF/RO FACILITY

CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
EXISTING PROCESS FLOW DIAGRAM

FIGURE WA5.C-2

Aquifer treated by reverse osmosis. In order to expand the facility to produce 18 MGD of finished water, the City will need to install new source water wells. It is planned to drill additional Floridan Aquifer wells to supply groundwater for the plant expansion. The minimum capacity of the wells for the membrane treatment is 7.05 MGD (assuming an 85% recovery). Two test wells have been installed in 2007 to determine the potential water quality of the Floridan Aquifer groundwater and productivity of the wells.

5.C.2.2 Pretreatment

In the current plant, groundwater is first pretreated by using an automatic backwash strainer (nominally rated 50 to 100 micron) to remove sand and other large particulates. Following the strainer treatment, two chemicals are injected to the groundwater. First, 93% sulfuric acid is added to adjust the pH to 6.2, to prevent the precipitation of calcium carbonate on the membrane elements and assist in the prevention of iron fouling. The acid is injected prior to a static mixer to ensure mixing of the acid. After the static mixer, an antiscalant is added to prevent precipitation of other salts on the membrane elements. The antiscalant is injected prior to cartridge filtration for mixing within the cartridge filtration vessels.

The sulfuric acid chemical feed system consists of a 12,000 gallon bulk tank, a 300 gallon day tank and 2 chemical pumps, sized to pump up to 77 gallons per hour of sulfuric acid into the groundwater.

The antiscalant feed system consists of a 1,800 gallon bulk tank, a 100 gallon day tank and 2 chemical pumps, sized to pump up to 5 gallons per hour of antiscalant into the groundwater.

Cartridge filtration is the last barrier to protect the nanofiltration membrane elements against particle plugging. The cartridge filtration system consists of four 5-MGD capacity, 5-micron cartridge filters for a total capacity of 20 MGD. During pretreatment, the conditioned water quality must meet pH and conductivity parameters monitored by the operational staff.

As discussed and recommended during pilot testing of the Peele Dixie membrane system there is a potential for iron fouling that is effectively limiting capacity at times. At full plant capacity, the sand strainer backwashed continuously because of the iron precipitation in the sand strainer and the resulting increase in sand strainer differential pressure. The City has modified the raw water system to minimize the introduction of air into the piping that would oxidize the iron. The City operating staff has also developed a protocol of pretreatment to help the issue. A short term remedy is to add a parallel sand strainer to reduce the pressure differential. A long term solution is to add pressure filtration to mitigate membrane fouling and the capacity bottleneck, as recommended in Reiss Engineering’s 2004 pilot study at Peele Dixie. A pressure filtration system for Peele Dixie would have a capital cost of $3,600,000.

5.C.2.3 RO/NF Hybrid System

After pretreatment, the water is pumped to the four 3-MGD membrane skids operating at a recovery rate of 85% and at a flux of 14 gallons per square foot per day (gfd). Each skid includes a dedicated 300-horsepower (hp) vertical turbine pump equipped with a variable frequency drive (VFD) to pump water to the skids. The feed pressure forces the water through the membrane against the natural osmotic gradient, thereby increasing the dissolved contaminant on one side of the membrane (“concentrate”) and increasing the volume of water with lower concentrations of dissolved contaminants on the other (“permeate”). Since there is a relatively small concentration of TDS in the Biscayne aquifer raw water, the required feed pressure for the membranes to operate effectively is 100 psi.

Each membrane treatment skid is a two-stage skid and consists of 53 pressure vessels in the 1st stage and 24 pressure vessels in the 2nd stage. Each pressure vessel contains seven (7)

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spiral-wound membrane elements. The membrane system is a hybrid system as the skids contain two types of membrane elements. The 1st stage pressure vessels contain seven (7) ultra-low pressure reverse osmosis (ULPRO) membrane elements. The 2nd stage pressure vessels contain four (4) ULPRO membrane elements and three (3) high-flow/low-rejection NF membrane elements. The membrane system removes hardness, organics, and other minerals from the water, creating an aggressive and corrosive water. Other than the iron fouling issue discussed above, no significant RO/NF hybrid system capacity issues were identified by the CUSMP Team including City operations personnel.

5.C.2.4 Post-Treatment

Permeate from the membrane skids is directed to the two degasifiers, each with a capacity of 6 MGD. Prior to the degasifiers, the water is treated with sodium hypochlorite for sulfide oxidation and to prevent biogrowth on the degasifiers. Corrosion inhibitor is also added to the water to lower the corrosivity and prevent damage to tanks, equipment, and the distribution system. Sodium hydroxide can be added in order to raise the pH slightly for corrosion control assistance; however, if the pH is raised higher than 6.8 standard units (SU), then the degasifiers lose their efficacy for hydrogen sulfide removal. Fans force air up through the degasifier to strip hydrogen sulfide gas from the permeate. The off-gas from the degasifiers is vented to atmosphere, and the water passes into the clearwell. There is a degasifier cleaning system that was manufactured by plant staff (in house); however, WTP staff have noted it does not efficiently/effectively clean the degasifiers. Degasifier media is due for replacement as it has reached its service life and is deteriorating. The CUSMP recommends that the City modify the cleaning system using in-house engineering to improve effectiveness, given higher priority needs for limited capital dollars in other areas, train staff on its use and set a regular cleaning schedule. No significant post treatment system capacity issues were identified by the CUSMP Team including City operations personnel.

5.C.2.5 Clearwell and Transfer Pumping System

Once the permeate passes through the air strippers, it is then discharged into a clearwell where post-treatment occurs. Sodium hypochlorite and ammonia are added for primary disinfection with chloramines. Sodium hydroxide is added for pH adjustment and additional corrosion inhibitor is added to protect the distribution system. The City adds fluoride to the finished water for dental benefits. The City adds sodium hypochlorite for free chlorine disinfection in the clearwell to achieve the necessary for 4-log reduction credit. The clearwell uses three motorized mixers to provide a well-mixed and consistent finished water. Ammonia is added to convert the free chlorine to chloramines and maintain a disinfection residual in the distribution system. Through the detention time in the clearwells, the City has successfully achieved a 4-log virus inactivation credit/certification according to FDEP regulations.

At the end of the clearwell, three transfer pumps discharge the water into the two (2) 4-MG ground storage tanks. Each transfer pump has a capacity of 6 MGD each. No significant clearwell and transfer pumping system capacity issues were identified by the CUSMP Team including City operations personnel.

5.C.2.6 Finished Water Storage and Distribution

Once the finished water is stored in the ground storage tanks, the water is pumped into the distribution system through a high-service pump station. The high service pump station consists of five (5) 250-hp vertical turbine pumps, each with a capacity of 6 MGD. These high service pumps operate at a pressure range of 70-85 psi. No significant finished water storage and distribution system capacity issues were identified by the CUSMP Team including City operations personnel.

5.C.3 6 MGD Expansion Plan

It was planned to expand the Peele-Dixie WTP from 12 to 18 MGD by adding 6 MGD of reverse osmosis membrane treatment, but since the recession, water demand projections to 2035 do not show the need for additional capacity. The source water for the expansion will be Floridan Aquifer groundwater. The source water is brackish and significantly different from the Biscayne aquifer groundwater feeding the existing NF skids. The existing NF skids are not designed to treat the brackish water and consequently, the membrane expansion would force the Floridan aquifer wells to be directed to the new membrane skids. The two source waters (Biscayne and Floridan aquifer) cannot be blended prior to treatment since the resulting increased salinity would require higher operating expenses and energy costs. Therefore, the membrane expansion will be independent of the existing NF treatment.

5.C.3.1 Raw Water

There are currently two Floridan aquifer test production wells (FAS-1 and FAS-2) that will be used to feed the plant expansion in conjunction with three future Floridan aquifer wells (FAS-3, FAS-4, and FAS-5). Each well will be equipped with a pump having a capacity of 2 MGD. The raw water flow will be approximately 8 MGD, with four out of five wells in operation. This arrangement will provide a firm capacity adequate to produce 6 MGD of permeate through the new membrane treatment that requires a minimum of 7.05 MGD of raw water (assuming 85% recovery).

5.C.3.2 Pretreatment

The groundwater from the Floridan aquifer wells will be pretreated by adding sulfuric acid and an antiscalant to prevent precipitation of salts on the RO membrane elements. The addition of chemicals will be followed by cartridge filtration. It is important to note that it is assumed that the water quality of the groundwater from the Floridan aquifer will not degrade and does not contain any contaminants that would require additional pretreatment.

5.C.3.3 Sulfuric Acid

The existing sulfuric acid system consists of a bulk storage tank, one day tank and two chemical pumps that pump sulfuric acid to the raw water feeding the existing four NF skids. For the RO expansion, it is recommended to add another chemical pump skid containing two pumps in the existing sulfuric acid room. An additional day tank will be added to feed the new sulfuric acid chemical pumps. The existing day tank does not provide sufficient capacity for a full day usage of sulfuric acid. The additional day tank will be connected to the existing day tank with the ability operate in parallel, providing sufficient capacity to operate all membrane skids for a full day. During the preliminary design of the RO expansion, the size of the pumps will be determined based on the quantity of acid to be added to the raw water, and the size of the new day tank will be designed such as they can hold a combined total of one day of acid use.

An additional bulk tank is required to accommodate the increase in sulfuric acid consumption. The sulfuric acid chemical room where the bulk tank is contained does not provide a method to introduce another bulk tank into the chemical room. Only manway doors exist for entry and exit into the room. In order to install a new bulk tank, it is recommended to open a hole in the wall and install a rolling door so a large tank can be delivered and installed. Without an additional bulk storage tank, the deliveries of sulfuric acid will increase in frequency. **Figure WA5.C-3** displays the proposed locations for the additional sulfuric acid bulk storage and day tanks.

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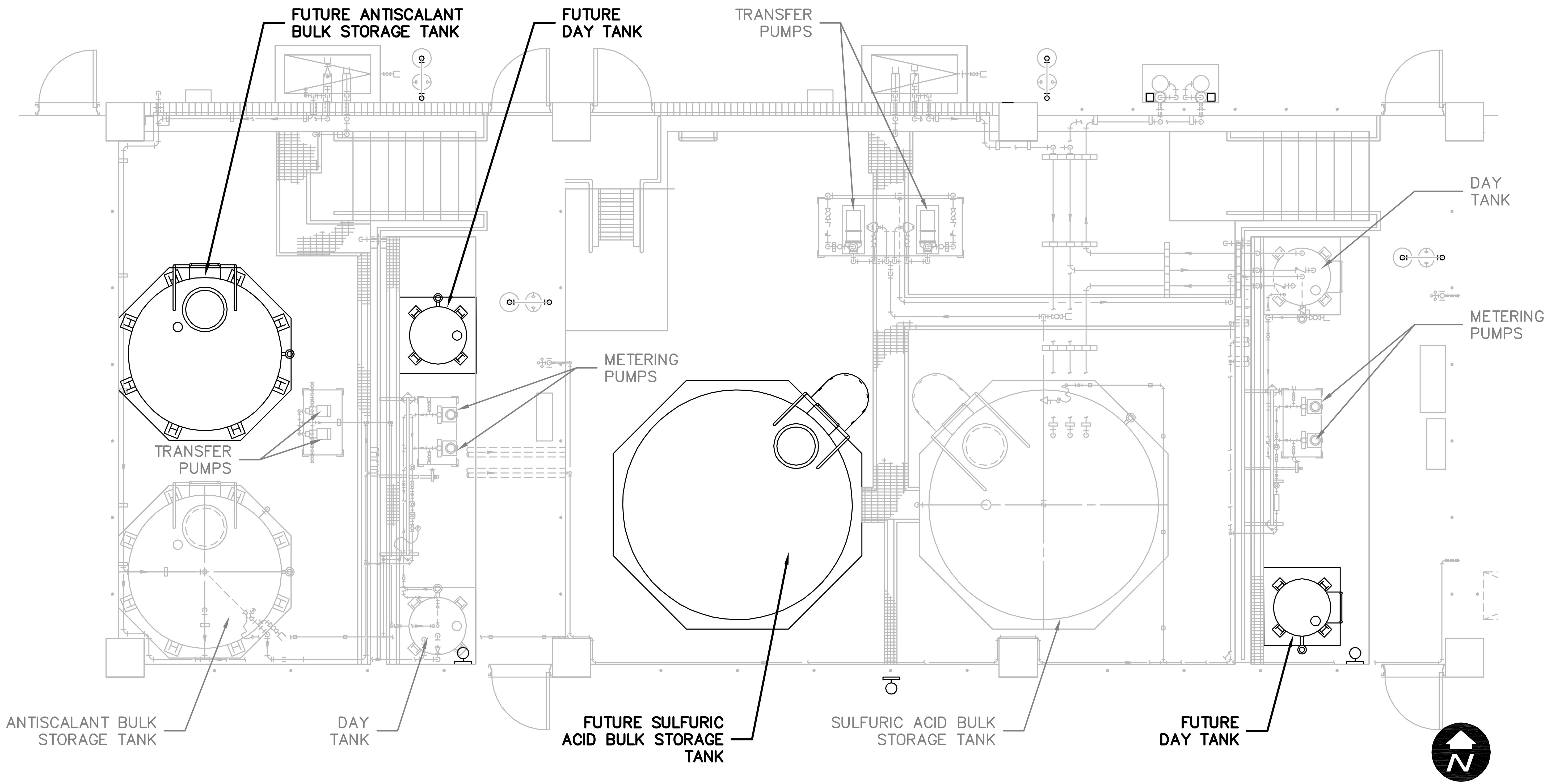

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CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
6 MGD EXPANSION-CHEMICAL STORAGE PLAN

FIGURE WA5.C-3

5.C.3.4 Antiscalant

Currently the antiscalant system consists of a bulk storage tank, one day tank and two chemical pumps that pump antiscalant to the raw water feeding the existing four NF skids. For the RO expansion, the CUS Master Plan Team recommends adding another chemical pump skid containing two pumps in the existing antiscalant room. An additional antiscalant day tank will be added to feed the new antiscalant chemical pumps. The additional day tank will be connected to the existing day tank with the ability to operate in parallel, providing sufficient capacity to operate all membrane skids for a full day. During the preliminary design of the RO expansion, the size of the pumps will be determined based on the quantity of antiscalant to be added to the raw water, and the size of the new day tank will be designed such that they can hold a combined total of one day of antiscalant use.

The existing bulk tank cannot accept delivery of a full truckload of antiscalant, increasing chemical costs because the delivery companies charge partial loads as full loads. An additional bulk tank is required to accommodate the increase in antiscalant consumption and allow for a full truckload delivery. The antiscalant chemical room where the bulk tank is contained does not provide a method to introduce another bulk tank into the chemical room. Only manway doors exist for entry and exit into the room. In order to install a new bulk tank, it is recommended to open a hole in the wall and install a rolling door so a large tank can be delivered and installed. During the design, the sizes of the existing bulk tank and the new bulk tank should be assessed and designed such as the new proposed bulk storage system is practical for the operation staff and result in full truck load deliveries. Without an additional bulk storage tank, the deliveries of antiscalant will increase in frequency. **Figure WA5.C-3** displays the proposed locations for the additional sulfuric acid bulk storage and day tanks.

Note that during preliminary design, it is possible that the antiscalant currently used may not be adequate for the RO expansion. Therefore, it may be required to change the type of antiscalant that would be appropriate for the NF and the RO treatments, or have two independent chemical feed systems.

5.C.3.5 Cartridge Filtration

The cartridge filtration system for the RO expansion will consist of three new cartridge filter vessels, each having a capacity of 2.5 MGD, if no redundancy is required, otherwise the capacity of each vessel would have to be 3.75 MGD. The CUS Master Plan Team recommends having redundancy such that one vessel can be removed from service for maintenance or change-out of cartridge filters without interrupting production of water from the RO skids. **Figure WA5.C-4** displays the location of the proposed additional cartridge filters in the existing membrane treatment room.

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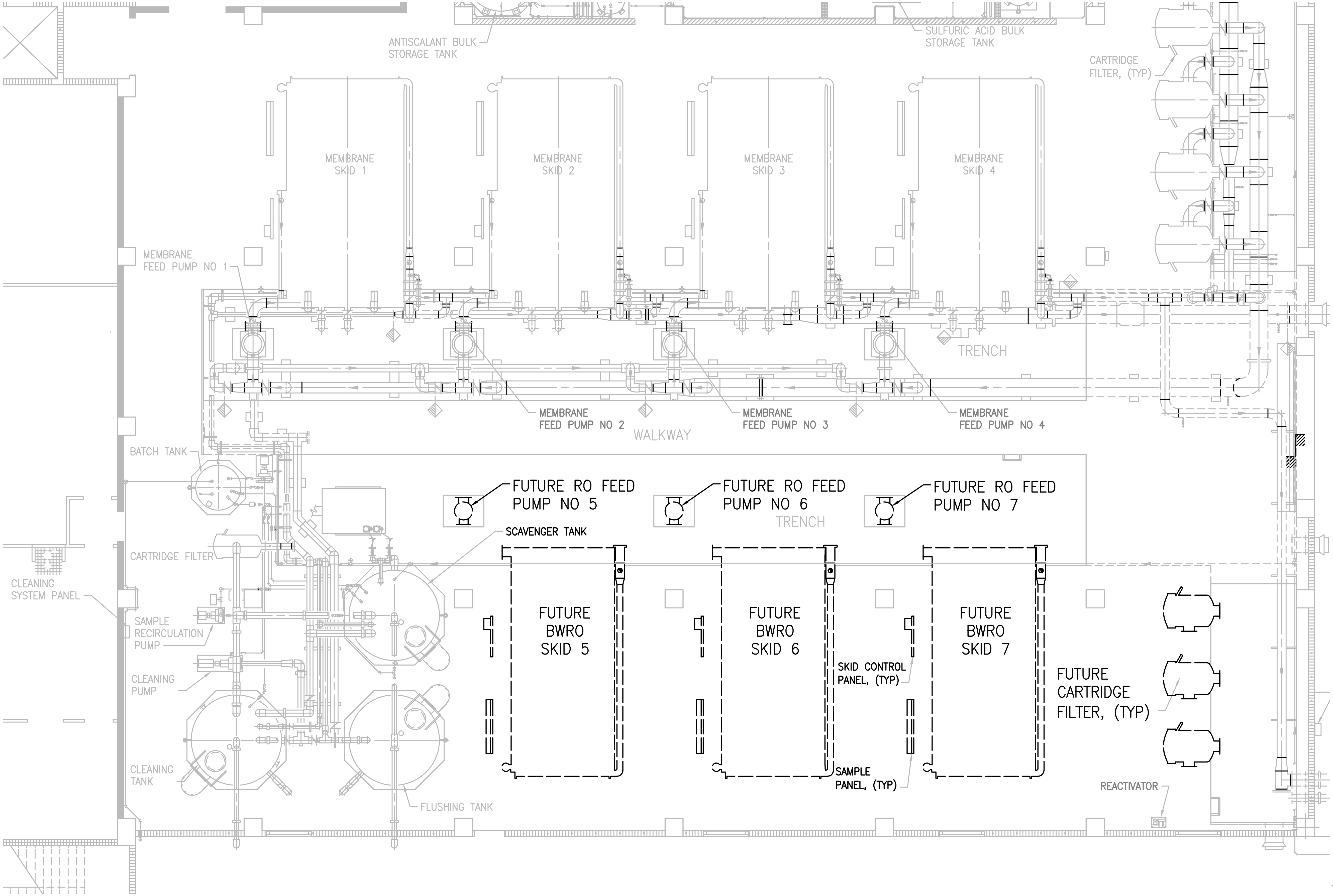

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CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
6 MGD EXPANSION-MEMBRANE TREATMENT

FIGURE WA5.C-4

5.C.3.6 Membrane Treatment

Figure WA5.C-4 shows that during the original design and construction of the plant, space was included for three additional skids, each having a permeate water capacity of 2 MGD. The new RO treatment skids will be designed to operate at an 85% recovery, which results in a feed flow of 2.35 MGD per skid. Each skid will have a dedicated high pressure pump capable to pump 2.5 MGD at the required pressure, to be finalized during design of the RO expansion.

5.C.3.7 Post-Treatment and Transfer Pumps

A third degasifier will be installed in the allocated location on top of the clearwell to remove hydrogen sulfide from the permeate. The new degasifier will have a capacity of 6 MGD, to match the two existing degasifiers. The chemical feed systems for chlorine, sodium hydroxide, ammonia, fluoride, and corrosion inhibitor would have to be evaluated to ensure that they are properly sized for the additional chemical demands. An additional transfer pump will be installed to transfer the treated water from the clearwell to the ground storage tanks. The transfer pump will be similar sized as the existing three transfer pumps, with a capacity of 6 MGD. **Figures WA5.C-5, 6, and 7** display the planned location of the future transfer pump and degasifier systems. In addition, the CUSMP Team recommends designing and installing an efficient/effective system to clean the degasifiers, as the current system has been deemed inadequate and unreliable by City staff. The original plant design accounted for the expansion and provided layout areas for the expansion.

5.C.3.8 6 MGD Expansion Costs

Planning level costs have been developed to capture the expense of expanding the facility. While demand forecast based on population projections indicates that expansion of the Peele Dixie WTP is not needed during the planning period up to 2035 based on capacity, expansion may occur for other reasons such as Biscayne Aquifer contamination or partial retirement of Fiveash WTP capacity. If expanded, it is estimated that the 6 MGD Peele Dixie WTP expansion will cost approximately $15.3 million. The Peele Dixie WTP expansion was not included in the 20-year Community Investment Plan. The operating costs for the new membrane skids and predicted chemical costs are estimated to be $0.50/kgal. This does not include well pumping costs or high service pumping costs. **Table WA5.C-1** displays a cost breakdown for each of the individual components of the expansion plan.

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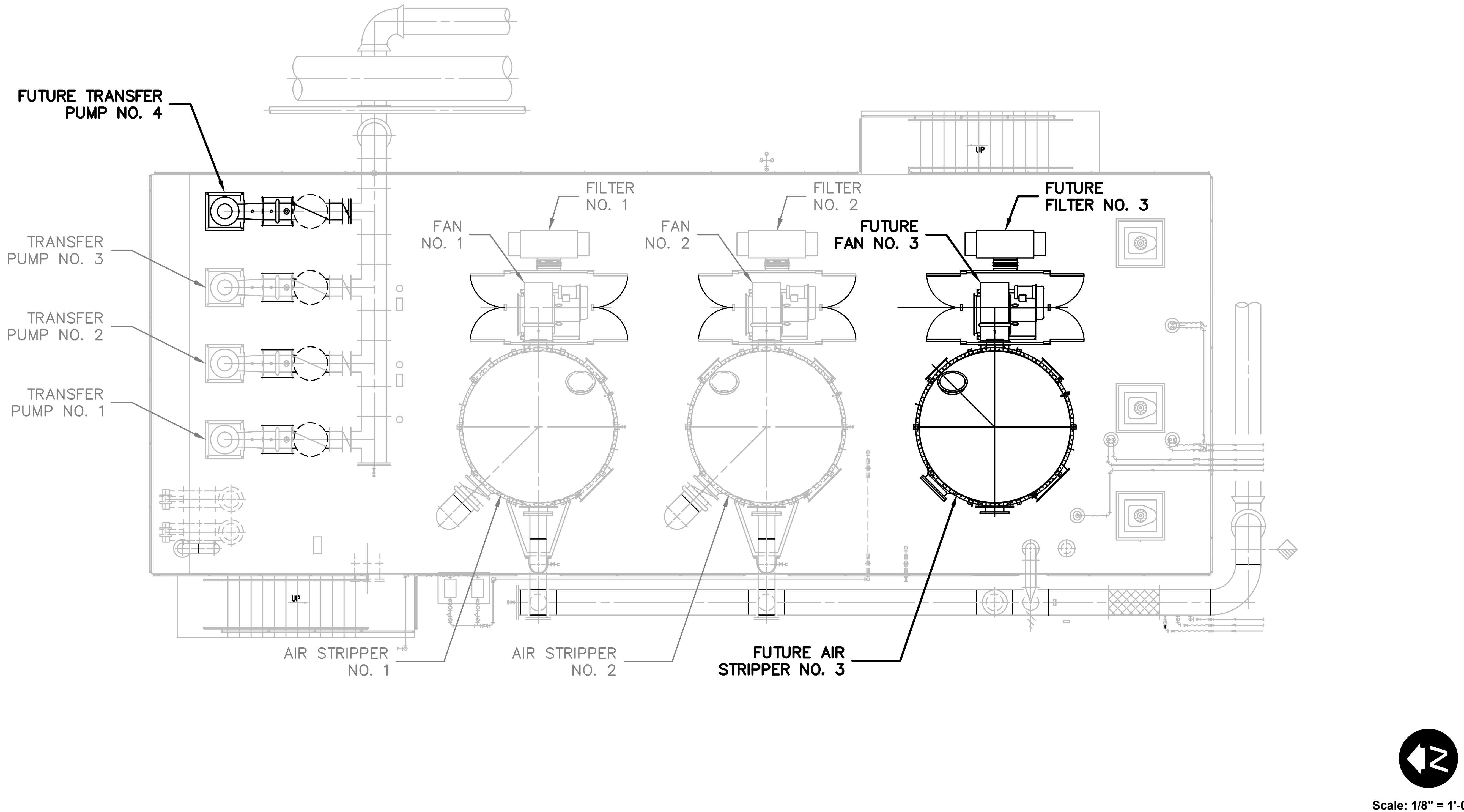
Table WA5.C-1. 6 MGD Plant Expansion Capital and O&M Costs

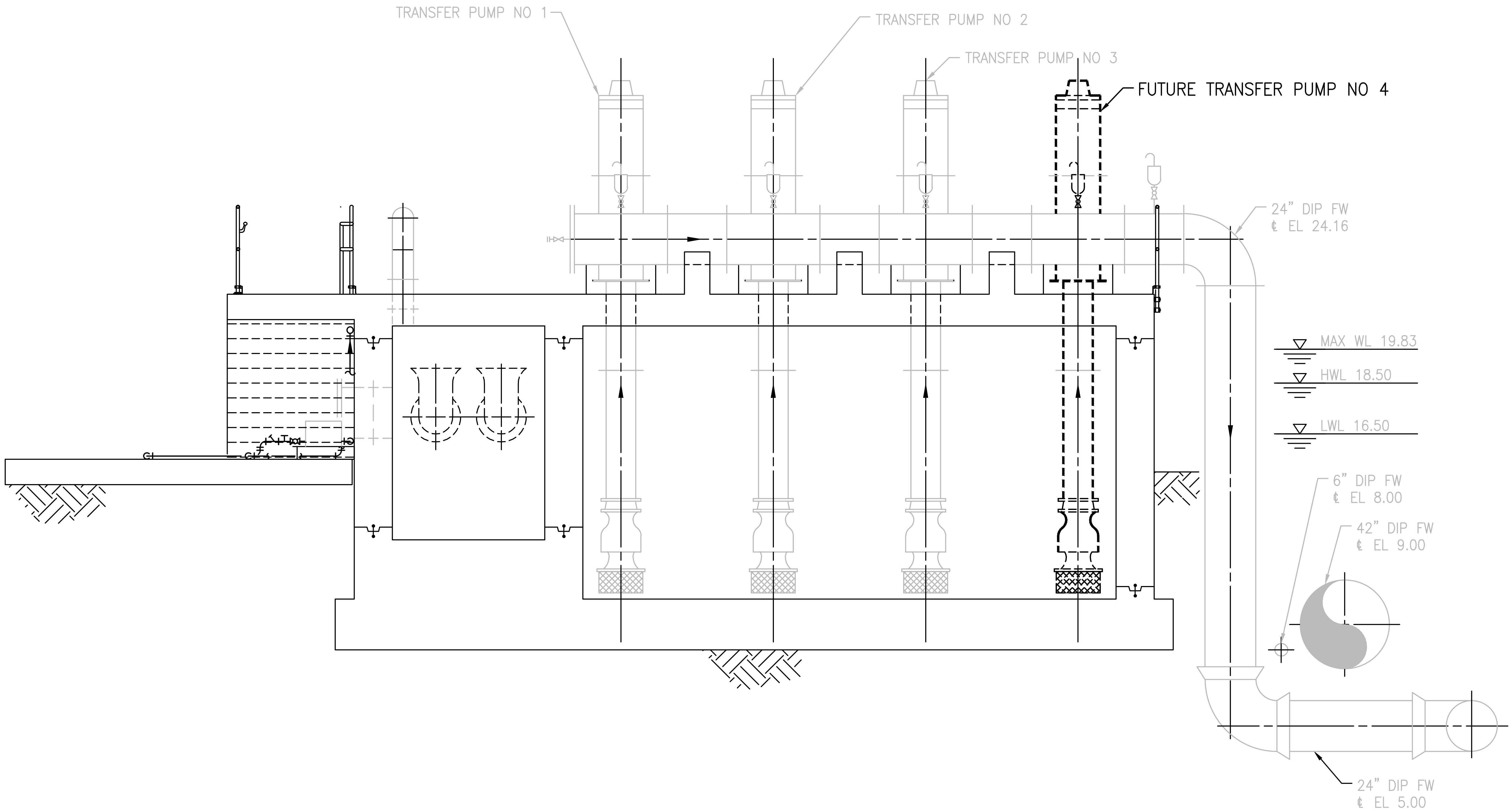
TITLE	TITLE
General Conditions (10% of total)	$ 850,000
Pretreatment	
Anti-Scalant Chemical Feed System	$ 90,000
Anti-Scalant Bulk Tank	$ 30,000
Anti-Scalant Day Tank	$ 15,000
Sulfuric Acid Chemical Feed System	$ 180,000
Sulfuric Acid Bulk Tank	$ 100,000
Sulfuric Acid Day Tank	$ 25,000
Membrane Treatment	
(3) 3.75 MGD RO Cartridge Filters	$ 200,000
(3) High Pressure Booster Pumps	$ 1,500,000
(3) 2 MGD RO Skids	$ 2,600,000
RO system piping and valves	$ 300,000
Post Treatment	
6 MGD Degasifier	$ 800,000
Corrosion Inhibitor Chemical Feed System	$ 100,000
Fluoride Chemical Feed System	$ 100,000
Caustic Chemical Feed System	$ 180,000
Ammonia Chemical Feed System	$ 120,000
Sodium Hypochlorite Chemical Feed System	$ 200,000
Miscellaneous	
2 Chemical Room Rolling Doors	$ 350,000
Site piping	$ 120,000
Electrical (Assume 10% of Capital Costs)	$ 780,000
Instrumentation (Assume 10% of Capital Costs)	$ 780,000
Subtotal Capital Costs	$ 9,420,000
Contingency (30%)	$ 2,600,000
Overhead and Profit (15%)	$ 1,700,000
Engineering (12%)	$ 1,600,000
TOTAL DESIGN AND CONSTRUCTION COST ESTIMATE	**$ 15,320,000**
Total Estimated O&M Costs	**$0.50/kgal**

Note: The demand forecast based on population projections indicates that expansion of the Peele Dixie WTP is not needed during the planning period up to 2035 based on capacity; therefore, the Peele Dixie WTP expansion was not included in the 20-year Community Investment Plan.



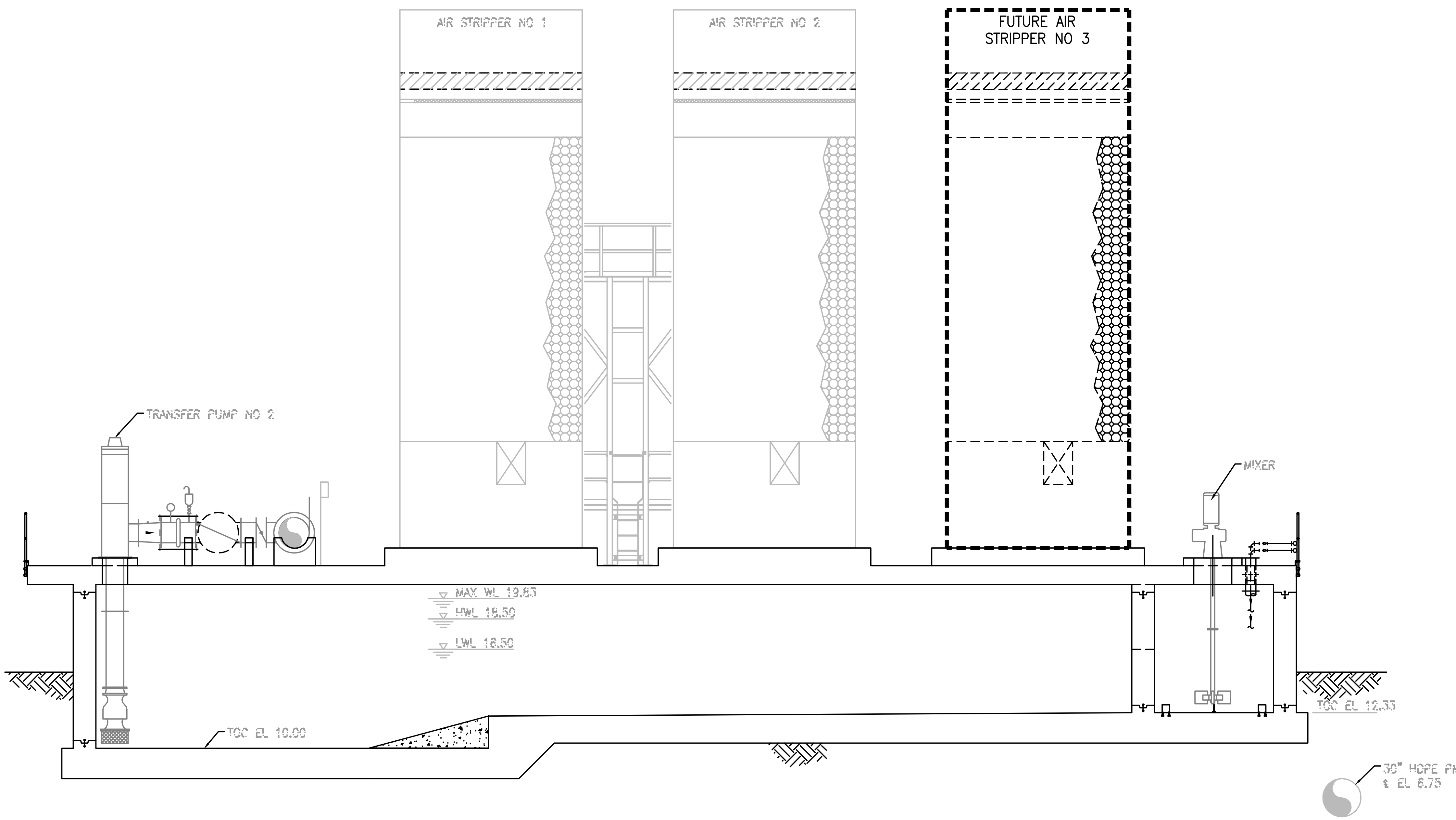
CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
6 MGD EXPANSION-AIR STRIPPERS/TRANSFER PUMP STATION PLAN

FIGURE WA5.C-5



CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
6 MGD EXPANSION-TRANSFER PUMPS SECTION

FIGURE WA5.C-6



CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
6 MGD EXPANSION-AIR STRIPPERS SECTION

FIGURE WA5.C-7

5.C.3.9 Finished Water Quality Goals

Table WA5.C-2 summarizes proposed water quality goals used in this evaluation**.**

Table WA5.C-2. Proposed Finished Water Quality Goals

Parameter	Units	Proposed Goal	Peele-Dixie Effluent Water Quality (2014)	Primary Drinking Water Standards	Secondary Drinking Water Standards
Total Hardness	mg/L as CaCO3	50 - 120	17.4	NS	NS
Sodium	mg/L	< 50	<50	160	NS
Total Dissolved Solids (TDS)	mg/L	< 500	<500	NS	500
Iron	mg/L	< 0.3	0.10	NS	0.3
Manganese	mg/L	< 0.05	<0.05	NS	0.05
Fluoride	mg/L	< 0.7	0.6	4.0	2.0
Sulfate	mg/L	< 200	<200	NS	250
Chloride	mg/L	<100	16.7	NS	250
Color	Pt-Co	< 8	1.9	NS	15
Turbidity	NTU	< 1	0.16	NS	NS
Alkalinity	mg/L as CaCO3	> 40	54.1	NS	NS
H_2S	mg/L	< 0.1	<0.1	NS	NS
pH	Units	8.0 – 8.5*	9.0	NS	6.5-8.5*
TTHM	mg/L	< 0.06	0.064	0.08	NS
HAA_5	mg/L	< 0.04	0.0318	0.06	NS
Free Ammonia	mg/L	<0.2	<0.5	NS	NS
Corrosivity	-----	Non-Corrosive	Non-Corrosive	NS	Non-Corrosive
LSI	units	0.25 - 0.50	0.3	NS	NS

Notes:

*Upper limit of 9.0 allowed with written approval from the Broward County Department of Health
NS = No Standard for groundwater systems.

Current finished water quality at the Peele-Dixie WTP has a slightly positive Langelier Saturation Index (LSI), elevated pH, and low hardness and alkalinity. While the Peele-Dixie WTP discharge water is stabilized and non-corrosive, distribution conditions including nitrification infrequently cause stability issues out in the far reaches of the system. The increase in capacity by the addition of brackish reverse osmosis treatment will not alleviate these water quality concerns. The elevated pH of the finished water is required to reduce the corrosive nature of the water, mitigate nitrification and match the pH from the Fiveash WTP. However, infrequent corrosion issues will likely continue to occur. Post stabilization treatment should be considered to fully alleviate corrosivity issues. The addition of calcium chloride or calcite will render the water non-corrosive and increase the calcium and total hardness.

Section WA5C accepted January 9, 2017.

5.C.4 Summary and Recommendations

Based upon the plant evaluation, improvements and investigations are recommended in order to ensure a reliable water quality that meets primary and secondary drinking water standards. In addition, these improvements will enhance operations and provide the required operational redundancy. **Section WA7-Water CIP** presents the recommended projects and costs for inclusion into the Community Investment Plan (CIP).

5.C.4.1 Lime Softening Plant Rehabilitation Investigation

Prior to the implementation of the reverse osmosis/nanofiltration system, the City used a conventional lime softening process with granular media filtration to treat its water. This original lime softening water treatment plant was in service for 82 years. Re-commissioning of the old lime process train was considered: the treated, lime softened water would have a higher pH and be stable enough that it could be blended with the membrane treated water to produce a less corrosive and more stable water in the ground storage tanks. Recommissioning the lime softening plant may also offset the expansion of the membrane system to potentially reduce operating costs and aid with Water Use Permit compliance. The City abandoned all but four of the original wells in accordance with SFWMD and FDEP rules (filled with grout, cut off and capped at 5 feet below ground). Two of the remaining wells were transferred to the golf course for use as irrigation wells and two have been demolished and await abandonment.

The City's own experience shows that the lime softening process is less expensive than the membrane filtration facility to operate. Therefore, recommissioning the lime softening plant will undoubtedly reduce operating costs. Based upon inspection of the previous lime softening system, some of the infrastructure appears to be suitable and structurally sound, however, many portions would have to be demolished and reconstructed. The CUSMP Team performed an investigation on re-commissioning the old lime process train and recommended the City abandon and de-commissioned the old lime process train (see **Section WA5E**). Expansion of the Peele Dixie WTP could alternatively include a new lime softening train to minimize operations cost that can be resolved in the 20 years until the expansion is actually needed.

5.C.4.2 Chemical Storage Area Investigation

During the Peele-Dixie WTP site visit, the Peele Dixie WTP operations staff described that the storage-and-feed system for the sodium hydroxide and sulfuric acid did not hold enough chemical supply to sustain the treatment process for 24 hours. In order to reduce staffing operation costs to refill the tanks twice a day, the CUSMP Team recommends additional storage should be added to the current storage-and-feed system. The installation of additional storage can be incorporated into the expansion of the membrane treatment system or performed independently.

The CUSMP Team observed that the chemical storage tanks were installed initially, followed by the construction of the secondary containment system and building structure. As a result, if one of the tanks needs to be removed or replaced, or if there is a need to install an additional tank, there will be little space and poor accessibility. In addition, the antiscalant and corrosion inhibitor bulk chemical tanks do not allow for a full-load delivery of chemicals. Less than full truckloads are charged as full truckloads by the delivery companies; resulting in costly, inefficient chemical purchases. To avert both issues, the CUSMP Team recommends investigating the installation of separate roll-up, over-head doors or possibly multiple, smaller tanks.

At each of the chemical storage and pumping areas, there is a significant stepdown adjacent to the entrance of the buildings. This poses a safety concern, and the CUSMP Team recommends the installation of grating to create a level, flat surface without a stepdown to prevent workplace accidents and still provide necessary containment.

5.C.4.3 Pumping Area Investigation

Two out of the five high service pumps that distribute finished water from the ground storage tanks to the service area currently have variable frequency drives (VFDs). The two existing VFD's handle the variances with the three fixed speed handling base load. VFDs allow pumps to increase or decrease speed to match system flow and pressure variances, resulting in improved distribution system operations. While installing VFDs on high service pumps 3, 4, and 5, would inevitably produce better control and lower operating costs, the City has no issues with the current system and there is no room in the electrical room for additional VFDs.

5.C.4.4 Operations and Maintenance Workshop

Currently, there is not a “workshop” or available space, for the operations and maintenance (O&M) staff to perform repairs and operate machinery. Including a separate space will allow for a proper, permitted area for the operations staff to perform repairs on the equipment as needed and potentially reduce costs by having to hire outside staff to perform the repairs. Based upon current conditions, the CUSMP Team suggests investigating the conversion of the 2nd floor area into a permitted area for maintenance workshop areas.

5.C.4.5 Post-Treatment Water Stabilization

The CUSMP Team recommends implementing post-treatment stabilization of the treated water. Currently, a chemical corrosion inhibitor is introduced into the water to prevent corrosion of equipment, tanks, and the distribution system. The efficacy of this was investigated in 2011 and the results were published in “Peele-Dixie Water Treatment Plant Corrosion Study Results”, March 2011. The 180-day test shows that the corrosion inhibitor is performing adequately, however, long-term impacts are not known. Post-stabilization of the water, beyond the existing corrosion inhibitor, should be explored to potentially include the removal of the corrosion inhibitor. **Section WA5.D** provides more detail into addressing post-treatment stabilization, and provides a recommended treatment option.

Section WA5C accepted January 9, 2017.

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WA5.D Peele Dixie Alternative Process Evaluation

The City currently operates the Walter E. Peele-Dixie Water Treatment Plant (Peele Dixie WTP) in the southwest portion of the City. The Peele Dixie WTP currently utilizes a state-of-the-art nanofiltration reverse osmosis treatment process train constructed in 2007. Co-located on the site is a historic-designated lime treatment process train, which has not been in operation since 2008. The CUSMP Team evaluated the potential to rehabilitate the old, currently inactive lime softening plant on-site to provide additional treatment capacity. The evaluation included cost estimates and recommendations based on the expense to rehabilitate versus expand the membrane facility. As discussed in **Sections WA5.A** and **WA5.E** rehabilitating the lime softening plant could cost in excess of $30,000,000, nearly the cost of a new similar size facility. Expanding the membrane treatment plant was estimated to cost $15,320,000, as shown in **Section WA5.C**, however, expansion is not required for capacity purposes over the next 20 years based on population and demand projections.

Figure WA5.D-1 is a simplified flow diagram for the 2007-constructed nanofiltration reverse osmosis process and the unused lime softening facilities. **Table WA5.D-1** outlines the existing finished water quality for the Peele Dixie WTP with the associated regulatory standards (Primary and Secondary Standards) and the proposed goals for the City.

5.D.1 Current Treatment

The raw water supply for the Peele Dixie WTP includes a firm, permitted Biscayne aquifer maximum daily raw water capacity of 15.0 MGD. Currently, the Biscayne aquifer supply is treated with a 12 MGD maximum day nanofiltration reverse osmosis process. This capacity requires all of the 15 MGD of firm raw water capacity at the 80% recovery conservatively used in the water use permit. The Peele Dixie WTP cannot sufficiently treat 12 MGD for a significant amount of time due to upconing of sand in the raw water wells. Additionally, this sand causes fouling of the cartridge filters. This issue, along with several CUS Master Plan Team solutions, is further discussed in **Section WA5.C.**

5.D.2 Base Treatment Expansion Plan

In addition to the 15 MGD raw water capacity from the Biscayne aquifer to feed the nanofiltration reverse osmosis plant, the City has a permitted Upper Floridan aquifer maximum daily raw water capacity of approximately 10 MGD, which can be used Citywide. Previous planning called for 8 MGD of this Upper Floridan aquifer raw water capacity to serve the Peele Dixie WTP. Although the City is currently permitted to draw 10 MGD from the Upper Floridan aquifer, doing so may cause significant changes in water quality over time (as described in **Section WA1**). Such water quality changes can result in costly modifications in wellfield and treatment plant design and operations, as has been demonstrated through case histories of operations at existing Upper Floridan aquifer wellfields in south Florida. Furthermore, the unit cost for installing an additional 2 MGD well in the Upper Floridan aquifer is significant and not economical for the City's water system.

Assuming 80% recovery of the Upper Floridan aquifer supply, there would be approximately 6 MGD of finished water produced from the brackish water reverse osmosis treatment process. Brackish (Upper Floridan) water reverse osmosis treatment would therefore, increase the Peele Dixie WTP maximum daily finished water flow capacity to 18 MGD (12 MGD + 6 MGD). **Figure WA5.D-2** is a simplified conceptual flow diagram of the Base Treatment Expansion Plan.

Section WA5D accepted December 16, 2016.

Table WA5.D-1. Finished Water Quality, Standards and Goals.

Parameter	Units	Proposed Goal	Peele Dixie Effluent Water Quality (2014)	Primary Drinking Water Standards	Secondary Drinking Water Standards
Total Hardness	mg/L as $CaCO_3$	50 – 120	17.4	NS	NS
Sodium	mg/L	< 50	<50	160	NS
Total Dissolved Solids (TDS)	mg/L	< 500	<500	NS	500
Iron	mg/L	< 0.3	0.10	NS	0.3
Manganese	mg/L	< 0.05	<0.05	NS	0.05
Fluoride	mg/L	< 0.7	0.6	4.0	2.0
Sulfate	mg/L	< 200	<200	NS	250
Chloride	mg/L	< 100	16.7	NS	250
Color	PCU	< 8	1.9	NS	15
Turbidity	NTU	< 1	0.16	NS	NS
Alkalinity	mg/L as $CaCO_3$	> 40	54.1	NS	NS
H_2S	mg/L	< 0.1	<0.1	NS	NS
pH	Units	8.0 – 8.5*	9.0	NS	6.5-8.5
THM	mg/L	< 0.06	0.064	0.08	NS
HAA	mg/L	< 0.04	0.0318	0.06	NS
Free Ammonia	mg/L	< 0.2	<0.5	NS	NS
Corrosivity	------	Non-Corrosive	Non-Corrosive	NS	Non-corrosive
LSI	units	0.25-0.5	0.3	NS	NS

Notes:

*Upper limit of 9.0 allowed with written approval from the Broward County Department of Health
NS = No Standard for groundwater systems.

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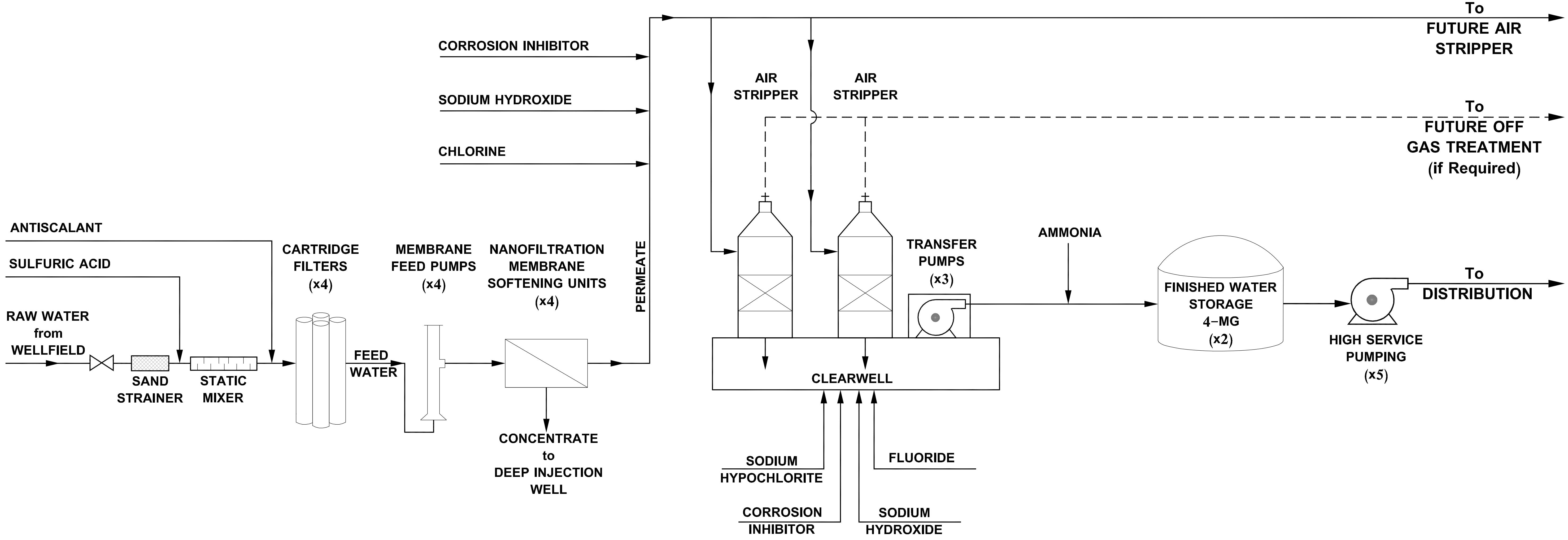
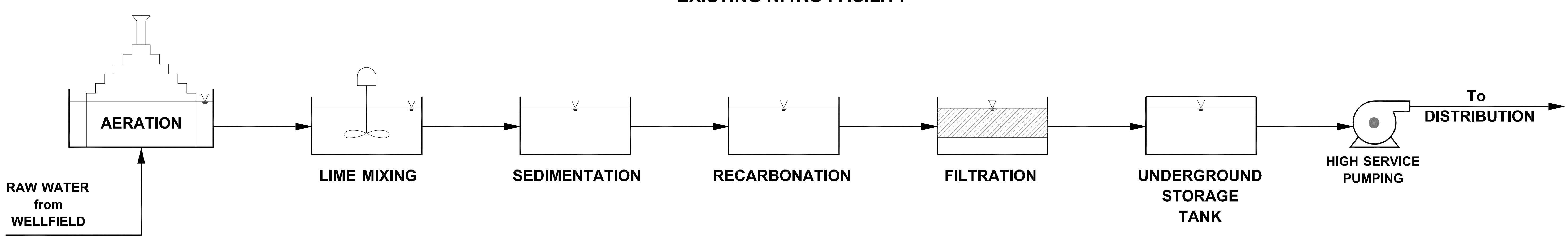
Figure WA5.D-1 Peele-Dixie WTP- Existing Process Flow Diagrams



EXISTING NF/RO FACILITY



PRIOR LIME SOFTENING TREATMENT FACILITY

(Has not been in use since April, 2008)

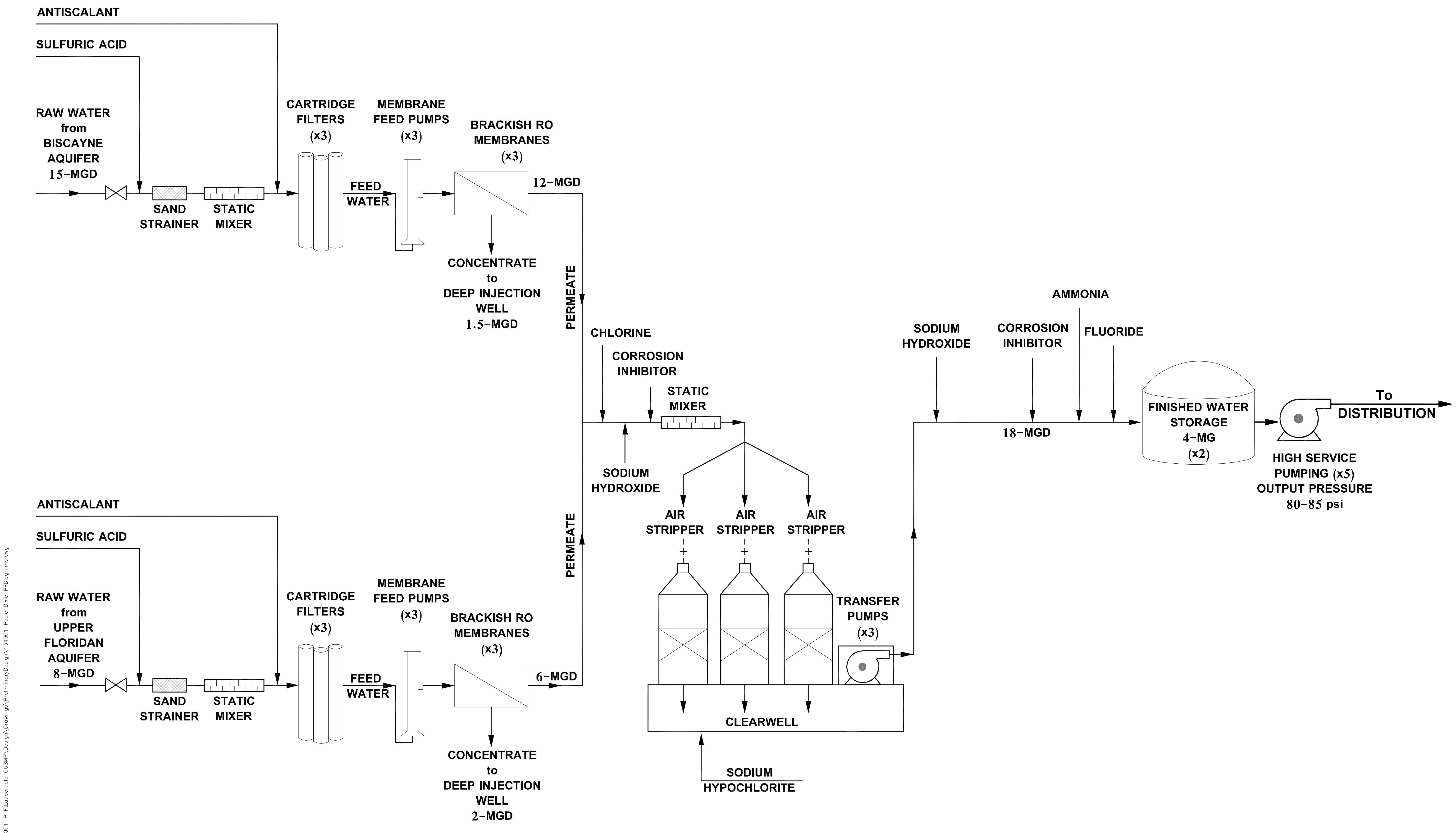
CITY OF FT. LAUDERDALE

PEELE-DIXIE WATER TREATMENT PLANT

EXISTING PROCESS FLOW DIAGRAMS

FIGURE WA5.D-1

Figure WA5.D-2 Peele-Dixie WTP- Base Treatment Expansion Plan



CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
BASE TREATMENT EXPANSION PLAN

FIGURE WA5.D-2

5.D.2.1 Water Quality Considerations

Current Peele Dixie WTP finished water has low hardness levels that can potentially lead to Fiveash WTP finished water-blending and distribution system corrosion issues. Peele Dixie WTP operations increase finished water pH above the regulatory limit of 8.5 with sodium hydroxide and add a corrosion inhibitor to address corrosion, however, the finished water remains low in total hardness versus the finished water quality goal, the root of the issue. The increase in capacity by the addition of brackish reverse osmosis treatment will not alleviate these water quality concerns; brackish treatment membranes that remove total dissolved solids also remove most of the total hardness. The addition of Upper Floridan aquifer brackish reverse osmosis treatment increases treated water chloride concentration to between 25 and 55 ppm when blended with nanofiltration reverse osmosis treated flows. Although higher than current conditions, this level of chloride is not expected to cause taste complaints. However, corrosion is still expected to be a concern and post stabilization treatment needs to be considered. The options considered to provide a more stable, non-corrosive water are:

Stabilization Option 1 - This option consists of providing post stabilization treatment by the chemical additions of calcium, alkalinity and caustic (**Figure WA5.D-3**). This option requires the installation of additional facilities for two new chemicals: calcium chloride to increase calcium concentration and sodium bicarbonate to increase alkalinity. The addition of these chemicals would be in a pipeline leaving the clearwell and carrying the degasified permeate from both the nanofiltration reverse osmosis and brackish water reverse osmosis treatment trains. Static mixers are required to mix the chemicals thoroughly. Following this treatment, water flows to finished water chemical treatment with chlorine, fluoride, and corrosion inhibitor and then to finished water storage with ammonia addition on the way. For all options, a retention time of approximately one hour is necessary between chlorine and ammonia addition points to achieve 4-log virus inactivation, dependent on dosing conditions.

Stabilization Option 2 - This option consists of providing post stabilization treatment using carbon dioxide and calcite contactors (**Figure WA5.D-4**) and requires the installation of additional facilities for two new chemicals, carbon dioxide and calcium carbonate (calcite). The addition of carbon dioxide would be into a pipeline carrying the degasified permeate from both the nanofiltration reverse osmosis and brackish water reverse osmosis treatment trains to calcite treatment. Calcite treatment before degasification could be possible if no hydrogen sulfide needs to be removed from the permeate. In this option, calcite would be contained in pressurized steel tanks through which the permeate comes in contact with the calcite; the calcite is then dissolved into the permeate due to the low pH of the water after addition of carbon dioxide. Following this treatment, the water flows to final finished water chemical treatment with chlorine, fluoride, and corrosion inhibitor and then transferred to finished water storage with ammonia addition on the way.

Stabilization Option 3 - This option consists of providing post stabilization treatment using carbon dioxide and calcite contactors using rehabilitated lime softening plant facilities (**Figure WA5.D-5**). This option requires the additional facilities for two new chemicals, calcium carbonate (calcite) and carbon dioxide. The addition of carbon dioxide would be in a pipeline carrying the degasified permeate from both the nanofiltration reverse osmosis and brackish water reverse osmosis treatment trains to calcite treatment. In this option, calcite would be contained in rehabilitated filter units through which the degasified and acidified permeate would come in contact with the calcite; the calcite is then dissolved into the permeate. The calcite treated flow would require pumping to transfer the flow for final finished water chemical treatment with chlorine, fluoride, and corrosion inhibitor and then ammonia addition and finished water storage.

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Figure WA5.D-3 Peele-Dixie WTP-Calcium, Alkalinity and Caustic Post Stabilization Base Option 1

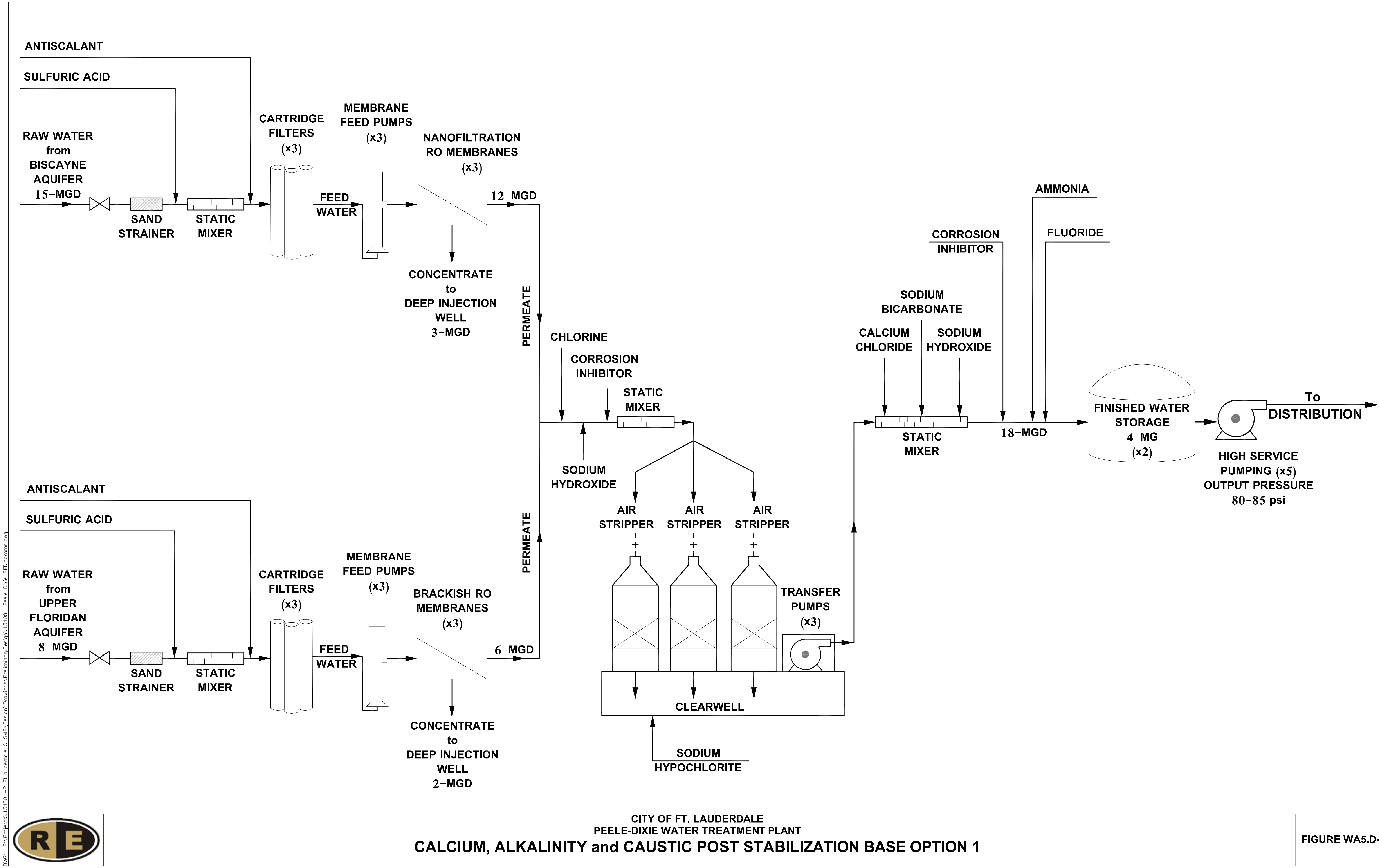
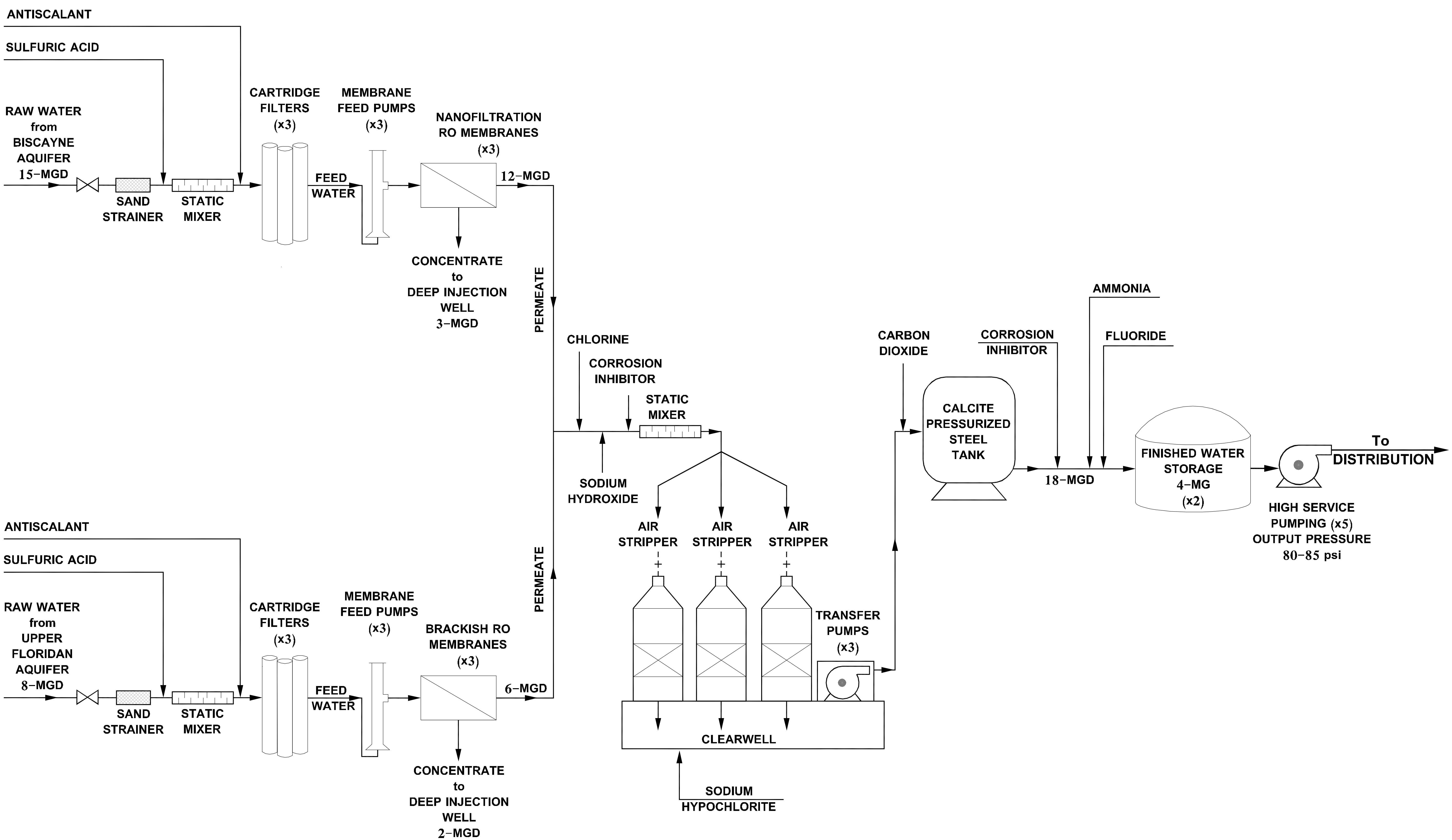


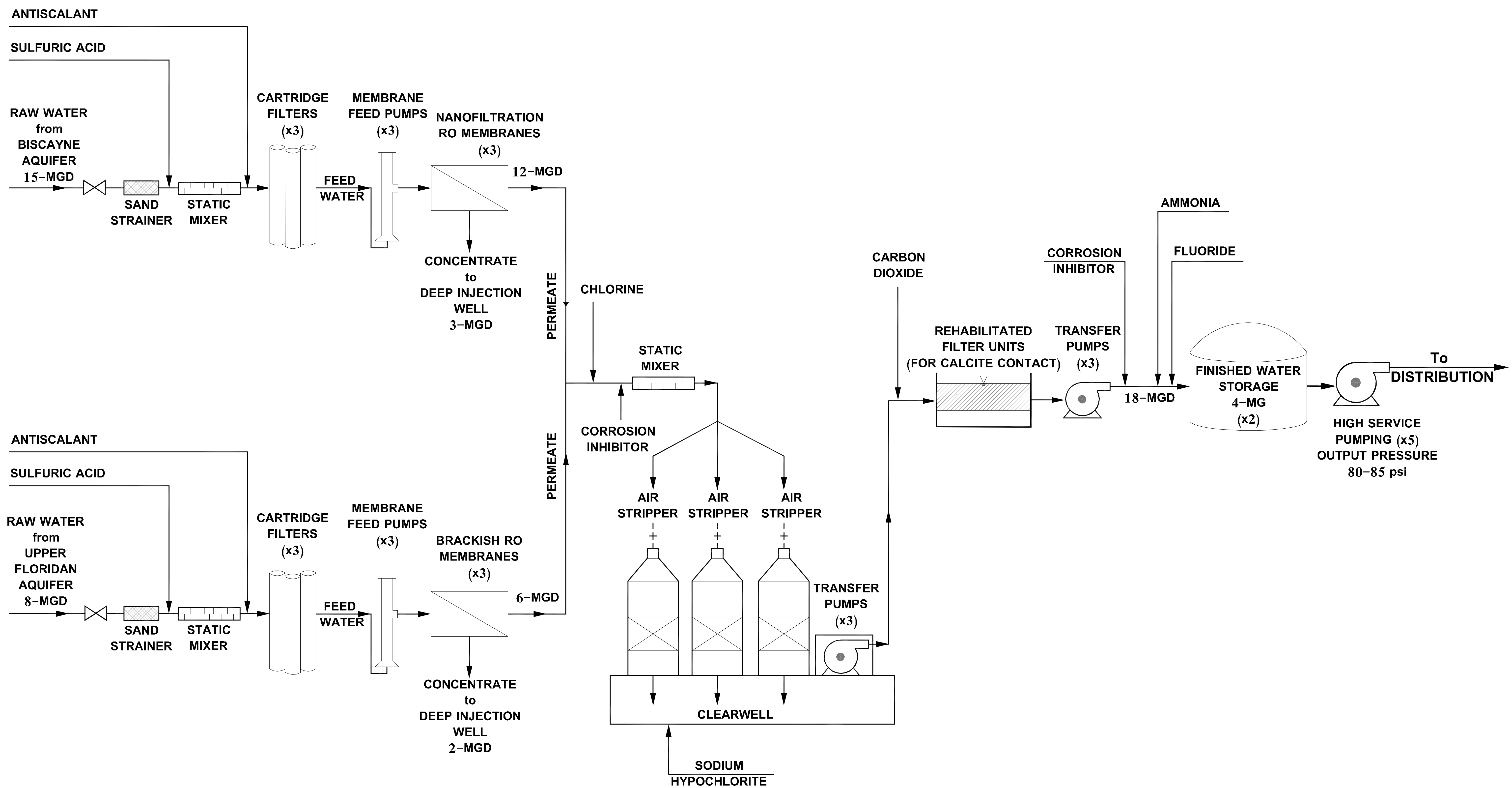
Figure WA5.D-4 Peele-Dixie WTP-Carbon Dioxide and Calcite Post Stabilization Base Option 2



CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
CARBON DIOXIDE and CALCITE POST STABILIZATION BASE OPTION 2

FIGURE WA5.D-4

Figure WA5.D-5 Peele-Dixie WTP-Rehabilitated Lime Softening Facilities Post Stabilization Base Option 3



CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
REHABILITATED LIME SOFTENING FACILITIES POST STABILIZATION BASE OPTION 3

FIGURE WA5.D-5

DWG: R:\Projects\134001-P FtLauderdale CUSMP\Design\Drawings\PreliminaryDesign\134001 Peele Dixie PFDiagrams.dwg

5.D.3 Alternative Expansion Treatment Options

An alternative capacity expansion concept is to increase the Peele Dixie WTP finished water capacity by blending Floridan aquifer raw water with Biscayne aquifer raw water as the feed supply to the existing nanofiltration reverse osmosis facility; and using the additional available Biscayne aquifer supply as the feed to a lime softening treatment process. This alternative would increase the total Peele Dixie WTP capacity without adding additional reverse osmosis facilities. Assuming a recovery rate of 80%, the existing nanofiltration reverse osmosis plant needs 15 MGD of raw water supply. The available firm raw water capacity to serve the Peele Dixie WTP with Upper Floridan aquifer water supply is approximately 6 MGD. The supply rate to the nanofiltration reverse osmosis plant from the Biscayne aquifer is, therefore, 9 MGD. Brine concentrate will be 3 MGD at maximum day operation. The remaining Biscayne aquifer raw water supply of 6 MGD is available to supply a lime softening facility and bring the total Peele Dixie WTP finished water maximum daily capacity to 18 MGD. This option would conserve approximately 2 MGD of raw water supply. **Figure WA5.D-6** is a simplified conceptual flow diagram of the Alternative Treatment Option.

The most notable change in raw water quality, when blending Upper Floridan aquifer raw water with Biscayne aquifer as feed raw water to the nanofiltration reverse osmosis plant, is an increase in salt concentration, which will result in higher membrane feed pump pressure. Modification or replacement of the existing feed pumps can provide for the necessary higher head. With the existing nanofiltration, reverse osmosis membrane rejection of only 70% for the small single valance charged chloride ion, finished water chloride becomes a limiting factor in determining this alternative's feasibility. Without replacement of the existing membranes, finished water from a blend of nanofiltration reverse osmosis treated and lime treated flows is expected to have a chloride concentration range of approximately 130 ppm to 260 ppm. Notably higher than current conditions, this level of chloride would likely cause taste complaints and could exceed the regulatory standard of 250 ppm. Corrosion due to elevated chloride concentration can be expected to be a concern.

Another alternative expansion concept is to simply bypass Biscayne Aquifer raw water around the nanofiltration reverse osmosis process train and blend into the clearwell. Bypassing could effectively increase the capacity marginally, less than 0.5 MGD, and reduce chemical and power usage. The permitted Biscayne well withdrawals and the total organic carbon and hardness present in the water limit the capacity of this option. Peele Dixie uses free chlorine to achieve 4-log virus inactivation and total organic carbon combined with free chlorine generate regulated disinfection byproducts. Additionally, the Biscayne Aquifer has historically had issues with bacteriological contamination and the City would be relying only upon chlorine to disinfect and inactivate viruses in the bypassed water. Sand from the wells would require removal periodically.

Section WA5D accepted December 16, 2016.

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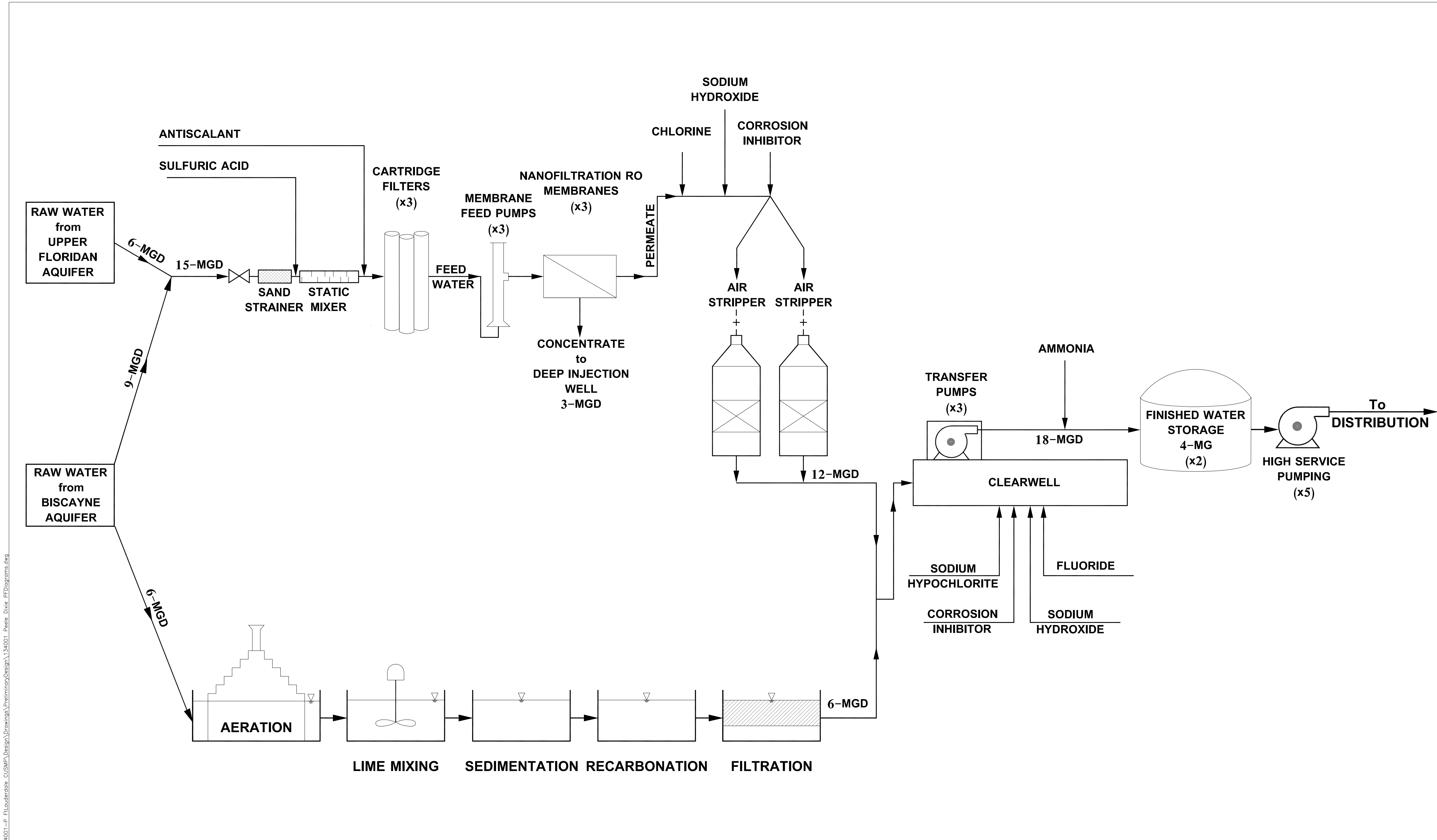
Figure WA5.D-6 Peele Dixie Combined Source Alternate Treatment Option



CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
COMBINED SOURCE ALTERNATE TREATMENT OPTION

FIGURE WA5.D-6

5.D.4 Comparison of Options

The established goals for stabilizing the finished water are: pH 7.5 to 8.5 standard units, LSI 0.25 to 0.5, and a Larson corrosion index (LI) less than 1.2. For the Base Treatment Expansion Plan (**Figure WA5.D-2**), with the only post treatment being caustic soda addition, the finished water would not meet the corrosion target goals, nor would it simultaneously meet pH and LSI goals. Stabilization Option 1 (**Figure WA5.D-3**) is for post stabilization treatment with calcium chloride, sodium bicarbonate and caustic soda; this option achieves all the post-stabilization goals for finished water. For Stabilization Option 2 and 3 (**Figure WA5.D-4 & Figure WA5.D-5**) the addition of calcite and carbon dioxide can also achieve all three stabilization goals.

The Alternate Treatment Expansion Option treatment cannot produce finished water meeting the corrosion goal due to excessive chlorides; but can meet both pH and LSI criteria. As discussed earlier, without membrane element change-out to higher salt rejecting membranes to treat the Upper Floridan supply, the potentially high concentration of chloride is problematic. Additionally, due to the elevated color in the Biscayne aquifer raw water supply, at the proportions of lime softened and nanofiltration reverse osmosis treated flows, the blended color is expected to be in the 10 pcu range. This color level may result in customer complaints.

Potentially the most cost effective and feasible stabilization option would be to design the budgeted Peele Dixie WTP Biscayne aquifer membrane replacement to pass hardness and effectively meet finished water quality goals. The Biscayne aquifer concentrate recovery, while more costly, would conserve approximately 2 MGD of water that could effectively expand the WTP without additional raw water supply. Both of these options would require more detailed process engineering and pilot testing to confirm viability.

5.D.5 Conclusions

Water quality concerns require the Base Treatment Plan Expansion to add post treatment, design the Peele Dixie WTP Biscayne aquifer membrane replacement to pass hardness, or recover and treat the Biscayne aquifer membrane concentrate. Post treatment Stabilization Option 1 or 2 both meet finished water quality goals. Stabilization Option 3, which utilizes rehabilitated existing lime treatment plant components to provide calcite treatment, also meets the water quality goals. The Alternate Treatment Option requires membrane change-out to higher salt rejecting membranes to treat the Upper Floridan supply to be feasible and meet the City's water quality goals.

5.D.5.1 Capital and Operating Cost Estimates - Post Stabilization Facilities

Estimates of capital costs, operating costs, and the net present value of the 20-year lifecycle costs are shown in **Table WA5.D-3.** The costs are for new or rehabilitated facilities needed for the post stabilization options for improved finished water quality. Option 1 with chemical additions has the highest operating cost. Options 2 and 3 with calcite and carbon dioxide addition have identical operating cost since they both use the same treatment process. The rehabilitation of the existing filter for use as calcite contactors has a higher capital cost compared to new pressurized steel contact tanks. Over a 20-year life and 1 %, return rate the Stabilization Option 1 is more than twice the cost of either of the other two options.

In addition to the capital cost associated with each option, there are additional land space requirements of: 7,000 square feet for Option 1, 2,000 square feet for Option 2, and 2,000 square feet for Option 3.

Section WA5D accepted December 16, 2016.

Table WA5.D-2. Capital and Operating Cost Estimates – Post Stabilization Facilities.

Option	Capital Cost	Capital Cost @ 20 yrs., 1% & 10 MGD average production, Per 1,000 Gallons	Operating Cost Per 1,000 Gallons	20-Year Net Present Value[1]
Stabilization Option 1 Chemical Additions	$10,000,000	$0.15	$1.50	$96,931,000
Stabilization Option 2 Carbon Dioxide & Calcite	$20,000,000	$0.30	$0.30	$36,529,000
Stabilization Option 3 Carbon Dioxide & Calcite w/ rehabilitation of filters	$25,000,000	$0.37	$0.30	$41,291,000

[1] Net present value based on a 3% inflation rate and 5% discount rate.

5.D.6 Recommendations

The CUS Master Plan Team recommends performing more detailed process engineering and pilot testing to confirm the viability of the Peele Dixie WTP Biscayne aquifer membrane replacement to effectively post stabilize the finished water. As the membrane replacement is budgeted and scheduled for 2017, this option could be the least cost capital and operationally if viable. Of the three conventional stabilization options analyzed, Stabilization Option 1 is ruled-out due to high operating cost, as the most costly option over the projected facilities' life span. Should the Biscayne aquifer membrane replacement not fully meet the Peele Dixie WTP finished water quality goals, the CUS Master Plan Team recommends pursuing Stabilization Option 2 of adding carbon dioxide and calcite treatment to accomplish post-stabilization and corrosion abatement. The initial design should be for the future total flow of 18 MGD. Construction is recommended in a phased approach, with the first phase for the existing 12 MGD plant capacity. **Section WA7-Water CIP** summarizes capital projects for inclusion into the Community Investment Plan (CIP).

WA5.E Peele-Dixie Decommission Plan/Implementation

The City operates the Walter E. Peele-Dixie Water Treatment Plant (Peele Dixie WTP) providing drinking water to the southern portion of the City's service area. The Peele Dixie WTP was originally constructed in 1926 with a lime softening process train (Lime Softening Process Train). The City constructed a state-of-the-art membrane reverse osmosis/nanofiltration process train (RO/NF Process Train) in 2008 to replace the original Lime Softening Process Train after 82 years of service. The CUSMP evaluated recommissioning the Lime Softening Process Train as an alternative capacity expansion concept in **Section WA5.D**. The benefits of recommissioning the Lime Softening Process Train include blending to add alkalinity to the finished RO/NF Process Train water and producing a more stable finished water to facilitate compliance with the Environmental Protection Agency's Lead and Copper Rule. Recommissioning could also offset the expansion of the membrane RO/NF Process Train to potentially reduce operating costs and aid with Water Use Permit (WUP) compliance.

The recommissioning evaluation concluded that the Lime Softening Process Train is in poor condition; the equipment is outdated and would require a complete replacement. The lime feed equipment and system requires complete replacement and the lime softening tanks either need complete replacement or thorough structural inspections to determine the feasibility and extent of the required rehabilitation and custom equipment retrofitting. Reconstruction of the Lime Softening Process Train would cost in excess of $30,000,000, nearly the cost of a new, similar-sized lime softening facility, and would require significant annual maintenance. If the City required additional treatment capacity, rehabilitation of the Lime Softening Process Train would be cost competitive on a life cycle basis with other expansion options. For use as a blending facility, replacement of membranes with "looser" membranes that allow some of the hardness and alkalinity to pass and effectively stabilize the finished water is much more cost effective than a renewed lime softening process train. Therefore, since treatment plant capacity is not needed at this time, the CUSMP Team recommends the Lime Softening Process Train be permanently decommissioned or repurposed. The land should be kept for future expansion needs and the key buildings maintained as a historical site. **Section WA5.D** discusses further the requirements for rehabilitating the old Lime Softening Process Train.

5.E.1 Decommissioning Components

The Lime Softening Process Train consists of a treatment plant building that houses a pump room, laboratory, filtered water basin, piping gallery, foyer, and an office. On the exterior, there are two rectangular carbonating chambers, several mixed media filters, one mixing basin, one chemical house, three subsidence basins, a subgrade clearwell, and one 138,000-gallon washwater tank. The decommissioning of the Lime Softening Process Train must be completed without compromising the operations and integrity of the RO/NF Process Train while protecting the historically important buildings of the Lime Softening Process Train.

The main decommissioning components of the Lime Softening Process Train include:

- Hydraulic/Electrical/Chemical separation from the RO/NF Process Train.
- Hydraulic separation from raw and effluent transmission mains.
- Identification and removal of any remaining hazardous materials.
- Protection of certain existing site features for historical preservation.
- Salvaging of notable parts and equipment.
- Building demolition and protection of the historically significant buildings and equipment
- Physical disconnection of utility services.

Section WA5E accepted February 24, 2017.

These tasks are outlined in more detail below.

5.E.2 Peele-Dixie Decommissioning Plan

5.E.2.1 Hydraulic/Electrical/Chemical Separation from the RO/NF Process Train

The Lime Softening Process Train was hydraulically, electrically, and chemically separated from the RO/NF Process Train during the construction of the new RO/NF Process Train in 2008.

5.E.2.2 Hydraulic Separation from Raw and Effluent Transmission Mains

The Lime Softening Process Train was previously hydraulically interconnected to the Dixie Wellfield with a 24” cast iron pipe (CIP) raw water main entering the plant site between the Lime Softening Process Train and the RO/NF Process Train. Per discussion with City staff, the 24” CIP raw water main entering the plant on the south side, west of the original fluoride tanks, was cut and capped in 2008 during the construction of the RO/NF Process Train. In addition, the 24” CIP raw water main has been cut and capped with a blind flange in the raw water vault located north of the northern clarifiers and filters. This raw water vault location is shown on **Figure WA5.E-1**.

There are currently two (2) existing CIP finished water mains connected to the plant that have not yet been taken out of service. As depicted in **Figure WA5.E-1**, both the 24” and 30” CIP finished water mains exit the Lime Softening Process Train just north of the main entrance facing State Road 7. The 24” finished water main vault is located on the northwest corner of the property. The 30” finished water main vault is also located in the northwest corner of the property, approximately 20 feet (ft) south of the 24” finished water main vault. The CUSMP Team recommends connecting the 30-inch finished water main to the plant’s high service pump discharge header to alleviate local capacity issues and better utilize existing infrastructure. In order to decommission these finished water mains from the Lime Softening Process Train, the finished water mains must be isolated from the main distribution line. Both finished water mains can be isolated from the active distribution system by closing the gate valves located just west of the vaults, noting that the valves are likely closed already, but not sealing properly. **Figure WA5.E-1** depicts the locations of the recommended gate valve closures. The CUSMP Team recommends closing two (2) gate valves per finished water main to ensure the finished water mains have been isolated from the live distribution system.

Once the finished water lines have been isolated, the 8” thick concrete caps must be removed from each of the vaults for access. The CUSMP Team recommends removing approximately 4-ft of the 24” finished water main (**Figure WA5.E-2**), and approximately 8-ft of the 30” finished water main (**Figure WA5.E-2**).

Once the respective sections of pipe have been removed, a mechanical joint plug with restraint should be installed on the distribution side of each of the severed water mains. The Lime Softening Process Train end of the severed pipe will remain open. If the concrete vault cap cannot be reinstalled, a 3/8” aluminum plate sheet will be installed to cover the existing vaults, preventing resident, personnel, or wildlife incursion.

5.E.2.3 Identification and Removal of Any Remaining Hazardous Materials

The CUSMP Team recommends leaving the existing infrastructure undisturbed, as City staff noted that approximately 75% of the existing buildings constitute a historical site. As such, the

CUSMP Team recommends to perform site restoration activities including identifying and/or removing any remaining hazardous material within the building such as asbestos insulation and lead paint.

5.E.2.4 Protection of Certain Existing Site Features

The CUSMP Team recommends leaving the existing infrastructure undisturbed, as City staff noted that approximately 75% of the buildings constitute a historical site.

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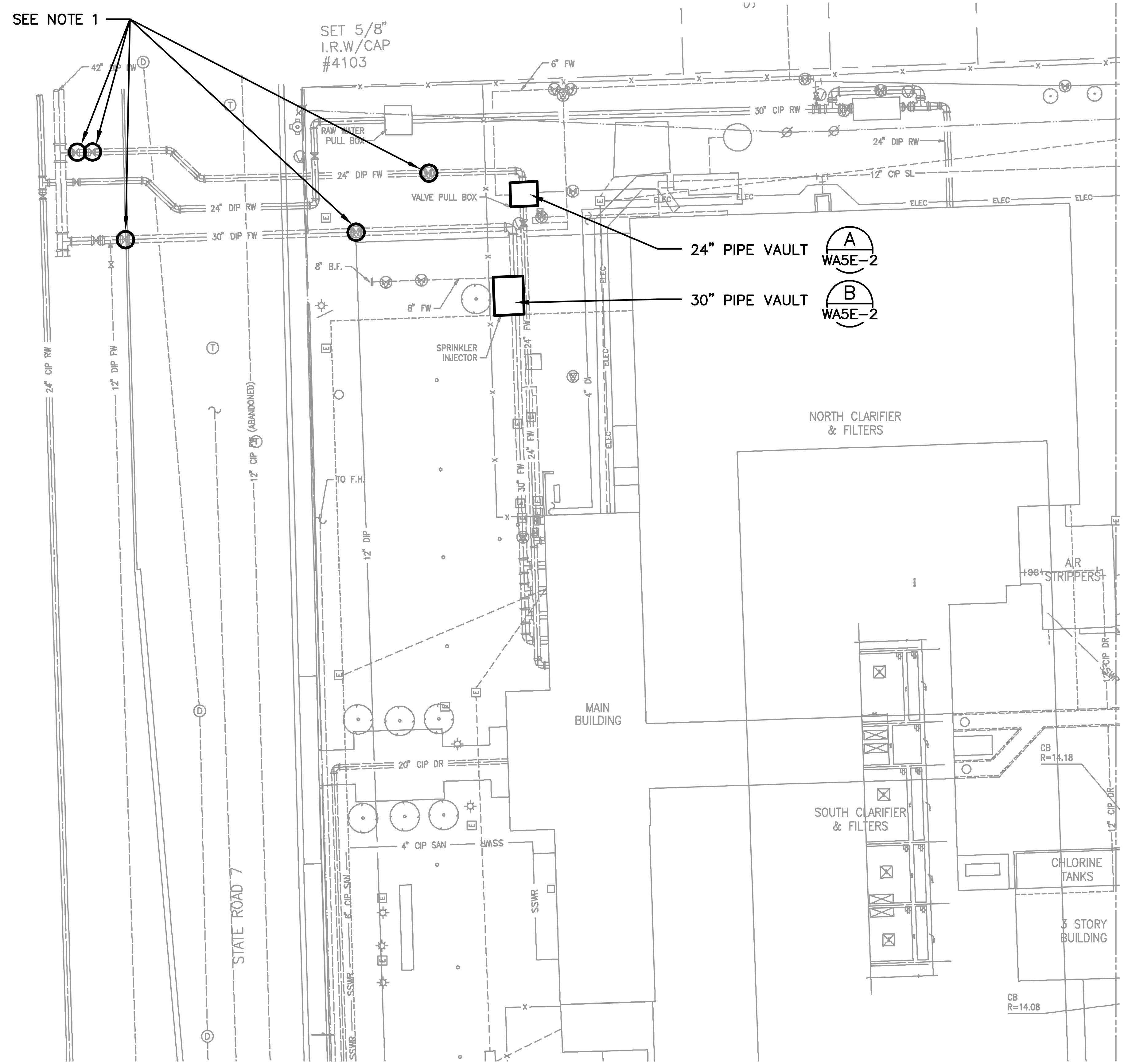
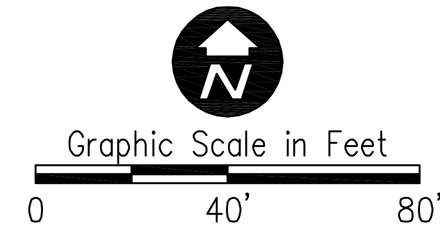




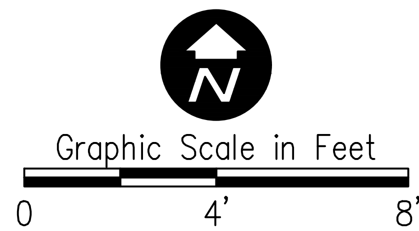
NOTES:

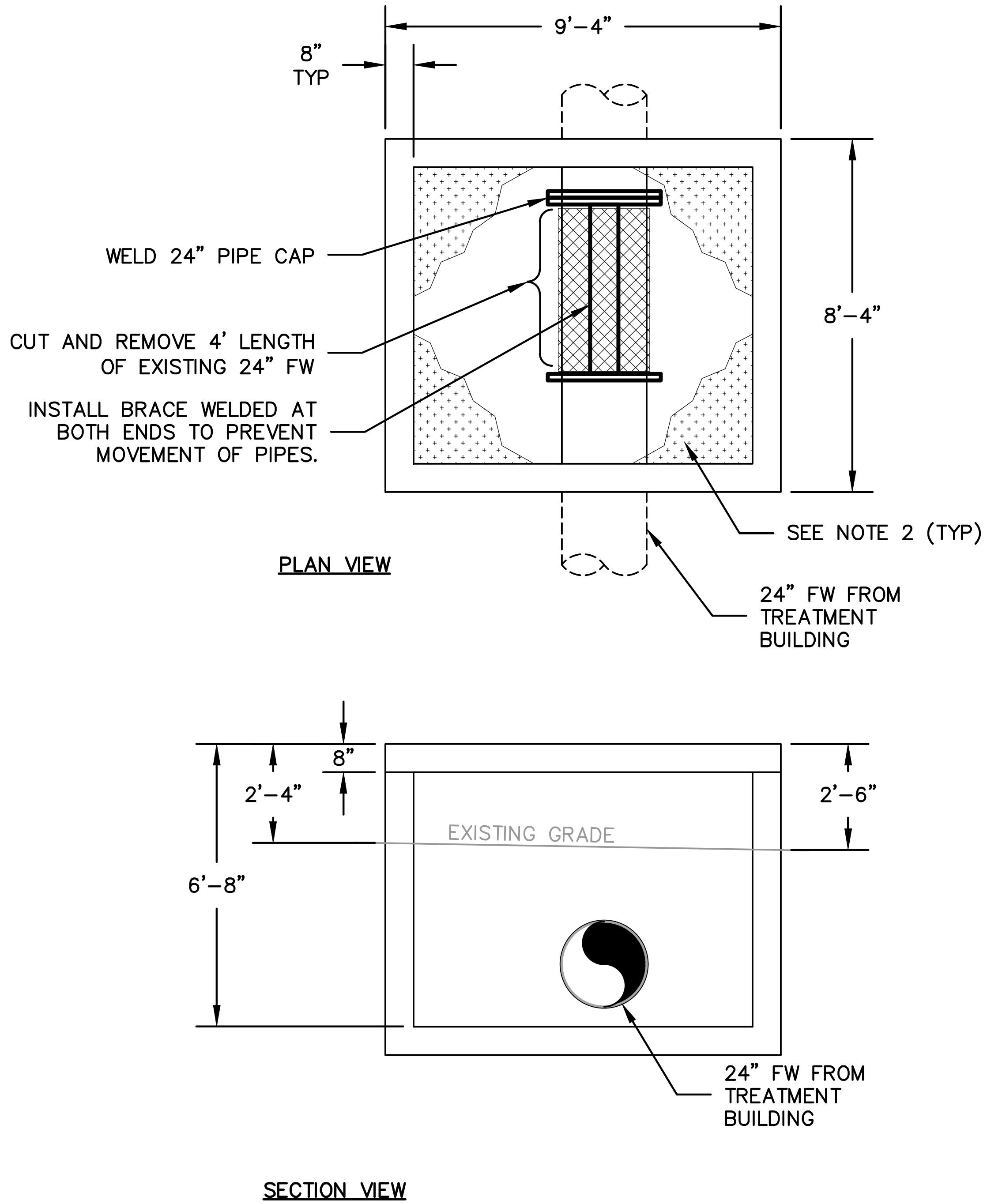
1. VERIFY ISOLATION VALVES ARE CLOSED AND FINISH WATER PIPES ARE DRAINED PRIOR TO PIPING MODIFICATIONS.
2. SAW-CUT AND REMOVE 8" THICK TOP OF CONCRETE VAULT. INSTALL BOLTED-ON 3/8" ALUMINUM PLATE COVER.

DWG: R:\Projects\134001-P FtLauderdale CUSMP\Design\Drawings\PreliminaryDesign\Peele Dixie Membrane Bldg\DecommissionFigures.dwg

CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
PIPE DECOMMISSIONING SITE PLAN

FIGURE WA5E-1

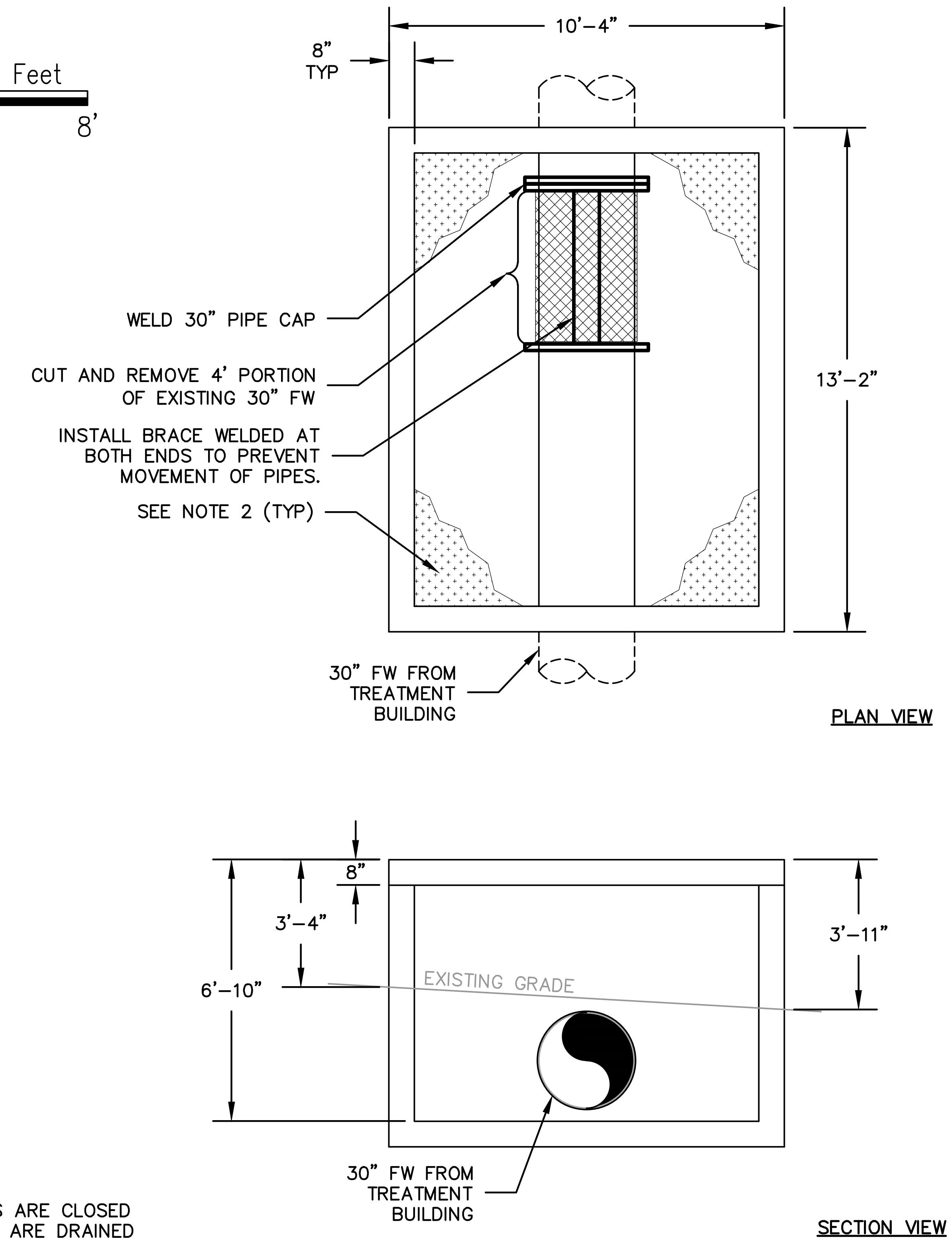




A
WA5E-1
24" PIPE VAULT DETAIL
SCALE: 1/4" = 1'-0"

NOTES:

1. VERIFY ISOLATION VALVES ARE CLOSED AND FINISH WATER PIPES ARE DRAINED PRIOR TO PIPING MODIFICATIONS.
2. SAW-CUT AND REMOVE 8" THICK TOP OF CONCRETE VAULT. INSTALL BOLTED-ON 3/8" ALUMINUM PLATE COVER.



B
WA5E-1
30" PIPE VAULT DETAIL
SCALE: 1/4" = 1'-0"

CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
PIPE DECOMMISSIONING DETAILS

FIGURE WA5E-2

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5.E.2.5 Salvaging of Notable Parts and Equipment

The CUSMP Team recommends cannibalizing and salvaging notable parts and equipment as appropriate for the City. Parts that could be utilized as spares for Fiveash WTP for example are cannibalization candidates. Salvaging scrap iron would generate some revenue at a cost of removal labor and transportation or contracting. Certain equipment could be left in place to remain part of the historical building site as the City prefers.

5.E.2.6 Building and Tank Demolition

The CUSMP Team recommends leaving the existing main building infrastructure relatively undisturbed and restricting access to the Lime Softening Process Train, as demolition would be prohibitively difficult given the historic status of the old Lime Softening Process Train. City staff noted that approximately 75% of the existing buildings constitute a historical site. With significant remodeling, the old WTP has potential to continue to serve the City and community. The City will evaluate possible future uses for this unique facility. Potential reuse of the facility must be balanced versus safety and maintenance cost issues. Tanks, walkways and buildings must be periodically inspected and maintained to ensure safety to City staff. Detached buildings such as the lime feed building could be demolished if part or all of the Lime Softening Process Train tanks are to be demolished depending on their historical designation.

The CUSMP recommends the City investigate reuse of the Lime Softening Process Train tanks for a purpose beneficial to the City. The Town of Davie successfully converted old tanks into aquaculture use and the City of St. Petersburg is currently investigating same. If no viable reuse option is identified for the tankage, all or part of the storage tanks that are not considered historic can be demolished. If kept, tanks and appurtenances including walkways and railings have to be periodically inspected and maintained to City safety standards.

5.E.2.7 Physical Disconnection of Utility Services

Once the Lime Softening Process Train is decommissioned, access to the facilities should be restricted. The CUSMP Team recommends that the power remain connected to the facility. Power is required to provide climate controls to areas deemed necessary by the City, and provide lighting internally/externally to the building (pertinent to safety concerns). The Lime Softening Process Train bathrooms and water fountains are still being used daily by Peele Dixie WTP staff and outside City employees allowing restriction of the new RO/NF Process Train facilities to Peele Dixie WTP employees only. If use and maintenance of the Lime Softening Process Train bathrooms and water fountains is no longer desired by the City, the facilities should be abandoned by cutting off water and rendering the bathrooms unusable by removing all sinks, toilets and urinals. If the bathrooms are to remain in service, new service lines may be required based on the recommended water pipe disconnections discussed previously.

5.E.3 Peele-Dixie Decommissioning Plan Implementation and Cost Estimate

The CUSMP Team recommends the following implementation steps to decommission the Peele Dixie Lime Softening Process Train:

1. Confirm which buildings/facilities carry the historical designation
2. Investigate a beneficial reuse of the buildings, site and tankage; prepare a business plan and cost estimates
3. Perform a safety inspection on the entire site, including asbestos and lead paint in buildings
4. If reuse of tankage is a possibility, perform structural inspection on tanks, walkways, etc.

Section WA5E accepted February 24, 2017.

5. Designate facilities to be demolished.
6. Determine if restroom facilities will stay in service and site restriction requirements
7. Prepare demolition/remodeling design contract documents
8. Bid and contract demolition/remodeling project
9. Budget for and expend annual maintenance at the site

Table WA5.E-1 summarizes the approximate costs to decommission the Lime Softening Process Train. The CUSMP Team recommends budgeting $50,000 to $100,000 a year for the remaining Lime Softening Process Train buildings and equipment maintenance; this is included in the annual repair and replacement budget included in **Section WA8**. The CUSMP team recommends using the 30-inch WM as an additional feed point to the distribution system. The costs for this connection is **Section WA4**. **Section WA7-Water CIP** summarizes this capital project for inclusion into the Community Investment Plan (CIP).

Table WA5.E-1. Lime Softening Process Train Decommissioning Plan Cost Estimate

Decommissioning Item	Cost	24” Vault Quantity	30” Vault Quantity	Total
Concrete Removal	**Cost per SY**	**24" Vault SY**	**30" Vault SY**	--
Vaults	$250.00	8.6	15.1	$5,950
Metal Pipe Removal	**Cost per LF**	**Pipe Removed (ft)**	**Pipe Removed (ft)**	--
24"-26"	$1,000.00	4	-	$4,000
30"-36"	$1,000.00	-	8	$8,000
Aluminum Plates	**Cost per SF**	**24" Vault SF**	**30" Vault SF**	--
Vault Cover	$75.00	77.8	136.1	$16,050
MJ Plug	**Cost for Each**	--	--	--
24"	$3,620	--	--	$3,620
30"	$6,580	--	--	$6,580
Tank/Building Demo	**Lump Sum**	--	--	--
Various	$300,000	--	--	$300,000
Subtotal	--	--	--	**$344,200**
Contractor Overhead and Profit (25%)				**$86,050**
Subtotal				**$430,250**
Engineering and Overhead (20%)				**$86,050**
Contingency (25%)				**$107,563**
Program Management (10%)				**$43,025**
Total (rounded)				**$667,000**

Notes: SY=Square Yards
LF=Linear Foot
SF=Square Foot
MJ=Mechanical Joint

WA5.F Distribution Water Quality Improvements

5.F.1 Distribution Water Quality Parameters

Water quality in the distribution system is judged by compliance with drinking water regulations and aesthetic qualities relating to customer satisfaction. The City, as part of the CUS Master Plan, established the water quality goals defined in **Table WA5.F-1**. Distribution water quality is monitored at the point of entry for the City's two water treatment plants (WTPs) and at key sampling locations in the distribution system. This section evaluates the distribution water quality in terms of color, odor, stability, disinfectant residual, reliability and consistency.

Table WA5.F-1. Water Quality Goals

Parameter	Units	Proposed Goal	Fiveash Effluent Water Quality (2014)	Primary Drinking Water Standards	Secondary Drinking Water Standards
Total Hardness	mg/L as CaCO3	50 - 120	77.3	NS	NS
Sodium	mg/L	< 50	36.5	160	NS
Total Dissolved Solids (TDS)	mg/L	< 500	197	NS	500
Iron	mg/L	< 0.3	0.02	NS	0.3
Manganese	mg/L	< 0.05	ND	NS	0.05
Fluoride	mg/L	< 0.7	0.58	4.0	2.0
Sulfate	mg/L	< 200	ND	NS	250
Chloride	mg/L	< 100	66.5	NS	250
Color	Pt-Co	< 8	15.2	NS	15
Turbidity	NTU	< 1	0.16	NS	NS
Alkalinity	mg/L as CaCO3	> 40	60.7	NS	NS
H2S	mg/L	< 0.1	ND	NS	NS
pH	Units	8.0 – 8.5*	9.19	NS	6.5-8.5
TTHM	mg/L	< 0.06	0.064	0.08	NS
HAA5	mg/L	< 0.04	0.0318	0.06	NS
Free Ammonia	mg/L	< 0.2	ND	NS	NS
Corrosivity	-----	Non Corrosive	Non Corrosive	NS	Non Corrosive
LSI	units	0.25 - 0.50	.86	NS	NS

Notes: *Operating above range will require compliance with F.A.C 62-550.520 Secondary Contaminants Monitoring Requirements: (1) Analysis to determine compliance with Rule 62-550.320, F.A.C., shall be conducted by all community water systems and shall be repeated once each compliance period. Lime softening facilities may operate above 8.5 but less than or equal to 9.0 pH units without Department approval, and may operate above 9.0, but less than or equal to 10.0 pH units upon approval by the Department of a written demonstration by the water system that operating at the higher pH will not cause the treatment plant to suffer operational failures, that minimum disinfectant levels can be maintained throughout the distribution system, and that the system can remain in compliance with the lead and copper and microbiological provisions of Chapters 62-550 and 62-555, F.A.C.
ND = No Data or not required to be monitored continually.
NS = No Standard for groundwater systems.
NM = Not measured, assumed ND based on chlorine addition

Section WA5F accepted December 16, 2016.

5.F.1.1 Color

The Fiveash WTP finished water has a visible yellow tint and exceeds the City's and secondary drinking water standards. The CUS Master Plan's treatment evaluation has proposed a color removal process for the Fiveash WTP to rectify the issue. The City's Peele Dixie WTP adequately removes color and meets the City's and secondary drinking water standards for color.

5.F.1.2 Odor

The City's distribution meets goals and secondary standards for odor. The use of chloramine as a disinfectant can result in ammonia odors due to excess ammonia feed and as chloramine decays into chloride and ammonia. Remaining organic material and nitrifying bacteria growth byproducts can also generate odors. Ultimately, if organic carbon removal is accomplished at the Fiveash WTP the City could switch disinfectants to free chlorine and avoid the ammonia and nitrification bacterial growth. While chloramine disinfection is in use, the City should set a target level of 0.2 mg/L excess ammonia leaving the WTPs to minimize odor issues.

5.F.1.3 Stability

The Fiveash WTP finished water is adequately stabilized due to the remaining alkalinity and calcium hardness and pH greater than 8 standard units. The Peele Dixie WTP removes most all of the alkalinity and calcium hardness leaving the water vulnerable to destabilization. Destabilization refers to the water becoming corrosive (having a negative Langelier Saturation Index (LSI)), especially in the presence of alkalinity consuming nitrifying bacteria associated with chloramine disinfectant systems. The City currently stabilizes by the addition of sodium hydroxide (to increase the pH) and a corrosion inhibitor, typically an orthophosphate chemical addition. Orthophosphates have not been proven efficient in all systems and can supply nutrients to nitrifying bacteria growth in the distribution system. The CUS Master Plan recommends that the Peele Dixie WTP stabilize its finished water with the addition of alkalinity and calcium hardness, potentially through membrane change out or a bypass process. Blending with Fiveash WTP finished water is also an alternative that would require piping directly to, or booster pumping from a Fiveash transmission main to the vicinity of the Peele Dixie WTP.

5.F.1.4 Water Age

The CUSMP Team constructed a new potable water distribution system hydraulic model and added water age modeling functionality. Water age varies diurnally; water age results are reported in average and maximum. The hydraulic model results, reflecting 2015 operational practice, indicate average potable water distribution system water age (from WTPs points of entry) varying from 0 to >240 hours, with a mean of 70 hours. Water ages >240 hours reflect dead ends and can be model demand allocation issues related to input data.

5.F.1.5 Chloramine Residual

Water suppliers add a disinfectant, such as free chlorine or chloramines, to drinking water to protect drinking water from disease-causing organisms and pathogens. Disinfectants provide a residual to reduce the chance of pathogen regrowth in water storage tanks or within the water distribution system. Large distribution systems can span many miles from the treatment facilities to it furthest customers; creating opportunities for pathogen regrowth if a proper disinfectant residual is not maintained. Additionally, water can stagnate in distribution storage tanks and

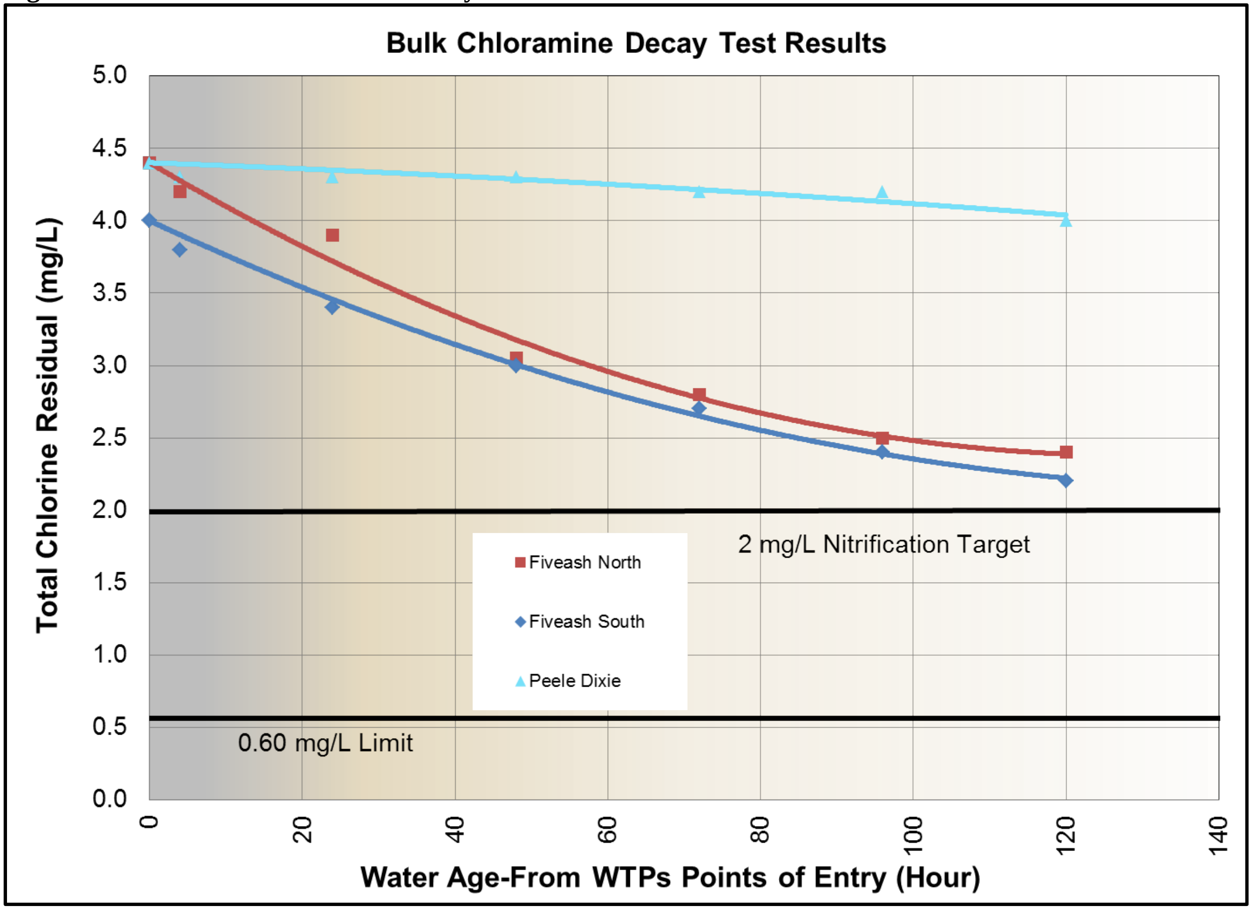
Section WA5F accepted December 16, 2016.

dead end sections potentially facilitating pathogen regrowth if not properly maintained and operated. Chloramine (combination of chlorine and ammonia) is the current disinfection method being used in the City's distribution system. **Appendix WA5.F-A** demonstrates that the City maintains a chloramine residual of approximately 3.8 mg/L at the WTPs' points of entry (POE). The distribution system residuals have historically varied from approximately 3.5 to less than 0.5 mg/L. However, .8% of the samples were less than .5mg/L for chloramine residuals. In addition to using chloramines, the City performs free chlorine burns twice a year to help reduce nitrification. The historical distribution system chloramine residuals show a stable and high chloramine residual along with low nitrite/nitrate concentrations during the month directly following a chlorine burn. Chloramine residuals are significantly lower and nitrite/nitrate concentrations greatly increase for the remaining months at many of the locations recorded. This indicates that the effects of a chlorine burn are relatively short lived.

Disinfectant decay is represented by two categories in water quality modeling: 1) bulk decay-interactions with the treated water only and 2) pipe wall decay-interactions in the distribution system with pipe walls, sediments and nitrifying bacteria. The CUSMP team performed bulk chloramine decay testing for both WTPs in 2015. The CUSMP samplers collected point of entry samples, recorded Time=0 residual results and monitored the remaining samples over time to characterize bulk decay. The recorded chloramine decay yielded bulk decay coefficients as shown in **Appendix WA5.F-A**. The bulk decay testing showed that the Peele Dixie WTP point of entry water has a very low bulk decay rate. The Fiveash WTP north and south point of entry bulk decay rates demonstrate significant decay as illustrated in **Figure WA5.F-1**. The likely cause of the difference in bulk decay rates is the total organic carbon removal at Peele Dixie WTP; total organic carbon consumes chlorine residual.

Section WA5F accepted December 16, 2016.

Figure WA5.F-1. Bulk Chloramine Decay Test Results



Pipe wall decay is determined empirically based on field sampling data. The City's field sampling total chlorine (primarily chloramine) data was analyzed and compared to model to estimate overall pipe wall residual decay effects. Pipe wall chlorine decay was categorized into three time periods based on the decay patterns observed:

- Chlorine Burn/Post Burn Month
- Moderate Nitrification Months
- Heavy Nitrification Months

Figure WA5.F-2 presents the relationship between hydraulic model water age and chlorine residual decay in the City's potable water distribution system. Note the comparison to the WTPs' bulk decay rates; the difference in bulk decay and actual field chlorine results is attributed to "pipe wall" decay. Figure WA5.F-2 indicates severely increased chlorine decay rates for heavy nitrification months as is expected for chloramine systems in South Florida.

Figure WA5.F-2. Field Total Chlorine Compared to Hydraulic Model Water Age (Pipe Wall Decay)

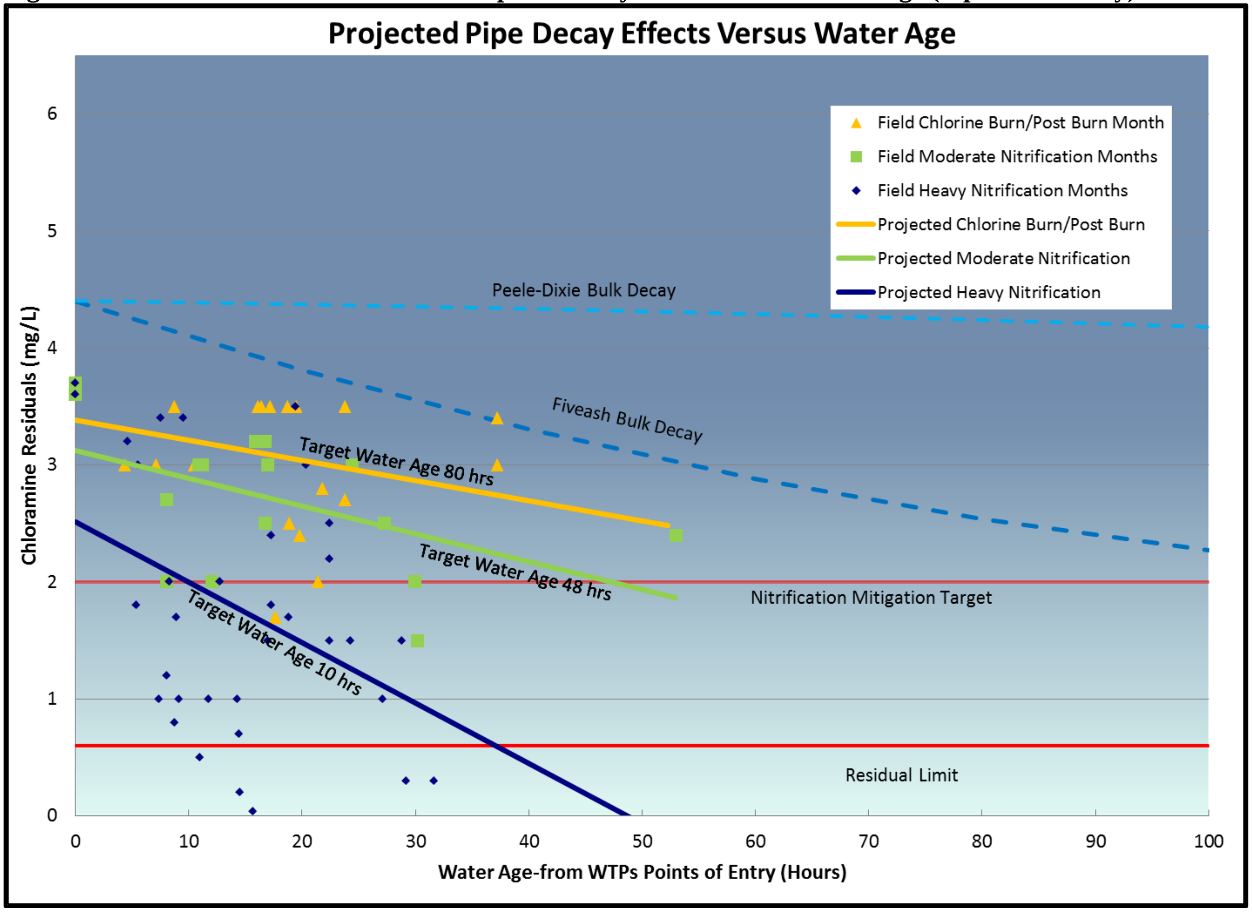


Figure WA5.F-2 yields target water ages of 10 to 45 hours for heavy nitrification months and 48 to 80 hours for moderate nitrification months. The target range includes above 2 mg/L to mitigate nitrification and above the limit of 0.6 mg/L to comply with federal drinking water regulations.

5.F.2 Reliability and Consistency

The City of Ft. Lauderdale’s WTPs consistently produce safe and reliable potable water. The Peele-Dixie WTP was upgraded in 2008 with a new, state-of-the-art membrane treatment process train in 2008 that replaced the old lime softening process train originally constructed in 1926. The Peele Dixie WTP now has low repair and replacement needs because of the new membrane treatment process train. The Fiveash WTP is over 50 years old and has significant repair and replacement needs. The City has forestalled significant repair and replacement needs at Fiveash WTP and much of its equipment and mechanical items are nearing useful life end. The finished water storage and clearwell hydraulic issues described in Section WA5A also negatively affect reliability and consistency at the Fiveash WTP. The City has scheduled the Fiveash WTP “Reliability Upgrades Project” for 2016 to replace several key mechanical items and automate the controls of key Fiveash WTP processes. Phases II and III of the Reliability Upgrades are under design and will be distributed for bid in the near future. The scheduled Reliability Upgrades do not address all of the key short term Fiveash WTP needs and should be reviewed and revised as necessary to align with the recommendations of the 2016 CUSMP. It is acknowledged that due to the multi-year delays in the project and the overdue needs for certain project components that the Reliability Upgrades will likely move forward in its current state regardless.

5.F.3 Nitrification

5.F.3.1 Nitrification Background

Nitrification in water distribution systems is caused by two distinct groups of bacteria, ammonia oxidizers (AOB) and nitrite oxidizers (NOB). AOB and NOB are distinguished by the utilization of substrate, either ammonia or nitrite. For potable water concerns, AOB are more noxious because AOB produces nitrite from ammonia in the potable water and the production of nitrite negatively impacts chloramine residuals. NOB requires nitrite which is produced from AOB, and their activity does not directly contribute to the instability of potable water quality since they convert nitrite to fully stable nitrate, which is referred to as complete nitrification. AOB and NOB withstand environmental conditions by growing in colonies within protective layers in biofilm and sediment. Nitrification is temperature dependent; water temperatures at and above 27^{o}C promote full nitrification activity while nitrifiers can go dormant to some extent at significantly lower temperatures.

The effects of nitrification include pH decrease, alkalinity decrease, nitrate increase, nitrite increase, and LSI and Calcium Carbonate Precipitation Potential (CCPP) decrease. Decreases in pH and alkalinity are useful indicators since pH and alkalinity should remain relatively constant in the distribution system.

In a non-nitrifying distribution system, nitrate and nitrite are found to be less than 0.01 mg/L. The AWWA guidelines state that if nitrite is above a concentration of 0.05 mg/L nitrification is occurring (AWWA 2006, Fundamentals and Control of Nitrification in Chloraminated Drinking Water Distribution Systems). The Environmental Protection Agency's National Primary Drinking Water Regulations set the nitrite limit at 1 mg/L. The City's distribution system was evaluated for nitrification based upon historical samples as well as samples collected as part of this project.

5.F.3.2 Nitrification Evaluation

Historical field data indicates significant chloramine decrease as water travels through the City's distribution system. Simultaneously, nitrite and nitrate levels clearly increased. Note that the distribution nitrite levels exceeded the 0.05 mg/L level identified by the AWWA as representing a distribution system undergoing nitrification. The City's distribution sampling also indicated low levels of nitrates at times coinciding with elevated nitrite levels corroborating nitrification is occurring through NOB activity.

5.F.3.3 Nitrification Conclusion

Based upon the findings and analyses presented, nitrification is concluded to be the primary reason for low chloramine residuals in the distribution system, resulting in the bi-annual chlorine burn. Nitrification was determined to be occurring based upon indicators referenced by the AWWA including reduced chloramine residuals and increased nitrite (substantially above AWWA 0.050 mg/L indication for nitrification). Nitrification occurs to some extent in all chloramine systems especially in warmer climates, e.g., Florida. While nitrification in chloramine systems cannot be eliminated, there are options to minimize and mitigate nitrification impacts.

Section WA5F accepted December 16, 2016.

5.F.4 Nitrification Mitigation Options

Nitrification has been identified to be the primary cause of the dramatic chloramine decay in the distribution system. Mitigation of nitrification takes continuous, proactive, aggressive management and ultimately a shift to a more robust disinfectant (free chlorine). Specified nitrification mitigation options available to the City were identified based on the water quality evaluation. Nitrification control begins with the removal/deactivation of nitrifying bacteria, and continues with a nitrification control operating procedure to minimize nitrification in the distribution system. The following section discusses possible options to mitigate nitrification:

- Hydraulic/Water Age
- Residual Production and Excess Ammonia Minimization
- Pipe Cleaning
- Disinfectant Type/Burns
- Temperature (Not feasible in water distribution systems)

5.F.4.1 Hydraulic/Water Age

Higher water age in the water distribution system allows nitrifying bacteria to grow and metabolize provided that favorable temperature and residual levels are present. Multiple studies in Florida indicate that nitrification will occur in areas with less than 2 mg/L of chloramine residual. Disinfectant decay is time dependent and the higher the water age, the higher the decay. Through water conservation efforts the City has reduced demands significantly over the last 10 years; while beneficial for water supply the reduced demand increases system water age. Adjustment of water storage operating levels, water demand, flushing and higher pumping pressures can minimize distribution system water age and help mitigate nitrification. Higher pumping pressures must be balanced against increased water main breaks that the City experiences at the higher pressures (greater than 85 psi). WTP discharge pressures should remain less than 85 psi to mitigate pipe breakage.

The City's potable hydraulic model was used under average demand conditions to quantify possible nitrification water age reduction-related mitigation options for the City. The existing model average day demand scenario output for maximum water age is graphically shown in **Figure WA5.F-3**. As shown in Figure WA5.F-3, water ages of less than 10 to 45 hours for the heavy nitrification months are infeasible. The moderate nitrification month target of 48 to 80 hours was adopted for modeling. Scenarios were run in an attempt to achieve targeted water ages and determine optimized flushing quantities for various improvement alternatives, as shown in **Figure WA5.F-4** and **Figure WA5.F-5**. Water age improvements modeled included remote storage tank turnover optimization, pipe looping and increased/targeted distribution flushing.

As shown in Figure WA5.F-3 the pre-Master Plan 2nd Avenue remote tank operation led to a water age issue. City staff has implemented full "turn over" of the remote tanks once per day and should consider possibly twice per day if tank filling hydraulics can be improved in the future with the remote tanks. Key dead ends and high water age areas should continue to be flushed by the City and possibly with auto-flushing devices that would minimize labor.

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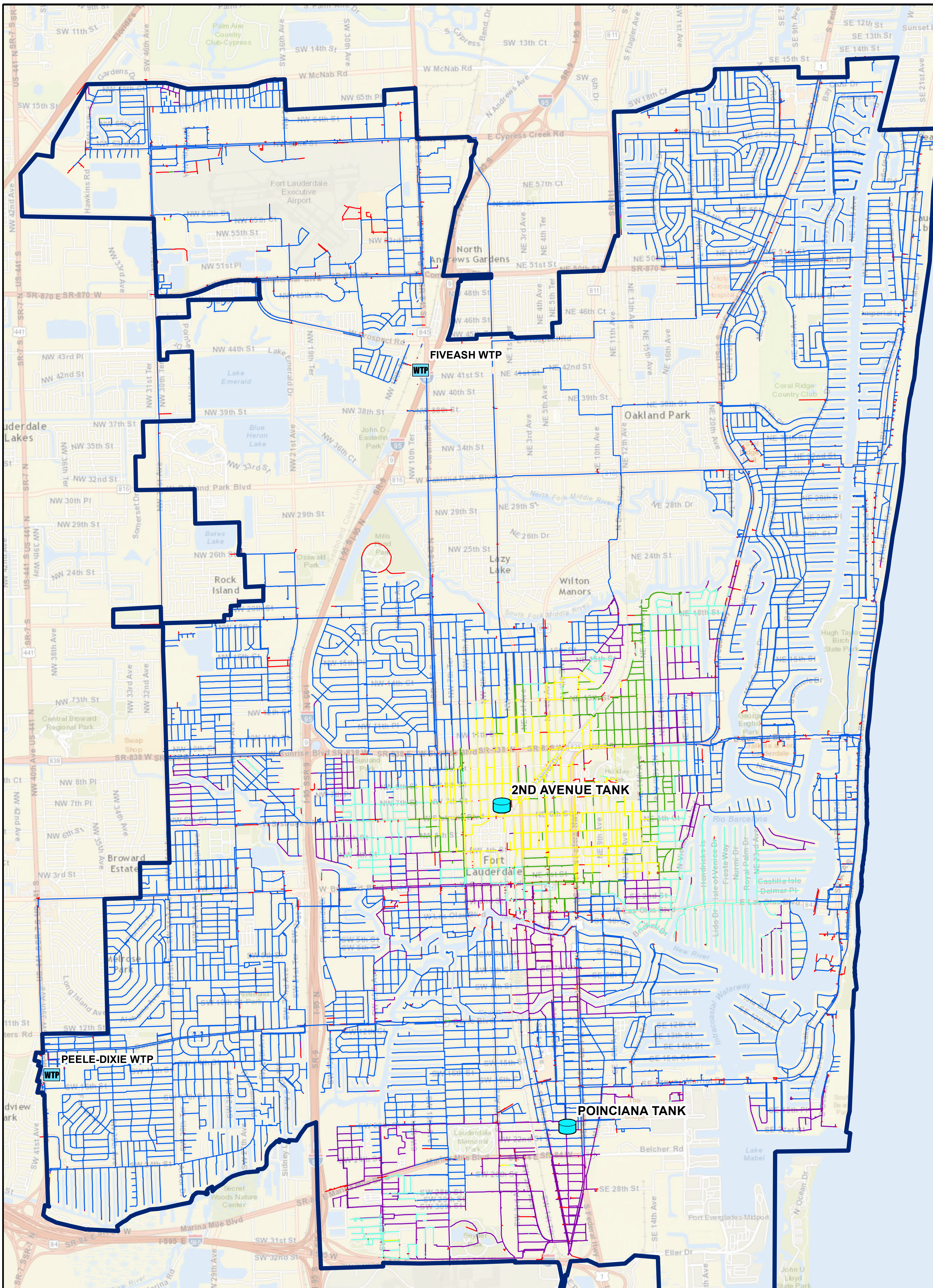

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0 1,250 2,500 5,000
Feet

LEGEND

WATER SERVICE AREA
DISTRIBUTION STORAGE
WTP WATER TREATMENT PLANT

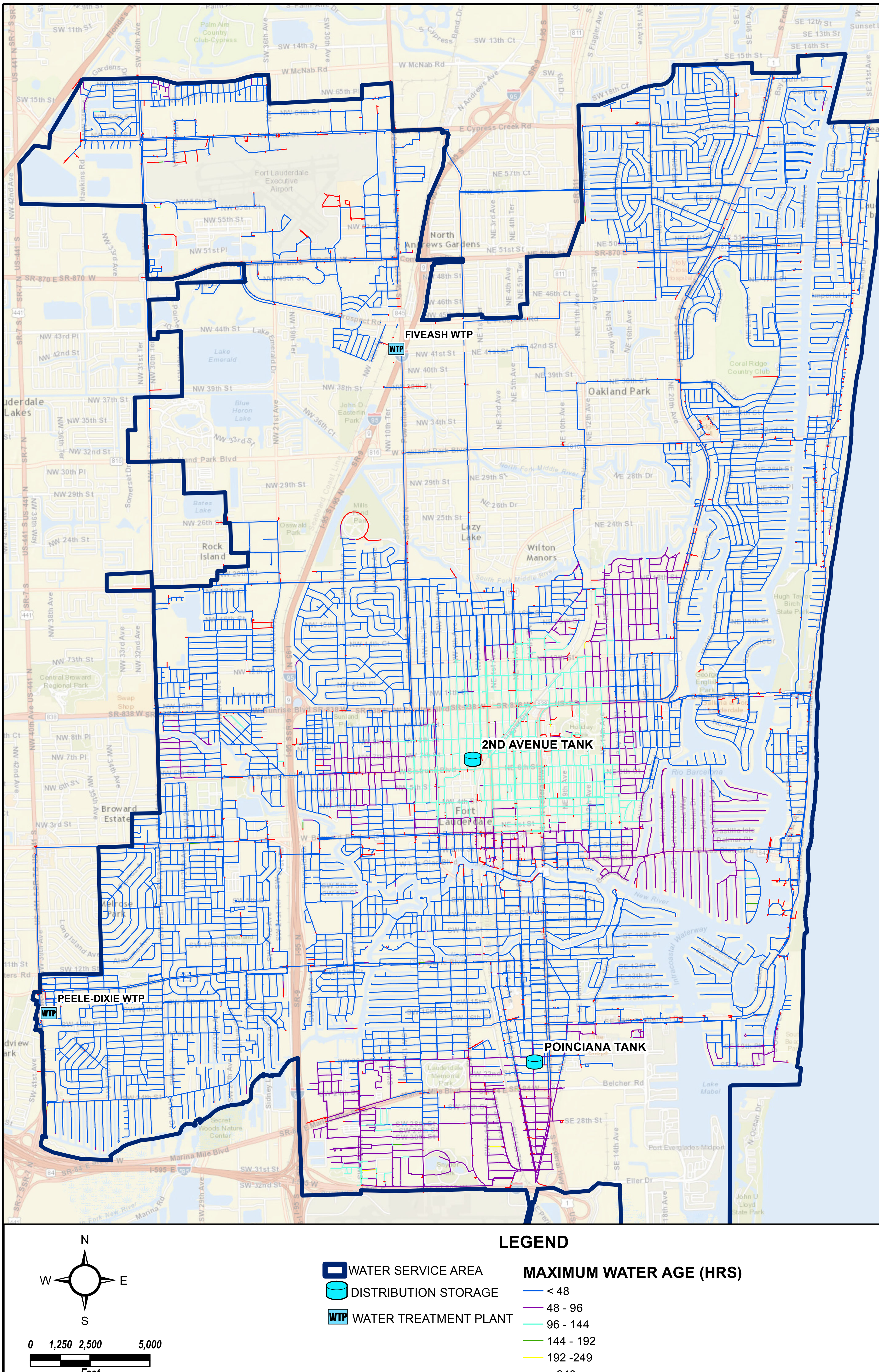
MAXIMUM WATER AGE (HRS)

- < 48
- 48 - 96
- 96 - 144
- 144 - 192
- 192 -249
- > 240

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2015 Existing - Maximum Water Age

FIGURE WA5.F-3

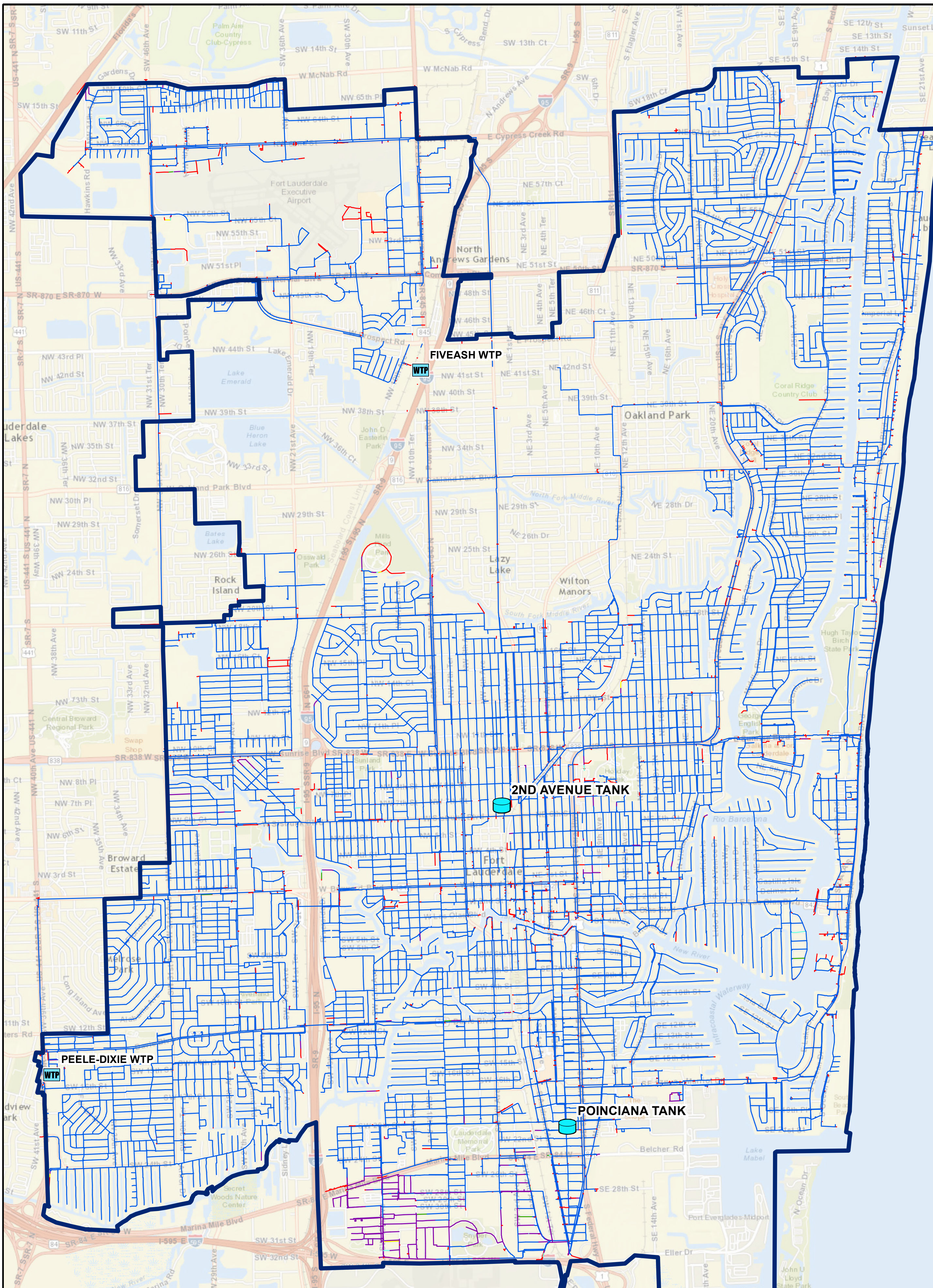
G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA5F - WQ\Figure WA5.F-1 Water Age Existing V2.mxd



CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2015 Existing - Optimized Maximum Water Age

FIGURE WA5.F-4

G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA5F - WQ\Figure WA5.F-3 Water Age Optimized V2.mxd



N
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0 1,250 2,500 5,000
Feet

LEGEND

- WATER SERVICE AREA
- DISTRIBUTION STORAGE
- WTP WATER TREATMENT PLANT

AVERAGE WATER AGE (HRS)

- < 48
- 48 - 96
- 96 - 144
- 144 - 192
- 192 -249
- > 240

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2015 Existing - Optimized Average Water Age

FIGURE WA5.F-5

G:\0gis\134001 - FTL Master Plan_MXDs\PW\WA5F - WQ\Figure WA5.F-3 Average Water Age Optimized V2.mxd

5.F.4.2 Residual Production and Excess Ammonia Minimization

Changes to the production of chloramines can inhibit nitrification. Field grab sampling identified that both Fiveash WTP and Peele-Dixie WTP had ammonia levels of greater than 0.5 mg/L Total Ammonia which includes the naturally occurring ammonia at POE and entering the distribution system. This excess free ammonia entering the distribution system is a food source for nitrifying bacteria. The goal is to optimize the production of chloramines by reaching the point where chlorine (as Cl2) has reacted with ammonia (as N) at a 5:1 ratio. The residual ammonia goal at the POE should be 0.2 mg/L free ammonia to minimize nitrification in the distribution system. The hydraulic issue at the Fiveash WTP mentioned in Section WA5A regarding flow from the clearwells to the storage tank is hampering residual production and monitoring and should be resolved immediately. From the bulk testing it is apparent that organic carbon content in the Fiveash WTP water is also decreasing bulk chlorine levels (versus Peele Dixie WTP); TOC removal would further benefit nitrification mitigation.

5.F.4.3 Pipe Cleaning Nitrification Mitigation Options

Research has indicated that a significant amount of nitrifying bacteria resides in pipe sediments in addition to pipe biofilm (EPA Nitrification Distribution Issue Paper, 2002). Therefore, removal of pipe sediments and biofilm could reduce nitrification in distribution systems. Pipe cleaning is also a regular maintenance item that should be periodically accomplished. Pipe cleaning options include swabbing, pigging, ice pigging and uni-directional flushing (UDF). UDF is significantly the most cost effective and feasible on a full scale. It is recommended that the City conduct a uni-directional flushing (UDF) program to remove sediment and biofilms from the system to accomplish pipe maintenance cleaning and potentially help mitigate nitrification.

5.F.4.4 Disinfectant Type/Burns

The City currently combats nitrification with periodic (2 per year) free chlorine burns. The free chlorine burns have been shown to be effective for approximately one month after the burn. Free chlorine burns send high levels of disinfection byproducts to customers, require copious flushing quantities and create taste and odor issues. A more sustainable long term solution involves removing total organic carbon from the Fiveash WTP raw water, as recommended in Section 5A for color removal, and switching to free chlorine as a primary disinfectant.

5.F.5 Water Quality Optimization Recommendations

Figure WA5.F-3 indicates that 2015 operational practices were adversely affecting water age in the 2nd Avenue tank area. **Figure WA5.F-4** and **Figure WA5.F-5** depict optimized water age. The CUS Master Plan Team recommends the City continue remote storage tank “turn overs” at least daily to minimize water age and improve remote tank fill hydraulics to reduce tank fill times. Looping, flushing, and replacing pipes are other water age optimization techniques recommended. Looping eliminates potential dead ends, and thus decreases water age. A uni-directional flushing program cleans pipes to remove sediment, biomass and biofilms to aid in maintaining acceptable water quality levels. Additionally, the chloramine production should be optimized to minimize free ammonia concentrations entering the system to minimize nutrients available to nitrifying bacteria. Residual free ammonia should be maintained at 0.1 mg/L or less. **Section WA7-Water CIP** lists the proposed distribution water quality improvement CIP projects. Note that the uni-directional flushing costs are represented in Section WA9 as a water conservation measure and total $2,000,000 over the next 5 years. Understanding that the City

Section WA5F accepted December 16, 2016.

recently undertook a valve assessment, a project was also added to locate and repair UDF valve and hydrant assets.

5.F.6 Conclusions

Based on the water quality assessment presented herein, the City's two WTP supply system provides relatively low water age water to the distribution system. Optimized operation of the remote storage facilities offers opportunity to further improve water age. The optimization techniques proposed as illustrated in **Figure WA5.F-5** would, upon implementation, reduce water age, especially in the area of the 2nd Avenue remote tank, thereby improving water quality. There are, however, significant water quality issues in the distribution system associated with nitrification as is the case with all utilities in warm climates utilizing chloramine as a primary disinfectant. The CUSMP evaluation drew the following conclusions;

Color

- The finished water color from the Fiveash WTP exceeds the City's secondary drinking water standards and the CUS Master Plan has proposed a color removal process to rectify the issue.
- The City's Peele Dixie WTP adequately removes color and meets the City's and secondary drinking water standards for color.

Odor

- The City's distribution meets goals and secondary standards for odor. Minimizing free ammonia concentrations at the POEs will further reduce odor concerns.

Stability

- The Fiveash WTP finished water is adequately stabilized.
- The CUS Master Plan recommended that the Peele Dixie stabilize its finished water with the addition of alkalinity and calcium hardness, potentially through membrane change out or a bypass process.

Disinfectant Residual

- Fiveash WTP has a significantly increased bulk disinfectant decay rate versus Peele-Dixie WTP likely due to total organic carbon.
- Dead ends notwithstanding, water age in relation to the source or bulk water chemical reactions is not the primary contributor to the City's low chloramine issues; the WTPs produce a stable chloramine residual.
- Nitrification is concluded to be the primary reason for low chloramine residuals in the distribution system.
- Continuing to "turn over" remote storage tanks on a daily basis will reduce local distribution water age and help reduce nitrification.
- Reducing free ammonia being introduced to the distribution system and optimizing chloramine production can help reduce nitrification.
- A UDF program to remove sediment and biofilms from the distribution piping can significantly improve water quality and potentially reduce nitrification activity.

Reliability and Consistency

- The City of Ft. Lauderdale's WTPs consistently produce safe and reliable potable water.
- The Fiveash WTP has significant repair and replacement needs that need to be addressed immediately.

Model Update

- In depth model demand allocation to remove some false high water age indications.

Appendix WA5.F-A

WA5.F-A.1 Bulk Chlorine Decay Coefficient Results

The decay of chlorine in a water distribution system is attributed to two main factors – bulk fluid and pipe wall effects. Bulk fluid chlorine decay reactions are caused by the reaction of chlorine with inorganic materials, such as iron or manganese, and through reactions with dissolved organic materials in the bulk fluid. Inorganic reactions take place quickly, typically while the water is still within the treatment plant's ground storage tank (GST), in contrast with organic reactions occur over a longer period of time.

Bulk fluid reactions occur within the fluid volume and are a function of initial constituent concentrations, reaction rates and orders, and concentrations of formation products. The bulk chlorine decay coefficient (Kb) was determined for each of the City's source waters. Summarizing the procedure, the decay coefficient for first order chorine decay was determined by placing a sample of water in a series of non-reacting glass bottles (sealed tightly with no head space) and analyzing the contents of each bottle at different points in time, over several days. If the reaction is first order, then plotting the natural log (Ct/C0) against time results in a straight line, where Ct is the concentration at time t and C0 is the initial concentration. The slope of the resulting line is the bulk chlorine decay coefficient, Kb. Calculations of the bulk chlorine decay coefficient for each WTP were completed and are illustrated in **Figure WA5.F-A.1** through **Figure WA5.F-A.3**. The higher chlorine decay rate at Fiveash than Peele-Dixie could be a result of higher ammonia levels leaving the plant. Ammonia levels leaving the north and south POE locations at Fiveash were measured at approximately 1.5 mg/l and the POE ammonia level for Peele Dixie was approximately 1.0 mg/l.

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Table WA5.F-A1. Fiveash South Chlorine Bulk Decay Field Sample

Fiveash South		
Holding Time, Hr	10/12/15 CL_2, mg/L	10/19/15 CL_2, mg/L
0	*8.5	4.00
4	*8.1	3.80
24	*7.2	3.40
48	2.90	3.00
72	2.80	2.70
96	2.70	2.40
120	2.50	2.20

*Sampling Equipment Malfunction
(Values thrown out for calculations)

Table WA5.F-A2. Fiveash South Chlorine Bulk Decay 1st Order Calculation

Fiveash South			
Avg Holding Time, Hr	Avg CL_2, mg/L	1st Order LN (C/C_0)	Calc CL_2, mg/L
0	4.00	0.0000	3.63
4	3.80	-0.0513	3.56
24	3.40	-0.1625	3.23
48	2.95	-0.3045	2.88
72	2.75	-0.3747	2.57
96	2.55	-0.4502	2.29
120	2.35	-0.5319	2.04
	R^2=	**0.97**	
	Slope=	**-0.00482**	

Table WA5.F-A3. Fiveash South Chlorine SCADA Average

Fiveash South	1st Order
SCADA Avg	3.63
R^2	0.97
Slope	**-0.0048**

Table WA5.F-A4. Fiveash North Chlorine Bulk Decay Field Sample

Fiveash North		
Holding Time, Hr	10/12/15 CL_2, mg/L	10/19/15 CL_2, mg/L
0	*8.2	4.40
4	*7.9	4.20
24	*6.8	3.90
48	2.70	3.40
72	2.60	3.00
96	2.30	2.70
120	2.30	2.50

*Sampling Equipment Malfunction
(Values thrown out for calculations)

Table WA5.F-A5. Fiveash North Chlorine Bulk Decay 1st Order Calculation

Fiveash North			
Avg Holding Time, Hr	Avg CL_2, mg/L	1st Order LN (C/C_0)	Calc CL_2, mg/L
0	4.40	0.0000	3.63
4	4.20	-0.0465	3.55
24	3.90	-0.1206	3.17
48	3.05	-0.3665	2.76
72	2.80	-0.4520	2.41
96	2.50	-0.5653	2.10
120	2.40	-0.6061	1.83
	R^2=	**0.96**	
	Slope=	**-0.00569**	

Table WA5.F-A6. Fiveash South Chlorine SCADA Average

Fiveash North	1st Order
SCADA Avg	3.63
R^2	0.96
Slope	**-0.0057**

Table WA5.F-A7. Fiveash South and North Chlorine Bulk Decay vs. Water Age

5ash South		5ash North	
Time, Hr	Calc CL_2 mg/L	Time, Hr	Calc CL_2 mg/L
0	3.63	0	3.63
4	3.56	4	3.55
24	3.23	24	3.17
48	2.88	48	2.76
72	2.57	72	2.41
96	2.29	96	2.10
120	2.04	120	1.83
127	1.96	127	1.76
145	1.80	145	1.59
163	1.66	163	1.44
180	1.52	180	1.30
198	1.40	198	1.18
216	1.28	216	1.06
233	1.18	233	0.96
251	1.08	251	0.87
269	0.99	269	0.79
287	0.91	287	0.71
304	0.84	304	0.64
322	0.77	322	0.58
340	0.71	340	0.53
357	0.65	357	0.48
375	0.60	375	0.43
393	0.55	393	0.39
410	0.50	410	0.35
428	0.46	428	0.32
446	0.42	446	0.29
463	0.39	463	0.26
481	0.36	481	0.24
499	0.33	499	0.21
516	0.30	516	0.19
534	0.28	534	0.17
552	0.25	552	0.16
569	0.23	569	0.14
587	0.21	587	0.13
605	0.20	605	0.12
622	0.18	622	0.11
640	0.17	640	0.10

Figure WA5.F-A1. Fiveash South Chlorine Bulk Decay 1st Order Calculation

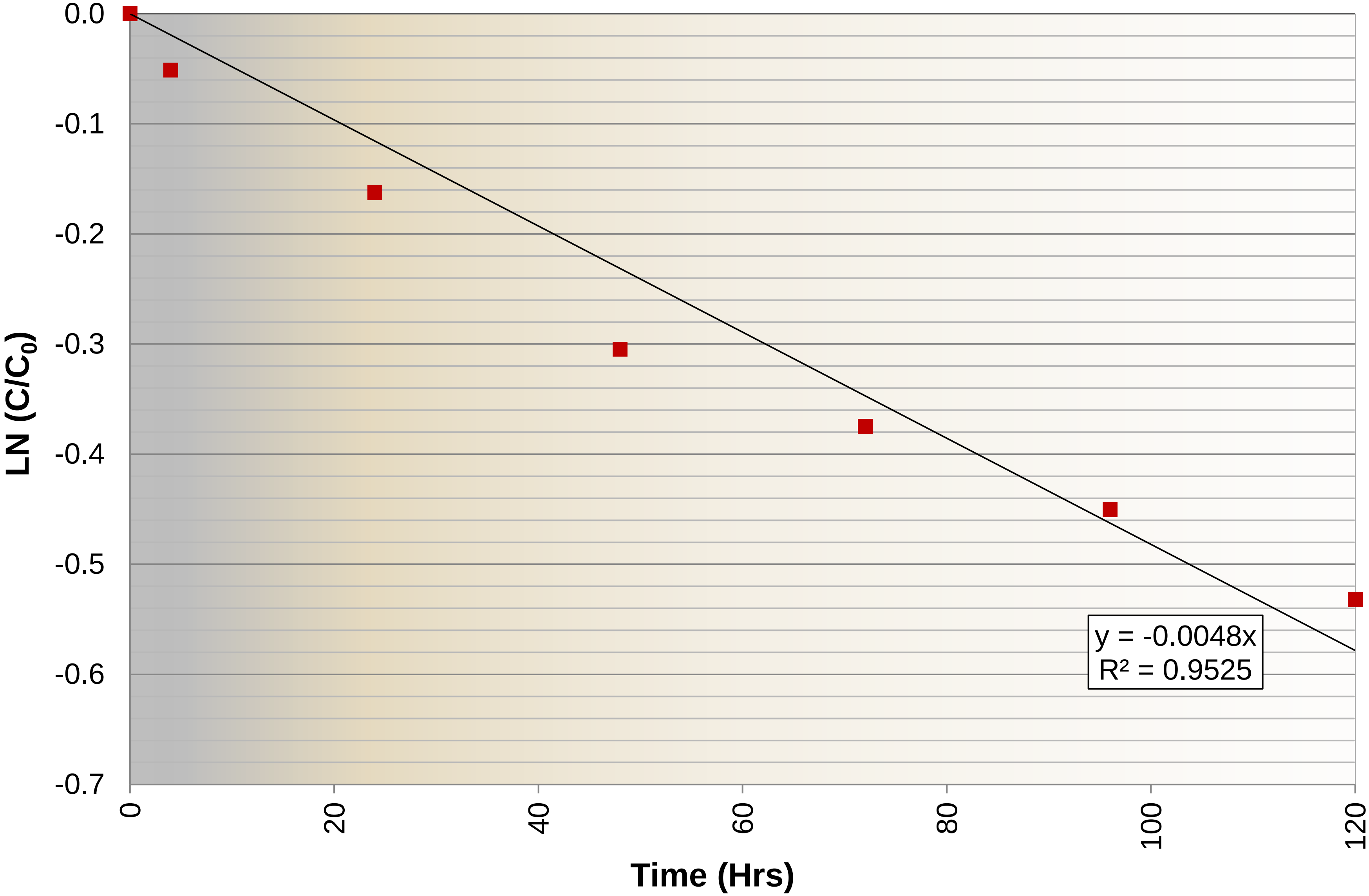
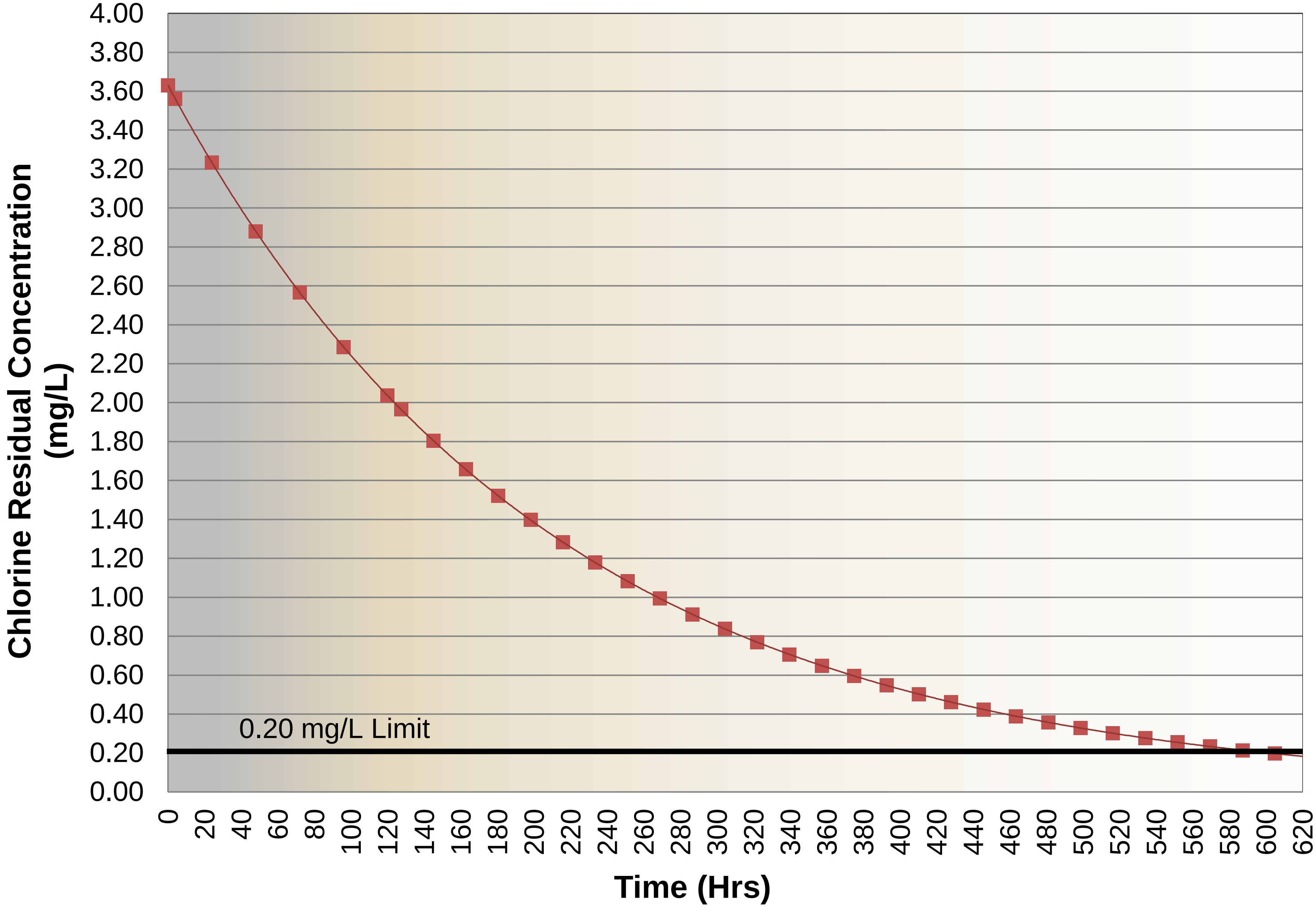


Figure WA5.F-A2. Fiveash South Chlorine Residual Water Age Target



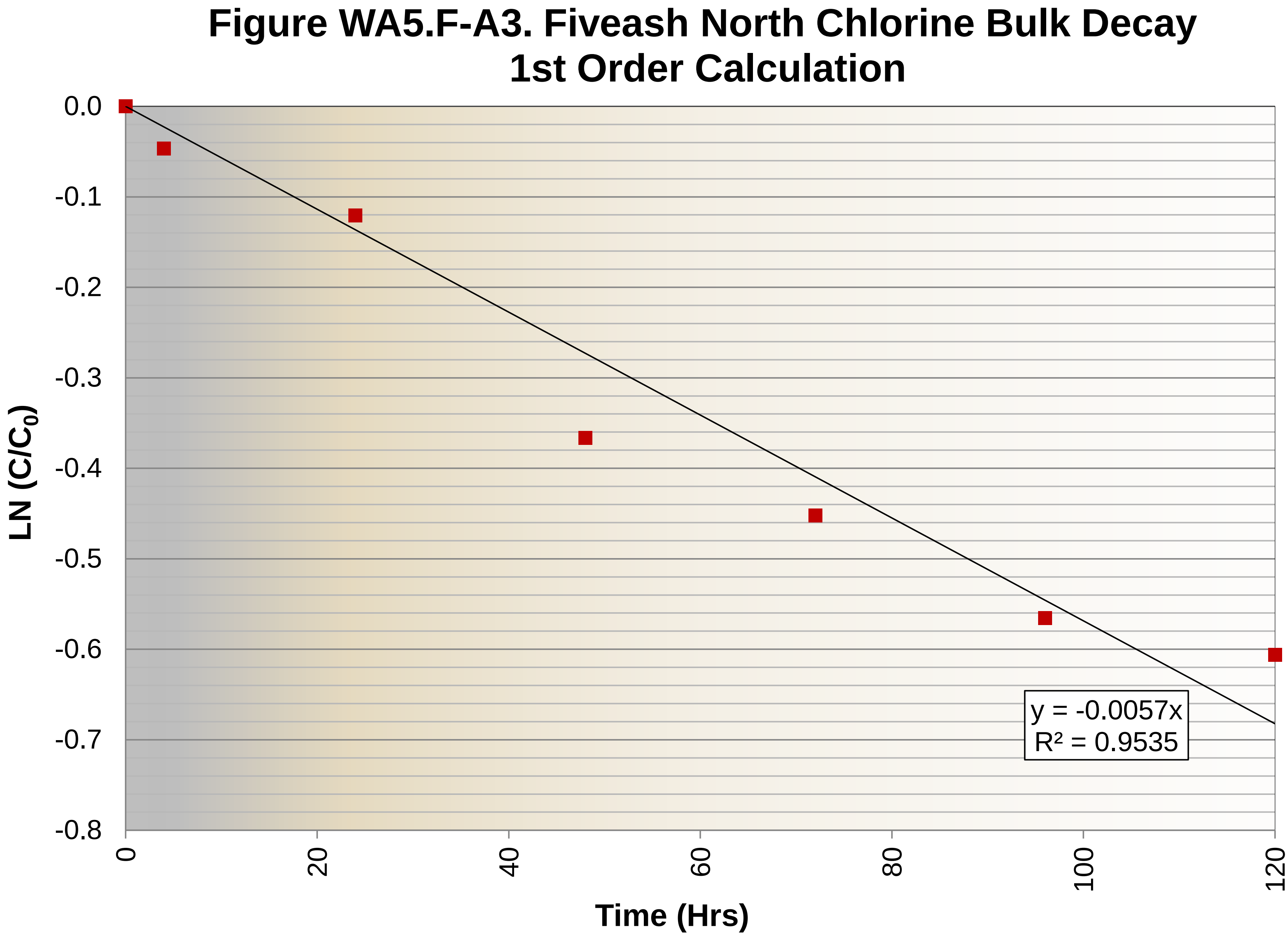


Figure WA5.F-A3. Fiveash North Chlorine Bulk Decay
1st Order Calculation
LN (C/C0)
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
0
20
40
60
80
100
120
Time (Hrs)
y = -0.0057x
R² = 0.9535

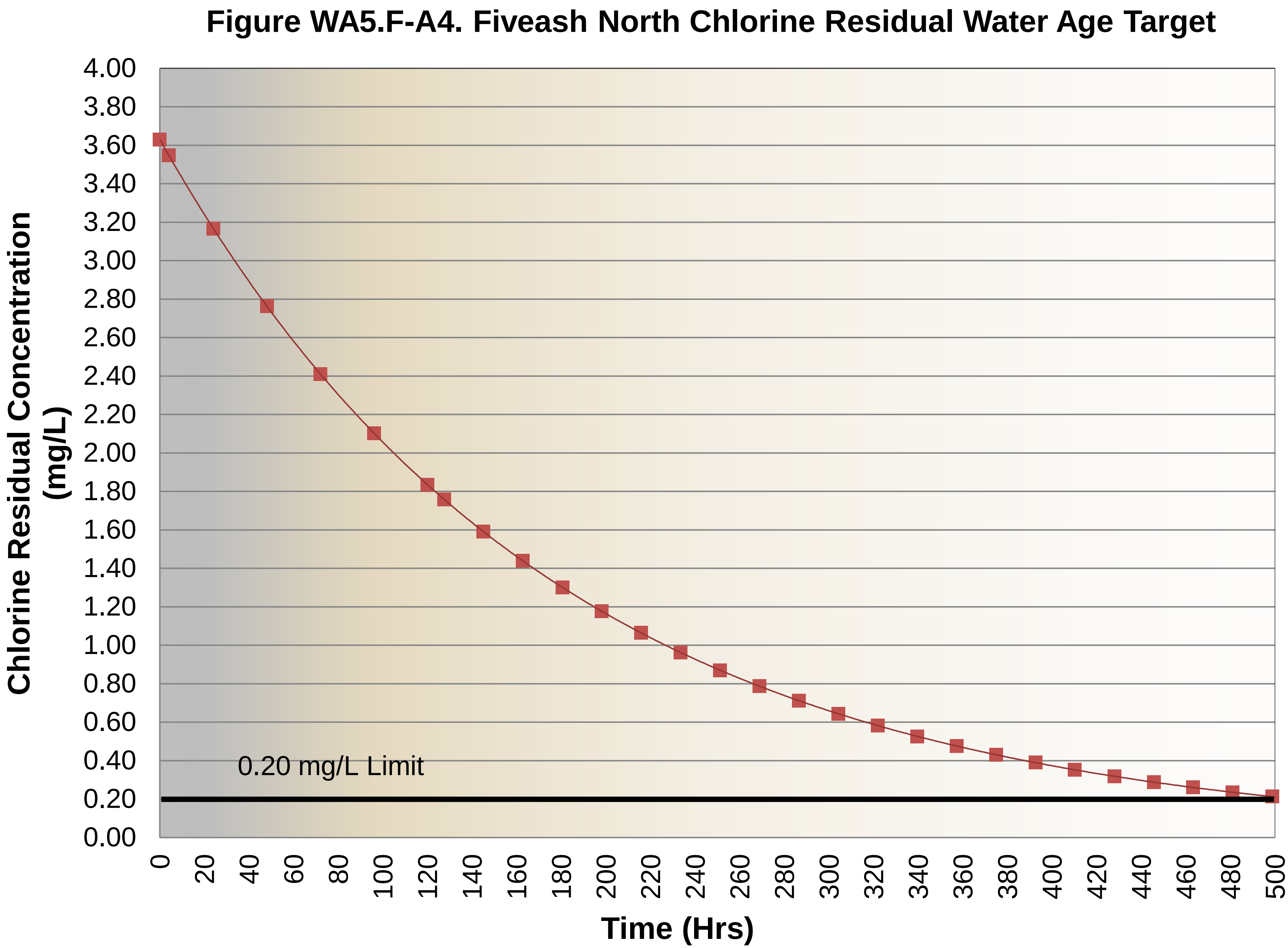


Figure WA5.F-A4. Fiveash North Chlorine Residual Water Age Target
Chlorine Residual Concentration (mg/L)
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.20 mg/L Limit
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
Time (Hrs)

Table WA5.F-A8. Peele-Dixie Chlorine Bulk Decay Field Sample

Peele Dixie		
Holding Time, Hr	10/12/15 CL_2, mg/L	10/19/15 CL_2, mg/L
0	*8.8	4.40
4	*8.8	4.30
24	*8.8	4.30
48	4.10	4.30
72	4.10	4.20
96	4.00	4.20
120	4.00	4.00

*Sampling Equipment Malfunction
(Values thrown out for calculations)

Table WA5.F-A9. Peele-Dixie Chlorine Bulk Decay 1st Order Calculation

Peele Dixie			
Avg Holding Time, Hr	Avg CL_2, mg/L	1st Order LN (C/C_0)	Calc CL_2, mg/L
0	4.40	0.0000	3.71
4	4.30	-0.0230	3.70
24	4.30	-0.0230	3.64
48	4.20	-0.0465	3.57
72	4.15	-0.0585	3.51
96	4.10	-0.0706	3.44
120	4.00	-0.0953	3.37
	R^2=	0.96	
	Slope=	-0.00080	

Table WA5.F-A10. Peele-Dixie Chlorine SCADA Average

Peele Dixie	1st Order
SCADA Avg	3.71
R^2	0.96
Slope	**-0.0008**

Table WA5.F-A11. Peele-Dixie Chlorine Bulk Decay vs. Water Age

Peele Dixie	
Time, Hr	Calc CL_2 mg/L
0	3.71
4	3.70
24	3.64
48	3.57
72	3.51
96	3.44
120	3.37
127	3.35
145	3.31
163	3.26
180	3.22
198	3.17
216	3.13
233	3.08
251	3.04
269	3.00
287	2.95
304	2.91
322	2.87
340	2.83
357	2.79
375	2.75
393	2.71
410	2.68
428	2.64

Figure WA5.F-A5. Peele Dixie Chlorine Bulk Decay 1st Order Calculation

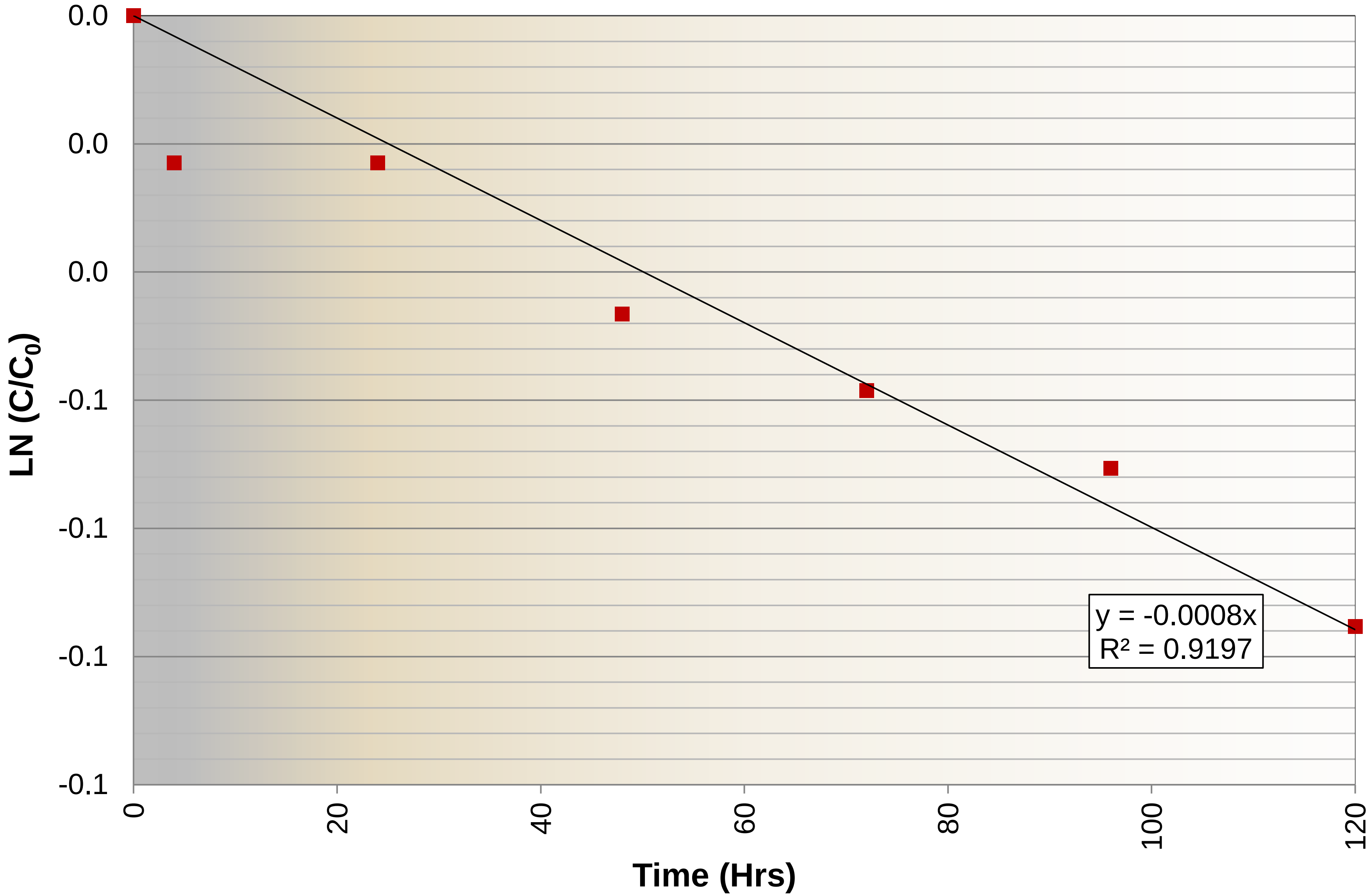
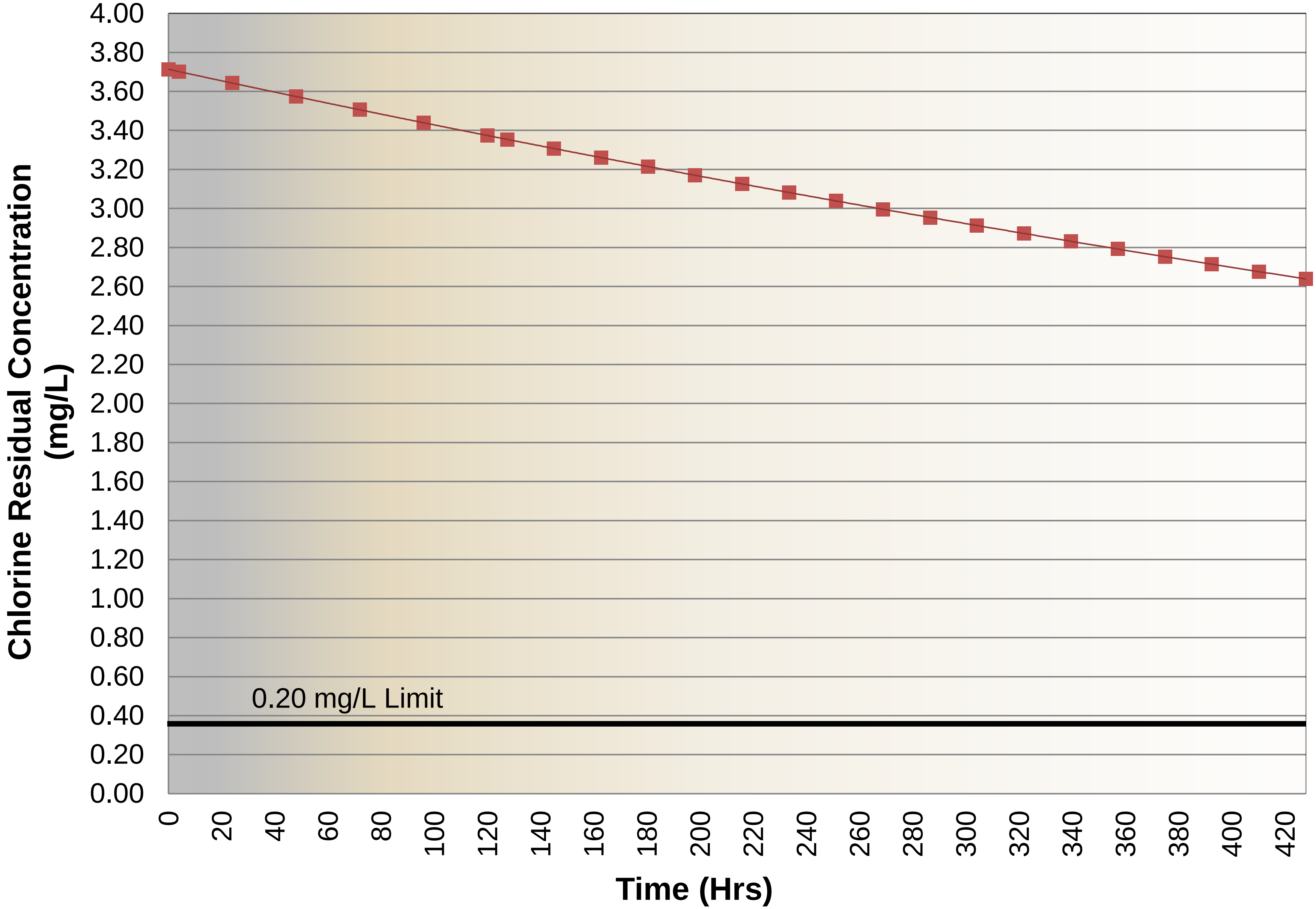


Figure WA5.F-A6. Peele Dixie Chlorine Residual Water Age Target



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WA6 Finished Water Storage Evaluation

Treated potable (finished) water produced by the City's Peele-Dixie Water Treatment Plant (WTP) and Fiveash WTP is stored in onsite storage tanks and in two separate remotely located tanks. **Figure WA6-1** shows the capacity of the storage tanks compared to Florida Administrative Code (FAC) required storage capacity. Finished water storage addresses diurnal demand variations, operational pressure optimization, fire flow demands and emergency distribution supply. The following evaluation of the finished water storage infrastructure addresses the City's existing and future conditions and needs.

6.1 Existing Finished Water Storage Facilities

On-site finished water storage at the Fiveash WTP and Peele-Dixie WTP is composed of ground storage tanks nominally totaling 22.5 million gallons (MG). The two remote (distribution) storage and pump stations, Poinciana Park Water Tank and Pump Station and the Northwest 2nd Avenue Water Tank and Pump Station, have a nominal total of 2.5 MG of distribution water storage; yielding a grand total (nominal) of 25.0 MG. Effective or usable volume is the storage that can actually be utilized during operations due to physical limitations such as cavitation or flow vortexing in the tank. The City replaced the Poinciana Park storage tank in 2006, rehabilitated the 2nd Avenue pump station in 2012, and scheduled to rehabilitate the 2nd Avenue water tower in 2016. **Table WA6-1** summarizes the nominal and usable volumes for on-site water storage facilities at Fiveash WTP and Peele-Dixie WTP along with the distribution storage facilities. The **WA8 - Water R&R Improvement's** section includes a more detailed tank maintenance and cleaning history.

Table WA6-1. Finished Water Storage Volume

Name	Nominal Volume	Usable Volume*	Material	Year Built
Fiveash WTP				
Tank 1	5.0 MG	4.5 MG	Steel	1963
Tank 3	5.0 MG	4.5 MG	Pre-stressed Concrete	1977
Tank 4	7.0 MG	6.3 MG	Pre-stressed Concrete	1999
Subtotal	**17.0 MG**	**15.3 MG**		
Peele-Dixie WTP				
Tank 1	4.0 MG	3.6	Pre-stressed Concrete	2007
Tank 2	4.0 MG	3.6	Pre-stressed Concrete	2007
Subtotal	**8.0 MG**	**7.2 MG**		
Distribution Storage				
Poinciana Park Tank	2.0 MG	1.6 MG	Pre-stressed Concrete	2006
Northwest 2nd Ave. Tank	1.0 MG	1.0 MG	Steel	1950s
Subtotal	**3.0 MG**	**2.5 MG**	-	-
Total	**28.0 MG**	**25.0 MG**	-	-

* The usable volume for Poinciana Park Tank and the NW 2nd Ave. Tank was estimated based on City feedback. All other usable volumes are calculated at 90% of the nominal volume.

Section WA6 accepted April 22, 2016.

6.2 Finished Water Storage Service Criteria

Finished water storage including distribution storage provides adequate flow reservoirs to accommodate peak demands above water treatment plant production capacities. Finished water storage capacity is governed by Florida Administrative Code (FAC) 62-555.320 (19) (a): minimum requirement of 25 percent of maximum day demand plus maximum fire flow volume with all tanks in service. Ten States Standards guidelines (Section 7.0.1) recommend that storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demands and fire flow demands. For this master plan and consistent with State of Florida requirements, FAC governs the storage capacity evaluation noting that clearwell volumes are not included in the storage calculations.

The City of Fort Lauderdale's level of service (LOS) for fire flow storage dictates that fire-fighting water demand be provided on a worst case maximum day demand condition. The Insurance Services Office (ISO) establishes water flow standards required for fire suppression services. Fire flow demands can vary based on building use, type of construction, building height, floor area, and distance to nearby buildings. Residential buildings may only require 500-1,500 gallons per minute (GPM), while industrial buildings may require up to 5,000 GPM. Therefore, and consistent with previous City master planning efforts, the maximum fire flow used to calculate the FAC-required fire flow storage is a 5,000 gallons per minute (gpm) fire flow over a four hour duration. Consequently, the City's required storage capacity for fire flow is 1.2 million gallons.

$$\frac{5{,}000\ gal}{min} * \frac{60\ min}{hr} * 4\ hr * \frac{MG}{1E6\ gal} = 1.2\ MG$$

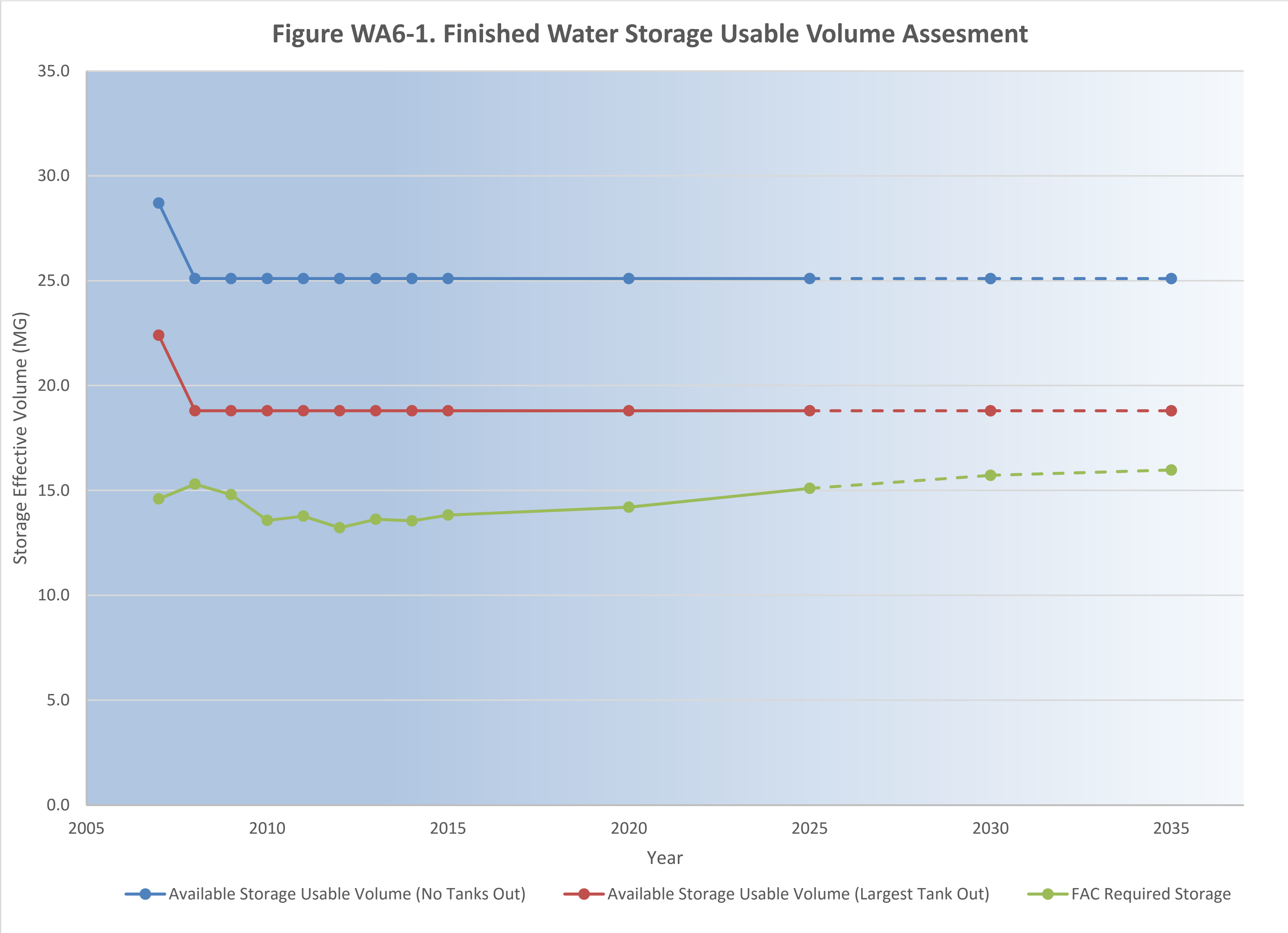
When evaluating individual facilities, including distribution or remote storage, storage should be able to supply 4 to 6 hours of peak hour pumping or discharge rates. While not a level of service standard, this criterion derives from standard engineering practice and is evaluated in the following section.

6.3 Finished Water Storage Level of Service Needs

Based upon the updated population and potable water demand forecast in Section WA2, the City's annual average demand could reach 45.4 MGD by year 2035 with a maximum day demand of 59.1 MGD. Twenty-five percent of the maximum day demand (14.8 MGD) plus the maximum fire flow volume (1.2 MG) equates to 16 MGD. The City's existing, usable storage capacity of 25.0 MGD will comply with FAC 62-555.320 (19) (a) in the year 2035. To test redundancy the existing storage capacity with the largest tank out of service was compared to the finished water storage level of service criteria. With the largest tank offline (7.0 MG) the usable storage capacity reduces to 18.7 MG and will still comply with FAC 62-555.320 (19)(a) through the 2035 forecasting period. **Figure WA6-1** illustrates existing storage verses FAC required storage and **Table WA6-2** shows usable capacity of the City's storage tanks in comparison to quantities required by legislation**.**

Considering the individual facility storage criteria, the onsite WTPs' storage easily meets the 4 to 6 hours of peak hour pumping volume. For the distribution storage, the Poinciana tank provides 4.6 hours of peak discharge volume, however, the 2nd Avenue tank currently only supplies 3 hours of peak discharge volume.

Section WA6 accepted April 22, 2016.



Section WA6 accepted April 22, 2016.

Table WA6-2. Finished Water Storage Volume

Year	Max. Day Finished Water Needed (MGD)	Available Finished Water Storage: Distribution System*: Poinciana Park Tank (MG)	Distribution System*: 2nd Ave Tank 1 (MG)	Existing Fiveash WTP*: Tank 1 (MG)	Existing Fiveash WTP*: Tank 2 (MG)	Existing Fiveash WTP*: Tank 3 (MG)	Existing Fiveash WTP*: Tank 4 (MG)	New Peele-Dixie Nanofiltration WTP*: Tank 1 (MG)	New Peele-Dixie Nanofiltration WTP*: Tank 2 (MG)	Available Storage Effective Volume (No Tanks Out) (MG)	Rule FAC 62-555.320(19) Criteria: Capacity Met? YES	Capacity Met? NO	Available Storage Effective Volume (Largest Tank Out) (MG)	Rule FAC 62-555.320(19) Criteria: Capacity Met? YES	Capacity Met? NO	Rule FAC 62-555.320(19) Criteria: FAC Required Storage (MG)
2007	53.6	1.6	1.0	4.5	3.6	4.5	6.3	3.6	3.6	28.7	X		22.4	X		14.6
2008	56.4	1.6	1.0	4.5	De-molished[2]	4.5	6.3	3.6	3.6	25.1	X		18.8	X		15.3
2009	54.4	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		14.8
2010	49.5	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		13.6
2011	50.3	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		13.8
2012	48.1	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		13.2
2013	49.7	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		13.6
2014	49.4	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		13.6
2015	50.5	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		13.8
2020	52.0	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		14.2
2025	55.6	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		15.1
2030	58.1	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		15.7
2035	59.1	1.6	1.0	4.5	0	4.5	6.3	3.6	3.6	25.1	X		18.8	X		16.0

* The usable volume for Poinciana Park Tank and the NW 2nd Ave. Tank was estimated based on City feedback. All other usable volumes are calculated at 90% of the nominal volume.

Section WA6 accepted April 22, 2016.

Table WA6-3 illustrates the existing storage volume and discharge flow for each distribution tank and the storage time available under the existing operations.

Table WA6-3. Individual Distribution Storage Evaluation

Distribution Tank	Usable Storage Volume (MG)*	Station Discharge Flow (gpm)	Storage Time (hrs)	Minimum 4 hours of Storage	Volume for 4 hours of Storage (MG)
2nd Avenue	1.0	5,500	3.0	No	1.3
Poinciana	1.6	5,800	4.6	Yes	1.4

* The usable volume for Poinciana Park Tank was estimated based on City feedback.

While the 2nd Avenue storage tank volume is just under the 4-hour peak flow criteria, it is currently impractical to expand the existing elevated storage tank. the CUS Master Plan Team recommends that operations staff delay discharge of the tank by approximately an hour to ensure that peak demands in the latter portion of the City's peak demand window (3:00 to 7:00 am) can be supplied by the tank. Most of the demand in the earlier part of the window assumes the inclusion of a significant amount of irrigation. The 2nd Avenue tank typically operates by discharging its full volume during peak demand. The tank then begins filling at approximately 10am, reaching its full capacity at approximately 9pm. Concurrently, the Poinciana tank discharges its volume down to the minimum operating level to prevent pump cavitation (at approximately 9ft.). The tank then begins filling at approximately 2pm, reaching approximately 24ft, or 40 percent of its effective volume, at approximately 11pm. During this period, the tanks may not have adequate water for fire flow/emergency situations, but the WTPs' storage tanks have a sufficient supply to accommodate such a demand.

In 2003, the City halted plans to remove the 2nd Avenue elevated tank and replace it with a larger ground storage tank due to opposition by the local community. The CUS Master Plan Team recommends beginning the selection of a new site for the future, expanded 2nd Avenue storage tank with at least 1.3 MG of usable volume, as the existing 2nd Avenue elevated tank becomes functionally obsolete due to insufficient capacity.

Hydraulic modeling assessed and confirmed the need for the remote storage capacity. **Figure WA6-2** and **Figure WA6-3** illustrates hydraulic model output for distribution system during 2015 peak hourly demand (PHD) conditions with and without the distribution storage tanks online. Similarly, **Figure WA6-4** and **Figure WA6-5** illustrates future potable water system hydraulic model output for 2035 peak hourly demand (PHD) conditions with and without the distribution storage tanks online. While the hydraulic model runs indicate that it is theoretically possible to take a distribution storage tank offline, current low pressure issues in the Harbor Beach area preclude the removal of the 2nd Avenue facility at this time. Additionally, the distribution storage tanks provide redundancy in the event of brief WTP outages or emergency conditions such as pipe breaks. Site visits to the finished water storage tanks identified an operational need at the Fiveash WTP. The treated Fiveash water flows from the clearwells to the storage tanks, and then back to the clearwells before distribution; this arrangement creates significant disadvantages to operations including potential tank water quality issues and reduced control of finished water quality.

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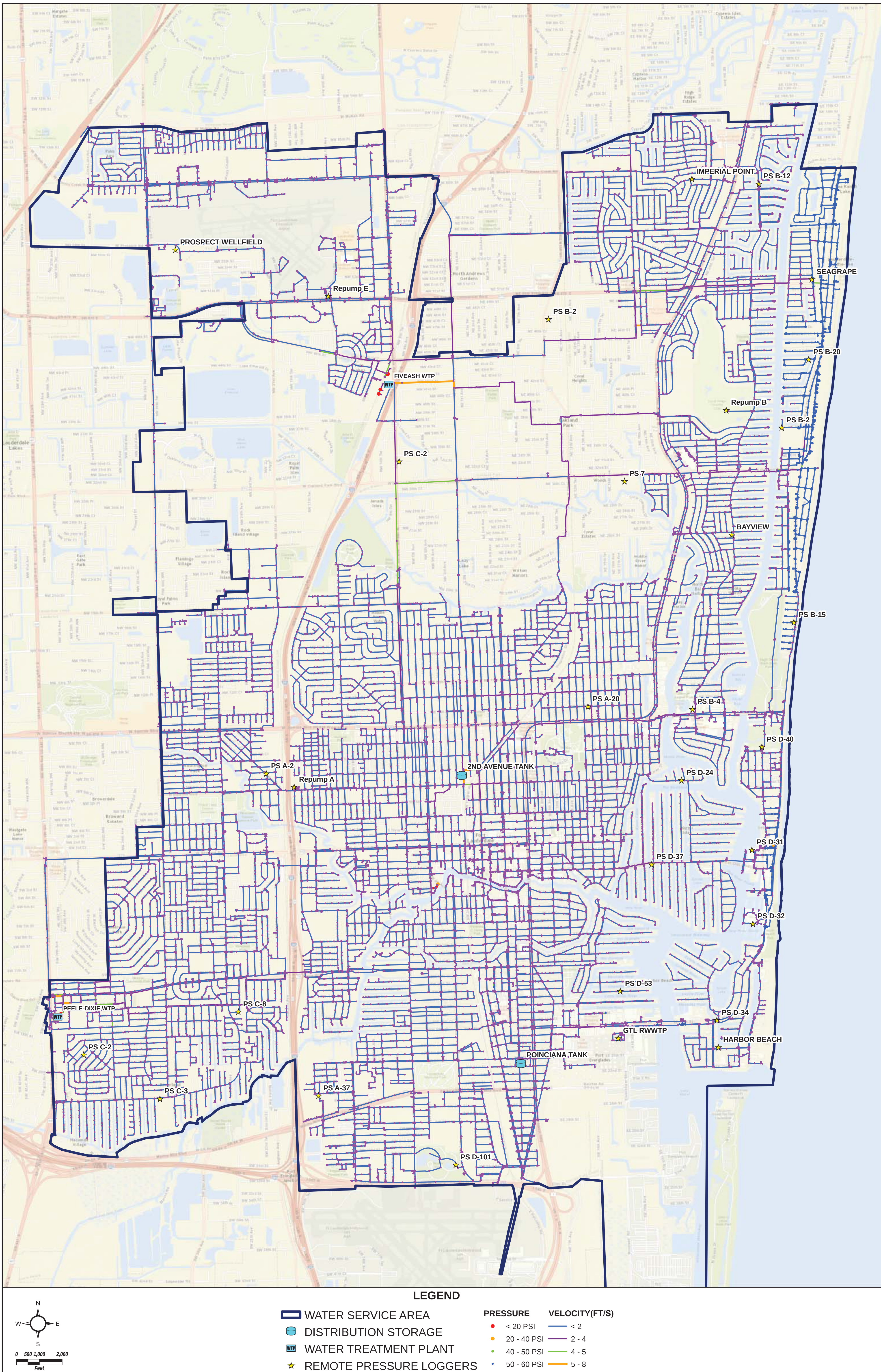

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2015 PEAK HOUR DEMAND

FIGURE WA6-2

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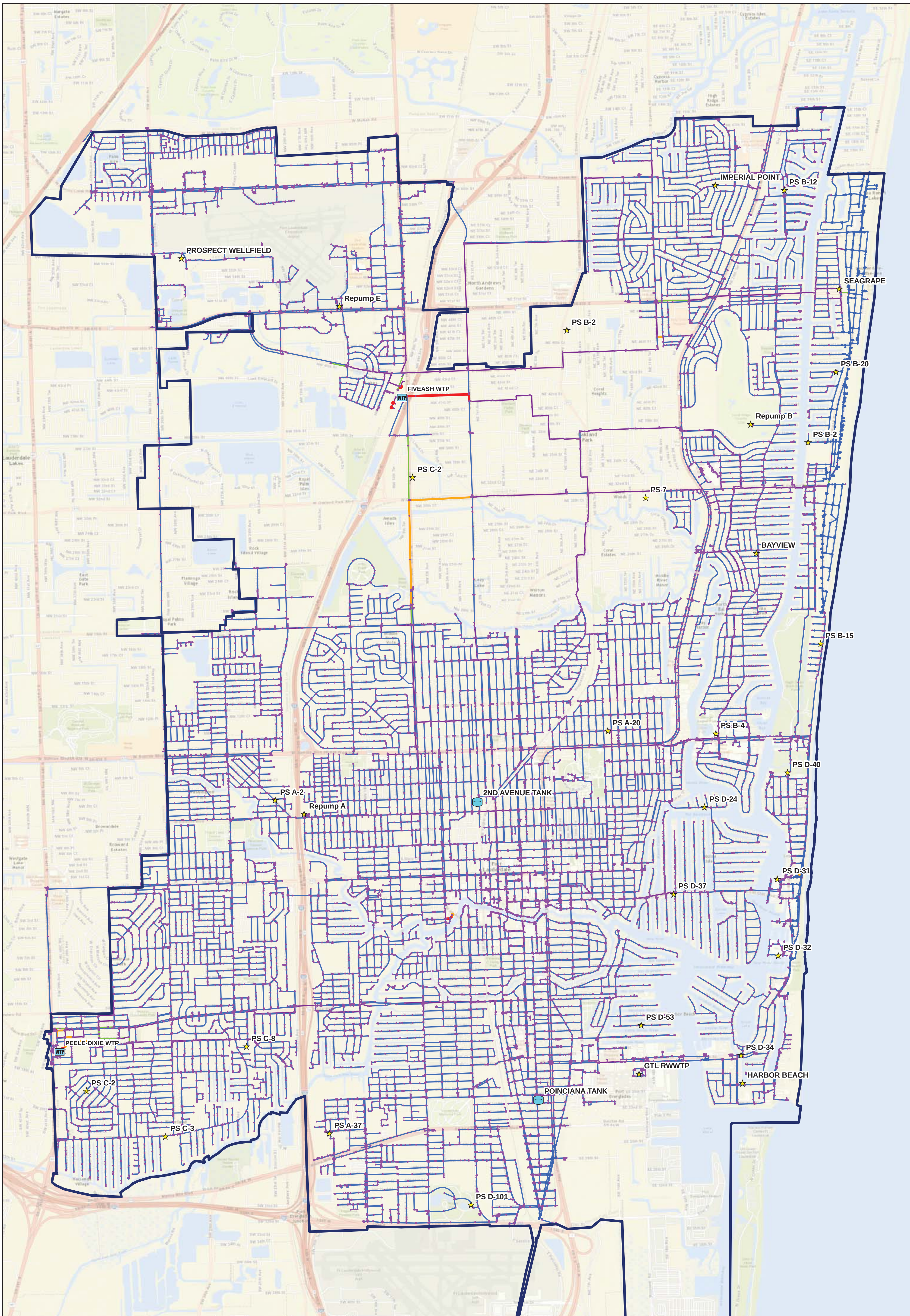

LEGEND

WATER SERVICE AREA	**PRESSURE**	**VELOCITY(FT/S)**
DISTRIBUTION STORAGE	< 20 PSI	< 2
WTP WATER TREATMENT PLANT	20 - 40 PSI	2 - 4
REMOTE PRESSURE LOGGERS	40 - 50 PSI	4 - 5
	50 - 60 PSI	5 - 8
	> 60 PSI	> 8

N W E S

0 500 1,000 2,000
Feet

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2015 PEAK HOUR DEMAND DISTRIBUTION TANKS OFFLINE

FIGURE WA6-3

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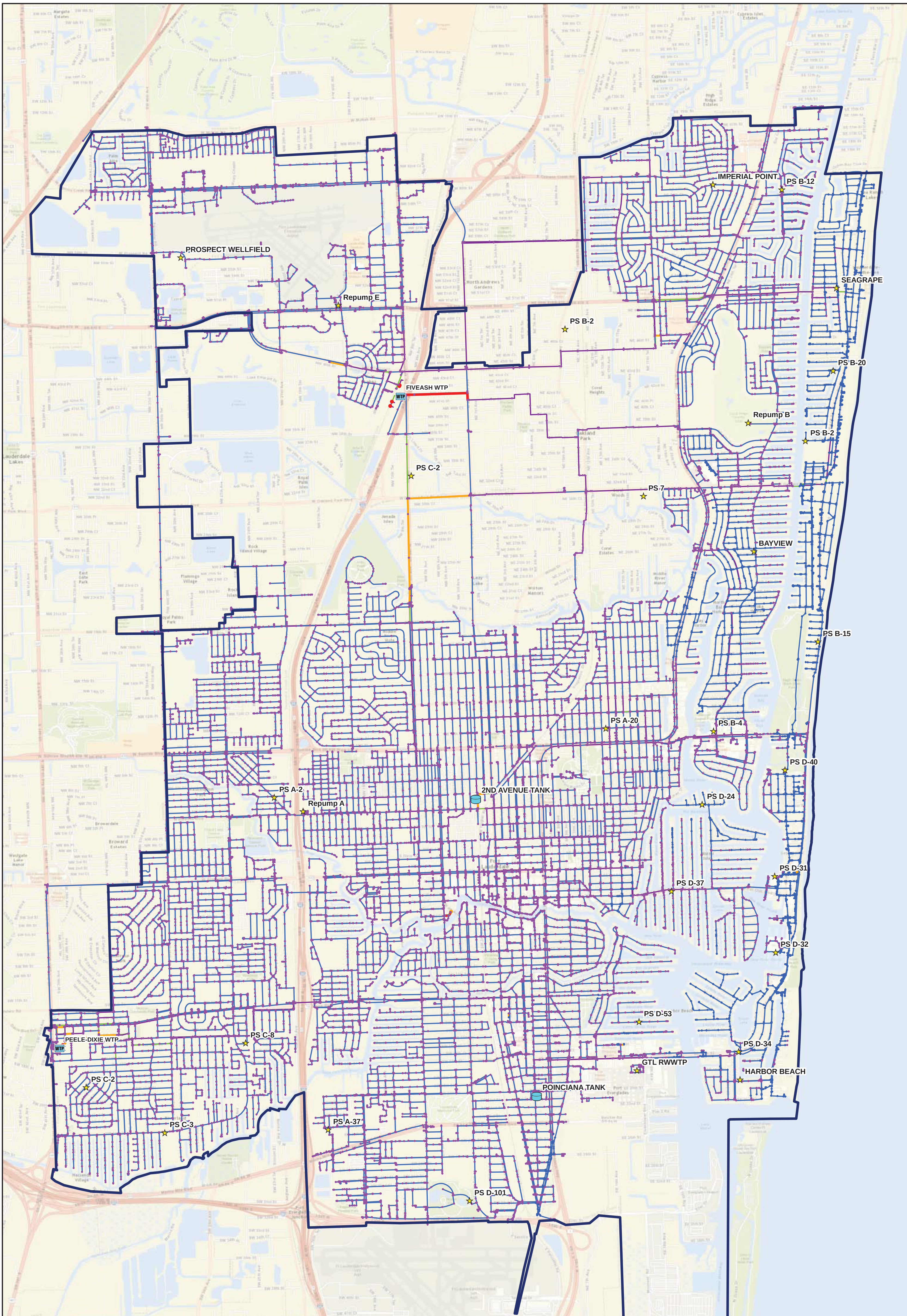

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0 500 1,000 2,000
Feet

LEGEND

WATER SERVICE AREA
DISTRIBUTION STORAGE
WATER TREATMENT PLANT
REMOTE PRESSURE LOGGERS

PRESSURE	VELOCITY(FT/S)
< 20 PSI	< 2
20 - 40 PSI	2 - 4
40 - 50 PSI	4 - 5
50 - 60 PSI	5 - 8
> 60 PSI	> 8

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2035 PEAK HOUR DEMAND

FIGURE WA6-4

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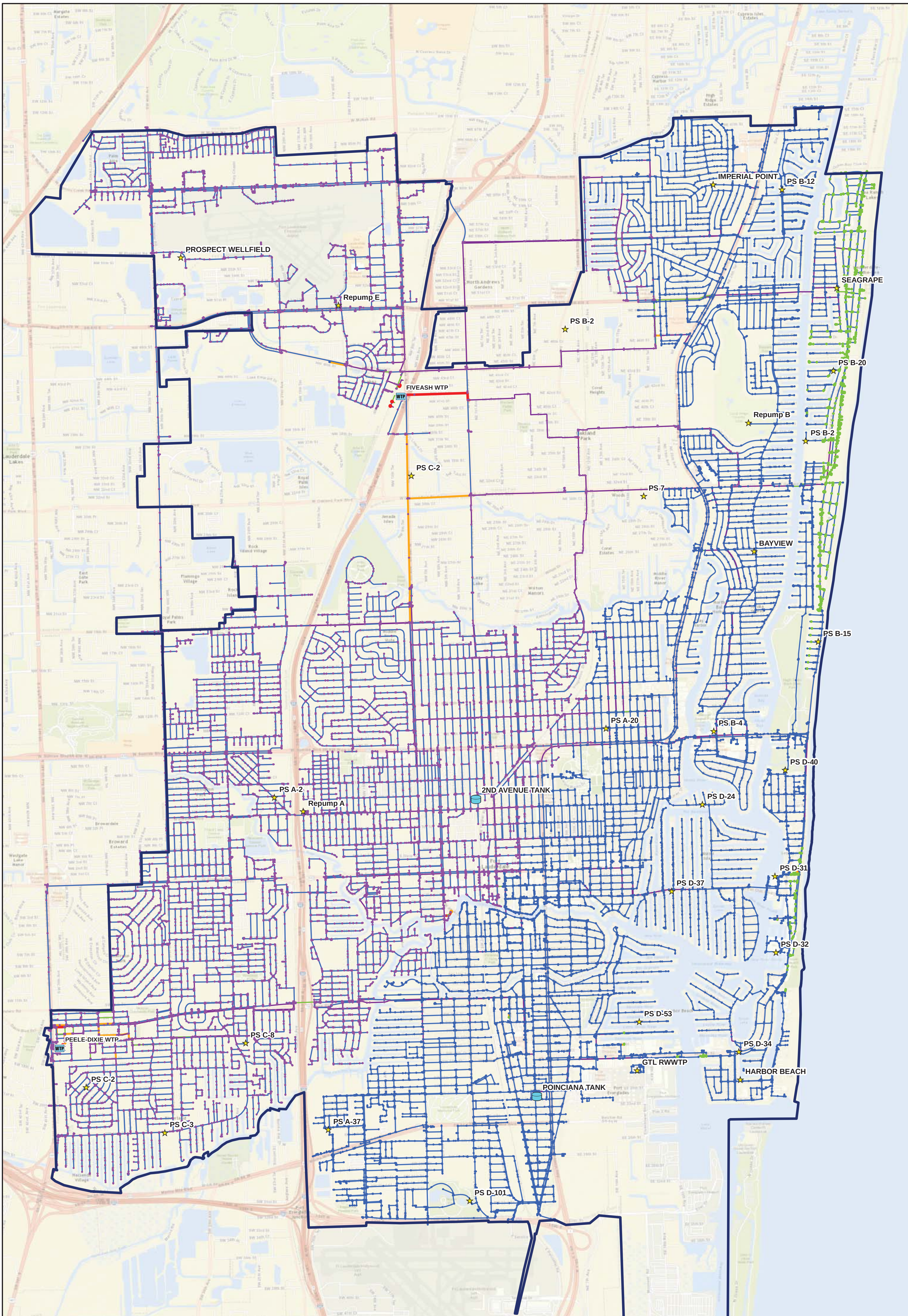

N
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0 500 1,000 2,000
Feet

LEGEND

WATER SERVICE AREA
DISTRIBUTION STORAGE
WTP WATER TREATMENT PLANT
REMOTE PRESSURE LOGGERS

PRESSURE	VELOCITY(FT/S)
< 20 PSI	< 2
20 - 40 PSI	2 - 4
40 - 50 PSI	4 - 5
50 - 60 PSI	5 - 8
> 60 PSI	> 8

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
2035 PEAK HOUR DEMAND DISTRIBUTION TANKS OFFLINE

FIGURE WA6-5

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The change in Fiveash WTP flow path includes modifications to the current clearwells' configuration, piping modifications and baffling in the existing storage tanks. The CUS Master Plan Team recommends that the City complete the Fiveash WTP storage flow improvements, as quickly as possible. Performing the recommended change could result in improved and more consistent water quality and better comply with point of entry water quality monitoring requirements.

6.4 Finished Water Storage R&R Needs

Finished water tanks have repair and rehabilitation (R&R) needs to maintain a high level of service and quality to the customers. The Peele-Dixie finished water storage tanks and the Poinciana Park Tank are relatively new (< ten years old) and have no major R&R needed currently. The Fiveash finished water storage tanks and the 2nd Avenue Tank require regular inspections and R&R to prolong service life and maintain the LOS to the customers. Finished water storage R&R includes tank cleaning, patching, repairing and re-coating. FDEP requires tank inspections every five years as well.

6.5 Finished Water Storage Summary

The CUS Master Plan Team provides the following conclusions from the finished water storage evaluation:

- The City has sufficient storage capacity in service to meet level of service criteria with and without the largest tank in service.
- At least one storage tank, Poinciana Park, has a pump cavitation issue that restricts tank drawdown limitations resulting in a reduced usable tank capacity. There are engineering solutions available to potentially minimize cavitation/vortexing issues in storage tanks.
- The City rehabilitated/replaced the Poinciana Park distribution storage facility within the last 10 years.
- The 2nd Avenue storage tank is scheduled for maintenance/recoating in 2016; the last repair/repainting was performed in 1991.
- The 2nd Avenue distribution storage tank does not currently meet the storage capacity criteria of 4 hours storage at peak flow; the CUS Master Plan Team recommends that the City operate this tank in a way to ensure that the tank adequately supplies the later portion of the PHD window.
- Any expansion of the 2nd Avenue storage capacity would likely be located at a different site due to the successful public opposition of expansion at the current location.
- Based on an onsite evaluation, the Fiveash WTP storage tanks require immediate piping modifications to allow more efficient flow and improved disinfection control and monitoring.
- Hydraulic modeling results indicate that distribution storage at Poinciana Park Tank plays a key role in maintaining adequate pressure issues in the Harbor Beach area.
- Hydraulic modeling results indicate that distribution storage at 2nd Avenue Tank helps supply peak hour demands, fire flow, and emergency storage during WTP power issues and pipe breaks.

Community Investment Program (CIP) project identification was a joint effort of City staff input, engineering analysis, strategic City initiative compliance, and previous program evaluation. **Section WA7** lists the proposed finished water storage CIP projects**.**

Section WA6 accepted April 22, 2016.

WA7 Water Community Investment Plan (CIP)

7.1 Introduction and Goals

The Water Community Investment Plan (CIP) and CUSMP recommended projects provides short term (five-year), mid-term (ten- to fifteen-year) and long-term (twenty-year) capital improvements necessary for the City's water system to provide reliable and quality service. The Water CIP and the CUSMP recommended projects include categories for wellfields, treatment plants and the distribution system. Funding methods for the improvements are proposed based on existing and potential funding resources.

The CIP was compiled to accomplish the following goals in alignment with the City's strategic utility vision:

Strategic Initiative	City Goals established in 2014
Treatment Improvements	• Improve water quality from Fiveash WTP by investigating different technologies • Increase redundancy in some processes to allow for efficient repair and cleaning • Better monitor and control of pH, ammonia and chlorine levels entering the distribution system
Water Supply and Climate Resilience	• Protect and sustain potable water supplies from contamination and saltwater intrusion • Analyze feasibility of ASR wells
Infrastructure Renewal	• Prioritize distribution system projects to prevent water main breaks and customer complaints • Renew or construct a new Fiveash WTP
Energy and Water Conservation	• Continued progress in water conservation to achieve and maintain 170 gallon per capita day unit demand set by the City in its Sustainability Action Plan and avoid the need to expand supply • Reduce energy consumption 20% by the year 2020 • Analysis of the efficiency of pumps in both process and service capacities

This section includes a schedule of capital improvement projects necessary to ensure reliable and/or improved water system service for the next 20 years; Fiscal Year (FY) 2015 to FY 2035. The CUSMP Team comprehensively evaluated the potable water utility system and built upon the City's Commission Approved FY 2016 CIP with updated projects, policies and procedures related to achieving the City's strategic goals and complying with state and federal drinking water regulations.

Section WA7 accepted February 7, 2017.

7.2 Supply and Wellfields

The City's two Biscayne Aquifer wellfields (Prospect and Peele Dixie) provide raw water for their respective Water Treatment Plants (WTPs). The City's progress in water conservation has forestalled the need to expand the wellfields or pursue costly alternative water supplies. The capital needs for the water system are primarily repair and replacement (R&R). The City did have a Citywide boiled water notice during the study due to a positive bacteriological sampling result. Continued maintenance and R&R to the system, along with 4-log virus inactivation credit goals will help minimize compliance issues going forward.

The Dixie Wellfield is in good condition and was recently replaced. The Prospect wellfield is in need of significant rehabilitation due to its age and outdated piping materials. Several Prospect wells are in need of replacement and the raw water piping also needs attention in the short term. The wells at Prospect wellfield began installation in the 1970s, however it is unknown if the raw water pipes installed for the wells is part of the defective pre-stressed concrete cylinder pipe (PCCP) produced by Interpace in the 1970's and 1980s, which concludes the attention for these pipes in the short term. Due to budget constraints, the City currently has zero capital dollars allocated for significant wellfield rehabilitation in the next five years.

The CUS Master Plan team analyzed the vulnerability of the wellfields to rising sea levels and saltwater intrusion. Recent groundwater monitoring studies jointly endeavored by the City, County and South Florida Water Management District (SFWMD) recommend coordinating operation of a SFWMD flood control structure to minimize saltwater intrusion throughout the study period understanding that continued groundwater monitoring will confirm future saltwater boundary projections. The Dixie Wellfield's proximity to the SFWMD's flood control structure (G-54) presents an opportunity for proactive saltwater intrusion mitigation. Both the Dixie and Prospect wellfields are not projected to experience significant saltwater intrusion issues over the next 20 years based on the groundwater modeling work performed recently in a joint effort by the City, Broward County and SFWMD. **Section WA11 Climate Change** discusses saltwater intrusion conclusions and options for coordination with the SFWMD on flood control structure G-54 in further detail.

7.3 Water Treatment Plants

The City's largest water treatment plant, the Charles W. Fiveash Water Treatment Plant (Fiveash WTP), has significant portions that are over 50 years old and has major, immediate capital needs. The 2007 Water Master Plan recommended over $129M (2007 dollars) in R&R improvements (not including treatment upgrades) at Fiveash WTP that have been delayed due to funding and implementation issues. The City is now embarking on this major rehabilitation effort that requires over $100M investment into the Fiveash WTP over the next five years. The first effort is a legacy Reliability Upgrades that will cost over $30M and began design twelve years ago. The CUSMP recommends alignment of Reliability Upgrades with the CUSMP by switching the plant's control standard to Rockwell from ABB and added Tier IV compliance to the generators, and especially the electrical and SCADA initiatives, and initiation of several other additional critical efforts. The finished storage and clearwell piping modifications are urgent and affect the ability to produce and monitor safe drinking water including complying with regulations.

An alternative to rehabilitating the Fiveash WTP, a life cycle cost analysis showed that constructing a new treatment facility would be as cost efficient as rehabilitation. A new Fiveash WTP, located at the current site or at the Prospect Wellfield, would cost an additional $60M in capital ($160M to $200M), versus full rehabilitation of the Fiveash WTP and adding color removal

($100M to $140M), but would dramatically lower R&R costs and reduce the very real risk of a calamitous failure. If located in the Prospect Wellfield, a new Fiveash WTP could reduce raw water main lengths and projected raw water main R&R costs; however, new finished water mains to connect the new Fiveash WTP to existing finished water transmission would also be required.

The Walter E. Peele-Dixie WTP (Peele Dixie WTP) is a much newer facility, less than ten years old, and has much lower R&R needs. The Peele Dixie WTP membranes are fast approaching their end of service life. It is recommended they be replaced with later technology membrane elements which are expected to reduce electrical consumption and potentially reduce chemical addition and improve blending with Fiveash WTP finished water. The WTP top needs are summarized below:

1. Finished storage and clearwell piping modifications (Fiveash)
2. Reliability Upgrades-modified (Fiveash)
3. PCCP and other pipe rehabilitation (Fiveash)
4. Membrane replacement/finished (Peele Dixie)
5. Color removal process (Fiveash)
6. Aeration efficiency improvements (Fiveash)
7. SCADA improvements (Peele Dixie and Fiveash)
8. Lime softening process and reliability improvements (Fiveash)
9. Lime feed system (Fiveash)
10. Furthered iron mitigation (Peele Dixie)
11. Chemical storage modifications (Peele Dixie)
12. Continued R&R at both WTPs

7.4 Distribution System

The potable water distribution system is a well-planned network with ample capacity to serve the City's existing and future needs. The distribution system is however, primarily 40 to 60 years old and much of the piping is outdated material and approaching service life end. The City has a rehabilitation program in place that is underfunded based on the wave of pipes reaching the end of service. The number of pipe breaks (including the annual Christmas day pipe break) exemplify the need to increase funding to the ongoing rehabilitation program. City distribution maintenance crews are primarily in reactive mode responding to failures with little or no time for proactive maintenance. The distribution system has also been subject to excess ammonia levels and experiences prolific, undesirable nitrification. In addition to age, corrosion and sedimentation, nitrification biomass has created the need to clean the distribution pipes to remove this debris and provide higher quality, safer drinking water to the City's customers.

A low pressure area in Harbor Beach hampers the distribution system which caused the City to elevate all systems pressures. The CUSMP team and hours of City distribution crew fieldwork pinpointed the primary problem to a closed 16" valve or blockage/disconnection of that pipe. City crews located and resolved the issue. An additional transmission main out of Peele Dixie WTP will also provide better pressure service and redundancy. The top capital needs of the potable water distribution system are summarized below:

1. Harbor Beach low pressure issue-field locate and resolve and tie in additional backfeed
2. Get the large transmission main back in service near Fiveash WTP
3. Continued, proactive pipe replacement program
4. Water quality improvements
5. Nitrification mitigation
6. Pipe cleaning (Uni-directional flushing, pigging, swabbing)

7. New Peele-Dixie redundant transmission main
8. Continued water conservation
9. Energy conservation to support the City's strategic initiative

7.5 Water and Energy Conservation

The City has done an excellent job of water conservation and achieving its goal of 170 gallon per day per capita set by the Sustainability Action Plan ahead of schedule. Maintaining this goal will require continued water conservation diligence. The CUSMP identified additional methods to add to the City's existing water conservation program including ozone laundry, water smart home, green lodging and uni-directional flushing.

Recommended energy conservation methods include resolving the Harbor Drive pipe disconnection issue, re-activating the large diameter pipe near the Fiveash WTP, changeout of the Peele-Dixie WTP membranes, continuing to replace high service pump motors with premium efficiency motors, high efficiency blowers and air transfer at Fiveash WTP and lowering distribution pressures during parts of the day. Note that treatment improvements to improve color removal at the Fiveash WTP will likely increase energy consumption at the facility.

7.6 City of Fort Lauderdale 20 Year Water System CIP

Table WA7-1 presents the summary of the City's 5-year CIP and the CUSMP additional recommended projects in five-year increments to year 2035. **Table WA7-2** presents the City's 5-year CIP for the Water and Sewer Master Plan Fund (454). **Table WA7-3** presents the additional CUSMP-recommended projects for the 20-year planning horizon also for Fund 454. The CIP tables are organized by the City's CIP fund and are sorted by the primary CUSMP task and the project number.

Table WA7-1. Projected CIP Summary and CUSMP Recommended Projects Comparison

Category		FY 2017-2021	FY 2022-2026	FY 2027-2031	FY 2032-2036
Water and Sewer Master Plan Fund (454)					
WA Wellfield	Planned CIP	$200,000	$0	$0	$0
	Unfunded CIP	$400,000	--	--	--
	CUSMP Additional	$50,816,218	$23,318,334	$8,412,453	$1,994,496
WA Treatment	Planned CIP	$41,193,495	$0	$0	$0
	Unfunded CIP	$0	--	--	--
	CUSMP Additional	$80,640,358	$81,813,174	$85,034,679	$22,393,880
WA Distribution	Planned CIP	$48,124,124	$0	$0	$0
	Unfunded CIP	$20,295,662	--	--	--
	CUSMP Additional	$5,256,900	$54,215,763	$55,278,080	$56,810,270
WW City Total	Planned CIP	$55,547,909	$0	$0	$0
	Unfunded CIP	$50,406,104	$91,935,250	$84,058,000	$131,410,000
	CUSMP Additional	$58,185,250	$91,935,250	$84,058,000	$131,410,000
Utility Wide City Total	Planned CIP	$3,121,472	$0	$0	$0
	Unfunded CIP	$22,997,500	--	--	--
	CUSMP Additional	$26,238,890	$18,247,229	$12,207,925	$10,402,925
Subtotal Planned CIP:		*$148,187,000*	*$0*	*$0*	*$0*
Subtotal Unfunded CIP:		*$94,099,266*	--	--	--
Subtotal CUSMP Additional:		*$221,137,616*	*$269,529,750*	*$244,991,137*	*$223,011,571*
Fund 454 TOTAL:		**$463,423,882**	**$269,529,750**	**$244,991,137**	**$223,011,571**

Notes:

- City Planned CIP totals include Unspent Balance as of 9/29/16
- Please Refer to this link for the existing Fort Lauderdale 2017 to 2021 Community Investment Plan. http://www.fortlauderdale.gov/departments/city-manager-s-office/budget-cip-and-grants-division/community-investment-plans

7.7 Funding

Internal and external funding sources are essential to the successful execution of the CIP projects that require funding and financing. Rates and impact fees for services internally generate the vast majority of water fund revenue. The Water and Sewer Master Plan Funds are established from residual funds transferred from the Water and Sewer operating fund. Fund 454 is used to fund improvements to the City's water and sewer system. The City utilizes projected rate increases that will augment the available revenue of Fund 454 by approximately 5% each year to help with inflation and allow the City to replenish the money within the fund.

The City's current water system has been underfunded for at least the last decade and now requires immediate attention, particularly the Fiveash WTP and the distribution system. For example, the 2007 Water Master Plan recommended investing $63M at the Fiveash WTP over the last nine years, not including treatment upgrades. However, less than $10M was invested in the Fiveash WTP in the last nine years. At an average of $6M per year (2007 Water Master Plan) required for Fiveash WTP R&R, the five-year need is now $93M ($63M + 5 x $6M). With the budgeted $30M Reliability Upgrades counting as R&R, the five-year Fiveash WTP R&R funding deficit is $63M ($93M - $30M) and does not include the significant capital to implement color removal. The Fiveash WTP will continue to have high R&R requirements after catching up with backlogged R&R needs. With parts of the current WTP being over 60 years old, building a new, state-of-the-art water treatment plant is an alternate option for the City that would require an additional $40M to $60M (redirecting R&R budget into the new facility) and increase the funding gap thusly.

Considering the other water assets and initiatives, the City has met the 2007 Master Plan recommended levels of distribution system improvements, however, the pipes are failing at a faster rate and with service lives nearing the end, an increased level of R&R is required. Adding the Peele Dixie WTP and both wellfields R&R/capital needs and water/energy conservation initiatives the CUSMP projected water system funding need for the next five years is approximately $250M. Considering the City's current five-year $60M water system budget there is a $190M funding gap.

The City is redirecting approximately $20 million a year collected from residents' water and sewer bills to cover other City expenses. The CUSMP team recommends pursuit of these funds first. The City already has automatically increasing rates. State and federal grant money is earmarked for alternative water supplies, stormwater reuse and reclaimed water reuse projects of which the City does not currently need. There are SFWMD grants available for water conservation efforts and potentially other federal conservation grants for energy and water conservation that should be pursued; however, the vast majority of the CIP will be funded through rates and grants. State revolving loan programs are recommended to benefit the City via reduced financing rates.

Section WA7 accepted February 7, 2017.

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Table WA7-2. City of Fort Lauderdale
Water Community Investment Plan - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WA01	P12101	NW 2ND AVE PUMP STATION APPEARANCE MOD	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	47,922	-	-	-	-	-	47,922	-	-	-	-
454	WA04	P10814	CENTRAL NEW RIVER WATER MAIN RIVER CROSSINGS	The City's existing water transmission system includes a 16-inch pipe that crosses the New River at SE 1 Avenue and an existing 12-inch pipe that crosses the New River at SW 7 Avenue. Both of these river crossings are sub-aqueous pipelines. Design of replacement pipelines stalled in 2008 after encountering easement difficulties. Replacement pipelines are currently under design under a separate task order. Staff has decided to run the transmission system	The hydraulic model developed for the 2015-2016 Master Plan will be run with several scenarios to determine the pressure impacts. The adequacy of the transmission system network shall be determined based upon a minimum required transmission system pressure of 45 psi during the peak hour demand.		-	-	-	-	-	-	-	-	-	2,000,000
454	WA05B	P11594	FIVEASH WATER TREATMENT PLANT - CHEMICAL SYSTEM IMPROVEMENTS	This project replaces portions of two chemical addition facilities at the Fiveash Water Treatment Plant. The current lime solution delivery system consists of one open air trough dedicated to each of the four water treatment units. The project will replace the delivery system with a central mixing and storage tank where computer controlled metering pumps will deliver more precise doses of lime solution of more consistent quality to the treatment units. Each pump will be able to deliver precise quantities of lime solution to any combination of treatment units. The new storage and delivery system for slaked lime will be constructed in the location presently occupied by the fluoride storage tanks and transfer pumps. The fluoride tanks and pumps will be replaced by a new fluoride storage and transfer system constructed nearby.	Both the lime system and fluoride storage and delivery system are near the end of their functional lives. The lime system is troublesome and frequently fails to deliver the proper amount or concentration of lime solution to the treatment units. Further flow in the lime delivery troughs cannot be accurately controlled. As a result the treatment process does not receive precise amounts of lime necessary for optimum water treatment. With the current system each lime shaker (mixing machine for lime and water) is dedicated to an individual treatment unit with no capability of feeding other treatment units. Failure or maintenance of one component of the delivery system removes an entire treatment unit from service. Replacing this system will improve treatment results as well as operational flexibility.		-	1,000,000	3,000,000	-	-	4,000,000	-	-	-	-
454	WA05D	FY 20150227	COMPREHENSIVE EVALUATION & IMPROVEMENTS AT PEELE DIXIE	The utilities bureau of the Public Works Department is requesting a specialized engineering consultant to implement a comprehensive evaluation of the Peele Dixie WTP and water supply. This study/evaluation will yield a set of recommendations to determine if any portion of the old lime softening plant can be returned to service or if other operational changes should be implemented. The consultant will be responsible for any required testing and analysis. The selected consultant will prepare a report with their recommendations to remineralize and stabilize the water and determine if the old lime softening plant can be returned to service producing a minimum of 3 MGD of finished water. This volume of water would be blended with the finished water from the current nano filtration membrane plant within the Peele Dixie WTP fence line.	This study/evaluation will yield a set of recommendations to provide for a more stable/blended finished water filtration and may return to service a portion of the historical lime softening plant or provide other recommendations. Use of a portion of the Lime Softening Plant or use of the Floridan wells will conserve our Biscayne Water Supply remineralizing the water and improve the water quality.		-	-	-	-	3,470,000	3,470,000	-	-	-	-
454	WA05D	FY 20150228	ANALYSIS OF CHEMICAL ADDITION SYSTEMS AT PEELE DIXIE	An engineering consultant will analyze the current chemical addition systems (fluoride corrosion inhibitor anti-scalant and sulfuric acid). The analysis is expected to yield a new configuration where the bulk tanks are capable of receiving a full load and the day tanks are of adequate size to provide at least 24 hour of operations before needing to be refilled. The analysis would make recommendations on the removal and replacement of tanks and equipment.	The analysis is expected to yield a new configuration where the bulk tanks are capable of receiving a full load and the day tanks are of adequate size to provide at least 24 hour of operations (12 MGD of finished water) before needing to be refilled. Dual tanks will improve reliability and allow maintenance of one tank with continual operation of the plant.		-	-	-	90,000	-	90,000	-	-	-	-
454	WA08	FY 20150170	THE LANDINGS OFF BAYVIEW DRIVE SMALL WATER MAIN REHABILITATION	This project is for small water main improvements in the Landings off Bayview Drive Neighborhood. Replace existing deteriorated small water mains with new 6 and/or 8-inch water mains and improve fire hydrant coverage. Approximately 8,000 linear feet.	To replace existing water mains as identified by the neighborhood complaints.		-	1,527,500	-	-	-	1,527,500	-	-	-	-

Table WA7-2. City of Fort Lauderdale
Water Community Investment Plan - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WA08	FY 20150175	TWIN LAKES NORTHWEST WATER MAIN	This is for a small water main replacement in Twin Lakes NW. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	-	-	-	-	-	-	50,000
454	WA08	FY 20150176	SW 29 (28) STREET SMALL WATERMAINS	This is for a small water main replacement project on SW 29 Street from SW 9 Avenue thru SW 12 Avenue. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	-	-	-	-	-	-	50,000
454	WA08	FY 20150177	2535 NORTH FEDERAL HIGHWAY SMALL WATERMAINS	This is for a small water main replacement at 2535 North Federal Highway. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	-	-	-	-	-	-	50,000
454	WA08	FY 20150178	SW 1 STREET (SW 28 AVE THRU SW 29 AVE) SMALL WATER	This is a small water main replacement on SW 28 Avenue and SW 29 Avenue. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	-	-	-	-	-	-	50,000
454	WA08	FY 20150181	LAUDERHILL SMALL WATER MAINS	This is for small water main replacement. This project will replace existing undersized and deteriorated small water mains with new water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	-	-	-	-	-	-	1,958,000
454	WA08	FY 20150182	POINSETTIA DRIVE SMALL WATER MAIN IMPROVEMENTS	This project is for small water main improvements on Poinsettia Drive. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	500,000	1,236,667	-	1,736,667	-	-	-	1,714,666
454	WA08	FY 20150183	CORAL SHORES SMALL WATER MAIN IMPROVEMENTS	This project is for small water main improvements in the Coral Shores neighborhood. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	766,000	766,000	-	1,532,000	-	-	-	-
454	WA08	FY 20150184	CORAL RIDGE COUNTRY CLUB SMALL WATER MAIN IMPROVEM	This project is for small water main improvements in the Coral Ridge Country Club community. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	-	-	-	-	-	-	50,000
454	WA08	FY 20150185	SEA RANCH LAKES SMALL WATER MAINS	This project is for small water main improvements in Sea Ranch Lakes. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	500,000	1,107,333	-	1,607,333	-	-	-	1,714,666
454	WA08	FY 20150186	BERMUDA RIVIERA SMALL WATER MAIN IMPROVEMENTS	This project is for small water main improvements in Bermuda Riviera neighborhood. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	500,000	1,264,666	-	1,764,666	-	-	-	2,029,332
454	WA08	FY 20150187	LAUDERDALE BY THE SEA SMALL WATER MAIN IMPROVEMENT	This project is for small water main improvements in the Lauderdale-by-the-Sea area. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	1,951,700	-	1,951,700	-	-	-	-
454	WA08	FY 20150188	CORAL RIDGE SMALL WATER MAIN IMPROVEMENTS	This project is for small water main improvements in the Coral Ridge neighborhood. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	550,000	-	-	550,000	-	-	-	297,332
454	WA08	FY 20150189	LAKE AIRE PALM VIEW SMALL WATER MAINS	This project is for small water main improvements in the Lake Aire Palm View neighborhood. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	331,000	-	331,000	-	-	-	-
454	WA08	FY 20150190	BAY COLONY SMALL WATER MAIN IMPROVEMENTS	This project is for small water main improvements in Bay Colony.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	1,662,332	-	1,662,332	-	-	-	831,166
454	WA08	FY 20150191	LAUDERGATE ISLES SMALL WATER MAIN IMPROVEMENTS	This project is for small water main improvements in Laudergate Isles. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.		-	-	-	541,000	-	541,000	-	-	-	-

Table WA7-2. City of Fort Lauderdale
Water Community Investment Plan - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WA08	FY 20160414	DAVIE BLVD. 18 WATER MAIN ABANDONMENT TO ANDREWS AVE	A new 24-inch water main was installed to replace the old 18-inch cast iron water main under the Waterworks Program in 2005-2007, but the old main was never properly abandoned. This work will include identifying and relocating all the service lines currently tied to the 18-inch main and moving them to the 24-inch main.	The old 18-inch cast iron water main has the potential to fail due to its age and condition. The pipe is oblong in shape, not circular. This condition makes repairs extremely difficult and they typically have to be performed by contract. Due to the sensitive location on a major east-west commuting route, this work should be completed before the pipe fails.	225,500	-	(225,500)	-	-	-	-	-	-	-	225,500
454	WA08	FY 20170497	ABANDON WELLS AT FORT LAUDERDALE EXECUTIVE AIRPORT	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	-	-	-	-	-	-	-	-	-	-	400,000
454	WA08	P10508	FIVEASH WATER PLANT PHASE 2 IMPROVEMENTS	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	34,983	-	-	-	-	-	34,983	-	-	-	-
454	WA08	P10850	VICTORIA PARK A - NORTH SMALL WATER MAIN IMPR	Small water main replacement in the Victoria Park-North neighborhood. Replace approximately 26,500 linear feet (LF) existing undersized and deteriorated small water mains with new 6 and 8-inch PVC (poly-vinyl chloride) water mains and improve fire hydrant coverage.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints (red water staining).	1,201,170	3,000,651	-	-	-	-	4,201,821	-	-	-	-
454	WA08	P10851	LAKE RIDGE - SMALL WATERMAIN IMPROVEMENTS	Small water main replacement in the Lake Ridge area. Replace approximately 19,616 linear feet of existing undersized and deteriorated small water mains with new 6 and 8-inch polyvinyl chloride pipe water mains and improve fire hydrant coverage.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints (red water staining).	373,569	82,358	-	-	-	-	455,927	-	-	-	-
454	WA08	P10853	FLAGLER HEIGHTS - SM WATERMAIN IMPROVEMENTS	Replace approximately 8,600 linear feet of existing 2-inch and 4-inch water mains in the Flagler Village neighborhood with new 6-inch and 8-inch polyvinyl chloride pipe water mains. Coordinated design with Keith and Schnars City project P-11193 Flagler Drive Greenway and Bicycle Facility.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints (red water staining). This project was completed in mid 2016.		-	-	-	-	-	-	-	-	-	-
454	WA08	P11080	PORT CONDO LARGE WATER MAIN IMPROVEMENTS	Replacing a small 6-inch water main with approximately 1,300 linear feet of large 12-inch water main on SE 17 Street north access road bounded by Eisenhower Boulevard and the intracoastal waterway.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints (red water staining).	671,278	36,500	-	-	-	-	707,778	-	-	-	-
454	WA08	P11246	WATER TREATMENT PLANT REPAIRS	Funding account only for costs related to the repairs and replacement of broken equipment in the water treatment plants (Fiveash and Peele-Dixie) and wellfields.	This funding is necessary to maintain and make repairs (including emergencies) to the water treatment plants & wellfields to continue providing quality potable water services.	198,050	-	-	-	-	-	198,050	-	-	-	-
454	WA08	P11247	DISTRIBUTION & COLLECTION R&R	D&C REPAIR/REPLACEMENT: The project accounts for costs associated with the replacement or repair of broken equipment in the Distribution and Collection Systems including valves pumps motors switchgear piping support equipment etc.	This funding is necessary to maintain capture and make repairs (including emergencies) to the broken equipment in the Distribution and Collection Systems to continue providing quality potable water services.	763,892	-	-	-	-	-	763,892	-	-	-	-
454	WA08	P11465	17TH STREET CAUSEWAY - LARGE WATER MAIN REPLACEMENT	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.		-	-	-	-	-	-	-	-	-	7,300,000
454	WA08	P11571	OAKLAND PARK BEACH AREA WATER MAIN	Restart the scope that was unfinished in Phase 1 (P10572) due to contamination easement and permitting issues and complete the replacement of the old water main in Oakland Park Blvd (circa 1957) that serves the beach area.	The existing iron pipe is past it's estimated lifespan (installed in 1957) and at 16-inches in diameter does not provide adequate redundancy for existing beach crossings and cannot provide adequate service for estimated future demands.	38,856	-	-	-	-	-	38,856	-	-	-	1,600,000

Table WA7-2. City of Fort Lauderdale
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Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WA08	P11589	FIVEASH DISINFECTION/ RELIABILITY UPGRADES	This project is for the construction of two separately designed projects under one construction contract. Combining the projects is necessary because they are both needed at the current time and neither one can wait the two to three years required to construct the other project. Having one construction contract will avoid disputes between two contractors working at the same time and competing for staging areas and storage space on the crowded water treatment plant site. Under this approach both projects can be constructed in three years. The first project Reliability Upgrades installs various repairs and replacements throughout the plant. Major items include replacement of the control system for the entire plant replacement of the obsolete emergency generators modifications to the high service pumps and increasing the weather resistance of the plant buildings. The second project Disinfection System Replacement replaces the existing gaseous chlorine system with a new facility.	The Reliability Upgrades project is necessary because the plant requires upgrades of outdated equipment and software and repairs and upgrades to the buildings at the plant. The computerized plant control system is outdated and cannot be maintained effectively. An entire new control system will be installed to control monitor and track the various processes at the plant. The plant's Emergency Generators have exceeded their life expectancy and will be replaced with a new generator facility. The Disinfection System Replacement project is required to allow discontinuation of the use and storage of large quantities of gaseous chlorine which is potentially dangerous.	15,958,534	563,565	6,602,556	4,250,221	2,822,223	-	30,197,099	-	-	-	-
454	WA08	P11719	SUNRISE BLVD MIDDLE RVR BDGE WM RELOC/DES	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	91,011	170,100	-	-	-	-	261,111	-	-	-	-
454	WA08	P11720	IMPERIAL POINT LARGE WATER MN - PHASE 2	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	116,375	-	-	-	-	-	116,375	-	-	-	-
454	WA08	P11770	SE 17 ST LARGE WATER MAIN REPLACEMENT	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification. This project was completed in April of 2015.	55,662	-	-	-	-	-	55,662	-	-	-	-
454	WA08	P11859	ANNUAL WATER SERVICE REPLACEMENT 2012-13	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	245,373	-	-	-	-	-	245,373	-	-	-	-
454	WA08	P11887	NW SECOND AVENUE TANK RESTORATION	This project repaints the elevated tank inside and out. Adds a new logo around the entire tank, adds a new LED lighting system for the logo, replaces ladders up the tank and upgrades railings around the tank to meet safety codes, makes structural repairs to the tan, replaces the aircraft obstruction lights with LED lights, replaces the fencing around the site, adds decorative fencing along the street side, of the site and adds landscaping to the site.	The tank has several areas of rust and deterioration the interior and exterior coatings are due for replacement the aircraft obstruction lights have become unreliable and City management has requested upgrades to the logo on the tank the site landscaping and site fencing.	1,454,195	573,709	-	-	-	-	2,027,904	-	-	-	-
454	WA08	P11901	VICTORIA PARK B- SOUTH SM WATERMAINS IMPROV	This project is for small water main replacements and improved fire hydrant coverage in the Victoria Park neighborhood - South. Approximately 29,000 linear feet (LF) of existing undersized and deteriorated small water mains will be replaced with new 6 and 8-inch PVC water mains and improving fire hydrant coverage.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.	516,437	-	-	-	2,246,323	2,246,323	5,009,083	-	-	-	-
454	WA08	P11932	AERATION BASIN REHAB AT FIVEASH WTP	The Aeration Basin will be drained and then evaluated for necessary repairs. After the evaluation and recommendation for repairs bids will be solicited for the repairs. Note: The Aeration Basin currently cannot be taken out of service. A plan to bypass the aeration basin was abandoned in 2008. Currently staff from Utilities is investigating a plan to bypass the aeration basin. There is no estimate on when this plan will be completed.	The Aeration basin built in 1963 currently leaks through several cracks. It is a critical point in the water treatment plant as 100% of the water entering the plant flows through the aeration basin and presently there is no way to bypass the aeration basin or take it out f service for repairs.	174,258	-	-	-	-	-	174,258	-	-	-	-
454	WA08	P12038	FILTER REHABILITATION AT FIVEASH	Three of the filters have failed in service; the mixed media (sand anthracite and gravel) needs to be replaced. In addition the under drain system is suspected of being compromised. Once the media is removed an assessment will be made. The cost of replacing the media and under drains is approximately $800,000. An emergency has been declared in accordance with Section 2-190 of the City Ordinance and a memo has been submitted to the Commissioners.	If the three filters are not rehabilitated the ability to produce the potable water for the City of Fort Lauderdale and its large users (Cities of Oakland Park Wilton Manor and Port Everglades) would be compromised and we would not be able to meet the system demands. An emergency has been declared in accordance with Section 2-190 of the City Ordinance and a memo has been submitted to the Commissioners. This project was completed in January of 2015.	437,395	-	-	-	-	-	437,395	-	-	-	-
454	WA08	P12100	PEELE-DIXIE WTP INJECTION WELL MIT	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification. This project was completed in July of 2015.	15,495	-	-	-	-	-	15,495	-	-	-	-
454	WA08	P12111	SMALL WATER MAIN RESURFACING	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	323,598	-	375,000	375,000	375,000	375,000	1,823,598	-	-	-	375,000
454	WA08	P12156	NE 57TH ST SMALL WATER MAIN IMP	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	129,945	-	-	-	-	-	129,945	-	-	-	-

Table WA7-2. City of Fort Lauderdale
Water Community Investment Plan - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WA08	P12179	TANBARK LANE SMALL WATER MAIN REPLACEMENT	This project is for small water main improvements on Tanbark Lane. Relocate approximately 200 linear feet of water main away from existing dwelling.	To replace existing water mains as identified by the neighborhood complaints.	146,249	-	-	-	-	-	146,249	-	-	-	-
454	WA08	P12180	CROISSANT PARK SMALL WATER MAINS	This project is for small water main improvements in the Croissant Park Neighborhood. Replace existing undersized and deteriorated small water mains with new 6 and/or 8-inch water mains and improve fire hydrant coverage. Approximately 10,400 linear feet.	To replace existing water mains as identified by the neighborhood complaints.	442,629	2,521,000	1,000,000	-	-	-	3,963,629	-	-	-	-
454	WA08	P12181	WATER TREATMENT PLANT FACILITIES CONCRETE RESTORATION	This project is to assess the concrete surfaces and structures at the George T. Lohmeyer Water Treatment Plant for failures. The work will create the bid specs for concrete repairs, oversee the bid process, and the construction inspection services.	There are many areas of the George T. Lohmeyer Water Treatment Plant showing concrete failures that are safety hazards due to falling concrete in work areas. The structural integrity of the building may also be compromised. The rehabilitation of the rebar and concrete is necessary to mitigate these safety hazards.	291,700	294,000	-	-	-	-	585,700	-	-	-	-
454	WA08	P12182	LAKE ESTATES SMALL WATER MAINS	This project is for small water main improvements. This project will replace existing undersized and deteriorated small water mains with new 6-inch water mains.	The reason for the project is to replace existing water mains as identified in the Water Master Plan and also to improve quality of service by improving pressure and reducing water quality complaints.	2,424,011	2,292,354	-	-	-	-	4,716,365	-	-	-	-
454	WA08	P12184	DAVIE BLVD. 18 WATER MAIN ABANDONMENT I-95 TO SW 9TH AVE	A new 24-inch water main was installed to replace the old 18-inch cast iron water main under the Waterworks Program in 2005-2007, but the old main was never properly abandoned. This work will include identifying and relocating all the service lines currently tied to the 18-inch main and moving them to the 24-inch main. The work includes approximately 4,341 linear feet of pipe to be abandoned from SW 19th Avenue to SW 9th Avenue.	The old 18-inch cast iron water main has the potential to fail due to its age and condition. The pipe is oblong in shape, not circular. This condition makes repairs extremely difficult, and they typically have to be performed by contract. Due to the sensitive location on a major east-west commuting route, this work should be completed before the pipe fails.	261,688	225,500	-	-	-	457,750	944,938	-	-	-	-
454	WA08	P12196	RELOCATE 16" DIP WTR MN AT E LAS	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	3,235,290	-	-	-	-	-	3,235,290	-	-	-	-
454	WA08	P12197	FIVEASH HYDROTREATERS 3 & 4 INF	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	490,515	-	-	-	-	-	490,515	-	-	-	-
454	WA08	P12211	WAVE STREETCAR WATER & SEWER RELOCATION	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	5,635,343	-	-	-	-	-	5,635,343	-	-	-	-
454	WA08	P12237	ABANDON WELLS AT FORT LAUDERDALE EXECUTIVE AIRPORT	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	200,000	-	-	-	-	-	200,000	-	-	-	-
454	WA08	P12275	PEELE DIXIE WTP RENEWAL & REPLACEMENT	Peele-Dixie Water Treatment Plant - renewal and/or replacement of miscellaneous equipment, structures, pipes, and other features critical to the continued safe, reliable, efficient, and compliant operation of the plant.	The Peele-Dixie Water Treatment Plant treats and transmits approximately 12 million gallons per day (mg) of the water used by City and other customers. Continued safe, reliable, efficient, and compliant operation of the plant requires renewal or replacement of a wide variety of plant infrastructure and equipment on a timely and as-needed basis.		200,000	1,300,000	-	-	-	1,500,000	-	-	-	-
454	WA14	P12050	FDOT BROWARD BLVD BRIDGE REPLACEMENT - 30-inch	This project is for the construction if a new 30-inch transmission water main to replace the existing 30-inch cast iron transmission main. The transmission main is carried alongside the Florida Department of Transportation (FDOT) Broward Bridge Blvd over the North Fork of the New River. The work includes construction of a temporary line to maintain water supply during bridge demolition. This also includes the construction of the permanent replacement and all tie-ins to existing waterlines. The replacement line will be located on a ledge off the south side of the new structure.	The FDOT is in the process of designing a structure to replace the existing bridge on Broward Blvd, located at the North Fork of the New River. The City has a major 30-inch transmission water main that is supported on piles and immediately next to the south side of the bridge. This main is a critical part of the network, and supplies water to downtown Fort Lauderdale. The bridge construction requires demolition and removal. A replacement main is also required, and the City intends to enter into an agreement.	392,865	-	-	-	-	-	392,865	-	-	-	-
Totals						**36,593,788**	**9,959,737**	**11,579,556**	**10,441,221**	**14,394,244**	**6,549,073**	**89,517,619**	**-**	**-**	**-**	**20,695,662**

Table WA7-3. City of Fort Lauderdale
Water Additional CUSMP Projects - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WA04	WA4-1	WATERMAIN IMPROVEMENTS AREA 1	• Bring the 54-inch water main on 38th Street back into service. • Add approximately 400 feet of 30-inch discharge from the Peel-Dixie high service pumps to the old west existing 30-inch discharge. • Upsize approximately 100 feet of 36 and 30-inch from the 42-inch reducer to the intersection of NE 37th Street and NE 11th Avenue with 42–inch.	This is a 2016 CUS Master Plan recommendation. The 54-inch was closed for maintenance but it has not been put back into service because of inability to disinfect. There are a variety of headloss and capacity issues around WTP with it offline. The other locations have a variety of headloss and capacity issues around the WTP (Velocity > 5 ft/s). This project is included in the "Infrastructure Renewal" Strategic Initiative.		-	-	260,000	78,000	-	338,000	-	-	-	
454	WA04	WA4-2	WATERMAIN IMPROVEMENTS AREA 2	• Upsize approximately 100 feet of the 6-inch from the 6x6x12 tee to 36x30x6 tee to 12-inch at the intersection of SE 12th Avenue and E Broward Boulevard. • Upsize approximately 100 feet of 8-inch from the 16x8x8 tee to the 16x8x6 tee with a 16-inch water main at the intersection of Middle Street and SW 14th Avenue. • Upsize approximately 50 feet of 6-inch from the 6x6x10 tee to the 6x10x10 tee with a 10-inch water main at the intersection of Commercial Boulevard to Bougainvillea Drive.	This is a 2016 CUS Master Plan recommendation. These project were identified through the hydraulic model as having insufficient capacity (Velocity > 5 ft/s). This project is included in the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	100,000	-	-	
454	WA05A	WA5A-1	PROSPECT WELLFIELD TESTING	Comprehensive wellfield testing for twenty-nine Biscayne Aquifer wells located in the Prospect Wellfield.	Evaluate individual production well condition to develop strategies to optimize wellfield performance.		-	58,000	-	-	-	58,000	-	-	-	
454	WA05A	WA5A-2	DIXIE WELLFIELD TESTING	Comprehensive wellfield testing for eight Biscayne Aquifer wells located in the Prospect Wellfield.	Evaluate individual production well condition to develop strategies to optimize wellfield performance.		-	16,000	-	-	-	16,000	-	-	-	
454	WA05A	WA5A-3	REPLACEMENT OF WELLS > 30 YEARS OLD	Identify and replace, as needed, oldest production wells (4 per year).	Improve wellfield performance to minimize operational and maintenance costs.		-	1,800,000	1,800,000	1,800,000	1,800,000	7,200,000	3,600,000	-	-	
454	WA05A	WA5A-4	REPLACEMENT OF WELLS < 30 YEARS OLD	Identify and replace, as needed, production wells less than 30 years old (2 per year).	Improve wellfield performance to minimize operational and maintenance costs.		-	-	-	-	-	-	2,700,000	900,000	-	
454	WA05A	WA5A-5	WELL REHABILITATION	Rehabilitation work on wells less than 30 years old prior to replacement. This includes maintaining pumps and motors, and replacement of mechanical and electrical components	Improve wellfield performance to minimize operational and maintenance costs.		-	296,000	148,000	148,000	148,000	740,000	740,000	148,000	-	
454	WA05A	WA5A-6	GROUNDWATER MODELING	Combine historical and ongoing saline monitoring data with variable density model simulations specific to City operations.	Evaluate risks of wellfield to saline intrusion, especially with respect to sea level rise projections.		-	50,000	50,000	-	-	100,000	-	-	-	
454	WA05A	WA5A-7	MONITORING WELL INSTALLATION	Contingent upon groundwater modeling results, field testing and construction of additional monitoring well(s).	Evaluate risks of wellfield to saline intrusion, especially with respect to sea level rise projections.		-	-	-	-	-	-	300,000	-	-	
454	WA05B	WA5B-1	FIVEASH WTP COLOR REMOVAL SYSTEM INVESTIGATION AND IMPLEMENTATION	Investigate and implement a color removal system to alleviate organics and assist in the removal of the "yellow tint" currently in the water. This will help keep the color levels below 8 Pt-Co Units.	This is a 2016 CUS Master Plan recommendation. Enhancing the aesthetics of the finished water will reduce complaints and remove the need for blowers/diffusers (if ozone is selected). Customer relations will be improved and energy savings could be established if ozone is used. Energy savings will reduce costs and help the City meet it's "Green Initiative" goals.		-	-	-	-	1,000,000	1,000,000	36,000,000	-	-	
454	WA05B	WA5B-2	FIVEASH WTP GST AND CLEARWELL UPGRADES	Modify the existing piping and system such that the water from the filters drops into a clearwell which the transfer pumps will deliver to the ground storage tanks. The water from the ground storage tanks will flow to a common clearwell for the high service pumps to deliver water.	The following items are 2016 CUS Master Plan recommendations. • Pipe upgrades will establish more stable disinfectant residuals, prevent "short-circuiting" and stagnant water, and allow for a more stable and controllable system for redundancy/maintenance and metering (for chemical injection).		-	-	-	-	800,000	800,000	7,200,000	-	-	

Table WA7-3. City of Fort Lauderdale
Water Additional CUSMP Projects - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WA05B	WA5B-3	FIVEASH AERATION BASIN IMPROVEMENTS	• Replace the diffusion apparatus with a more efficient diffuser rod system, possibly rubber, in order to limit the potential clogging. • Replace the existing blower with a more efficient turbo blower. Reduce energy costs. • Replace the isolation slide gates and operators for the aeration basins, including the addition of motorized operators: Allow each aeration basin to function independently.	The following items are 2016 CUS Master Plan recommendations. • Reduction in energy costs and provide a higher oxygen transfer efficiency and sulfide removal. • Replacing the blower with a turbo blower will reduce energy consumption and operating cost as well as helping the City meet its "Green Initiative" goals. • Improvements to the isolation gates will allow each aeration basin to be isolated for maintenance purposes, and create a better flow split and automated control of the system.		-	-	-	-	3,500,000	3,500,000	-	-	-	
454	WA05B	WA5B-4	FIVEASH WTP PCCP REPLACEMENT	Replace PCCP pipe feeding the high service pumps.	This is a 2016 CUS Master Plan recommendation. The pipe is old, a high risk asset, and is at the end of its useful life. This critical pipeline should be upgraded for reliability to a new ductile iron pipe or rehabilitated with an interior structural liner.		-	-	-	4,000,000	-	4,000,000	-	-	-	
454	WA05C	WA5C-1	PEELE DIXIE WTP IRON REMOVAL MODIFICATIONS	The plant is constrained from running at its 12 MGD capacity by iron precipitation in the raw water. This projects adds filtration and oxidation to remove the iron.	This is a 2016 CUS Master Plan recommendation. It allows the facility to operate at its 12 MGD capacity and is a capacity recovery project.		-	-	3,600,000	-	-	3,600,000	-	-	-	
454	WA05C	WA5C-2	PEELE-DIXIE WTP CHEMICAL STORAGE IMPROVEMENTS	The anti-scalant and corrosion inhibitor bulk chemical tanks do not allow for a full load delivery of chemicals. Investigate the addition of another tank and/or the replacement with multiple, smaller tanks. Also the day tanks for the sodium hydroxide and sulfuric acid do not hold enough chemical to last a whole day and additional storage is required.	This is a 2016 CUS Master Plan recommendation. Due to additional chemical addition, the bulk tanks cannot accept a full delivery which wastes money spent on a full load of chemical that is not utilized by the City.		-	-	-	850,000	-	850,000	-	-	-	
454	WA05C	WA5C-3	PEELE-DIXIE WTP POST TREATMENT STABILIZATION	Utilize portions of the existing, decommissioned lime softening facility to store and provide treatment options for the addition of chemicals to the membrane permeate.	This is a 2016 CUS Master Plan recommendation. The finished water delivered from the Peele-Dixie WTP has a high corrosivity and a low (sometimes negative) LSI. The pH is raised to reduce the corrosion potential of the water in the distribution system. This project would add minerals, specifically calcium, to increase hardness, alkalinity, and the LSI providing the overall benefit of a stable, non-corrosive water.		-	-	-	-	-	-	6,500,000	-	-	
454	WA05C	WA5C-5	PEELE-DIXIE WTP GRATING INSTALLATION	At each of the chemical storage and pumping areas, there is a stepdown right near the door which is a safety concern. Install grating to create a flat surface.	This is a 2016 CUS Master Plan recommendation. Installing grating to create a flat surface without a stepdown will help improve safety, prevent workplace accidents and still provide the necessary chemical containment.		-	-	-	-	100,000	100,000	-	-	-	
454	WA05C	WA5C-6	PEELE-DIXIE WTP INVESTIGATION AND CREATION FOR WORKSHOP ADDITION	There is not a current workshop area for the operations and maintenance staff to perform repairs and maintain machinery. Evaluate locations within the plant and construct a suitable maintenance workshop.	This is a 2016 CUS Master Plan recommendation. The addition of a defined workshop section will allow for a proper, permitted area for the operations staff to perform repairs on the equipment as needed and potentially reduce costs by having to hire outside staff to perform the repairs.		-	-	-	-	100,000	100,000	1,000,000	-	-	
454	WA05C	WA5C-8	PILOT MEMBRANE SYSTEM UNIT INSTALLATION	To allow operations/engineering staff to test different dosages of various chemicals in operation and test different membranes to obtain the most optimum dosages, develop and purchase a pilot membrane system unit.	This is a 2016 CUS Master Plan recommendation. This will allow operations/engineering staff to test different dosages of various chemicals in operation and test different membranes to obtain the most optimum dosages and potentially reduce chemical costs and energy costs.		-	-	-	-	-	-	500,000	-	-	
454	WA05C	WA5C-9	OPERATIONAL UPGRADES (PEELE DIXIE MEMBRANE PLANT)	Add actuators and controls for major valves and provide a SCADA program to allow the operators to perform a periodic open/close ("cycling") of the valves for maintenance purposes.	This is a 2016 CUS Master Plan recommendation. This will allow operations/engineering staff to perform a periodic open/close automation of the valves for maintenance purposes.		-	-	2,500,000	-	-	2,500,000	-	-	-	
454	WA05E	WA5E-1	LIME SOFTENING PROCESS TRAIN DECOMMISSIONING	Decommissioning the lime softening plant at Peele Dixie (includes Concrete, and metal pipe removal . Aluminum plate removal and tank/building demolition.	This is a 2016 CUS Master Plan recommendation. This will allow operations/engineering staff to investigate the potential reuse of the lime softening storage tanks and existing infrastructure left over from the decommissioned lime softening process train.		-	-	-	667,000	-	667,000	-	-	-	

Table WA7-3. City of Fort Lauderdale
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Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WA05F	WA5F-1	MODEL DEMAND ALLOCATION UPDATE	In depth model demand allocation to remove some false high water age indications.	This is a 2016 CUS Master Plan recommendation. Removing false high water age indications in the model will allow the City to improve their treatment process and provide more accurate assessments of areas with in the distribution system that are in need of improvements.		-	-	25,000	-	-	25,000	-	-	-	
454	WA05F	WA5F-2	MISCELLANEOUS WATER QUALITY IMPROVEMENTS	Investigate adding additional automatic flushers at the following locations to reduce water age: PLUG_F10015 – Snyder Park PLUG_F5472 – SW 15th Avenue/SW 33rd Street PLUG_F4373 – SW 32nd Place PLUG_F4366 – SW 32nd Street	This is a 2016 CUS Master Plan recommendation. Auto flushers reduce water age and help prevent nitrification. Using auto flusher instead of manual flushing will also decrease water wasted when flushing is required.		-	25,000	-	-	-	25,000	-	-	-	
454	WA05F	WA5F-3	MINOR WATER MAIN PIPE LOOPING PROJECTS	Complete small pipe looping projects in areas such as NW 59th Street/NW 31st Avenue and Mills Pond Park, for example.	This is a 2016 CUS Master Plan recommendation. Pipe looping projects improve water quality in the distribution system.		-	-	-	-	200,000	200,000	-	-	-	
454	WA05F	WA5F-4	VALVE AND HYDRANT REPAIR	Inspect and repair UDF valves and hydrants.	This is a 2016 CUS Master Plan recommendation. This project will prepare the City's assets for UDF, which helps improve water quality and color by moving debris in the pipeline, and also improves water age in the distribution system.		-	-	-	300,000	-	300,000	-	-	-	
454	WA06	WA6-1	2ND AVENUE TANK REPLACEMENT/RELOCATION INVESTIGATION	Begin planning and selection of a new site for the future, expanded 2nd Avenue storage tank, with a minimum usable volume of 1.3 MG. Additionally the current tank takes about 12 hours to fill, so the distribution system around the tank is not adequate either.	Plans to remove the 2nd Avenue elevated tank and replace it with a larger ground storage tank were halted due to opposition by the local community. Increasing the capacity and relocating the tank will ease public tension and increase storage capacity and discharge time during emergency and peak events in the water distribution system.		-	-	-	25,000	-	25,000	-	-	-	
454	WA06	WA6-2	2ND AVENUE TANK REPLACEMENT/RELOCATION IMPLEMENTATION	Installation of 1.3 MG ground storage/repump station or elevated storage tank to replace the outdated 2nd Avenue storage tank.	The 2nd Avenue storage tank volume is just under the 4 hour peak flow criteria, to ensure adequate storage volume the tank is to be replaced by a new 1.3 MG storage tank.		-		-	-	-	-	-	-	4,150,000	
454	WA08	WA8-1	FIVEASH WATER TREATMENT PLANT R&R	General R&R services for Fiveash WTP not specifically called out in other CIP projects. (Reference Water R&R Report provided in the Master Plan for a list of projects to be included).	This is a 2016 CUS Master Plan recommendation. This project is for R&R for items at the Fiveash WTP.		-	$28,148,282	$6,514,107	$0	$12,848,936	47,511,324	21,786,466	65,565,534	9,233,727	
454	WA08	WA8-2	PEELE-DIXIE WATER TREATMENT PLANT R&R	General R&R services for Peele-Dixie WTP not specifically called out in other CIP projects. (Reference Water R&R Report provided in the Master Plan for a list of projects to be included).	This is a 2016 CUS Master Plan recommendation. This project is for R&R for items at the Peele-Dixie WTP.		-	$2,518,026	$1,413,709	$0	$2,238,823	6,170,558	5,702,816	15,189,145	9,860,154	
454	WA08	WA8-3	PROSPECT WELLFIELD R&R	General R&R services for Prospect Wellfield not specifically called out in other CIP projects. (Reference Water R&R Report provided in the Master Plan for a list of projects to be included).	This is a 2016 CUS Master Plan recommendation. This project is for R&R for items at Prospect Wellfield.		-	$11,133,040	$12,029,936	$10,574,402	$8,078,687	41,816,066	14,935,885	5,416,504	1,528,257	
454	WA08	WA8-4	DIXIE WELLFIELD R&R	General R&R services for Dixie Wellfield not specifically called out in other CIP projects. (Reference Water R&R Report provided in the Master Plan for a list of projects to be included).	This is a 2016 CUS Master Plan recommendation. This project is for R&R for items at Dixie Wellfield.		-	$48,973	$390,885	$301,661	$21,633	763,152	834,450	1,947,949	466,239	
454	WA08	WA8-5	NW 2nd AVE ELEVATED STORAGE TANK & PUMP R&R	General R&R services for the NW 2nd Ave elevated storage tank not specifically called out in other CIP projects.	This is a 2016 CUS Master Plan recommendation. This project is for R&R for items for the NW 2nd Ave elevated storage tank.		-	$70,450	$70,450	$120,450	$70,450	331,800	380,500	606,500	1,340,500	
454	WA08	WA8-6	POINCIANA ELEVATED STORAGE TANK & PUMP R&R	General R&R services for the Poinciana elevated storage tank not specifically called out in other CIP projects.	This is a 2016 CUS Master Plan recommendation. This project is for R&R for items for the Poinciana elevated storage tank.		-	$70,000	$120,000	$72,500	$70,000	332,500	417,063	2,927,250	417,500	
454	WA08	WA8-7	DISTRIBUTION SYSTEM R&R	General R&R services for the City's distribution system not specifically called out in other CIP projects. (Reference Water R&R Report provided in the Master Plan for a list of projects to be included)	This is a 2016 CUS Master Plan recommendation. This project is for R&R for the City's distribution system .		-	$0	$0	$0	$0	-	49,785,000	42,285,000	27,935,000	
454	WA09	P90008	CONTINUOUS WATER CONSERVATION EDUCATION	Provide education to the public via pamphlets, brochures, and meetings to provide education on ways to conserve water.	Improved sustainability and reduction in cost		-	20,000	20,000	20,000	20,000	80,000	100,000	100,000	100,000	-
454	WA09	P90009	WATER CONSERVATION POLICY MAKING & INCENTIVES	Create policies to establish new water conservation methods. Add incentives to policies ensure goals are achieved.	Improved sustainability and reduction in cost		-	-	300,000	-	-	300,000	300,000	300,000	600,000	-

Table WA7-3. City of Fort Lauderdale
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454	WA09	WA9-1	CURRENT WATER CONSERVATION PROGRAMS	Maintain current level of water conservation effort, including rebating high efficiency toilets, promoting Florida-friendly landscaping and green infrastructure, educational programs, system wide leak detection, replacing old water meters, etc.	The City's current water conservation programs have proven to be effective in reducing water consumption. Since 2009, the City's potable water demand per capita has decreased by 15%, from 195 gpcd to 165 gpcd in 2014. It's important to keep implementing the existing programs to keep moving towards a lower gallons per capita consumption. City should congratulate the users and encourage them to continue their efforts.		-	100,000	50,000	50,000	50,000	250,000	250,000	250,000	250,000	
454	WA09	WA9-2	UNIDIRECTIONAL FLUSHING PROGRAMS	UDF involves using clean water to flush the system from the source outward by isolating portions of the distribution system to achieve water flow in one direction. UDF sequences are designed to achieve velocities of five feet per second. By achieving such high velocities in the target pipe(s), pipe(s) can be properly scoured. Scouring the pipe(s) removes deposits and debris from the water main and removes them from the distribution system. UDF uses hydraulic modeling to achieve the unidirectional flow patterns.	UDF uses approximately 40 percent less water than conventional flushing. The benefits of a UDF program include increased hydraulic capacity, prolonged water main life expectancy, lower turbidity and color water, higher chlorine residuals, reduced flushing volumes, significantly lower customer complaints, etc.		-	1,000,000	1,000,000	-	300,000	2,300,000	1,500,000	1,500,000	1,500,000	
454	WA09	WA9-3	IMPLEMENT & EVALUATE OTHER NEW WATER CONSERVATION PROGRAMS	Further investigate and implement other recommended water conservation programs including Strategic Water Auto Flushing (SWAF) Program, Water Smart Home Program, Ozone Laundry Program, and Energy Performance Contracting Program. Also periodically re-revaluate City's water conservation program and identify new programs for implementation.	In order to help maintain the City's water consumption goal of 170 gpcd by 2028, City needs to keep implementing new water conservation programs to help reduce water consumption. The recommended programs have been proven effective in reducing water consumption by other utilities. With future population and economic growth and climate change implication it is also imperative to re-evaluate the City's water conservation program and identify new programs.		-	100,000	100,000	100,000	100,000	400,000	-	30,000	30,000	
454	WA09	WA9-4	LEAK DETECTION PROGRAM	Detecting and repairing leaks is one of the main components of water conservation. This system wide leak detection program includes acoustic leak detection on the smaller and metal pipes and helium leak detection on larger and plastic pipes.	Leak detection is a water conservation method that is widely used by utilities. A successful leak detection program can offer important information that can help improve operational efficiency, lower water system operational cost, reduce potential for contamination, extend life of facilities, reduce potential property damage, etc.		-	50,000	50,000	50,000	50,000	200,000	250,000	-	-	
454	WA12	WA12-1	REDUNDANT LIME SLUDGE DISPOSAL SYSTEM	Add parallel pipeline from Fiveash lime sludge pumps to wellfield or gravity thickener at Fiveash WTP for redundant disposal.	This is a 2016 CUS Master Plan recommendation. Adding redundancy to the lime sludge disposal system is necessary for emergencies and maintenance.		-	-	4,900,000	-	-	4,900,000	-	-	-	
454	WA12	WA12-2	EXCAVATE AND DISPOSE OF DRY LIME SLUDGE	This project includes the excavation and disposal of dry lime sludge from the west cell sludge pit or delivery to a cement kiln.	This is a 2016 CUS Master Plan recommendation. Disposal of sludge is necessary for upkeep and sludge maintenance.		-	-	2,600,000	-	-	2,600,000	2,600,000	2,600,000	2,600,000	-
454	WA13	WA13-1	PROSPECT WELLFIELD MOTOR REPLACEMENT 1	Replace motors on (18) well pumps at Prospect Wellfield	Energy Savings		-	-	41,000	41,000	41,000	123,000	82,000	-	-	
454	WA13	WA13-10	Peele-Dixie Building Envelope Improvements	Perform small scale demonstration of alternative sources of heat pump "heat sinks" such as the raw water main or the piping to the distribution system at the Peele-Dixie WTP.	Energy Savings		-	-	5,000	5,000	5,000	15,000	10,000	-	-	
454	WA13	WA13-11	Peele-Dixie Building Envelope Improvements	Complete replacements of the Peele-Dixie WTP site lighting with LED fixtures.	Energy Savings		-	-	10,000	10,000	10,000	30,000	20,000	-	-	
454	WA13	WA13-2	PROSPECT WELLFIELD MOTOR REPLACEMENT 2	Replace motors on (11) well pumps at Prospect Wellfield	Energy Savings		-	-	-	-	-	-	126,000	-	-	
454	WA13	WA13-3	Fiveash Motor Improvements - Replace Low Efficiency Motors with High Efficiency Motors	Replace motors on hydrotreater Recirculation Pumps #1, #2, #3, and #4 with high efficiency motors.	Energy Savings		-	-	2,000	2,000	2,000	6,000	2,000	-	-	
454	WA13	WA13-4	Fiveash Motor Improvements - Replace Low Efficiency Motors with High Efficiency Motors	Replace motors on filter Surface Wash Pumps #1 and #2 with high efficiency motors.	Energy Savings		-	-	6,527	16,047	3,892	26,466	3,892	-	-	
454	WA13	WA13-5	Fiveash Motor Improvements - Replace Low Efficiency Motors with High Efficiency Motors	Replace motors on Backwash Pump #2 with a high efficiency motor.	Energy Savings		-	-	-	5,000	-	5,000	-	-	-	
454	WA13	WA13-6	Fiveash Building Envelope Improvements	Complete replacements of the Fiveash WTP site lighting with LED fixtures.	Energy Savings		-	-	22,000	22,000	22,000	66,000	44,000	-	-	

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454	WA13	WA13-7	Fiveash Building Envelope Improvements	Perform small scale demonstration of alternative sources of heat pump "heat sinks" such as the raw water main or the piping to the distribution system at the Fiveash WTP.	Energy Savings		-	-	5,000	5,000	5,000	15,000	10,000	-	-	
454	WA13	WA13-8	Fiveash Building Envelope Improvements	Perform a building envelope energy analysis at the Fiveash WTP to identify potential modifications which can save HVAC energy.	Energy Savings		-	-	1,000	1,000	1,000	3,000	1,000	-	-	
454	WA13	WA13-9	Peele-Dixie Building Envelope Improvements	Complete replacements of the Peele-Dixie WTP site lighting with LED fixtures.	Energy Savings		-	-	16,500	16,500	16,500	49,500	33,000	-	-	
454	WA14	WA14-01	NW 62ND ST AND NW 39TH ST WATER MAIN IMPROVEMENTS	This project includes rehabilitation or replacement of approximately 90 feet of 30-inch DIP water main installed in 1974 along NW 62nd Street crossing under Powerline Road and approximately 500 feet of 24-inch ductile iron water main installed in 1983 along NW 39th Street from NW 31st Avenue to approximately 350 feet east of NW 30th Terrace including inspection, and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	261,800	-	
454	WA14	WA14-02	NE 45TH ST, NE 18TH AVE, AND N ANDREWS AVE PROSPECT RD WATER MAIN IMPROVEMENTS	This project includes the evaluation, and rehabilitation or replacement of: approximately 92 feet of 36-inch and approximately 20 feet of 30-inch water main of unknown material installed in 1957 along N Andrews Avenue from the intersection with E Prospect Road to approximately 115 feet north of the intersection, approximately 4,700 feet of 36-inch water main of unknown material along E Prospect Road from N Andrews Avenue to N Dixie Highway and then north along N Dixie Highway to NE 45th Street, as well as rehabilitation or replacement of approximately 4,060 feet of 30-inch water main of mostly unknown material along NE 45th Street from N Dixie Highway to NE 18th Avenue and 2,060 feet of 24-inch water main of unknown material along NE 18th Avenue from NE 45th Street to E Commercial Boulevard, all including inspection and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	6,074,280	-	
454	WA14	WA14-03	POWERLINE RD, NW 9TH AVE, N ANDREWS SQ, N ANDREWS AVE WATER MAIN IMPROVEMENTS	Includes the evaluation, and rehabilitation or replacement of approximately: 4,500 feet of 36-inch CIP water main (WM) along Powerline Road., near Fiveash WTP east across Powerline Road./SR 845 north of the intersection of Powerline Road. and I-95 to W Oakland Park Boulevard, 1.8 miles of 30-inch and 0.25 miles of 24-inch WM of mostly CIP along NW 9th Avenue from W Oakland Park Boulevard to W Sunrise Boulevard, approximately 95 feet of 30-inch WM of unknown material crossing SR-845 S from the Fiveash WTP, and 1.86 miles of 30-inch mostly CIP water main along N Andrews Avenue from NW 42th Street to 175 feet south of the intersection with NE 19th Court including a 67 foot section at the intersection of NW 21st Court along NW 21st Court, 65 feet along NE 26th Street at the intersection with N Andrews Avenue, 1.05 miles of 24-inch WM of CIP along N Andrews Square. from about 170 feet south of NE 19th Court then turning and continuing along NW 1st Avenue to Sunrise Boulevard including inspection and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	-	15,957,270	

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454	WA14	WA14-04	WATER MAINS FROM FIVEASH TREATMENT PLANT IMPROVEMENTS	This project includes rehabilitation or replacement of approximately 200 feet of 42-inch water main of unknown material along SR-845 S/Powerline Road at the intersection with I-95 from the Fiveash WTP, approximately 65 feet of 48-inch water main of unknown material along SR-845 S/Powerline Road at the intersection with I-95 from the Fiveash WTP, approximately 111 feet of 54-inch water main of unknown material along SR-845 S/Powerline Road at the intersection with I-95 from the Fiveash WTP and approximately 15 feet of 60-inch water main of unknown material along SR-845 S/Powerline Road at the intersection with I-95 from the Fiveash WTP including inspection, and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	358,000	-	-	
454	WA14	WA14-05	NW 42ND ST WATER MAIN IMPROVEMENTS	This project includes rehabilitation or replacement of approximately 2,260 feet of 30-inch water main of CIP along NW 42nd Street from about 190 feet east of I-95 to N Andrews Avenue including inspection, and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	1,175,200	-	-	
454	WA14	WA14-06	SE 20TH ST WATER MAIN IMPROVEMENTS	This project includes rehabilitation or replacement of approximately 730 feet of 24-inch CIP water main along SE 20th Street from approximately the intersection with SE 1st Avenue to approximately 55 feet east of SE 4th Avenue and approximately 150 feet of 24-inch CIP south along SE 4th Avenue including inspection, and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	402,050	-	
454	WA14	WA14-07	E SUNRISE BLVD WATER MAIN IMPROVEMENTS	This project includes rehabilitation or replacement of approximately 1,020 feet of 24-inch CIP water main along E Sunrise Boulevard from NE 17th Way to the intersection of E Sunrise Boulevard and US-1 and approximately 80 feet of 12-inch water main of unknown material near N Birch Road and E Sunrise Boulevard behind the Mexican restaurant, including inspection, and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	554,600	-	-	554,600	-	-	-	
454	WA14	WA14-08	W BROWARD BLVD WATER MAIN IMPROVEMENTS	This project includes rehabilitation or replacement of approximately 1,810 feet of 30-inch CIP water main along W Broward Boulevard from NW 18th Avenue to River Highlands Avenue including inspection, and all related work. The portion of this water main running along the bridge of North Fork New River will be completed in the 2017-2021 CIP project P12050.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	941,200	-	
454	WA14	WA14-09	US-441 AND W BROWARD BLVD WATER MAIN IMPROVEMENTS	This project includes rehabilitation or replacement of approximately 425 feet of 30-inch CIP water main along US-441 just south of the intersection with W Broward Boulevard which crosses over from US441 N to US441 S and runs along US441 S as well and approximately 1.84 miles of 30-inch CIP water main along W Broward Boulevard east of the intersection with US-441 to NW 22nd Avenue including inspection, and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	-	5,230,000	
454	WA14	WA14-10	FIVEASH WTP TRANSFER PUMP IMPROVEMENTS	This project includes replacement of the control valve and motors for the transfer pumps.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the treatment processes at Fiveash WTP. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	1,720,510	-	1,720,510	-	-	-	
454	WA14	WA14-11	FIVEASH WTP HIGH SERVICE PUMP IMPROVEMENTS	This project includes replacement of the distribution system headers for the south, northwest, and southeast HSPs.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the treatment processes at Fiveash WTP. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	1,000,000	-	

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454	WA14	WA14-12	FIVEASH WTP CLEARWELL AND RECARBONATION IMPROVEMENTS	This project includes replacement of the sluice gate for Clearwell #1 and the replacement of the sluice gates for the recarbonation system.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the treatment processes at Fiveash WTP. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	250,000	-	
454	WA14	WA14-13	HYDROTREATER SYSTEM IMPROVEMENTS	This project includes replacement of hydro recirculation pumps 1, 2, 3, and 4.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to reduce the risk associated with a portion of the treatment processes at Fiveash WTP. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	30,000	-	
Totals						**-**	**-**	**45,503,771**	**38,605,714**	**21,001,070**	**31,602,921**	**136,713,476**	**159,347,270**	**148,725,212**	**81,198,646**	**-**

WA8 Water R&R Improvements

The CUS Master Plan Team recommends that the City of Fort Lauderdale (City) set aside a certain amount of funding to be used for the renewal & replacement (R&R) needs of the potable water system. This report examines each aspect of the potable water system, including the Prospect and Dixie Wellfields, Fiveash Water Treatment Plant (Fiveash WTP), Peele-Dixie Water Treatment Plant (Peele-Dixie WTP), as well as the associated distribution system, and provides an estimate of anticipated renewal and replacement expenditures to the end of the 2035 planning period.

R&R projects are considered maintenance to repair unscheduled and scheduled deficiencies during the time period in which they occur. This includes preventative maintenance for buildings, structures, treatment process equipment, wells, pipe infrastructure, etc. R&R projects can be created and managed with the CUSMP Team's proposed asset management software system.

The Capital Improvement Program, or Community Investment Program, as it is known in Fort Lauderdale (CIP) is annually prepared to assess the long-term capital project requirements of a government entity and to establish funding of high-priority projects in a timely and cost-effective fashion. The written plan identifies and describes capital projects, the years in which funding each project is to occur, and the method of funding. While a CIP may be designed to forecast any period of time, it generally extends beyond the current operating cycle and usually covers a three to five year time frame.

Project Scope:
This Water R&R analysis involved the following tasks:

1. Review record drawings, previous 2007 Water Master Plan, and other documents to identify the major water supply and treatment equipment.
2. Meet with key City operations and maintenance staff to jointly develop a list of prioritized items for the water works system.
3. Estimate the remaining useful lives of major equipment and facilities on the basis of age or date of rehabilitation.
4. Develop a schedule for anticipated future equipment replacement/rehabilitation.
5. Estimate the cost of anticipated equipment replacement expenditures.
6. Calculate annual equipment replacement funding requirements for FY 2016 – 2035.
7. Summarize the results of the analysis in a written report.

Key Assumptions Used:
The key assumptions used in this report are summarized as follows:

1. Expected Equipment Life/Routine Maintenance Items: **Table WA8-1** depicts the estimation, based upon engineering judgment, of how many years the equipment is expected to function adequately prior to replacement. **Table WA8-1** also reflects the routine maintenance items and how often the maintenance should occur.

2. Replacement need was determined based on age of equipment, existing equipment condition, equipment usage frequency, and existing equipment environmental conditions.

Section WA8 accepted March 29, 2017.

Table WA8-1. Expected Equipment Life/Routine Maintenance Items

Item	Useful Life (Years)
Air Stripper Packing Material	10
Air Strippers	50
Basket Strainer	20
Blower	20
Bridge Crane	20
Cartridge Filter Elements	0.2
Cartridge Filter Vessels	50
Chemical Storage and Feed	20
Compressor	20
Concrete Structures	50
Dechlorinator Tablet Feeder	10
Deep Injection Well	50
Diesel Engine	30
Electrical Systems	20
Transformers	15
Filter Media	10
Filter Under Drain	20
Fuel Storage	15
Generator	20
HVAC System	15
Hydro Recirculation Pumps	10
Hydrotreater Rake and Drive Unit	15
Instrumentation	10
Instrumentation & Control Hardware	7
Software & Programming	3
Lime Slakers	10
Lime Storage System	20
Membrane Elements	5
Membrane Skid	50

Item	Useful Life (Years)
Mixer	20
Painting	7
Piping, Valves, and Accessories (>8")	30
Power Distribution System	30
Pressure Switch	10
Pump & Motor	20
Pump & Motor, small (< 5 HP)	10
Pump Header	30
Roofing	15
Sludge Pumps	15
Sluice Gates	30
Software Licensing (Control)	1
Strainer	20
Transmitter	10
Trolley Hoist	20
Underground Piping	50
Vacuum Priming System	20
Valve Operators	15
Variable Frequency Drive	10
Well Flow Meter	20
Well Panels (SCADA)	20
Well Pump & Motor	20
Well Redevelopment	10
Well Replacement	30

Maintenance Items	Routine Life (Years)
Deep Injection Well Complete Testing	5
Monitor Well Sampling	5
Air Stripper Cleaning	0.5
Deep Injection Well Acidization Cleaning	10-15
Production Well Inspection	1-5
Underground Wire Testing	5
Production Well Cleaning	As Needed

Section WA8 accepted March 29, 2017.

3. Date of Installation: Date of installation was determined using City operation and maintenance staff knowledge, information listed in record drawings, and/or information/documentation pertaining to major facility improvements and/or upgrades.

4. Replacement/Rehabilitation Cost: Replacement/rehabilitation costs were determined based off equipment manufacturer budgetary estimates and recent construction costs that included a construction scope similar to the replacement item being estimated. Routine maintenance (i.e. oil changes, lubrication, belt adjustments, cleaning, etc.), installation, labor, and engineering service costs are excluded from the cost estimates. The cost estimates presented herein include a 25% contingency factor and were prepared for guidance in project evaluation/implementation from preliminary planning information available at the time of the estimate. The final cost of the proposed renewal and replacements will depend on actual labor and material costs, competitive marketing conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. As a result, the final project costs will vary from the estimates presented. The estimates presented herein should be considered Order of Magnitude estimates with an accuracy range of + 50% to - 30%. Also, salvage value is assumed to be negligible. R&R cost calculated for each project should be reviewed annually considering cost inflation to ensure that an appropriate amount is being funded, similar to the process followed for the regional wastewater facilities annual R&R reporting.

   Note: Identifying the funding required for the recommended prioritized R&R projects is included in **Section WA7** and is dependent on the R&R needs of the water utility system.

8.1 Transmission Needs

The City currently operates two Biscayne Aquifer wellfields to provide water to the Fiveash and Peele-Dixie WTPs. The wellfields include the Prospect Wellfield, which consists of 29 active wells and supplies raw water to the Fiveash Lime Softening WTP, and the Dixie Wellfield, which consists of 8 active wells and supplies water to the Peele-Dixie Membrane WTP.

8.1.1 Prospect Wellfield

Raw water to the Fiveash WTP is supplied from groundwater wells that surround Prospect Lake. This site is known as the Prospect Wellfield. The Fiveash WTP currently maintains twenty-nine (29) active production wells, with Production Well No. 25 as a standby well, that were constructed from 1969 through 2006.

The Prospect Wells have pumping capacities of approximately 3 MGD each, which equates to a total wellfield capacity of approximately 87 MGD. The well pumps are 100-horsepower (HP) (with the exception of well 27 at 75-HP), 3 stage vertical turbine pumps. A pair of 42-inch water main transmits the raw water from the wellfield to the Fiveash WTP.

Much of the equipment and mechanical items for the wellfield system are at the end of their useful life. Additionally, the existing primary and backup electrical system at the Prospect Wellfield is on the brink of failure. For specific electrical R&R needs, please refer to **Section UW3**. The CUS Master Plan Team met with key City wellfield plant operations and maintenance staff to jointly create and prioritize R&R improvements for the Prospect Wellfield. **Table WA8-2** illustrates the updated 2015 Renewal and Replacement requirement analysis and the anticipated schedule and expenditures.

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Table WA8-2. Prospect Wellfield 2015 Renewal and Replacement Requirement Analysis (2015 Dollars)

Item	Quantity	Useful Life (Yrs.)	Year Purchased/ Rehabbed	Remaining Useful Life (Yrs.)	Condition (Good, Fair, Poor)	Priority	Unit Cost (2015 $)	FY2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017- FY 2021 CIP Total	FY 2021- FY 2026 CIP Total	FY 2027- FY 2031 CIP Total	FY 2032- FY 2036 CIP Total
Production Wells 25, 26, 27 & 35 - Well Replacement and Wellhead Mechanical (Shutoff Valves, Backpressure Valves, Air Valves, Etc.)	4	40	1960	0	Poor	1	$528,856	$0	$2,115,424	$0	$0	$0	$2,115,424	$0	$0	$0
Production Wells 28, 30, 31 & 32 - Well Replacement and Wellhead Mechanical (Shutoff Valves, Backpressure Valves, Air Valves, Etc.)	4	40	1970	0	Poor	1	$528,856	$0	$0	$2,115,424	$0	$0	$2,115,424	$0	$0	$0
Production Wells 33, 34, 36 & 37 - Well Replacement and Wellhead Mechanical (Shutoff Valves, Backpressure Valves, Air Valves, Etc.)	4	40	1970	0	Poor	1	$528,856	$0	$0	$0	$2,115,424	$0	$2,115,424	$0	$0	$0
Production Wells 38, 39, 40 & 41 - Well Replacement and Wellhead Mechanical (Shutoff Valves, Backpressure Valves, Air Valves, Etc.)	4	40	1980	0	Poor	1	$528,856	$0	$0	$0	$0	$2,115,424	$2,115,424	$0	$0	$0
Production Wells 42, 43, 44 & 45 - Well Replacement and Wellhead Mechanical (Shutoff Valves, Backpressure Valves, Air Valves, Etc.)	4	40	1980	0	Poor	1	$528,856	$0	$0	$0	$0	$0	$0	$2,115,424	$0	$0
Production Wells 46, 47, 48 & 49 - Well Replacement and Wellhead Mechanical (Shutoff Valves, Backpressure Valves, Air Valves, Etc.)	4	40	1980	0	Poor	1	$528,856	$0	$0	$0	$0	$0	$0	$2,115,424	$0	$0
Production Wells 50, 51, 52, 53 & 54 - Well Replacement and Wellhead Mechanical (Shutoff Valves, Backpressure Valves, Air Valves, Etc.)	4	40	2002	0	Good	3	$528,856	$0	$0	$0	$0	$0	$0	$0	$0	$0
Production Wells 25, 26, 27 & 35 - Well Pump & Motor	4	20	2004-2008	10	Fair	2	$148,000	$0	$592,000	$0	$0	$0	$592,000	$0	$0	$0
Production Wells 28, 30, 31 & 32 - Well Pump & Motor	4	20	2004-2008	13	Fair	2	$148,000	$0	$0	$592,000	$0	$0	$592,000	$0	$0	$0
Production Wells 33, 34, 36 & 37 - Well Pump & Motor	4	20	2004-2008	8	Fair	2	$148,000	$0	$0	$0	$592,000	$0	$592,000	$0	$0	$0
Production Wells 38, 39, 40 & 41 - Well Pump & Motor	4	20	2004-2008	9	Fair	2	$148,000	$0	$0	$0	$0	$592,000	$592,000	$0	$0	$0
Production Wells 42, 43, 44 & 45 - Well Pump & Motor	4	20	2004-2008	10	Fair	2	$148,000	$0	$0	$0	$0	$0	$0	$592,000	$0	$0
Production Wells 46, 47, 48 & 49- Well Pump & Motor	4	20	2004-2008	11	Good	3	$148,000	$0	$0	$0	$0	$0	$0	$592,000	$0	$0
Production Wells 50, 51, 52, 53 & 54 - Well Pump & Motor	5	20	2004-2008	12	Good	3	$148,000	$0	$0	$0	$0	$0	$0	$740,000	$0	$0
Underground Raw Water Piping, Valves, and Accessories	-	30	1980	0	Poor	1	$45,883,226	$0	$9,176,645	$9,176,645	$9,176,645	$9,176,645	$36,706,581	$9,176,645	$0	$0
Field Instruments	-	10	1999	0	Poor	1	$1,376,400	$0	$688,200	$688,200	$0	$0	$1,376,400	$0	$1,376,400	$0
Instrumentation and Control Hardware[4]	-	10	1999	0	Poor	1	$2,150,625	$0	$1,075,313	$1,075,313	$0	$0	$2,150,625	$0	$2,150,625	$0
Instrumentation and Control Software and Programming[4]	-	3	1999	0	Poor	1	$35,844	$0	$35,844	$0	$0	$0	$35,844	$71,688	$35,844	$35,844
Electrical R&R[4]	-	-	-	-	Fair	2	-	$0	-	-	-	-	$0	$0	$0	$0
East Primary Power Distribution System[1]	-	30	1980	0	Poor	1	$2,575,260	$0	$1,287,630	$1,287,630	$0	$0	$2,575,260	$0	$0	$0
East Primary Power Distribution System Transformers[1]	18	15	1980	0	Poor	1	$43,013	$0	$387,113	$387,113	$0	$0	$774,225	$0	$0	$774,225
West Primary Power Distribution System[2]	-	30	2009	24	Good	3	$2,354,524	$0	$0	$0	$0	$0	$0	$0	$0	$0
West Primary Power Distribution System Transformers[2]	8	15	2009	8	Fair	2	$43,013	$0	$0	$0	$0	$0	$0	$344,100	$344,100	$0
Primary Power Distribution System Maintenance	-	-	2007	-	Fair	2	$58,863	$0	$0	$0	$0	$0	$0	$58,863	$0	$0
East Emergency Generators 1 & 2	2	20	2009	4	Fair	2	$573,540	$0	$0	$0	$1,147,081	$0	$1,147,081	$0	$0	$0
East Fuel Storage	1	15	1980	0	Poor	1	$286,770	$0	$0	$286,770	$0	$0	$286,770	$0	$0	$286,770
West Emergency Generator 1	1	20	2009	14	Good	3	$573,540	$0	$0	$0	$0	$0	$0	$0	$573,540	$0
West Fuel Storage[3]	1	15	2009	9	Good	3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Generator / Electrical Building Painting (East)	2	7	2009	1	Poor	1	$14,338	$0	$0	$28,675	$0	$0	$28,675	$28,675	$0	$28,675
Generator / Electrical Building Roofing (East)	2	15	2009	14	Fair	1	$35,844	$0	$0	$0	$0	$0	$0	$0	$71,688	$0
Production Well Flow Meters (Mag Meters, ABB Flowmasters)	29	20	-	-	Fair	2	$3,500	$0	$0	$101,500	$0	$0	$101,500	$0	$0	$0
Master Flow Meter (to replace four plant meters)	1	20	-	-	Fair	2	$3,500	$0	$0	$3,500	$0	$0	$3,500	$0	$0	$0
Raw Water Main Flow Meters	2	20	-	-	Fair	2	$3,500	$0	$0	$7,000	$0	$0	$7,000	$0	$0	$0
Pressure Gauges	29	1	-	-	Fair	2	$400	$0	$11,600	$11,600	$11,600	$11,600	$46,400	$58,000	$58,000	$58,000
Properly Abandon Airport Wells - 1, 6, 11, 16	4	-	-	-	Poor	2	$15,000	$0	$60,000	$0	$0	$0	$60,000	$0	$0	$0
Properly Abandon Airport Wells - 2, 7, 12, 17	4	-	-	-	Poor	2	$15,000	$0	$0	$0	$0	$0	$0	$60,000	$0	$0
Properly Abandon Airport Wells - 3, 8, 13, 18	4	-	-	-	Poor	2	$15,000	$0	$0	$0	$0	$0	$0	$0	$60,000	$0
Properly Abandon Airport Wells - 4, 9, 14, 21	4	-	-	-	Poor	2	$15,000	$0	$0	$0	$0	$0	$0	$0	$0	$60,000
Properly Abandon Airport Wells - 5, 10, 15, 23	4	-	-	-	Poor	2	$15,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Production Well Inspections	29	1	-	0	Poor	2	$500	$0	$14,500	$14,500	$14,500	$14,500	$58,000	$72,500	$72,500	$72,500
Underground Wire Testing	-	5	-	0	Poor	2	$93,750	$0	$93,750	$0	$0	$0	$93,750	$93,750	$93,750	$93,750
Well Panels (when SCADA is implemented)	29	20	-	-	-	2	$31,250	$0	$0	$0	$0	$0	$0	$31,250	$0	$0
Security Fence Replacement	-	15	1980	0	Fair	2	$788,563	$0	$0	$0	$788,563	$0	$788,563	$788,563	$788,563	$788,563
Total								**$0**	**$15,538,018**	**$15,775,870**	**$13,845,812**	**$11,910,169**	**$57,069,870**	**$16,938,881**	**$5,625,009**	**$2,198,326**

Notes:

[1] "East primary power" means the system that serves the wells east of Hawkins Road.

[2] "West primary power" means the system that serves the wells west of Hawkins Road.

[3] The new western generator system will include a belly tank under the generator. Therefore, assume that "West Fuel Storage" item cost is zero.

[4] See CUSMP Section UW3-Plants Electrical Study for detailed R&R Electrical Needs

Priority: 1=High, 2=Medium, 3=Low, 4 = To be revaluated during subsequent master plans

8.1.2 Dixie Wellfield

The feed water source for the Peele-Dixie WTP is the South Florida Biscayne Aquifer. The aquifer is located in South Florida in parts of Dade, Broward, and Palm Beach Counties. This aquifer underlies an area of approximately 4,000 square miles and is a highly permeable aquifer that consists mainly of limestone, less-permeable sandstone, and sand.

In 2008, the City installed eight (8) new raw water wells into the Peele-Dixie Wellfield and abandoned the existing wells. The new well pumps have capacities of approximately 2.5 MGD each, which equates to a total wellfield capacity of approximately 20 MGD. All well pumps are 100-horsepower (HP), 3 stage vertical turbine pumps. A 30-inch water main transmits the raw water from the wellfield to the Peele-Dixie WTP.

Much of the equipment and mechanical items at the Dixie Wellfield will extend through the 20-year planning period, as the wells were installed in 2008 and are in fairly good condition. The CUS Master Plan Team met with key City wellfield plant operations and maintenance staff to jointly create and prioritize R&R improvements for the Dixie Wellfield. **Table WA8-3** illustrates the updated 2015 Renewal and Replacement requirement analysis and the anticipated schedule and expenditures. For specific electrical R&R needs, please refer to **Section UW3**.

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Table WA8-3. Dixie Wellfield 2015 Renewal and Replacement Requirement Analysis (2015 Dollars)

Item	Quantity	Useful Life (Years)	Year Purchased/ Rehabbed	Remaining Useful Life (Yrs.)	Condition (Good, Fair, Poor)*	Priority	Unit Cost (2015 $)	FY2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017- FY 2021 CIP Total	FY 2021- FY 2026 CIP Total	FY 2027- FY 2031 CIP Total	FY 2032- FY 2036 CIP Total
Production Wells 27, 28, 29, 30, 31, 32, 33 & 34 - Well Replacement and Wellhead Mechanical (Shutoff Valves, Backpressure Valves, Air Valves, Etc.)	8	40	2006	30	Good	4	$528,856	$0	$0	$0	$0	$0	$0	$0	$0	$0
Production Wells 27, 28, 29, 30, 31, 32, 33 & 34 - Well Pump & Motor	8	20	2006	10	Fair	4	$148,000	$0	$0	$0	$0	$0	$0	$0	$1,184,000	$0
Underground Raw Water Piping, Valves, and Accessories	-	30	2006	21	Good	4	$12,903,750	$0	$0	$0	$0	$0	$0	$0	$0	$0
Production Well Flow Meters (Magmeters, ABB Flowmasters)	8	20	2006	11	Fair	2	$3,500	$0	$0	$0	$0	$0	$0	$0	$28,000	$0
Electrical R&R[1]	-	-	2006	-	Good	2	-	$0	-	-	-	-	$0	$0	$0	$0
Pressure Gauges/Field Instruments	8	1/10	2006	0	Poor	1	$1,250/ $344,100	$0	$1,250	$345,350	$1,250	$1,250	$349,100	$6,250	$350,350	$6,250
Instrumentation and Control Hardware	-	7	2006	0	Poor	1	$444,463	$0	$0	$444,463	$0	$0	$444,463	$444,463	$0	$444,463
Instrumentation and Control Software and Programming	-	3	2006	0	Poor	1	$35,844	$0	$35,844	$0	$0	$35,844	$71,688	$35,844	$71,688	$71,688
Primary Power Distribution System	-	30	2006	21	Good	3	$1,103,988	$0	$0	$0	$0	$0	$0	$0	$0	$0
Primary Power Distribution System Transformers	10	15	2006	5	Fair	2	$43,013	$0	$0	$0	$0	$0	$0	$430,125	$0	$0
Primary Power Distribution System Maintenance	-	-	2006	-	Good	3	$28,675	$0	$28,675	$28,675	$28,675	$28,675	$114,700	$143,375	$143,375	$143,375
Emergency Generator	1	20	2006	11	Good	3	$573,500	$0	$0	$0	$0	$0	$0	$0	$573,500	$0
Fuel Storage	1	15	2006	6	Good	3	$107,531	$0	$0	$0	$0	$0	$0	$107,531	$0	$0
Generator Building Painting	1	7	2006	0	Poor	1	$14,338	$0	$0	$14,338	$0	$0	$14,338	$14,338	$0	$14,338
Generator Building Roofing	1	15	2006	6	Good	3	$35,844	$0	$0	$0	$0	$0	$0	$35,844	$0	$0
Total								**$0**	**$65,769**	**$832,826**	**$29,925**	**$65,769**	**$994,289**	**$1,217,770**	**$2,350,913**	**$680,114**

Notes:

* Based on City Operations Staff Knowledge

[1] See CUSMP Section UW3-Plants Electrical Study for detailed R&R Electrical Needs

Priority: 1=High, 2=Medium, 3=Low, 4=To be revaluated during subsequent master plans

8.2 Treatment R&R Needs

8.2.1 Fiveash WTP

The City's largest water treatment plant is the Charles W. Fiveash WTP, with a design capacity of 70 million gallons per day (MGD). However, City operations staff have noted that treating more than 55 MGD through the lime softening process shows a significant increase in finished water turbidity and decreased color removal. Therefore, the Fiveash WTP currently has a reduced, effective capacity of approximately 55 MGD. The Fiveash WTP is located in northwest Fort Lauderdale and draws its raw water from the Prospect Wellfield, which is fed from the surficial Biscayne Aquifer. The Fiveash WTP processes include the following:

a. Pretreatment Aeration
b. Lime Softening Total Organic Carbon (TOC) Removal
c. Chemical Treatment and Filtration
d. Clearwell and Transfer Pumps
e. Ground Storage Tanks and High Service Pumping
f. Lime Sludge Management

Many of the equipment and mechanical items for the lime softening system are at the end of their useful life. Additionally, the majority of the electrical power distribution system is out of date and is in need of replacement. More than half of the equipment is not in a conditioned environment and is subject to humidity, heat, and a corrosive atmosphere, causing the equipment to deteriorate faster. For specific electrical R&R needs, please refer to **Section UW3**. A Fiveash WTP "Reliability Upgrades Project" is on-going to replace several key mechanical items and automate the controls of key plant processes. Phases II and III of the Reliability Upgrades are under design and will be distributed for bid in the near future.

The CUS Master Plan Team met with key City water treatment plant operations and maintenance staff to jointly update and prioritize R&R improvements for the Fiveash WTP. **Table WA8-4** illustrates the updated 2015 Renewal and Replacement requirement analysis and the anticipated schedule expenditures.

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Table WA8-4. Fiveash WTP 2015 Renewal and Replacement Requirement Analysis

Item	Quantity	Useful Life (Years)	Year Purchased/ Rehabbed	Remaining Useful Life (Years)*	Condition (Good, Fair, Poor)*	Priority*	Unit Cost (2015 $)	FY2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017- FY 2021 CIP Total	FY 2021- FY 2026 CIP Total	FY 2027- FY 2031 CIP Total	FY 2032- FY 2036 CIP Total
Aeration Basin - Blower Motors	2	20	1998	2	Poor	2	$716,875	$0	$0	$0	$1,433,750	$0	$1,433,750	$0	$0	$0
Aqueous Ammonia System	1	20	2005	2	Good	3	$1,290,375	$0	$0	$0	$0	$0	$0	$1,290,375	$0	$0
AC Units - Transformer Room & Switch Gear Room[6]	2	15	2000	0	Poor	1	$7,500	$0	$0	$15,000	$0	$0	$15,000	$0	$0	$15,000
Backwash Motor 2,3[8]	1	20	1980	1	Fair	1	$375,000	$0	$0	$750,000	$0	$0	$750,000	$0	$0	$0
Backwash Pump 2,3 (150 HP)	1	20	1980	1	Fair	1	$860,250	$0	$0	$860,250	$0	$0	$860,250	$0	$0	$0
Chlorine Injector Motor 1, 2, 3 & 4 (480 Volt)[6,8]	4	20	1980	0	Poor	1	$3,750	$0	$15,000	$0	$0	$0	$15,000	$0	$0	$0
Chlorine Injector Pump 1, 2, 3 & 4 (10 HP)[6]	4	20	1980	0	Poor	1	$10,000	$0	$40,000	$0	$0	$0	$40,000	$0	$0	$0
Clearwells 1-7	7	50	1954/1974/1980	30	Good	4	$1,000,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Clearwell 1 - Strikedown Valves	2	30	2006	21	Good	4	$107,531	$0	$0	$0	$0	$0	$0	$0	$0	$0
Clearwell 7 - Strikedown and Shutoff Valves	4	30	2006	21	Good	4	$107,531	$0	$0	$0	$0	$0	$0	$0	$0	$0
Clearwell Interconnect Valve	1	30	2006	21	Good	4	$272,413	$0	$0	$0	$0	$0	$0	$0	$0	$0
Coagulant Polymer System	1	20	2006	20	Fair	3	$1,147,000	$0	$0	$0	$0	$0	$0	$0	$1,147,000	$0
Decant Pumps for Washwater Recovery Basins 1	2	10	1985	0	Fair	1	$28,675	$0	$0	$57,350	$0	$0	$57,350	$57,350	$0	$57,350
Decant Pumps for Washwater Recovery Basins 2	2	10	2015	10	Good	3	$28,675	$0	$0	$0	$0	$0	$0	$0	$57,350	$0
Diesel Engines # 6 and 8 (500 HP)	2	20	Varies	3	Fair	2	$125,000	$0	$0	$0	$250,000	$0	$250,000	$0	$0	$0
Diesel Engines # 7 (450 HP)	1	20	Varies	3	Fair	2	$112,500	$0	$0	$0	$112,500	$0	$112,500	$0	$0	$0
Diesel Engines # 9, 10, 11 (650 HP)	3	20	Varies	3	Fair	2	$162,500	$0	$0	$0	$487,500	$0	$487,500	$0	$0	$0
Diesel Engine Air Start System Compressors 1, 2, & 3[6]	3	20	1993/1999	0	Poor	1	$573,500	$0	$0	$0	$0	$0	$0	$0	$0	$0
Electrical R&R[1]	-	-	-	-	Poor	1	-	$0	-	-	-	-	$0	$0	$0	$0
Field Instruments	-	10	2006	1	Fair	2	$8,960,938	$0	$0	$0	$0	$8,960,938	$8,960,938	$0	$8,960,938	$0
Filters 5, 10, 15, 16, 17, 18 - Valves, Valve Operators, and Filter Underdrain	6	15-20	2007	11	Good	3	$902,263	$0	$0	$0	$0	$0	$0	$0	$5,413,578	$0
Filters 6, 7, 8, 11, 13 - Valves, Valve Operators, and Filter Underdrain	5	15-20	2008	12	Good	3	$902,263	$0	$0	$0	$0	$0	$0	$0	$4,511,315	$0
Filters 1, 2, 3, 4, 9, 14, 20, 21, 22 - Valves, Valve Operators, and Filter Underdrain	9	15-20	2010	14	Good	3	$902,263	$0	$0	$0	$0	$0	$0	$0	$8,120,367	$0
Filters 12, 19 - Valves, Valve Operators, and Filter Underdrain	2	15-20	2000	4	Fair	2	$902,263	$0	$0	$0	$1,804,526	$0	$1,804,526	$0	$0	$0
Filters 10, 11, 12, 13 - Filter Media	4	10	2010	5	Good	3	$100,000	$0	$0	$0	$0	$400,000	$400,000	$0	$400,000	$0
Filters 6, 7, 8, 9, 14, 15 - Filter Media	6	10	2015	9	Good	3	$100,000	$0	$0	$0	$0	$0	$0	$600,000	$0	$600,000
Filters 5, 15, 16, 17, 18, 19 - Filter Media	6	10	1990	0	Poor	1	$100,000	$0	$0	$600,000	$0	$0	$600,000	$0	$600,000	$0
Filters 1, 2, 3, 4, 9, 14, 20, 21, 22 - Filter Media	9	10	2010	4	Poor	1	$100,000	$0	$0	$0	$0	$0	$0	$900,000	$0	$900,000
Fluoride System[6]	1	20	1980	0	Poor	1	$2,437,375	$0	$2,437,375	$0	$0	$0	$2,437,375	$0	$0	$0
Freight Elevator[6]	1	50	1954	0	Poor	1	$125,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Fuel Storage	1	15	2007	8	Good	3	$1,893,984	$0	$0	$0	$0	$0	$0	$1,893,984	$0	$0
Ground Storage Tank 1 (5 MG)	1	50	1958	10	Fair	1	$2,867,500	$0	$0	$0	$0	$0	$0	$0	$0	$0
Ground Storage Tank 3 (5 MG)	1	50	1980	15	Good	3	$2,867,500	$0	$0	$0	$0	$0	$0	$0	$2,867,500	$0
Ground Storage Tank 4 (7 MG)	1	50	2000	35	Good	4	$4,301,250	$0	$0	$0	$0	$0	$0	$0	$0	$0
High Service Motors 4, 5 (4160 Volt)[5]	2	20	2006	11	Good	3	$375,000	$0	$0	$0	$0	$0	$0	$0	$750,000	$0
High Service Motors 9, 10 (4160 Volt)[5]	2	20	2010	15	Good	3	$375,000	$0	$0	$0	$0	$0	$0	$0	$0	$750,000
High Service Motor 11 (4160 Volt)[5]	1	20	2015	20	Good	4	$375,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
High Service Motors 12, 13, 14, 15, 16 (4160 Volt)[5]	5	20	1987	0	Fair	2	$375,000	$0	$0	$0	$1,875,000	$0	$1,875,000	$0	$0	$0
North High Service Pump Header[2]	1	30	1963	0	See Note 2	1	$71,688	$0	$0	$0	$71,688	$0	$71,688	$0	$0	$0
Southeast High Service Pump Header[2]	1	30	1982	0	See Note 2	1	$71,688	$0	$71,688	$0	$0	$0	$71,688	$0	$0	$0
South High Service Pump Header[2]	1	30	1991	5	Fair	1	$71,688	$0	$0	$0	$0	$0	$0	$71,688	$0	$0
High Service Pumps 12, 13, 14, 15 & 16 (350 HP)	5	20	2005	7	Good	3	$860,250	$0	$0	$0	$0	$0	$0	$4,301,250	$0	$0
High Service Pumps 4 (350 HP)	1	20	2005	5	Good	2	$860,250	$0	$0	$0	$0	$0	$0	$860,250	$0	$0
High Service Pumps 5 (350 HP)	1	20	2010	10	Good	2	$860,250	$0	$0	$0	$0	$0	$0	$0	$860,250	$0
High Service Pumps 6, 7, & 8 (Diesel Drive only)	3	20	1983	0	Poor	1	$2,294,000	$0	$2,294,000	$4,588,000	$0	$0	$6,882,000	$0	$0	$0
High Service Pumps 9, 10, & 11 (Diesel/Electric Drive) 600HP	3	20	2005	5	Fair	2	$2,580,750	$0	$0	$0	$0	$0	$0	$2,580,750	$5,161,500	$0
Hydraulic Operated Valve in Transfer Pump Header[2,6]	1	30	1983	0	See Note 2	1	$430,125	$0	$430,125	$0	$0	$0	$430,125	$0	$0	$0
Hydro Washdown Booster Pump (19 HP)	1	20	1995	0	Fair	2	$18,750	$0	$0	$18,750	$0	$0	$18,750	$0	$0	$0
Hydro Booster Pump Motor (480 Volt)	1	20	1995	0	Fair	2	$5,875	$0	$0	$5,875	$0	$0	$5,875	$0	$0	$0
Hydro Recirculation Motor 1, 2 (480 Volt)[8]	2	20	Pre-1990	0	Fair	1	$4,750	$0	$9,500	$0	$0	$0	$9,500	$0	$0	$0

Table WA8-4. Fiveash WTP 2015 Renewal and Replacement Requirement Analysis (Continued)

Item	Quantity	Useful Life (Years)	Year Purchased/ Rehabbed	Remaining Useful Life (Years)*	Condition (Good, Fair, Poor)*	Priority*	Unit Cost (2015 $)	FY2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017- FY 2021 CIP Total	FY 2021- FY 2026 CIP Total	FY 2027- FY 2031 CIP Total	FY 2032- FY 2036 CIP Total
Hydro Recirculation Motor 3, 4 (480 Volt)[8]	2	20	Pre-1990	0	Fair	1	$4,750	$0	$18,750	$0	$0	$0	$18,750	$0	$0	$0
Hydro Recirculation Pumps 1, 2 (7.5 HP)	2	20	Pre-1990	0	Fair	1	$9,375	$0	$37,500	$0	$0	$0	$37,500	$0	$0	$0
Hydro Recirculation Pumps 3, 4 (15 HP)	2	20	Pre-1990	0	Fair	1	$18,750	$0	$37,500	$0	$0	$0	$37,500	$0	$0	$0
Hydrotreator 1 - Rake and Drive Unit	1	15	2015	15	Good	3	$903,263	$0	$0	$0	$0	$0	$0	$0	$0	$903,263
Hydrotreator 2 - Rake and Drive Unit	1	15	1954	0	Poor	1	$903,263	$0	$903,263	$0	$0	$0	$903,263	$0	$0	$903,263
Hydrotreator 3 - Rake and Drive Unit	1	15	2010	10	Good	3	$1,003,625	$0	$0	$0	$0	$0	$0	$0	$1,003,625	$0
Hydrotreator 4 - Rake and Drive Unit	1	15	2007	10	Good	3	$1,003,625	$0	$0	$0	$0	$0	$0	$1,003,625	$0	$0
Instrumentation and Control Hardware[1]	-	7	1999	0	Poor	1	$12,617,000	$0	$12,617,000	$0	$0	$0	$12,617,000	$12,617,000	$0	$12,617,000
Instrumentation and Control Software and Programming[1]	-	3	1999	0	Fair	2	$143,375	$0	$143,375	$0	$0	$143,375	$286,750	$143,375	$286,750	$286,750
Lime Blower and Diffusers (75 HP)[5]	2	20	2000	0	Fair	1	$80,000	$0	$0	$0	$0	$160,000	$160,000	$0	$0	$0
Lime Blower Motor (480 Volt)	2	20	2010	5	Fair	2	$5,625	$0	$0	$0	$0	$0	$0	$0	$11,250	$0
Lime Slakers 1, 2, 3 & 4	4	10	2007	0	Poor	1	$716,875	$0	$1,433,750	$1,433,750	$0	$0	$2,867,500	$0	$2,867,500	$0
Lime Storage System	1	20	1960	1	Fair	1	$2,580,750	$0	$0	$2,580,750	$0	$0	$2,580,750	$0	$0	$0
Sludge line to Prospect Wellfield	1	40	Pre 1980	0	Poor	1	$3,584,375	$0	$3,584,375	$0	$0	$0	$3,584,375	$0	$0	$0
Operations Building HVAC Systems[6]	1	15	2009	3	Fair	2	$1,290,375	$0	$0	$0	$1,290,375	$0	$1,290,375	$0	$0	$1,290,375
Painting - Exterior	1	7	2009	2	Fair	1	$716,875	$0	$0	$716,875	$0	$0	$716,875	$716,875	$0	$716,875
Painting - Interior	1	7	2009	3	Fair	2	$716,875	$0	$0	$0	$716,875	$0	$716,875	$0	$716,875	$716,875
Washwater Transfer PCCP[2]	-	50	Varies	0	See Note 2	1	$5,000,000	$0	$5,000,000	$0	$0	$0	$5,000,000	$0	$0	$0
Plant Air Compressor 5	1	20	2005	5	Fair	3	$358,438	$0	$0	$0	$0	$0	$0	$358,438	$0	$0
Plant Air Compressor 6[6]	1	20	1986	0	Poor	1	$358,438	$0	$358,438	$0	$0	$0	$358,438	$0	$0	$0
Plant Emergency Power Generator J[6]	1	20	1982	20	Good	4	$2,724,125	$0	$0	$0	$0	$0	$0	$0	$0	$0
Plant Emergency Power Generator K[6]	1	20	1982	0	Poor	2	$2,724,125	$0	$0	$2,724,125	$0	$0	$2,724,125	$0	$0	$0
Pumps & Motors, Small (<5hp) (e.g., sump pumps, sampling pumps, etc.)	-	10	Varies	2	Fair	2	$286,750	$0	$0	$0	$286,750	$0	$286,750	$0	$286,750	$0
Roofing[6]	1	15	Prior to 2009	0	Poor	1	$1,863,875	$0	$0	$0	$0	$0	$0	$0	$0	$0
Shutoff Valves on Finished Water Yard Piping	23	30	1980	1	Poor	1	$272,413	$0	$1,089,650	$1,089,650	$1,089,650	$1,089,650	$4,358,600	$1,906,888	$0	$0
Shutoff Valves on Transfer Piping	3	30	1983	2	Fair	1	$157,713	$0	$0	$473,138	$0	$0	$473,138	$0	$0	$0
Sludge Holding Tank Mixer	1	20	2006	5	Good	3	$71,688	$0	$0	$0	$0	$0	$0	$0	$71,688	$0
Sludge Pit Motors 7201, 7202, 7203 (480 Volt)	3	20	2006	5	Good	3	$12,500	$0	$0	$0	$0	$0	$0	$0	$37,500	$0
Sludge Pump 7201, 7202 &7203 (32.2 HP)	3	20	2006	5	Good	3	$31,250	$0	$0	$0	$0	$0	$0	$0	$93,750	$0
Sludge Pumps for Washwater Recovery Basins 1 & 2	4	15	2006	3	Fair	2	$43,013	$0	$0	$0	$0	$0	$0	$172,050	$0	$0
Sluice Gates for Aeration Basins 1 & 2	14	30	1963	0	Poor	1	$215,063	$0	$430,125	$430,125	$430,125	$430,125	$1,720,500	$1,290,375	$0	$0
Sluice Gates for Clearwell 7[2]	8	30	1983	0	See Note 2	1	$215,063	$0	$430,125	$430,125	$430,125	$430,125	$1,720,500	$0	$0	$0
Sluice Gates for Clearwell No. 1[2]	1	30	1960	0	See Note 2	1	$215,063	$0	$215,063	$0	$0	$0	$215,063	$0	$0	$0
Sluice Gates for Hydrotreaters 1 & 2 (Effluent)	2	30	1959	0	Poor	1	$215,063	$0	$430,125	$0	$0	$0	$430,125	$0	$0	$0
Sluice Gates for Recarbonation Basin 1 & 2	1	30	1959	0	Poor	1	$215,063	$0	$0	$215,063	$0	$0	$215,063	$0	$0	$0
Sluice Gates for Recarbonation Basin 3	4	30	1963	0	Fair	2	$215,063	$0	$0	$0	$430,125	$430,125	$860,250	$0	$0	$0
Sluice Gates for Recarbonation Basin 4	3	30	1981	4	Fair	2	$215,063	$0	$0	$0	$430,125	$215,063	$645,188	$0	$0	$0
Surface Wash Motors 1 & 2 (480 Volt)[8]	2	20	1963/1983	0	Fair	1	$12,500	$0	$0	$25,000	$0	$0	$25,000	$0	$0	$0
Surface Wash Pumps 1 & 2	2	20	1963/1983	0	Fair	1	$71,688	$0	$0	$143,375	$0	$0	$143,375	$0	$0	$0
Transfer Motor 1 & 2 (150 HP, 480 Volt)[8]	2	20	1983	2	Fair	1	$375,000	$0	$0	$750,000	$0	$0	$750,000	$0	$0	$0
Transfer Motor 3 & 6 (100 HP, 480 Volt)[8]	2	20	1991	2	Fair	1	$375,000	$0	$0	$750,000	$0	$0	$750,000	$0	$0	$0
Transfer Pumps 1 & 2 (150 HP)	2	20	1983	2	Fair	1	$860,250	$0	$0	$1,720,500	$0	$0	$1,720,500	$0	$0	$0
Transfer Pumps 3 & 6 (100 HP)	2	20	1991	2	Fair	1	$860,250	$0	$0	$1,720,500	$0	$0	$1,720,500	$0	$0	$0
Vacuum Priming System 1 &2[6]	1	20	1986	0	Poor	1	$573,500	$0	$0	$0	$573,500	$0	$573,500	$0	$0	$0
Washwater Recovery Basin Influent Valves	2	30	2006	20	Good	4	$215,063	$0	$0	$0	$0	$0	$0	$0	$0	$0
Washwater Transfer Combination Submersible Pumps 1, 2 & 3 (74 HP)	3	20	2005	5	Good	3	$222,231	$0	$0	$0	$0	$0	$0	$666,694	$0	$0
Total								**$0**	**$32,026,725**	**$22,098,200**	**$11,712,614**	**$12,259,400**	**$78,096,939**	**$31,430,966**	**$44,225,485**	**$19,756,750**

Notes:

* Based on City Operations Staff Knowledge

[1] See CUSMP Section UW3-Plants Electrical Study for detailed R&R Electrical Needs

[2] City staff indicate an examination is needed for accurate condition of asset

[3] Unknown

[4] To be addressed in WA5B-Fiveash WTP Process Evaluation

[5] Recommend to replace with high-efficiency motors as detailed in WA.13-Water Energy Conservation Section

[6] To be addressed in 2016 Reliability Upgrades

[7] Diesel Engine #10 overhauled in 2012.

[8] All motors fabricated prior to 1997 should be replaced with high-efficiency motors to reduce energy costs, as detailed in WA.13-Water Energy Conservation Section

Priority: 1=High, 2=Medium, 3=Low, 4=To be revaluated during subsequent master plans

8.2.2 Peele-Dixie WTP

The City operates the Walter E. Peele-Dixie WTP, providing drinking water to the southern portion of the City's service area. The Peele-Dixie WTP was originally constructed in 1926 as a lime-softening plant, and was eventually replaced by a nanofiltration plant. The nanofiltration plant was constructed adjacent to the old plant in 2008. The Peele-Dixie WTP maintains a Florida Department of Environmental Protection (FDEP) permitted treatment capacity of 12 MGD. The plant is located in southwest Fort Lauderdale and draws its raw water from the Dixie Wellfield, which is fed from the surficial Biscayne Aquifer.

For calendar year 2014, the Peele-Dixie WTP treated an annual average day flow of 8.1 MGD of groundwater, producing 6.9 MGD of finished water. The plant is designed to recover 85% water as permeate, while the remaining 15% concentrate water is disposed of into an underground deep injection well. The Peele-Dixie WTP is designed to allow for an expansion for an additional 6 MGD of membrane treatment skids. The Peele-Dixie WTP processes include the following:

a. Reverse Osmosis/Nanofiltration Hybrid System
b. (1) Aeration, (2) Concentration Disposal; concurrently
c. Clearwell, Post Treatment, and Transfer Pump System
d. Finished Water Storage and Distribution

Much of the equipment and mechanical items at the Peele-Dixie WTP will extend through the 20-year planning period, as the WTP was constructed in 2008 and is relatively new. In addition, most of the equipment is contained indoors, where it is protected from atmospheric conditions. The CUS Master Plan Team met with key City water treatment plant operations and maintenance staff to jointly update and prioritize R&R improvements for the Peele-Dixie WTP. **Table WA8-5** illustrates the updated 2015 Renewal and Replacement requirement analysis and the anticipated schedule expenditures. For specific electrical R&R needs, please refer to **Section UW3**.

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Table WA8-5. Peele-Dixie WTP 2015 Renewal and Replacement Requirement Analysis (2015 Dollars)

Item	Quantity	Useful Life (Years)	Year Purchased/ Rehabbed	Remaining Useful Life (Years)*	Condition (Good, Fair, Poor)*	Priority*	Unit Cost (2015 $)	FY2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2021-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total
Membrane Elements (per Skid)	4 Skids	5	2007	0	Fair	1	$1,706,163	$0	$1,706,163	$1,706,163	$1,706,163	$1,706,163	$6,824,650	$6,824,650	$6,824,650	$6,824,650
Air Strippers Packing Material	2	10	2007	0	Poor	1	$100,363	$0	$200,725	$0	$0	$0	$200,725	$0	$200,725	$0
Air Stripper Cleaner	1	5	--	0	Poor	1	$40,000	$0	$0	$40,000	$0	$0	$40,000	$40,000	$40,000	$40,000
Air Stripper Fans 1 & 2 (50 HP)	2	15	2007	6	Good	3	$35,844	$0	$0	$0	$0	$0	$0	$71,688	$0	$0
Membrane Cleaning and Flushing System	1	10	2007	2	Good	3	$203,593	$0	$0	$203,593	$0	$0	$203,593	$0	$203,593	$0
Electrical R&R[1]	-	-	2007	-	Good	3	-	$0	-	-	-	-	$0	$0	$0	$0
Sulfuric Acid Storage Tank[2]	1	20	2017	21	Good	3	$12,500	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sulfuric Acid Metering Pump	1	20	2007	4	Good	3	$18,750	$0	$0	$0	$0	$0	$0	$0	$18,750	$0
Sulfuric Acid VFD	1	10	2007	0	Poor	1	$3,125	$0	$3,125	$0	$0	$0	$3,125	$0	$3,125	$0
Scale Inhibitor Storage Tank[2]	1	20	2017	21	Good	3	$12,500	$0	$0	$0	$0	$0	$0	$0	$0	$0
Scale Inhibitor Metering Pump	1	20	2007	5	Good	3	$18,750	$0	$0	$0	$0	$0	$0	$0	$18,750	$0
Scale Inhibitor VFD	1	10	2007	0	Poor	1	$3,125	$0	$3,125	$0	$0	$0	$3,125	$0	$3,125	$0
Aqueous Ammonia Storage Tank	1	20	2007	5	Good	3	$12,500	$0	$0	$0	$0	$0	$0	$0	$12,500	$0
Aqueous Ammonia Metering Pump	1	20	2007	5	Good	3	$18,750	$0	$0	$0	$0	$0	$0	$0	$18,750	$0
Aqueous Ammonia VFD	1	10	2007	0	Poor	1	$3,125	$0	$3,125	$0	$0	$0	$3,125	$0	$3,125	$0
Sodium Hypochlorite Storage Tank	1	20	2007	2	Fair	1	$12,500	$0	$0	$0	$0	$0	$0	$0	$12,500	$0
Sodium Hypochlorite Metering Pump	1	20	2007	5	Good	3	$18,750	$0	$0	$0	$0	$0	$0	$0	$18,750	$0
Sodium Hypochlorite VFD	1	10	2007	0	Poor	1	$3,125	$0	$3,125	$0	$0	$0	$3,125	$0	$3,125	$0
Sodium Hydroxide Storage Tank[2]	1	20	2017	21	Good	3	$12,500	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sodium Hydroxide Metering Pump	1	20	2007	5	Good	3	$18,750	$0	$0	$0	$0	$0	$0	$0	$18,750	$0
Sodium Hydroxide VFD	1	10	2007	0	Poor	1	$3,125	$0	$3,125	$0	$0	$0	$3,125	$0	$3,125	$0
Corrosion Inhibitor Storage Tank[2]	1	20	2017	21	Good	3	$12,500	$0	$0	$0	$0	$0	$0	$0	$0	$0
Corrosion Inhibitor Metering Pump	1	20	2007	5	Good	3	$18,750	$0	$0	$0	$0	$0	$0	$0	$18,750	$0
Corrosion Inhibitor VFD	1	10	2007	0	Poor	1	$3,125	$0	$3,125	$0	$0	$0	$3,125	$0	$3,125	$0
Fluoride Storage Tank	1	20	2007	11	Good	3	$12,500	$0	$0	$0	$0	$0	$0	$0	$12,500	$0
Fluoride Metering Pump	1	20	2007	5	Good	3	$18,750	$0	$0	$0	$0	$0	$0	$0	$18,750	$0
Fluoride VFD	1	10	2007	0	Poor	1	$3,125	$0	$3,125	$0	$0	$0	$3,125	$0	$3,125	$0
Monitor Well Instrumentation and Sampling	-	5	2007	0	Good	3	$26,668	$0	$26,668	$0	$0	$0	$26,668	$26,668	$0	$26,668
Deep Injection Well MIT Testing	1	5	2015	5	Good	3	$143,375	$0	$0	$0	$0	$143,375	$143,375	$143,375	$143,375	$143,375
Deep Injection Well Casing Cleaning	1	15	2015	15	Good	4	$5,000	$0	$0	$0	$0	$0	$0	$0	$5,000	$0
Fuel Storage System	2	15	2007	9	Good	4	$31,543	$0	$0	$0	$0	$0	$0	$63,085	$0	$0
Instrumentation (I&C)[1]	-	10	2007	2	Fair	1	$1,154,169	$0	$0	$1,154,169	$0	$0	$1,154,169	$0	$1,154,169	$0
Hardware (I&C)[1]	-	5	2007	0	Fair	1	$2,000,081	$0	$0	$2,000,081	$0	$0	$2,000,081	$2,000,081	$2,000,081	$2,000,081
Software (I&C)[1]	-	3	2007	0	Fair	1	$114,700	$0	$114,700	$0	$0	$114,700	$229,400	$114,700	$229,400	$229,400
Lime Softening Process Trian buildings and equipment maintenance	1	1	2016	0	Fair	1	$75,000	$0	$75,000	$75,000	$75,000	$75,000	$300,000	$375,000	$375,000	$375,000
HVAC Systems, Air Compressor (5 HP)	10	15	2007	3	Fair	2	$418,655	$0	$0	$0	$0	$0	$0	$2,093,275	$0	$0
Pumps & Motors, Small (<5hp) (e.g., sump pumps, sampling pumps, etc.)	-	10	2007	0	Fair	2	$71,688	$0	$71,688	$0	$0	$0	$71,688	$0	$71,688	$0
Painting	-	7	2007	0	Fair	1	$408,619	$0	$0	$0	$408,619	$0	$408,619	$0	$408,619	$408,619
VFDs for MFPs and HSPs	-	10	2007	0	Good	3	$782,828	$0	$782,828	$0	$0	$0	$782,828	$0	$782,828	$0
Backwash Strainer	1	20	2007	10	Good	3	$3,000	$0	$0	$0	$0	$0	$0	$0	$3,000	$0
Cartridge Vessels	4	30	2007	20	Good	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Vertical Turbine Membrane Pump 1, 2, 3, & 4 (300 HP)	4	20	2007	10	Good	3	$437,500	$0	$0	$0	$0	$0	$0	$0	$1,750,000	$0
Vertical Turbine Membrane Pump Motor 1,2,3 & 4 (300 HP)	4	20	2007	10	Good	2	$20,000	$0	$0	$0	$0	$0	$0	$0	$80,000	$0
Deep Injection Well	1	50	2007	35	Good	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Degasifier Casing	2	50	2007	35	Good	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Clearwell Motorize Mixer 1, 2, 3 (3 HP)	3	20	2007	10	Good	3	$9,000	$0	$0	$0	$0	$0	$0	$0	$27,000	$0
Transfer Pump 1,2, & 3 (60 HP)	3	20	2007	10	Good	3	$50,000	$0	$0	$0	$0	$0	$0	$0	$150,000	$0
Clearwell	1	50	2007	40	Good	4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Ground Storage Tank	2	50	2007	40	Good	4	$2,000,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
High Service Pumps 1, 2, 3, 4, & 5 (250 HP)	5	20	2007	10	Good	3	$375,000	$0	$0	$0	$0	$0	$0	$0	$1,875,000	$0
High Service Pump Motor 1,2,3,4 & 5 (250 HP)	5	20	2007	10	Good	3	$18,750	$0	$0	$0	$0	$0	$0	$0	$93,750	$0
Aqueous Ammonia Transfer Pump/Motor 1 & 2 (0.5 HP)	2	20	2007	10	Good	3	$1,250	$0	$0	$0	$0	$0	$0	$0	$2,500	$0
Antiscalant Transfer Pump/Motor (0.5 HP)	1	20	2007	10	Good	3	$1,250	$0	$0	$0	$0	$0	$0	$0	$1,250	$0
Corrosion Inhibitor Transfer Pump/Motor (0.5 HP)	1	20	2007	10	Good	3	$1,250	$0	$0	$0	$0	$0	$0	$0	$1,250	$0
Air Stripper Fans Motor 1 & 2 (50 HP)	2	20	2007	10	Good	3	$3,750	$0	$0	$0	$0	$0	$0	$0	$7,500	$0
Cleaning Pump (40 HP)	1	20	2007	10	Good	3	$31,250	$0	$0	$0	$0	$0	$0	$0	$31,250	$0
Cleaning Pump Motor (40 HP)	1	20	2007	10	Good	3	$3,750	$0	$0	$0	$0	$0	$0	$0	$3,750	$0
Fluoride Transfer Pump 1 &2 (0.5 HP)	2	20	2007	10	Good	3	$1,250	$0	$0	$0	$0	$0	$0	$0	$2,500	$0
Fluoride Transfer Pump Motor 1 &2 (0.5 HP)	2	20	2007	10	Good	3	$1,250	$0	$0	$0	$0	$0	$0	$0	$2,500	$0
Concentrate Booster Pump 1,2 & 3 (50 HP)	3	20	2007	10	Good	3	$37,500	$0	$0	$0	$0	$0	$0	$0	$112,500	$0
Concentrate Booster Pump Motor 1,2 & 3 (50 HP)	3	20	2007	10	Good	3	$37,500	$0	$0	$0	$0	$0	$0	$0	$112,500	$0
Concentrate Disposal Pump/Motor 4 (50 HP)	1	20	2007	10	Good	3	$37,500	$0	$0	$0	$0	$0	$0	$0	$37,500	$0
Motorized Strainer (0.25 HP)	1	20	2007	10	Good	3	$10,000	$0	$0	$0	$0	$0	$0	$0	$10,000	$0
Sodium Hydroxide Transfer Pump (2HP)	2	20	2007	10	Good	3	$2,500	$0	$0	$0	$0	$0	$0	$0	$5,000	$0
Sodium Hypochlorite Transfer Pump/Motor 1&2 (5 HP)	2	20	2007	10	Fair	3	$6,250	$0	$0	$0	$0	$0	$0	$0	$12,500	$0
Sulfuric Acid Transfer Pump/Motor 1&2 (3 HP)	2	20	2007	10	Fair	3	$2,500	$0	$0	$0	$0	$0	$0	$0	$5,000	$0
Total								**$0**	**$2,999,645**	**$5,179,005**	**$2,189,781**	**$2,039,238**	**$12,407,669**	**$11,752,522**	**$16,956,002**	**$10,047,793**

Notes:

*Based on City Operations Staff Knowledge

[1] See CUSMP Section UW3-Plants Electrical Study for detailed R&R Electrical Needs

[2] The chemical storage tanks will replaced during Project No. WA5C-2 due to sizing constraintints

Priority: 1=High, 2=Medium, 3=Low, 4=To be revaluated during subsequent master plans

8.3 Distribution R&R Needs

8.3.1 R&R Prioritization Criteria

The Fiveash and Peele-Dixie WTP high service pumps deliver water through 750 miles of distribution system pipelines, 34 interconnects, as well as a 1 MGD elevated tank and pump at Northwest 2nd Avenue, and a 2 MGD ground storage tank and pump station at Poinciana Park. The performance of the distribution system relates directly to providing sufficient service to the City's water customers. The City's distribution pipelines range in diameter from 1.25 inches to 60 inches.

The distribution system was assessed for R&R needs on a likelihood of failure basis. For pipelines, physical conditions such as the material of the pipe, the installation date and the level of service requirements for capacity make up the basis for likelihood of failure score. The City's GIS and the CUSMP Team's hydraulic model results were used as sources of information for determining the likelihood of failure. The criteria and weighting for likelihood of failure are included in **Table WA8-6**.

Table WA8-6. Likelihood of Failure of Pipe

Category	Basis	Weighting	Low Probability				High Probability
			1	2	3	4	5
Likelihood of Failure	Pipe Material[2]	40%	PVC or HDPE	DIP	Unknown	RCP, GIP, GSP	PCCP, VCP, CIP
	Installation Date	40%	2000 or later	1990-2000	1980-1990, Unknown	1970-1980	Earlier than 1970
	LOS Require-ments[1]	20%	Velocity < 5 fps (Meets LOS requirements)	--	Velocity 5-6 fps (Near LOS requirements)	--	Velocity > 6 fps (Fails LOS requirements)

[1] Level of service assessed from the 2015 Peak Hour Flow output.
[2] Pipe Material Acronyms: Polyvinyl Chloride (PVC), High-Density Polyethylene (HDPE), Ductile Iron Pipe (DIP), Reinforced Concrete Pipe (RCP), Galvanized Iron Pipe (GIP), Galvanized Steel Pipe (GSP), Prestressed Concrete Cylinder Pipe (PCCP), Vitrified Clap Pipe (VCP), Cured-In-Place Pipe (CIP).

8.3.2 R&R Assessment and Analysis

R&R was assessed for large diameter (24" and greater) distribution pipe based on a risk analysis that included the combination of likelihood of failure and consequence of failure documented in **Section WA14**. R&R was assessed for small (less than 12") and intermediate (12" to 20") diameter distribution pipe using only the likelihood of failure criteria listed above. The relevant small and intermediate diameter pipe data dictated likelihood of failure categories as defined below:

- Likelihood Score (1-2) "Low Likelihood of Failure": The asset has a low likelihood of failure and should be monitored and maintained per typical standards; no other action needs to be taken.
- Likelihood Score (2-3) "Low-Moderate Likelihood of Failure": The asset should be maintained per the usual schedule; no other action is required.

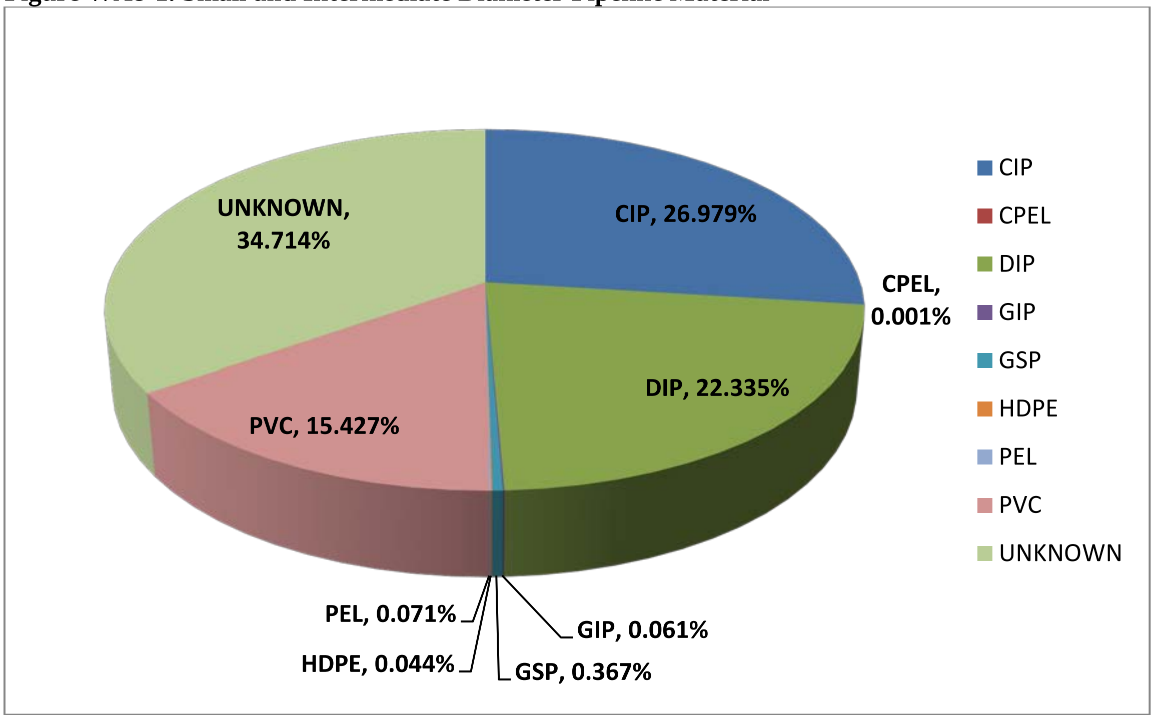
Section WA8 accepted March 29, 2017.

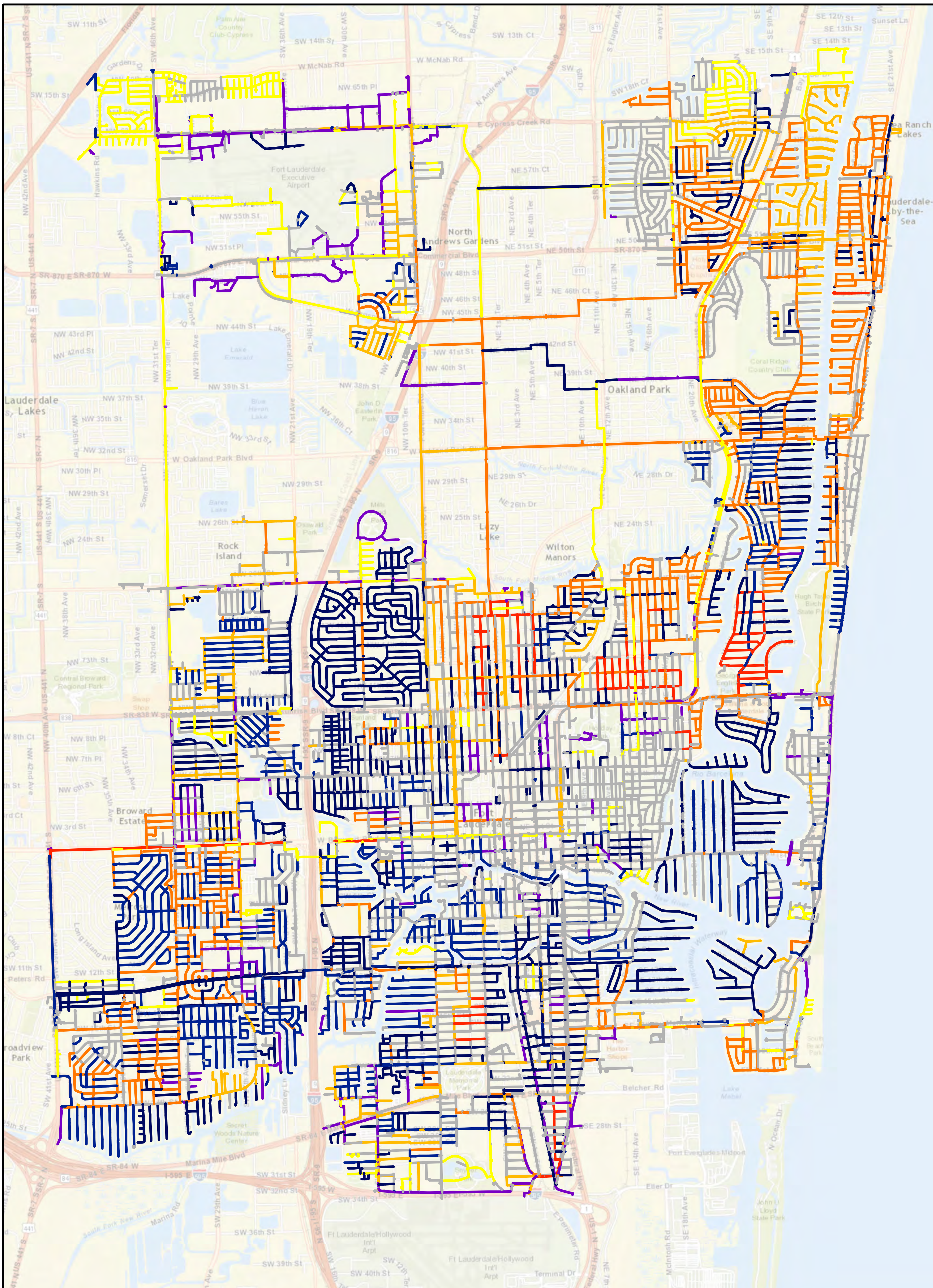
- Likelihood Score (3-4) “Moderate-High Likelihood of Failure”: The asset is at risk of failure and should be rehabilitated or replaced within the planning period.
- Likelihood Score (4-5) “High Likelihood of Failure”: The asset has a high likelihood of failure and should be rehabilitated or replaced within the next five years.

8.3.3 R&R Assessment Results

From **Figure WA8-1** it can be seen that almost 35% of the small and intermediate diameter (24 inches and below) is of unknown material, the most prevalent materials are cast iron pipe (CIP), ductile iron pipe (DIP) and polyvinyl chloride pipe (PVC). The majority of the small and intermediate diameter pipe was installed before 1970 or has an unknown installation date, as can be seen in **Figure WA8-2**. **Figure WA8-3** shows that almost two-thirds (64%) of the large diameter pipe in the system is DIP. A significant portion is CIP and almost a quarter of the pipes are of unknown material. Much of the large diameter CIP was installed before 1970. Inspections would allow for an assessment of the remaining service life. Based on the likelihood of failure results, the City should be budgeting funds to address the most critical of these pipes during the next 5 to 10 years and a significant portion of the small and intermediate diameter pipes over the next 20 years. Corrosion of pipes should also be considered when assessing, renewing and replacing pipes in the distribution system. The external corrosion of pipe is determined by the corrosiveness of the soil. Corrosiveness is largely determined by resistivity; if resistivity is low, then corrosivity is high. Resistivity is directly related to the moisture and salt content of a soil; therefore, high groundwater tables and saltwater intrusion could exacerbate degradation of metallic pipes such as DIP and CIP. **Figure WA8-4** presents a map of the City’s potable water distribution system with small and intermediate diameter pipes in the system categorized by material, and **Figure WA8-5** shows the large diameter pipes categorized by material. The results of the large diameter potable water main likelihood of failure scores are shown in **Figure WA8-6** for small and intermediate diameter pipes and **Figure WA8-7** for large diameter pipes.

Figure WA8-1. Small and Intermediate Diameter Pipeline Material





Legend

Pipeline Installation Date

- Unknown
- 1940-1949
- 1950-1959
- 1960-1969
- 1970-1979
- 1980-1989
- 1990-1999
- 2000 or Later

0 0.5 1
Miles

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY SERVICE STRATEGIC MASTER PLAN
Potable Water System: Pipeline Installation Date

FIGURE WA8-2

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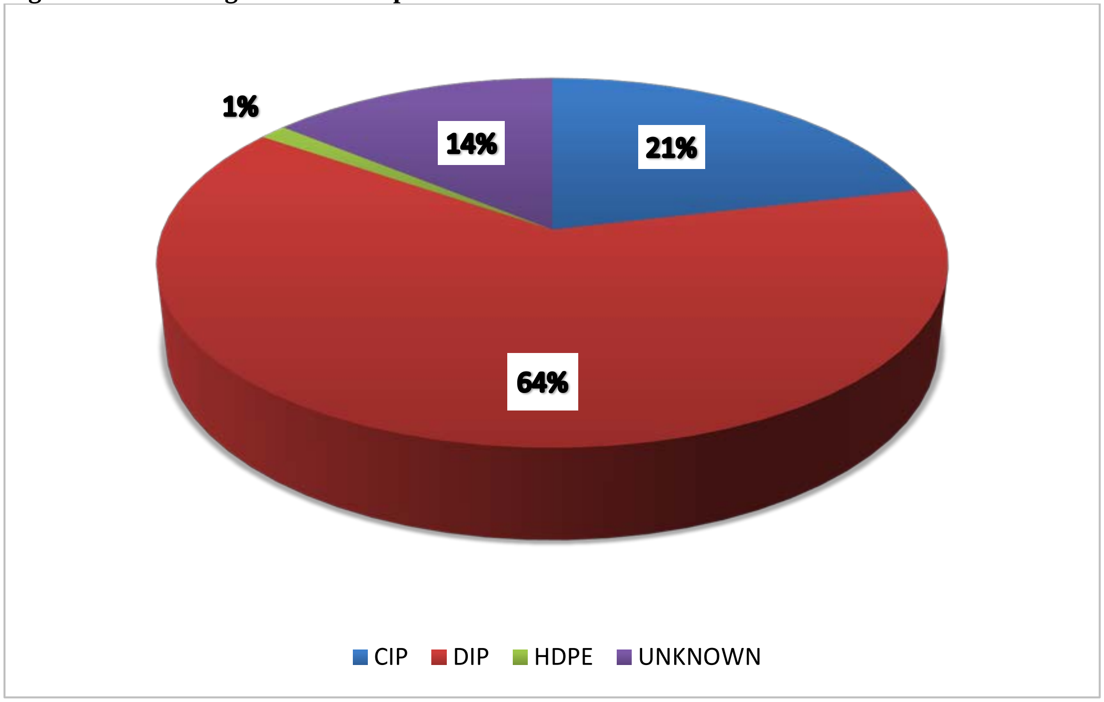
Figure WA8-3. Large Diameter Pipeline Material



Section WA8 accepted March 29, 2017.

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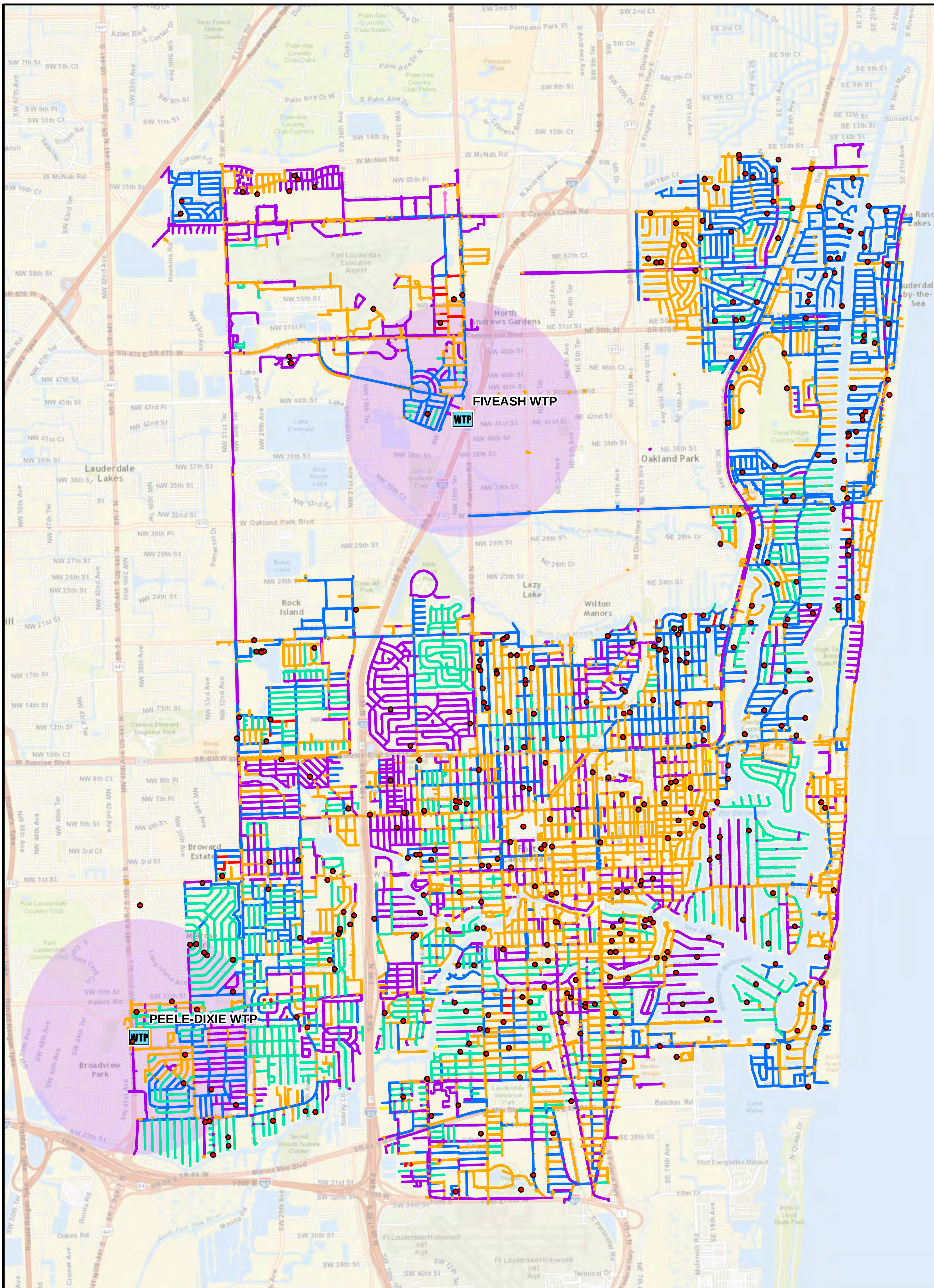

N
W E
S

0 0.5 1
Miles

Legend

Small Diameter Water Main
Material
- Unknown
- Cast Iron
- Ductile Iron
- High Density Polyethylene
- Galvanized Iron
- Galvanized Steel
- Polyethylene
- Polyvinyl Chloride

Water Pipe Breaks (Jan 2010-Jan 2014)
WTP **Water Treatment Plant**
WTP 1-Mile Buffer

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
Potable Water System: Small Diameter Pipe Materials

FIGURE WA8-4

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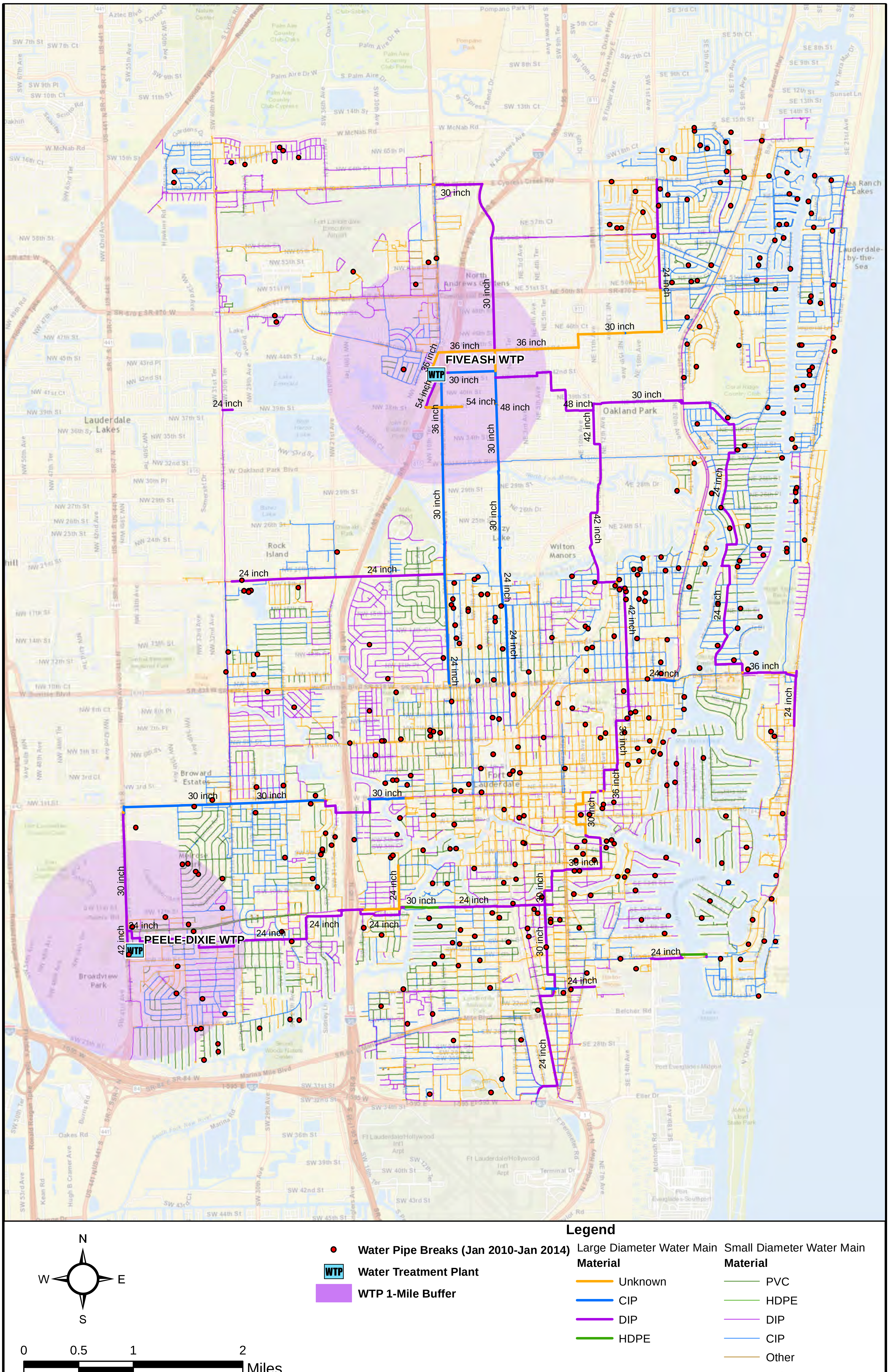


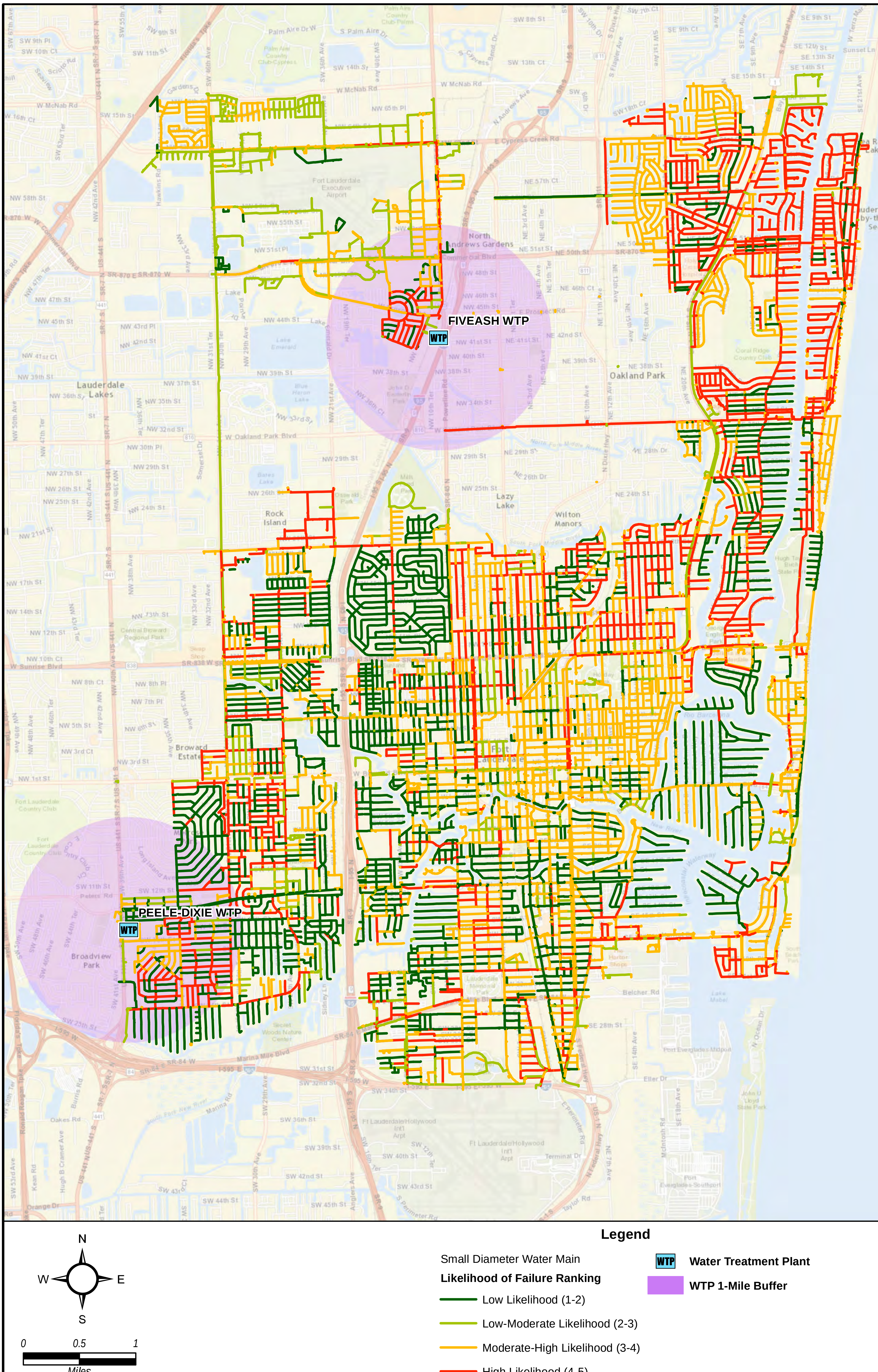
CITY OF FORT LAUDERDALE

COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

Potable Water System: Large Diameter Pipe Materials

FIGURE WA8-5

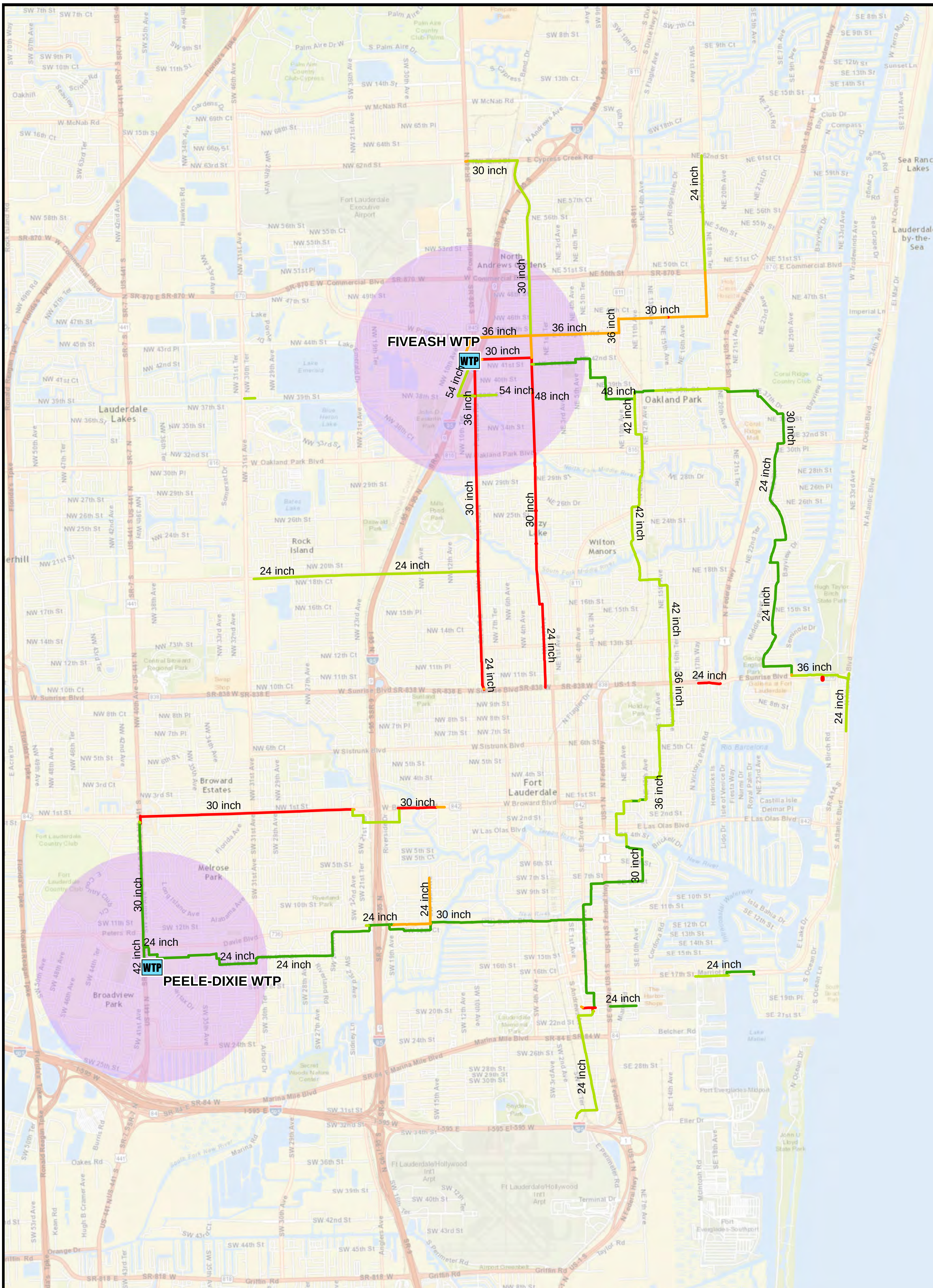
G:\0gis\134001 - FTL Master Plan_MXDs\WA8\WA8_LargeDiamPipeMaterial.mxd



CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
Potable Water System: Small Diameter Likelihood of Failure

FIGURE WA8-6

G:\0gis\134001 - FTL Master Plan_MXDs\WA8\WA8_SmallDiamPipe_LikelihoodRanking.mxd



Legend

Large Diameter Water Main Risk

Likelihood of Failure Rank

- Low Likelihood (1-2)
- Low-Moderate Likelihood (2-3)
- Moderate-High Likelihood (3-4)
- High Likelihood (4-5)

- **Water Treatment Plant**
- **WTP 1-Mile Buffer**

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

Potable Water System: Large Diameter Pipe Likelihood of Failure

FIGURE WA8-7

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8.3.4 R&R Recommendations

Small and intermediate diameter pipes in the water distribution system with high risk (4-5) likelihood of failure scores were used to estimate the cost of R&R for the 20-year planning period. The distribution system was divided up into six (6) zones to estimate the cost of R&R projects. **Figure WA8-8** shows the zones and small and intermediate diameter pipes within each zone. **Tables WA8-7** through **WA8-12** summarize each zone's small and intermediate diameter pipes recommended for R&R by diameter and estimates a capital cost based on total length for each diameter. **Table WA8-13** presents the capital cost for all of the City and REI distribution R&R projects including large and small/intermediate diameter improvements based on the six (6) zones. The capital cost for small/intermediate diameter improvements' zones 1 through 6 was divided across the 20-year planning period and adjusted to meet the suggested annual water distribution R&R investment of 10 million dollars per year. The large diameter pipes were assessed and prioritized in **Section WA14's** risk analysis. Using the City's existing prioritized list of R&R improvements, the CUS Master Plan Team met with key City distribution operations and maintenance staff to jointly update and prioritize R&R improvements for the potable water distribution system that are included in the Water CIP **Section WA7**. These recommendations were made based on best available knowledge at the time of the section development, additional analysis may need to be completed for items not included in the section.

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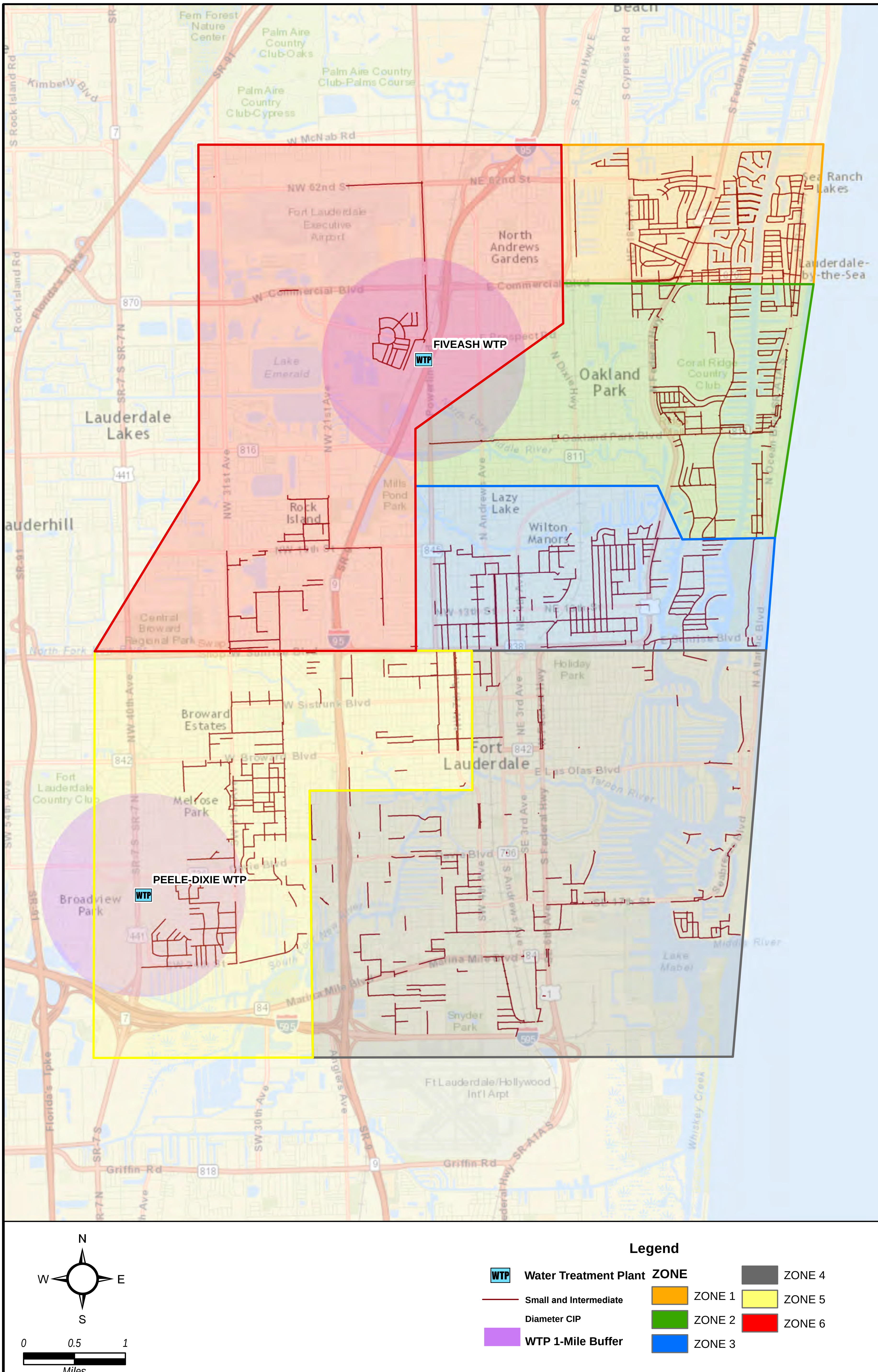

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN Potable Water System: Small and Intermediate Diameter CIP

FIGURE WA8-8

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Table WA8-7. Small and Intermediate Diameter Water Main Zone 1 R&R Capital Cost Estimate

Diameter (in)	Total Length (LF)	Cost$/LF	Total Cost
2	1,401	219	$306,894
4	15,302	233	$3,565,420
6	118,160	248	$29,303,786
8	33,530	264	$8,852,039
10	10,294	280	$2,882,248
12	7,135	290	$2,069,014
16	1,880	360	$676,915
20	5,170	380	$1,964,540
		Total:	$49,620,856

Table WA8-8. Small and Intermediate Diameter Water Main Zone 2 R&R Capital Cost Estimate

Diameter (in)	Total Length (LF)	Cost$/LF	Total Cost
2	467	219	$102,165
3	20	226	$4,520
4	6,830	233	$1,591,335
6	87,460	248	$21,690,082
8	27,586	264	$7,282,583
10	8,055	280	$2,255,386
12	5,271	290	$1,528,719
16	26,033	360	$9,372,040
		Total:	$43,826,830

Table WA8-9. Small and Intermediate Diameter Water Main R&R Zone 3 Capital Cost Estimate

Diameter (in)	Total Length (LF)	Cost$/LF	Total Cost
2	279	219	$61,033
4	971	233	$226,268
6	120,591	248	$29,906,540
8	26,578	264	$7,016,562
10	5,437	280	$1,522,411
12	6,379	290	$1,849,909
16	1,876	360	$675,530
20	12,951	380	$4,921,303
		Total:	$46,179,557

Table WA8-10. Small and Intermediate Diameter Water Main R&R Zone 4 Capital Cost Estimate

Diameter (in)	Total Length (LF)	Cost$/LF	Total Cost
2	563	219	$123,348
4	5,871	233	$1,367,845
6	81,498	248	$20,211,397
8	27,953	264	$7,379,659
10	7,849	280	$2,197,748
12	16,290	290	$4,724,205
16	12,893	360	$4,641,382
18	4,007	370	$1,482,512
20	1,667	380	$633,342
		Total:	$42,761,438

Table WA8-11. Small and Intermediate Diameter Water Main R&R Zone 5 Capital Cost Estimate

Diameter (in)	Total Length (LF)	Cost$/LF	Total Cost
2	346	219	$75,862
4	1,599	233	$372,605
6	125,544	248	$31,134,907
8	27,366	264	$7,224,689
10	4,254	280	$1,191,097
12	5,065	290	$1,468,875
16	4,159	360	$1,497,319
20	5,051	380	$1,919,231
		Total:	$44,884,585

Table WA8-12. Small and Intermediate Diameter Water Main R&R Zone 6 Capital Cost Estimate

Diameter (in)	Total Length (LF)	Cost$/LF	Total Cost
2	160	219	$34,984
4	5,079	233	$1,183,515
6	44,661	248	$11,076,006
8	5,035	264	$1,329,303
10	13,952	280	$3,906,678
12	13,848	290	$4,016,000
18	21	370	$7,951
		Total:	$21,554,438

Table WA8-13. Potable Water Distribution System 2015 Renewal and Replacement Requirement An

Project	City/REI Project #	Pipe Diameter	Quantity (linear feet)	Year Purchased/ Rehabbed	Priority[3]	FY2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2021-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total
Water Distribution R&R Projects - City Funded	Varies	Varies	Varies	--	1	$1,826,750	$9,081,750	$4,723,500	$2,816,000	$8,860,698	$27,308,698			
Water Distribution R&R Projects - City Unfunded	Varies	Varies	Varies	--	1	$3,627,000	$3,627,000	$3,627,000	$3,627,000	$3,627,000	$18,135,000			
E Broward Boulevard From Federal Highway To Victoria Park Road - 12" CIP WaterMain[2]	--	12"	4,147	1949	1		$1,503,288				$1,503,288			
N Andrews Avenue and the FEC Railway - 16" CIP WaterMain[2]	--	16"	550	1949	1		$247,500				$247,500			
Water Distribution R&R Projects (WA14-1 - WA14-9)	WA14-1 - WA14-9	Varies	Varies	--	2			$554,600			$554,600	$1,533,200	$7,679,330	$21,187,270
Water Distribution R&R - Zone 1 Small/Intermediate Diameter[1]	--	< 24"	See Note 1	Varies	1-2							$16,540,285	$16,540,285	$16,540,285
Water Distribution R&R - Zone 2 Small/Intermediate Diameter[1]	--	< 24"	See Note 1	Varies	1-2							$14,608,943	$14,608,943	$14,608,943
Water Distribution R&R - Zone 3 Small/Intermediate Diameter[1]	--	< 24"	See Note 1	Varies	1-2							$15,393,186	$15,393,186	$15,393,186
Water Distribution R&R - Zone 4 Small/Intermediate Diameter[1]	--	< 24"	See Note 1	Varies	1-2							$14,253,813	$14,253,813	$14,253,813
Water Distribution R&R - Zone 5 Small/Intermediate Diameter[1]	--	< 24"	See Note 1	Varies	1-2							$14,961,528	$14,961,528	$14,961,528
Water Distribution R&R - Zone 6 Small/Intermediate Diameter[1]	--	< 24"	See Note 1	Varies	1-2							$7,184,813	$7,184,813	$7,184,813
Total						**$5,453,750**	**$14,459,538**	**$8,905,100**	**$6,443,000**	**$12,487,698**	**$47,749,086**	**$84,475,768**	**$90,621,898**	**$104,129,838**

[1] See Small & Intermidiate Diameter Pipe Section in WA.8 Report for details on linear quantity and pipe diameter

[2] From City's D&C Project Collection that are not included in City's current CIP

[3] Priority: 1=High, 2=Medium, 3=Low, 4=To be Evaluated During Subsequent Master Plans

8.4 Finished Water Storage R&R Needs

The two remote (distribution) storage and pump stations, Poinciana Park Water Tank and Pump Station and the Northwest 2nd Avenue Water Tank and Pump Station, have a nominal total of 2.5 MG of distribution water storage. The City replaced the Poinciana Park storage tank in 2006, and rehabilitated the 2nd Avenue pump station in 2012.

The Poinciana Park Water Tank and Pump Station is located at 2011 Southeast 4th Avenue, Fort Lauderdale, FL. The pumping station contains two pumps: Pump No. 1 is a high pressure low flow (relative to Pump No. 2) pump. Pump No. 2 is a low pressure high flow pump (relative to Pump No. 1). Both pumps are horizontal split case, 150-HP pumps equipped with variable frequency drives (VFDs). The Poinciana Park Water Tank and Pump Station uses diesel fuel for the backup power generator.

The Northwest 2nd Ave Water Tank and Pump Station is located at 625 Northwest 2nd Ave, Fort Lauderdale, FL. The pumping station currently has one horizontal split case, 200-HP pump. This pump station was upgraded in 2012 and the work included replacing the existing pump with a higher capacity pump, along with associated piping, electrical, and control improvements.

Most of the City's finished water storage is relatively new and has not reached the end of its useful life. The CUS Master Plan Team met with key City operations and maintenance staff to jointly create and prioritize R&R improvements for the finished water storage system. **Table WA8-14** illustrates the updated 2015 Renewal and Replacement requirement analysis and the anticipated schedule and expenditures. The most critical R&R project for the finished water storage is the rehabilitation of the Northwest 2nd Ave 1.0 MG Tank, which is summarized in **Table WA8-14**. For specific electrical R&R needs, please refer to **Section UW3**.

Table WA8-14. Finished Water Storage 2015 Renewal and Replacement Requirement Analysis (2015 Dollars)

Item	Quantity	Useful Life (Years)	Year Purchased/ Rehabbed	Remaining Useful Life (Years)	Condition (Good, Fair, Poor)*	Priority	Unit Cost (2015 $)	FY2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2021-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total
Poinciana Elevated Storage Tank & Pump Station																
Poinciana Pump/Motor No. 1 (150 HP)	1	20	2007	12	Good	2	$860,250	$0	$0	$0	$0	$0	$0	$0	$860,250	$0
Poinciana Pump/Motor No. 2 (150 HP)	1	20	2007	12	Good	2	$860,250	$0	$0	$0	$0	$0	$0	$0	$860,250	$0
Check Valves	1	30	2007	22	Good	4	$18,750	$0	$0	$0	$0	$0	$0	$0	$0	$0
Magnetic Flow Meter	1	20	2007	12	Good	2	$3,500	$0	$0	$0	$0	$0	$0	$0	$3,500	$0
Pressure Gauges	1	1	2007	0	Good	1	$1,250	$0	$1,250	$1,250	$1,250	$1,250	$5,000	$6,250	$6,250	$6,250
Pressure Transmitter	1	10	2007	2	Good	1	$625	$0	$625	$0	$0	$0	$625	$0	$625	$0
Poinciana VFD_6201	1	10	2015	9	Good	1	$8,750	$0	$0	$0	$0	$0	$0	$8,750	$0	$8,750
Poinciana VFD_6202	1	10	2015	9	Good	1	$8,750	$0	$0	$0	$0	$0	$0	$8,750	$0	$8,750
Poinciana 2.0 MG Tank	1	50	2007	42	Good	4	$375,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Basket Strainer 16" SS	1	20	2007	12	Good	2	$50,000	$0	$0	$0	$0	$0	$0	$0	$50,000	$0
Tank Fill Valve	1	30	2007	22	Good	4	$5,625	$0	$0	$0	$0	$0	$0	$0	$0	$0
Level Control Valve	1	30	2007	22	Good	4	$16,875	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tank Level Transmitter	1	10	2007	2	Good	1	$1,875	$0	$1,875	$0	$0	$0	$1,875	$0	$1,875	$0
Poinciana Generator and Engine	1	20	2007	12	Good	2	$62,500	$0	$0	$0	$0	$0	$0	$0	$62,500	$0
Diesel Fuel Storage Tank	1	15	2007	7	Good	2	$3,750	$0	$0	$0	$0	$0	$0	$3,750	$0	$0
Poinciana Park Bridge Crane	1	20	2007	12	Good	2	$33,375	$0	$0	$0	$0	$0	$0	$0	$33,375	$0
Trolley Hoist	1	20	2007	12	Good	1	$8,250	$0	$0	$0	$0	$0	$0	$0	$8,250	$0
Exhaust Fans	-	15	2007	7	Good	2	$1,875	$0	$0	$0	$0	$0	$0	$1,875	$0	$0
Air Handling Unit	1	15	2007	7	Good	2	$3,750	$0	$0	$0	$0	$0	$0	$3,750	$0	$0
Air Cooled Condensing Unit	1	15	2007	7	Good	2	$4,188	$0	$0	$0	$0	$0	$0	$4,188	$0	$0
Hardware Components	-	7	2007	0	Good	1	$50,000	$0	$0	$50,000	$0	$0	$50,000	$50,000	$0	$50,000
Software Components	-	3	2007	0	Good	1	$68,750	$0	$68,750	$0	$0	$68,750	$137,500	$68,750	$137,500	$137,500
Main Circuit Breaker	1	20	2007	12	Good	2	$7,500	$0	$0	$0	$0	$0	$0	$0	$7,500	$0
Automatic Transfer Switch ATS_5301	1	20	2007	12	Good	2	$9,125	$0	$0	$0	$0	$0	$0	$0	$9,125	$0
Power Distribution Panel PNL_5301	1	20	2007	12	Good	2	$100,000	$0	$0	$0	$0	$0	$0	$0	$100,000	$0
Transformer_XFRMR5601	1	15	2007	6	Good	1	$3,500	$0	$0	$0	$0	$0	$0	$3,500	$0	$0
Emergency Generator Set DG_5403	1	20	2007	12	Good	3	$562,500	$0	$0	$0	$0	$0	$0	$0	$562,500	$0
Northwest 2nd Ave Elevated Storage Tank & Pump Station							**SUBTOTAL**	$0	$72,500	$51,250	$1,250	$70,000	$195,000	$159,563	$2,703,500	$211,250
Northwest 2nd Ave Pump/Motor (200 HP)	1	20	2012	17	Good	3	$850,000	$0	$0	$0	$0	$0	$0	$0	$0	$850,000
Northwest 2nd Ave 1.0 MG Tank	1	50	1950's	0	Poor	1	$1,000,000	$0	$0	$0	$0	$0	$0	$0	$750,000	$0
Pump Suction Pressure Switch	1	10	2012	27	Good	4	$875	$0	$0	$0	$0	$0	$0	$875	$0	$875
Pump Suction Pressure Gauge	1	1	2012	0	Good	1	$250	$0	$250	$250	$250	$250	$1,000	$1,250	$1,250	$1,250
Pump Discharge Pressure Switch	1	10	2012	7	Good	2	$875	$0	$0	$0	$0	$0	$0	$875	$0	$875
Pump Discharge Pressure Gauge	1	1	2012	0	Good	1	$250	$0	$250	$250	$250	$250	$1,000	$1,250	$1,250	$1,250
Pump Discharge Pressure Transmitter	1	10	2012	7	Good	2	$750	$0	$0	$0	$0	$0	$0	$750	$0	$750
Pressure Control Valve (Included Solenoid Valve and Pilot Control Valve)	1	30	2012	27	Good	4	$19,375	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tilting Disk Check Valve	1	30	2012	27	Good	4	$30,000	$0	$0	$0	$0	$0	$0	$0	$0	$0
Check Valve Limit Switch	1	10	2012	7	Good	2	$1,750	$0	$0	$0	$0	$0	$0	$1,750	$0	$1,750
Transmission System Pressure Transmitter	1	10	2012	7	Good	2	$875	$0	$0	$0	$0	$0	$0	$875	$0	$875
Tank Water Level Indicator	1	10	2012	27	Good	4	$1,250	$0	$0	$0	$0	$0	$0	$1,250	$0	$1,250
Pump Station Flow Indicator	1	10	2012	27	Good	4	$10,000	$0	$0	$0	$0	$0	$0	$10,000	$0	$10,000
Flow Meter	1	20	2012	17	Good	3	$10,000	$0	$0	$0	$0	$0	$0	$0	$0	$10,000
Tank Fill Valve	1	30	2012	27	Good	4	$5,625	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pressure Gauge (downstream of Altitude Valve)	1	1	2012	0	Good	1	$400	$0	$400	$400	$400	$400	$1,600	$2,000	$2,000	$2,000
Pressure Gauge (between Tank Fill & Altitude Valve)	1	1	2012	0	Good	1	$400	$0	$400	$400	$400	$400	$1,600	$2,000	$2,000	$2,000
Pressure Gauge (measures transmission system)	1	1	2012	0	Good	1	$400	$0	$400	$400	$400	$400	$1,600	$2,000	$2,000	$2,000
Local Control Panel	1	20	2012	17	Good	2	$9,375	$0	$0	$0	$0	$0	$0	$0	$0	$9,375
Hardware Components	-	7	2012	0	Good	1	$50,000	$0	$0	$0	$50,000	$0	$50,000	$0	$50,000	$50,000
Software Components	-	3	2012	0	Good	1	$68,750	$0	$68,750	$0	$0	$68,750	$137,500	$68,750	$137,500	$137,500
Operator Interface Terminal	1	10	2012	7	Good	2	$11,250	$0	$0	$0	$0	$0	$0	$11,250	$0	$11,250
Utility Transformer	1	15	2012	11	Good	2	$187,500	$0	$0	$0	$0	$0	$0	$0	$187,500	$0
Utility Meter	1	10	2012	7	Good	2	$1,500	$0	$0	$0	$0	$0	$0	$1,500	$0	$1,500
Current Transformer	1	15	2012	11	Good	2	$3,000	$0	$0	$0	$0	$0	$0	$0	$3,000	$0
Motor Control Center	1	20	2012	17	Good	3	$45,000	$0	$0	$0	$0	$0	$0	$0	$0	$45,000
Transformer	1	15	2012	11	Good	2	$7,500	$0	$0	$0	$0	$0	$0	$0	$7,500	$0
Lighting Panel	1	20	2012	17	Good	3	$3,125	$0	$0	$0	$0	$0	$0	$0	$0	$3,125
Dechlorinator Tablet Feeder	1	10	2012	7	Good	3	$3,750	$0	$0	$0	$0	$0	$0	$3,750	$0	$3,750
Air Conditioner	1	15	2012	12	Good	3	$6,250	$0	$0	$0	$0	$0	$0	$0	$6,250	$0
Total								**$0**	**$70,450**	**$1,700**	**$51,700**	**$70,450**	**$194,300**	**$110,125**	**$1,150,250**	**$1,146,375**

Notes:

Priority: 1=High, 2=Medium, 3=Low, 4=To be revaluated during subsequent master plans

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WA9 Water Conservation

Water conservation is a key part of the City's water supply strategy. Due to increasing water demand from population growth and water supply stress resulting from climate change, most water agencies are ready to prepare for those issues and initiate strategic planning for water conservation. The Department of Energy has prepared a new report – *The Water-Energy Nexus: Challenges and Opportunities* – that examines the interaction between present-day energy and water systems. Water is necessary in all phases of energy production and electricity generation, and energy is required to extract, convey and deliver water prior to its return to the environment. Constraints on water can challenge the reliability of existing operations as well as the physical, economic, and environmental viability of future projects. Water is facing rising demands and constraints in the City of Fort Lauderdale (City) because of economic and population growth and climate change. As a result, water conservation is vitally important to the City.

The City established an ultimate goal of reducing finished water demand to 170 gallons per person per day by the year 2028. The City has set water conservation initiatives as part of its strategic planning effort for achieving this goal. The City's water conservation plan has been effective for more than 25 years and there are 14 major ongoing water conservation activities. Those efforts are:

- Broward Water Partnerships;
- ConservationPay$ Program;
- NatureScape Irrigation Services;
- Water Matters Day;
- Conservation Rate;
- Florida-Friendly Landscaping Structure;
- Florida-Friendly Landscaping;
- Irrigation System Design Code;
- Landscape Irrigation Restrictions;
- Water Conservation Education Program;
- Sustainability Action Plan 2011 Update;
- 2035 Fast Forward Vision Plan;
- 2018 Press Play Strategic Plan.
- New Utility Rates (Effective 10/1/2015)

(Source: http://www.fortlauderdale.gov/documents/pzb/2014/111914/T14011_web.pdf.)

9.1 Water Conservation Methods

Water conservation techniques can be divided into two categories: price-based and non-price based. Price-based water conservation techniques include approaches that directly involve a change in water price to the public; for example, a conservation rate structure technique that has progressively higher rates as water usage increases. Non-price based water conservation techniques include approaches such as required or voluntary adoption of water-conserving technologies, mandatory water-use restrictions, educational programs, and other programs that do not directly involve a change in the price of water to the public. According to *Managing Water Demand Price vs. Non-Price Conservation Programs (2007),* price-based techniques tend to be more cost-effective than non-price based methods. For example, a recent study of twelve (12) cities in the United States and Canada shows that replacing two-days-per-week outdoor watering restrictions with drought pricing could achieve the same level of total water savings, along with welfare gains of approximately $81 per household per summer drought. Although more cost-effective, price-based water conservation techniques are usually more difficult to implement because of the political effort and ramifications associated with increasing water prices.

Water prices can be shaped in a variety of ways to achieve water conservation. Unmetered consumption is the water used by customers without being volumetrically measured by meters; therefore, customers only pay a flat fee, usually monthly. However, unmetered consumption is not advisable because customers have no incentive to conserve water nor are they penalized for

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using too much. Metered consumption can be priced in four different ways: uniform rate, increasing block (current City structure), decreasing block, and seasonal. Under a uniform rate pricing structure, customers are charged the same price per gallon consumed regardless of how much or how little water they consume. If the price structure is in increasing blocks, the more water is consumed per billing period, the higher the cost per gallon. Decreasing block pricing structure is the actual rate price reflecting per unit costs of production and delivery that go down as customers consume more water. Lastly, seasonal water charges, as implied by the name, varies unit water pricing during the dry and wet seasons; water will cost more during the dry season and less during the wet season. **Table WA9-1** presents the price structures and their conservation effectiveness.

Table WA9-1. Price Structure Summary

Price Structures that Encourage Conservation	
Increasing block rates	Increasing block rates reduces water use by increasing the per-unit charges for water as the amount used increases. The first block is charged at one rate, the next block is charged at a higher rate, and so forth. The City currently uses this structure.
Seasonal rates	Prices rise and fall according to water demands and weather conditions (with higher prices usually occurring in the dry months).
Price Structures that are Less Effective in Encouraging Conservation	
Uniform rate structures	A uniform rate charges the same price-per-unit for water usage beyond the fixed customer charge, which covers some fixed costs. The rate sends a price signal to the customer because the water bill will vary by usage. Uniform rates by class charge the same price-per-unit for all customers within a customer class (e.g., residential or non-residential).
Decreasing block rates	The declining block rate structure provides cheaper water to high volume users with little incentive to conserve water.

Studies have shown estimated water savings attributed to non-price based conservation techniques, such as water restrictions and low-flow fixtures, vary from zero to significant savings. The actual water savings from non-price based are usually smaller than expected, due to customer behavioral responses. For example, customers may take longer showers with low-flow showerheads, flush multiple times with low-flow toilets, and water lawns longer under irrigation restrictions. Scholars concluded that non-price based conservation programs are effective if the water utility achieves a critical mass of programs over a period of time. While it’s difficult to quantify the effectiveness of non-price based conservation programs, mandatory and well-enforced policies are usually more successful than voluntary policies and educational programs. That said, non-price based conservation strategies including pumping pressure reductions are still critical components of a water conservation program.

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9.2 Evaluation of Current Water Conservation Program

The City of Fort Lauderdale has been promoting water conservation for more than 25 years. Conservation is a proven strategy for delaying or eliminating implementation of expensive alternative water supply technologies. Since 2009, the City's potable water demand per capita has decreased by 11%, from approximately 195 gpcd to 173 gpcd in 2015.

In an effort to protect critical natural resources, the City of Fort Lauderdale developed and published the Sustainability Action Plan (SAP), updated in 2015. Included in the SAP are action plans that, if accomplished, will assist the City to continue to achieve its water consumption goal of 170 gpcd. The SAP action plans include continuing to increase potable water fees in single-family zoning, requiring landscape that needs little watering, and engaging all large water users in constant water conservation techniques. The City currently uses an increasing block structure, where customers that consume more water pay more for each additional unit consumed. The City also encourages the use of Florida-friendly drought resistant vegetation and constantly informs wholesale customers about water conservation methods and opportunities.

The economic recession is the likely cause for some of the unit water consumption decline since 2009. However, the continued water consumption reduction from 2010 to 2014, accompanied by an increase in population, can be substantially attributed to the City's continuing conservation efforts. In 2014, the daily unit water consumption was 165 gpcd. Unit water consumption will be monitored closely to determine if this level is sustainable going forward, and not just a weather-related anomaly. With the large variety of water conservation methods currently in place and with the implementation of the recommendations discussed in this section, the objective is to continue to achieve or exceed the unit water consumption goal for the City during the planning period.

The City's current water conservation methods include a combination of price-based and non-price based programs. The large array of programs allows the City to reach a vast range of audiences; Water Matters Day is mainly directed towards families, and NatureScape Irrigation Services is directed towards owners of large properties such as golf courses. The water conservation programs discussed in this subsection as a whole (**Table WA9-2**) have been effective in decreasing the daily per capita water consumption. However, recommendations to increase their effectiveness include:

- Increasing the advertising of rebates for water efficient equipment.
- Providing water conservation educational content in the monthly bill sent to customers.
- Increasing the monitoring and enforcement of Code of Ordinances (City Law) water conservation requirements.
- Continued contributions and improvement to City building code standards for water efficient equipment.

In order to stimulate water conservation, the City uses an increasing block or "conservation rate" pricing structure. **Table WA9-2** displays the current monthly usage charges for potable water, as of October 1, 2015.

Table WA9-2. Potable Water Rate

Blocks	Consumption	Rate
Single Family (1,000 gallons per month per dwelling unit)		
Block 1	0-3,000	$2.00
Block 2	4,000-8,000	$4.43
Block 3	9,000-12,000	$ 5.53
Block 4	13,000-20,000	$ 7.47
Block 5	>20,000	$ 10.83
Multifamily Residential (1,000 gallons per month per dwelling unit)		
Block 1	0-1,000	$2.00
Block 2	2,000-3,000	$4.43
Block 3	4,000-5,000	$ 5.53
Block 4	6,000-8,000	$ 7.47
Block 5	>8,000	$ 10.83
Commercial		
Commercial	>1,000	$ 4.57
Master Meter (for each 1,000 gallons per month or fraction thereof)		
Master Meter	>1,000	$ 4.16

Source: City of Fort Lauderdale Public Works Department, October 1, 2015.

In addition to rates per 1,000 gallons consumed, customers are also required to pay a fixed monthly base charge that is directly related to the size of the meter; the base charge increases as the size of the meter increases. The same pricing structure, with different blocks and rates, also applies for sewer and irrigation meter accounts. **Table WA9-3** summarizes the water conservation programs currently adopted by the City.

Table WA9-3. Existing Water Conservation Programs

Water Conservation Program	Program Description
Price-Based:	
1. Conservation Rate Structure	Increasing block rate structure increases the price per unit of water as the consumption increases.
Non-Price Based:	
2. Broward Water Partnership	The Broward Water Partnership is a corporation between nineteen (19) municipalities within Broward County with the objective of saving water, providing water from other water source options (reclaimed water, ground water or salt water), and the environment. The City's ConservationPay$ Program, within the Partnership, provides up to $100.00 in toilet rebates for qualifying customers that exchange toilets that use more than 1.6 gallons of water per flush (gpf) for high efficiency toilets that use 1.28 gpf or less. During the 2014 fiscal year (FY2014) the City provided 247 toilet rebates. As of June 2015, the City has provided 176

Water Conservation Program	Program Description
	toilet rebates for the 2015 fiscal year (FY2015). Overall, 795 toilet rebates have been provided by the City since the beginning of the Program at a cost of approximately $79,500. The City estimates that the Partnership and the ConservationPay$ Program conserves approximately 23,450 gallons of water per day.
3. NatureScape Irrigation Services (NIS)	The program is led by Broward County and comprised of eighteen (18) municipalities and water utilities. The purpose of the NIS is to reduce water consumption and improve the quality of surface waters through efficient irrigation and Florida-friendly landscape practices. The NIS program focuses on large properties, such as government facilities, parks, schools, and multifamily residential complexes, where the effectiveness of water conservation can be maximized. The NIS program conserved totally 70,562,039 gallons of water from 2010 to 2014, which yields 17.6 million gallons per year.
4. Water Matters Day	Water Matters Day is an educational program with the main objective to decrease long-term water demand. The one-day annual event teaches participants the importance of water conservation through workshops that provide in-depth information. Additionally, participants receive rebates and incentives to exchange outdated devices for water-conserving devices.
5. Water Conservation Education Program	In addition to sponsoring Water Matters Day, the City also distributes brochures and literature on water conservation upon request. Additional information on water conservation is readily available to the public on the City's website.
6. Leak Detection	Between the years of 1990 and 1992, the City surveyed its entire water distribution system to detect and correct leaks. The City's field personnel continue to perform visual checks to ensure physical integrity.
7. Meter Replacement Program	The City continuously tests and replaces water meters that are more than 10 years old.
8. City's Code of Ordinances	Section 28-1B of the City's Code of Ordinances (Code) is devoted to water conservation measurements adopted by the City. Included in the Code are water shortage and landscape irrigation restrictions, requirements for heating, cooling, or processing water, commercial power washing, and displaying water for decorative purposes.

Source: City of Fort Lauderdale 10-Year Water Supply Facilities Work Plan, November 2014.

It is of importance to note the natural reduction in water use as the City changes their development path. As the City continues to develop, there is no longer a focus on single family home construction but rather on apartment and condominium construction. As residents continue to populate these developments, the City's per capita water use will fall without any conservation efforts for two reasons: 1) new construction incorporates new water conserving building codes and 2) Apartment and Condominium dwellers use significantly less water than older, less water efficient, single family homes which require irrigation of landscaping.

9.3 Recommendation of Potential Water Conservation Methods and Cost-to-Benefit Analyses

As discussed previously, price-based water conservation techniques can be difficult to implement because of political issues. However, raising the conservation rate structure will inevitably encourage some consumers to reduce water consumption. The Comprehensive Utility Master Plan (CUSMP) Team recommends the City continue with increasing block rate for pricing structure; however, for continued feasibility, the recommended water conservation programs discussed in this section are non-price based programs.

The following programs have been implemented by other utilities and have indicated decreased water consumption. Additionally, two (2) programs have also indicated decreased energy use, as energy and water usages are directly related through the water-energy nexus. The cost-to-benefit analyses of the programs are also presented in this section.

9.3.1 Residential Water Conservation Program – Water Smart Home Program

In an effort to educate potential home buyers and to encourage home builders to build more water efficient homes, the Southern Nevada Water Authority (SNWA) created the Water Smart Home Program (WSHP). The SNWA partnered with the Southern Nevada Home Builders Association (SHNBA) to certify new homes and neighborhoods as water-smart. The homes built through this program are required to include water-smart landscaping and water-efficient appliances. The ultimate cost impact of building these homes as water-smart is minimal. The incremental construction costs range from $250 to $500 per home. A major factor in this incremental cost is the hot water delivery system. With smaller homes (1,000 to 1,400 ft^2), the footprint of the house allowed hot water to be delivered to any source with less than 0.5 gallon of water wasted and no additional costs. For each house, a water-smart program can save as much as 75,000 gallons of water each year compared to conventional homes. Approximately 1,700 Water Smart Homes were built during a two-year period between 2007 and 2008 compared to 23,000 conventionally built homes.

The WSHP is comprised of outdoor and indoor features. Outdoor features include landscaping, irrigation systems, and swimming pools. Indoor features include plumbing, appliances, and hot water delivery. The SNWA provides a free Indoor Water Audit and Retrofit Kit to test the efficiency of the fixtures including a kitchen faucet fixture, bathroom sink aerators, a water flow testing bag, leak detection tablets, thread-sealing Teflon tape, and a water-efficient shower head. **Table WA9-4** shows the outdoor feature rebates and potential water savings.

For this and all water conservation measures, the City's Finance Department and financial rate consultant should periodically adjust water rates for reduction in revenues resulting from water savings and ensure water production operations and fixed costs are covered.

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Table WA9-4. SNWA Outdoor Feature Rebates

Outdoors Features	Rebate Amount	Water Conserved
Landscaping	$1.50 per square foot of grass removed and replaced with drought-resistant landscaping for the first 5,000 square feet covered per property annually. Beyond the first 5,000 square feet, SNWA provides $1.00 in rebates per additional square foot. The maximum annual rebate per property per year is $300,000.	Approximately 55 gallons of water per year per square foot.
Irrigation	$25 or 50 percent off the purchase price of a qualifying soil moisture sensor, whichever is less. 50 percent or up to $200 off the purchase price of a smart irrigation clock, whichever is less.	Approximately 15-30 percent reduction of outdoor water use.

Source: Southern Nevada Water Authority

9.3.2 Commercial and Industrial Water Conservation Program – Energy Performance Contracting Program

The City of Boulder implemented energy and water efficiency improvements in selected public buildings over four years (June 2009 - June 2013) for a total cost of $16.2 million. This water conservation program resulted in savings of over 7.8 GWh of electricity, 180,000 therms of natural gas, 2.7 million gallons of water (around 8% of all indoor consumption in city of Boulder facilities) and $660,000 in utility costs annually.

The cost of the program was paid through an energy performance contract. In energy performance contracts (EPC), the public building improvements are financed from cost savings in future utility bills over a multi-year period up to 20 years. Through a lease purchase agreement, the energy service company pays the upfront costs of the investments and guarantees cost savings from reductions in energy and/or water consumption. When the investment is paid off, the utility becomes the exclusive beneficiary of the reduced utility costs.

9.3.3 Commercial Water Conservation Program – Ozone Laundry Program

Between 2009 and 2010, the City of Santa Rosa Utilities implemented the Ozone Laundry Program. The program consisted of offering rebates for hotels and commercial laundry facilities that adopted the ozone laundry technology. The City of Santa Rosa offered $200 for every 1,000 gallons of sustainable reduction in water use and wastewater flow achieved using the ozone technology. The annual cost of the program was approximately $20,000.

This program resulted in a 40 percent decrease in the water demand from hotels and commercial laundry facilities. Approximately 200,000 gallons of water are conserved annually. This decrease in water demand was measured by inline sub-meters installed on the cold and hot water intake of each washing machine. The sub-meters were installed 30 days prior to the implementation of the ozone technology and were removed 30 days after the technology had been implemented. One relevant challenge of this program is that this advanced technology requires specialized technicians to perform installations and repairs.

9.3.4 Implementing a Unidirectional Flushing Plan to Reduce Water Use and Improve System Operations

Unidirectional flushing (UDF) achieves high velocities that efficiently remove loose pipe deposits because water is only allowed to flow in one (1) direction. In conventional flushing, the water is allowed to flow freely within the system. UDF is currently used by many municipalities in Florida not only because of the cleaning efficiency but also because it utilizes less water than conventional flushing. According to *Unidirectional Flushing: An Asset Management Program with Long-Term Benefits (Water World, 2015)*, UDF consumes on average 40 percent less water than conventional flushing. Other Florida municipalities, including City of Melbourne, Seminole County, and Palm Beach County, have implemented UDF programs.

The costs of performing UDF are dependent on the length of pipe treated, size of pipe, location, and labor costs. Therefore, the CUSMP Team recommends that the City perform an assessment of their distribution system to determine the total cost of implementing UDF. If the UDF proves to be beneficial to the City, the implementation of the program will include prioritization of critical areas, modeling of the system, ensuring that valves and hydrants can withstand UDF, preparing flushing maps, notifying the public, and performing the flushing; all of these steps and their specific costs must be taken into consideration when pricing UDF programs. Therefore, it is not possible to estimate a total cost for the City without a proper assessment. However, after Reiss Engineering Inc. (REI) conducted an extensive pilot study, the City of St. Petersburg found that implementing UDF would lead to a cost benefit of $0.37 per 1000 gallons saved.

9.3.5 Strategic Auto-Flushing and Pressure Water Conservation Project

In an effort to conserve potable water and improve distribution water quality, the City of St. Petersburg initiated the Strategic Auto-Flushing Water Conservation Project. The City, as well as utilities across Florida, is currently facing an unintended consequence from operation of their reclaimed water systems. Reduction of potable water demands leads to increased water age in the potable water distribution system. Increased water age leads to extensive water quality issues. To mitigate these water quality concerns, the City uses state-of-the-art modeling tools to locate and direct automatic line flushing devices to minimize potable water flushing and decrease potable water age. This Strategic Auto-Flushing Project conserves water by replacing current potable flushing methods with pinpointed automatic line flushing devices, as well as improving distribution water quality.

The Strategic Auto-Flushing Project will require the development of a distribution water quality model and field water quality data to generate specific action items for optimized water quality and conservation. These action items will include determining auto flusher locations, establishing flushing protocols, and training of City staff to enable future reactions to changing water usage patterns and locations. The City of St. Petersburg estimated that the Strategic Auto-Flushing Project was implemented through design, construction, and educational measures with a total project cost of $400,000.

According to the SFWMD auto flusher funding (WaterSIP) program, Municipalities around South Florida have seen water savings from 50 to 90% when compared to manual flushing, reaching volumes in the tens to hundreds of thousands of gallons per year, per device. The Port LaBelle Utilities' Strategic Auto-Flushing Project is estimated to conserve around 8.4 million gallons per year with an estimated cost benefit of $0.50 per 1000 gallons saved. (Source: http://www.sfwmd.gov/csol_dad/docs/F113097966/6000000165%20addendum%201c.pdf.)

Additionally, utilities have lowered water treatment plant pumping pressures to conserve water. The International Water Association Water Loss Task Force recommended that the best practice form of equation for representing pressure irrigation consumption is a simple power law.

$$Q_1/Q_0 = (P_1/P_0)^{N1}$$

Q – Leakage flow rate through a hole/crack on the pipe wall
P – Pipe pressure
N1 – Exponent, typically varies from 0.5 to 1.5

Using these equations to create pressure dependent demands, water savings can be estimated in the future with the hydraulic model. The City of Clearwater for example conserved approximately 9% of demands with a 10 psi pressure reduction during a construction project. While the City currently has low pressure issues in some of the higher irrigation areas, lowering pressures on off-peak periods could conserve water. Additionally, once the low pressure areas are resolved, the water treatment plant pressures could be lowered all of the time.

9.3.6 Automated Meter Reading/Advanced Metering Infrastructure

Almost 5 million automatic meter reading (AMR) and advanced metering infrastructure (AMI) units were shipped to North American water utilities in 2007, a 21% increase over the number shipped in the previous year, based on data recently compiled by the 2008 Scott Report on AMR. Major cities such as Chicago, Detroit, Atlanta and Kansas City are in the throes of installation, while large water utilities like New York, Toronto, Dallas and San Francisco are in the procurement process.

AMI based consumption data has tremendous potential to augment utilities' water conservation programs, whether they are directed at discouraging household leaks, short-term droughts or long-term water scarcity. Some utilities are exploring using AMI-generated short interval data as a conservation tool. By obtaining interval data, they can notify customers when consumption is much higher than normal.

The consumption data can be used to identify the "signature" of a leak. With AMI, the utility can notify customers when there is a small leak (e.g., from a running toilet), or a larger leak (such as from a broken sprinkler head) prior to the customer getting the bill.

AMR can have a significant impact on water conservation by (1) enabling more frequent meter reading and billing; (2) parsing consumption into frequent time intervals to enable the utility and its customers to look at consumption profile data for education and awareness, feedback or compliance monitoring/enforcement (such as odd/even day water sprinkling); (3) detecting continuous flow at customers' premises, which might indicate a leak; and (4) providing meter readings at precisely the beginning and end of certain periods (which would support seasonal or other time of use pricing).

The CUSMP Team recommends the City establish a long-term goal, once other higher priority capital needs are addressed, to purchase and install AMI units for the City’s retail service population of approximately 170,000. Consider phasing AMI implementation by neighborhoods starting in ten to fifteen years to minimize capital impacts.

Section WA9 accepted December 16, 2016.

9.3.7 Green Lodging Program Collaboration

As a key tourist destination, a portion of the City's water resource is consumed by non-residents in the hospitality industry. In the hotels, laundry represents a major consumer of water. The State of Florida has a Green Lodging Program which features both water and energy conservation. The Florida Green Lodging Program is a voluntary initiative of the Florida Department of Environmental Protection (FDEP) that designates and recognizes lodging facilities that make a commitment to conserve and protect Florida's natural resources. The program's environmental guidelines allow the hospitality industry to evaluate its operations, set goals and take specific actions to continuously improve environmental performance.

The CUSMP Team recommends implementing a strategy to work directly with groups like the Greater Fort Lauderdale Convention and Visitor's Bureau, Florida Restaurant and Lodging Association (FRLA), and the Chamber of Commerce to increase the number of hotels, motels and lodges in the Green Lodging Program.

9.3.8 Individual Water Metering

As the City continues to grow and develop, much of the new residential construction is projected to be multi-family dwellings, such as apartment complexes and condominiums. Most water providers currently bill apartments, condominiums, townhouses, mobile-home parks, and commercial properties through one or several master meters. Charges for water are allocated and included in the occupants' monthly rent. Because these practices neither promote conservation nor provide for awareness of water use and responsibility, water providers may wish to implement a program to meter individual units for all new residential and commercial construction. Metering that occurs downstream of a master meter is referred to as "submetering." The state of Georgia now requires all new apartments, condominiums, and mixed-use units to be plumbed for individual meters, and proposed local regulations would require water billing in new apartments and mixed-use buildings to be based upon actual metering and not allocation.

A national study on submetering and allocation programs conducted in 2004 found 15 percent water savings (8,000 gallons per dwelling unit) and 21 percent indoor energy savings associated with submetering by third-party billing entities (non-water providers) at existing MF buildings. In new construction, the savings is estimated to be approximately 6,000 gallons per dwelling unit, due to the installation of water efficient fixtures required by the plumbing code.

The CUSMP Team recommends the City administer an expanded submetering and read-and-bill program targeting all future residential and commercial construction.

The cost to benefit analysis of the first five (5) recommended water conservation programs are summarized below in **Table WA9-5**.

Table WA9-5. Summary of Cost-to-Benefit for Water Conservation Program

	Conservation Program	Cost-to-Benefit (/1000 gallon)	Estimated Water Conserved
1	Water Smart Landscape Rebate Program	$ 2.78	75,000 gallon / (house * year)
	Smart Irrigation Clock Program	$ 22.22	9,000 gallons / (house * year)
2	Energy Performance Contracting Program	$ 5,882.35	2,700,000 gallons / year
3	Ozone Laundry Program	$ 200.00	200,000 gallons / year
4	Unidirectional Flushing Plan	$ 0.37	40% less than conventional flushing water use
5	Strategic Water Auto Flushing Program	$ 0.50	8,400,000 gallons / year

9.4 Water Conservation Summary

The City has a wide variety of conservation programs currently in place. As previously mentioned, this combination of programs has indicated to be effective in reducing the per capita water consumption within the City's water distribution area. However, with an ever-growing population, it is ecologically and perhaps economically more beneficial to expand water conservation programs as opposed to potable water sources.

The City's water consumption was reduced to 170 gallons per capita per day or less in 2014, ahead of the 2028 schedule established in the Water Use Permit (WUP). However, factors like increased precipitation during recent years may have contributed to this trend. The continuous population growth, economic recovery and potential reduction in precipitation may cause a regression of City's water consumption in the future. The City's 10-Year Water Supply Facilities Work Plan presented a conservative goal with margin that allows the City to achieve the WUP goal with potential factors aforementioned. On the other hand, the City is predicted to continue to achieve water consumption of 170 gpcd or less in 2015. If the recent decrease in water consumption is believed to be a reliable indicator of significant water conservation success, the alternative water consumption goal and alternative total water demand goal can be considered. **Table WA9-6** displays the recommended water conservation goals for the 20-year forecasted period.

The alternative total water demand for the forecasted periods presented in **Table WA9-6** was calculated by multiplying the alternative water consumption per capita by the projected population. The CUSMP Team recommends maintaining the water consumption goal presented in the City's 10-Year Water Supply Facilities Work Plan to account for factors like population growth, economic growth, and potential reduced precipitation.

Table WA9-6. Water Conservation Goals for the Forecasted Periods

Year	Population	Recommended Water Consumption per Capita[1] (gpcd)	Recommended Total Water Demand [1] (MGD)	Alternative Water Consumption per Capita[2] (gpcd)	Alternative Total Water Demand[2] (MGD)
2015	228,546	181	41.4	170	38.9
2020	235,489	177	41.7	170	40.0
2025	251,758	172	43.3	170	42.8
2030	263,068	170	44.7	170	44.7
2035	267,196	170	45.4	170	45.4

[1] Data from City's 10-Year Water Supply Facilities Work Plan
[2] Estimated with the assumption that future total unit water demand remains at the projected 2015 demand level

Based on the available supporting documentation and cost-to-benefit analysis, the CUSMP Team recommends six (6) additional water conservation programs with implementation steps listed below (capital project information is provided in **Section WA7**):

1. Continue to fund current water conservation programs
   - Keep the increase block rate structure
   - Continue to rebate high efficiency toilets
   - Continue to promote Florida-Friendly landscaping and green infrastructure
   - Keep the current educational programs and introduce new programs
   - Perform system wide leak detection
   - Continue to replace water meters that are at least 10 years old

2. Ozone Laundry Program ($ 200.00 / 1,000 gallon)
   - Initiate ozone laundry luncheons and invite hotel owners
   - Further investigate ozone laundry technologies
   - Identify potential ozone laundry technology providers

3. Unidirectional Flushing Plan ($ 0.37 / 1,000 gallon)
   - Hire a professional engineering consultant as a UDF program manager
   - Implement UDF field work
   - Summarize improvement and effectiveness of the UDF program

4. Water Smart Home Program ($ 12.50 / 1,000 gallon)
   - Develop City's water smart home program
   - Enforce the installation of drought-resistant (Florida-friendly) grass
   - Promote irrigation clocks/rain/soil sensors for water smart homes
   - Identify providers of other appliances needed for water smart home program
   - Implement public education program on water smart home program
   - Research incentives to encourage home builders to join the water smart home program

5. Strategic Water Auto Flushing (SWAF) Program ($ 0.50 / 1,000 gallon)
   - Hire a professional engineering consultant as a SWAF program manager
   - Implement SWAF field work and lower the system pressure (lowering system pressure will require modeling and possible transmission system improvements)

- Summarize improvement and effectiveness of the SWAF program

6. Energy Performance Contracting Program ($ 5,882.35 / 1,000 gallon)
    - Further investigate the feasibility of energy performance contracting program
    - Identify potential energy companies

7. Automated Metering Infrastructure
    - Purchase and install AMI units, phased starting in ten to fifteen years, to service the City's retail population of approximately 170,000

8. Green Lodging Program
    - Collaborate with groups such as the Greater Fort Lauderdale Convention and Visitor's Bureau, FRLA, and the Chamber of Commerce to increase the number of hotels, motels, and lodges in the Green Lodging Program

9. Individual Water Metering
    - City administer an expanded submetering and read-and-bill program

Section WA9 accepted December 16, 2016.

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WA10 WUP Credit/Offsets

10.1 Background

City raw water withdrawal limitations from Biscayne Aquifer wellfields are imposed by the current Water Use Permit (WUP) and reflect conditions imposed by the Regional Water Availability (RWA) rule passed by the South Florida Water Management District (SFWMD) on February 16, 2007. Limited Biscayne Aquifer withdrawals apply to the RWA rule because of their influence on Lower East Coast Everglades Waterbodies, and represent a component of the recovery strategy for Minimum Flows and Levels (MFLs) for the Everglades. The impact of Biscayne Aquifer withdrawals on Everglades Waterbodies is typically identified by the extent to which such withdrawals induce seepage from SFWMD canals and other inter-connected surface water bodies within the area of influence from the withdrawals. The RWA restricts withdrawals based on the maximum historical quantity withdrawn during a consecutive 12-month period within five years prior to April 2006. Additional Biscayne Aquifer withdrawals above this base condition may be permitted through the application of offsets or substitution credits.

Offsets can increase permitted withdrawals above the base condition identified in the WUP provided the offsets can be shown to eliminate a projected increase in volume or change in timing of withdrawals from the Everglades Waterbodies resulting from the proposed increased withdrawals. Examples of potential offsets are impact offsets, recharge systems, and seepage barriers. Impact credits relate to positive influences on saltwater intrusion, depletion of wetland or other surface water bodies and groundwater supplies, and other negative issues associated with water withdrawals. In fact, the City has the opportunity to work jointly with Broward County to use an interconnect with C12/C13 to recharge the Peele-Dixie Wellfield. Mr. Todd Hiteshew, the City's Public Works Environmental Services Manager was consulted on the status of this project and relayed "As of right now, the project is not moving forward. We still have approximately $360,000 in a funded project but due to increased costs and scope changes it is not moving forward. A final decision has to be made by the higher ups but my recommendation was to not move forward or move the project forward but not commit further dollars. The City's only involvement in the project was to provide a cost share."

An impact offset derived from the use of reclaimed water may enable additional Biscayne Aquifer withdrawals above the base condition to be permitted. The requested increase in withdrawals must be supported by analyses demonstrating how reclaimed water usage offsets harmful impacts otherwise caused by the withdrawals, which in this instance would involve impacts on Everglades Waterbodies.

An additional approach to increase Biscayne Aquifer withdrawals above the base condition involves substitution credits, whereby reclaimed water is provided to replace existing permitted withdrawals from the Aquifer. The amount of substitution credit applied depends on several factors, including demonstration of how the timing, location and quantities of terminated withdrawals compare with the timing, location, and quantities of proposed increased withdrawals.

10.2 Impact Offsets and Substitution Credits

The distinction between an impact offset and a substitution credit appears somewhat nebulous, based upon conversations with SFWMD staff. In either case, analyses to identify how offsets/credits may enable additional City withdrawals involve application of calibrated numerical groundwater models. Model simulations evaluate changes in direct and/or indirect (induced

Section WA10 accepted December 16, 2016.

seepage) from canals associated with reclaimed use compared to proposed increased Biscayne Aquifer withdrawals. Reclaimed water reuse may include substituting reclaimed water for discontinued withdrawals and/or applying reclaimed water to offset seepage-induced impacts. Quantities of increased Biscayne Aquifer withdrawals ultimately permitted depend upon the extent to which reclaimed water usage results in equivalent or potentially less impacts to Everglades Waterbodies than those resulting from existing permitted withdrawals.

Once specific WUPs are identified for potential change from the Biscayne Aquifer to reclaimed water provided by the City, then the potential offsets would be further evaluated using complex groundwater model simulations of the existing permitted WUPs at their respective allocations to identify their withdrawal impacts on Everglades Waterbodies. Such impacts would then be compared with potential impacts from increased withdrawals from the City wellfields. Model simulations would evaluate previously permitted and proposed new withdrawals on a monthly basis during average and 1-in-10 year drought conditions. The magnitude of offsets that the City could apply for increased Biscayne Aquifer withdrawals would depend upon the modeling results. For the purposes of this planning effort, the WUP offsets were estimated at 50% of the reclaimed water reuse demand.

10.3 WUP Holders Identification

With the creation of the Comprehensive Everglades Restoration Project (CERP) it was determined that virtually all available water resources are currently allocated to existing users making it difficult for future expansion to take place in South Florida. Alternative sources need to be identified in order to meet future water use and reduce the overall demand from the Biscayne Aquifer. One alternative is the reallocation of permitted capacities from existing WUP holders through water conservation methods such as irrigation by means of reclaimed water.

Review of SFWMD permitting databases revealed there are 129 WUPs issued to entities within Broward County for irrigation with water withdrawn from the Biscayne Aquifer and/or connected surface water bodies. These WUPs include Individual permits and Major General Permits (GPs) for which use of reclaimed water could be required if shown to be technically feasible. The combined maximum monthly allocations for these current WUPs equate to approximately 70 MGD. **Figure WA10-1** provides a map of WUP holders within Broward County to help identify large permit holders that may benefit from switching to reclaimed water.

There are two large and several small to medium WUP users within 5 miles of the GTL. The SC 1 Funeral Services of Florida and US 1 / FLL are the two large WUP holders near the GTL plant with listed capacities of 500 gallons per minute (gpm) and 350 gpm, respectively. There are also several users near the GTL that use potable water for landscape irrigation and industrial uses, as well as two large water users currently utilizing surface water. These irrigation and industrial water users could convert to reclaimed water reuse which would contribute credits/offsets to the City for the WUP for Fiveash and Peele Dixie water treatment plants. Other potential reclaimed water users in the vicinity of the GTL include Florida Power and Light (FPL), Broward County Convention Center, Evergreen Cemetery, Lauderdale Memorial Park Cemetery, Snyder Park and Floyd Hull Stadium.

Although impact offsets and substitution credits are associated with reclaimed water use, the intent is to provide a positive benefit for the groundwater source. Per SFMWD, an example of an impact offset is recharging with reclaimed water to provide a saltwater barrier. Since groundwater removed through I/I reduces the saltwater barrier, it may be worth investigating using I/I reduction as a potential impact offset.

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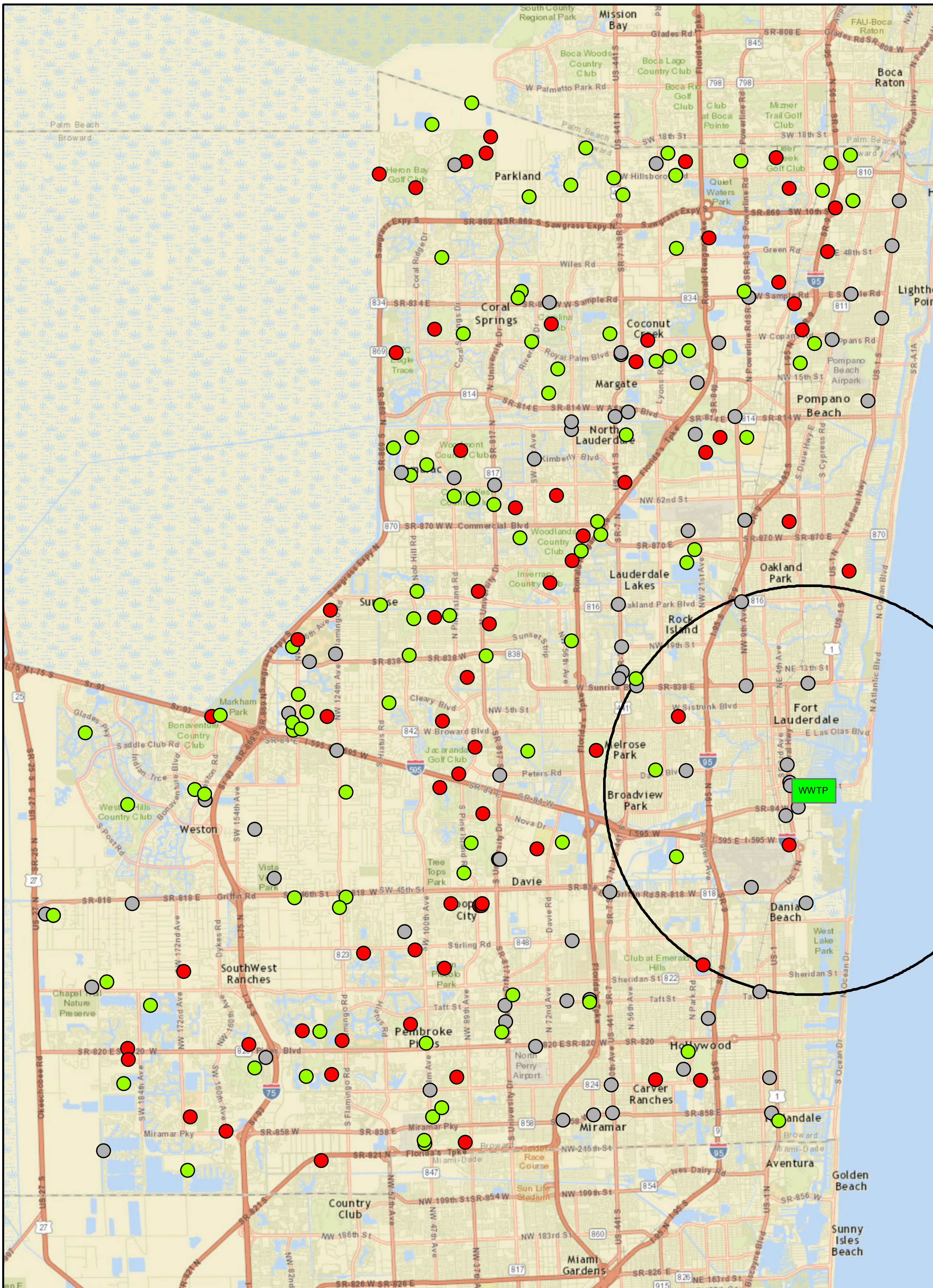


Legend

Pump Capacity (gpm)

- 0 - 70 (Small User)
- 70 - 347 (Medium User)
- > 347 (Large User) GTL
- 5 Mile Radius

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
BROWARD COUNTY: CONSUMPTIVE USE PERMITTED CAPACITIES

FIGURE WA10-1

R:\Projects\134001-P FtLauderdale CUSMP\Study-Report\Draft_Report\1.0 Water\WA.10 CUP Credit-Offsets\GIS CUP\CUP Users V2.mxd

10.4 Evaluation of Reductions for Additional WUP Withdrawals

To facilitate WUP holders potentially reducing their overall demand by switching irrigation, and/or other water demands to reclaimed water, the City has undertaken reuse feasibility studies. While the GTL does not currently provide reclaimed water for reuse, the City is participating in the Countywide Integrated Water Resources Plan Grants for feasibility studies related to potential beneficial reuse. These have included a 2008 feasibility study for selected reclaimed water projects within the City for a 50% cost share for $125,000. The City participated in a second feasibility study in 2009 for reclaimed water in the area of the Broward County Convention Center at a 50% cost share for $5,000, as well as the 2012 reuse feasibility update. The City continues to consider water reuse and options that can be used to help develop alternative water supplies.

Included in the 2008 and 2012 reuse feasibility efforts was identification of potential reuse options for City-produced reclaimed water including:

- Reclaimed water applied to recharge Pond Apple Slough;
- Reclaimed water use by Florida Power & Light (FPL) for boiler feed;
- Landscape irrigation of City parks and golf courses with reclaimed water supplied from satellite wastewater treatment plants utilizing membrane bioreactor (MBR) technology;
- Recharge of the Prospect Wellfield with reclaimed water;
- Recharge of the Dixie Wellfield with reclaimed water;
- Use as a barrier against saltwater intrusion;
- Reclaimed water use for cooling water and irrigation at the Greater Fort Lauderdale Convention Center provided by the GTL;
- Reclaimed water use for irrigation at the Fort Lauderdale-Hollywood International Airport; and
- Reclaimed water use for irrigation at City-owned facilities supplied by and located in the vicinity of the GTL.

From these previous alternatives, updated with current information and regional initiatives, four options for implementing reclaimed water reuse were reviewed.

10.4.1 Alternative 1 – GTL Upgrade and Local Area Reuse

The 2012 Feasibility Study declared 8 potential reclaimed water users including Florida Power and Light (FPL), Broward County Convention Center, Evergreen Cemetery, Lauderdale Memorial Park Cemetery, Snyder Park, and Floyd Hull Stadium in the vicinity of the GTL. The feasibility study prepared an alternative that included treatment improvements and reclaimed water distribution pipe as shown in **Figure WA10-2**. The treatment processes that will have to be added to the GTL for industrial and irrigation could include ultraviolet light (UV) disinfection, microfiltration (MF), and reverse osmosis (RO). Cost analyses for providing reclaimed water from the GTL to the Convention Center and City-owned facilities indicated it would be uneconomical compared to producing potable water for identical use. The feasibility studies concluded, however, that reclaimed usage offered intangible benefits when compared to the more economic potable water usage. Intangible benefits include the potential for securing credits/offsets that could be applied for increasing allocation for Biscayne Aquifer withdrawals. Additionally, the study concluded reclaimed use would foster collaborative relationships with applicable regulatory agencies that would assist the City in achieving goals regarding environmental policy.

10.4.2 Alternative 2 – Satellite Treatment and Reuse/Saltwater Intrusion Barrier

Alternative 2 involves satellite wastewater treatment for potable water reuse and saltwater intrusion barrier as shown in **Figure WA10-3.** Evaluation of using reclaimed water to recharge Pond Apple Slough or for boiler feed at FPL facilities indicated that neither were viable options. Irrigating parks and golf courses with reclaimed water from a satellite wastewater treatment plant was considered to be a viable but costly option. The potentially best candidate for such use, Coral Ridge Golf Course Option B, involved estimated life cycle costs of $12.40/1000 gallons for demand on the order of 5 MGD. Additionally, the limited volumes, decreased demand during the wet season, and need for negotiation with the private golf course owner reduced the attractiveness of this option.

Previous studies estimated costs associated with facilities to provide 5 million gallons per day (mgd) of recharge to the Prospect Wellfield included: $78 million capital expenses; $5 million for annual operation and maintenance; $5.4 million annual capital recovery fixed cost. An estimated unit production cost of $9.17/1,000 gallons resulted for this option. Combined with uncertainties involving regulatory issues, pilot testing, and other unknowns, it appeared that wellfield recharge was not worth pursuing previously.

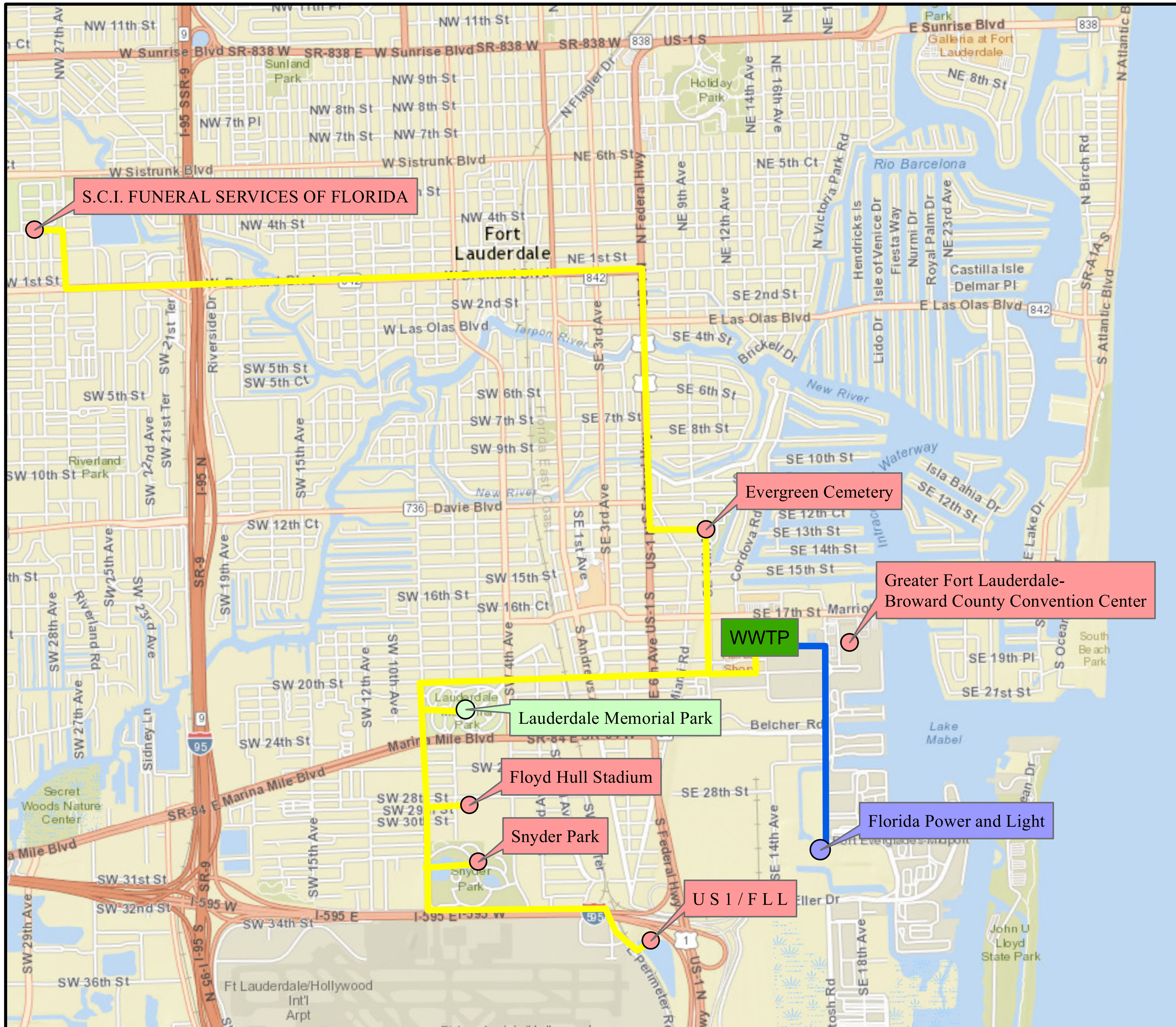
10.4.3 Alternative 3 – Satellite Treatment and Indirect Potable Reuse

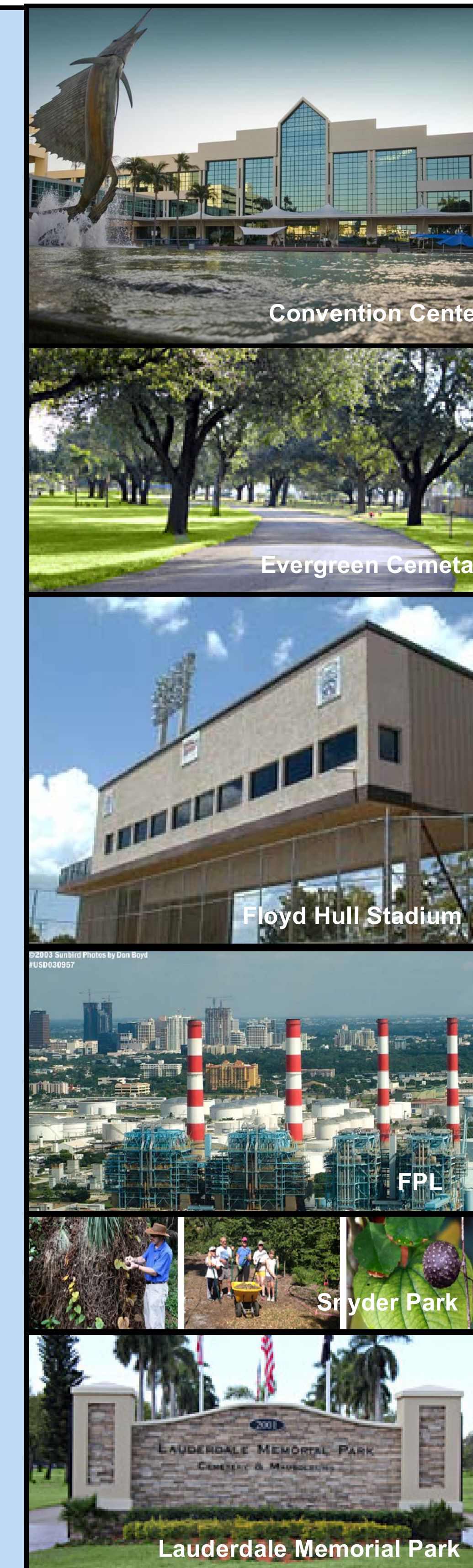
The City of Hollywood has pilot tested this option and is currently in discussions with regulatory agencies to implement. For Fort Lauderdale, the satellite treatment would treat the wastewater to potable drinking water standards for all parameters except salinity or total dissolved solids. The highly treated water would be discharged to the upper Floridan Aquifer near the Peele Dixie WTP and indirectly reused for potable water supply using reverse osmosis treatment technology (also see **Figure WA10-4**). The City of Hollywood's pilot indicated successful treatment for contaminants including emerging contaminants such as endocrine disruptors. Conversely, the Sierra Club recently filed for sole source status for the Floridan Aquifer which could preclude the use of the aquifer for discharge of treated wastewater.

10.4.4 Alternative 4 – C-12 and C-13 Canal Interconnect Project

In 2010 the City executed an interlocal agreement with Broward County to provide a direct connection for surface water flows between the C-13 and C-12 Canals. Connecting the two canals facilitates redirection of C-13 flows that would otherwise be discharged to tide to the C-12. Increased C-12 flows enable enhanced water deliveries to the North Fork of the New River (North Fork) shown in **Figure WA10-5**. The remaining link to be constructed is an interconnection under Sunrise Blvd. It will cost approximately $1 million to construct, and the City and County will share the costs equally. More frequent and controlled flows from the C-12 should result in improved water quality in the North Fork, which is currently considered a verified impaired waterbody by the State.

A possibility exists that redirection of C-13 Canal flows that otherwise would be discharged to tide could be applied as offsets to enable increased Biscayne Aquifer withdrawals from City wellfields. The magnitude of potential offsets cannot be determined at this point. It will depend upon how much of the flows diverted from the C-13 to the C-12 may result in recharge of the





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Potential Public Access Reuse Users

Capacity (gpm)

- Small User (0-70)
- Medium User (71-347)
- Large User (>347)

Pipeline

- 4-Inch Proposed Reclaim Pipe
- 8-Inch Proposed Reclaim Pipe
- GTL WWTP

*This Alternative includes components from the 2012 Updated Reclaimed Water Feasibility Study

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
ALTERNATIVE 1: POTENTIAL END USERS FOR RECLAIMED WATER

FIGURE WA10-2

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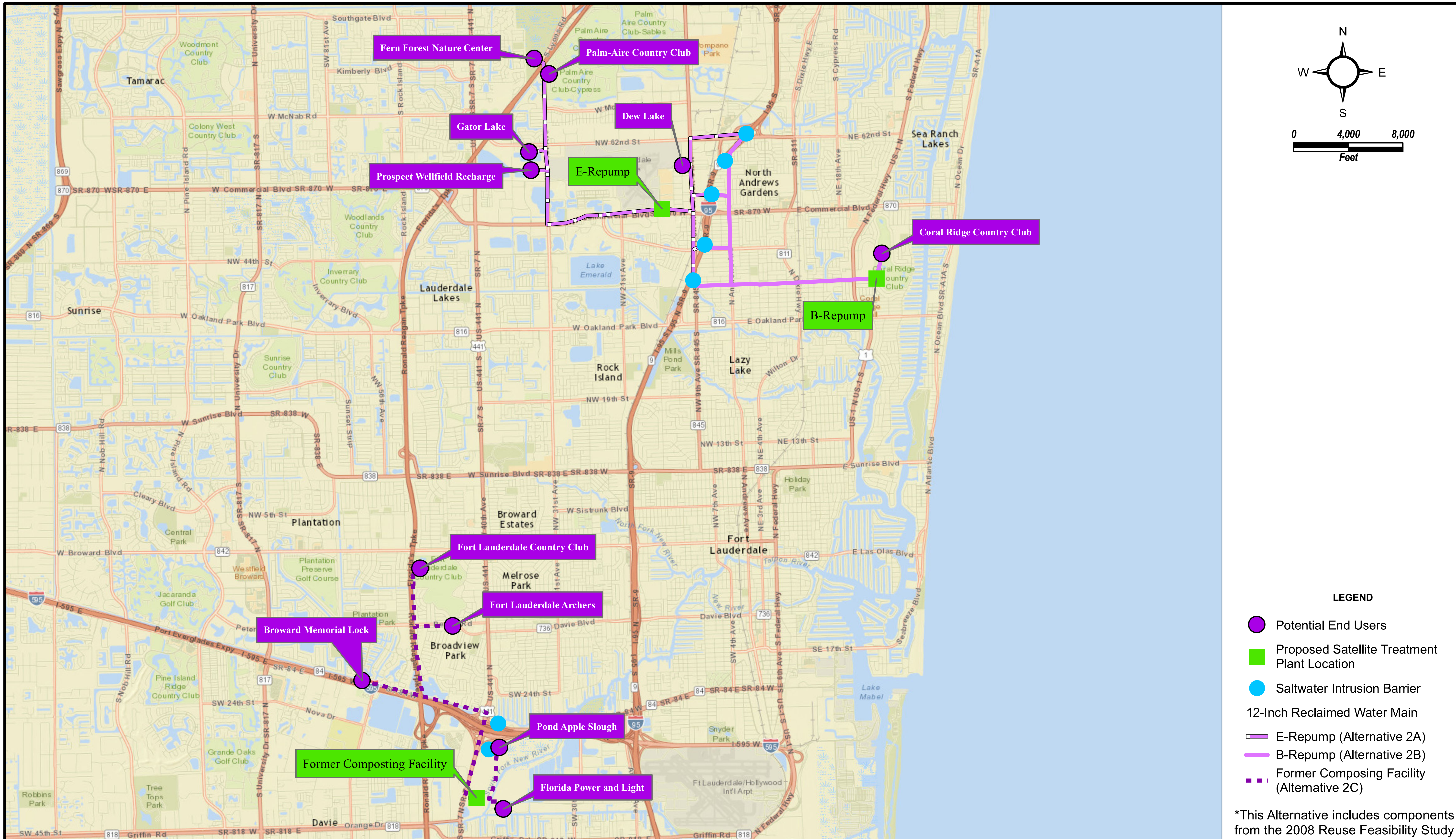

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

ALTERNATIVE 2: POTENTIAL END USERS OF SATELLITE TREATMENT FOR REUSE AND SALTWATER INTRUSION BARRIER

FIGURE WA10-3

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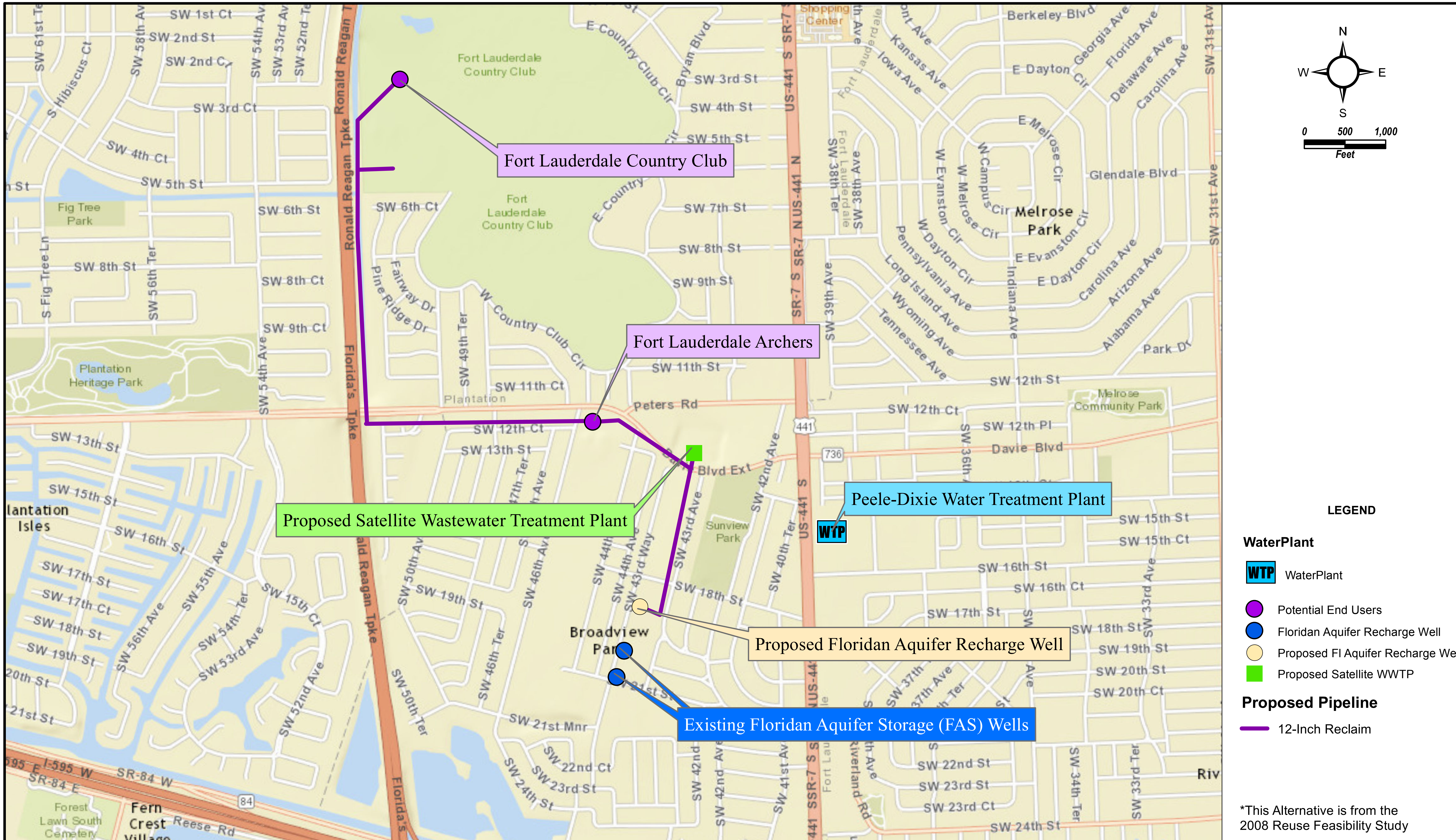

*This Alternative is from the 2008 Reuse Feasibility Study

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

ALTERNATIVE 3: POTENTIAL END USERS OF SATELLITE TREATMENT FOR AQUIFER INJECTION AND REUSE

FIGURE WA10-4

G:\0gis\134001 - FTL Master Plan_MXDs\CUP Offset and credit\Option 3.mxd

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LEGEND

- Lake
- Proposed Pipe
- Existing Waterway
- Existing Control Structure
- Proposed Control Structure

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
ALTERNATIVE 4: C12 AND C13 CANAL INTERCONNECT

FIGURE WA10-5

G:\0gis\134001 - FTL Master Plan_MXDs\CUP Offset and credit\option 4.mxd

Biscayne Aquifer compared to historical conditions. This will likely involve a combination of monitoring canal flows and stages, groundwater elevations, with numerical modeling. The primary purpose of the interconnection is to divert flows from one canal to another that will still ultimately be discharged to tide; consequently, this suggests that the extent of aquifer recharge that may be applied as an offset for increased Biscayne Aquifer withdrawals would be minimal.

It is understood that various issues encountered during construction of the interconnect have resulted in delayed completion of the project. Construction beneath Sunrise Boulevard could not be accomplished as originally intended, and alternative construction methods for this portion of the interconnect are being redesigned. Funding availability combined with redesign activities have delayed continuation of construction activities. Broward County will request funding from the City for 50% of the construction costs, which will be contingent upon funding approval by the City Commission. Estimates of increased costs associated with the changes include City contributions from approximately $375,000 to $500,000.

10.5 Cost Estimates for Reuse Improvements

Table WA10-1 presents capital and annual operations and maintenance (O&M) costs for the 4 alternatives.

Table WA10-1. Cost for Increased Water Treatment and Distribution Lines

Option[1]	Description	Capital Cost[2]	Annual O&M Cost	Capacity (MGD)	WUP Offset[3] (MGD)
1	Increased Treatment local to GTL to provide reclaimed water	$16,230,000	$811,500	1.0	0.5
2	New satellite scalping WWTP to provide local reclaimed water and injection barrier wells	$170,413,300	$8,530,000	12.0	6.0
3	New satellite scalping WWTP to provide indirect potable reuse to the Floridan aquifer	$112,584,500	$5,629,300	6.0	3.0
4	C12 and C13 Canal	$1,000,000	$10,000	--	0.1

[1] Option 1: Capital cost were provided from the 2012 Updated Reclaimed Water Feasibility Study and O&M costs were assumed to be 5% of the capital cost.
Option 2: Capital Cost and O&M Costs were provided from the 2008 Feasibility Study for the Implementation of Selected Reclaimed Water Projects Within the City of Fort Lauderdale.
Option 3: Capital cost was provided from the 2008 Feasibility Study for the Implementation of Selected Reclaimed Water Projects Within the City of Fort Lauderdale and O&M costs were assumed to be 5% of the capital costs.

[2] Capital Costs are in 2015 dollars and there was a 3% inflation rate per year assumed to bring the 2008 and 2012 costs to 2015.

[3] WUP Offset: The ratio of offset is determined by complex groundwater and hydrology modeling as described herein, and was estimated at 50% of the reuse capacity for the purposes of this master plan.

10.6 External Funding Sources

The Department of Environmental Protection (DEP) and the Water Management Districts in Florida have recognized that the encouragement of reuse is a state objective and have provided funding for planning, construction and implementation of projects to increase reuse of wastewater. The South Florida Water Management district will jointly fund projects that are proven to significantly reduce the amount of ground water and surface water used by residential, commercial, and industrial potential end users. The SFWMD's Alternative Water Supply Grant Program could grant up to 50% of the total capital costs for implementing reclaimed water projects that provide potential end users WUP Credits or Offsets. The FDEP has State Revolving Fund (SRF) which loans money primarily to local governments for a variety of projects including reuse, ground water protection, and sewer system rehabilitation. The Senate Bill 536 statewide alternative water supply initiative was recently completed in draft form and may also have funding implications. Allocation may likely occur through the SFWMD as well.

10.7 WA10 WUP Credit/Offsets Summary

Based on this updated evaluation, the CUS Master Plan Team drew the following conclusions:

1. The City is not projected to exceed its WUP in over the study period of the next 20 years.
2. Being long sighted, the City is interested in extending its available water supply through the possibility of WUP credits and offsets and has consistently participated in regional efforts to further reuse of reclaimed water.
3. Historical studies of reclaimed water implementation for the City have deemed the efforts as not economically feasible due to the following reasons:
    a. The GTL is a large, high rate treatment facility on a very area-restricted site that does not include treatment and high level disinfection components to facilitate producing public access level reclaimed water.
    b. The City's collection system is old and experiences high levels of infiltration resulting in high total dissolved solids concentrations (1,100 parts per million) including chlorides which would be harmful to most landscape plants. Therefore, demineralization in the form of reverse osmosis would be required which significantly increases both the capital and operations cost including high energy consumption.
    c. The cost of reclaimed water distribution in existing, heavily urbanized areas is very expensive and difficult.
4. Four alternatives were identified for generating WUP credits/offsets from updated information and historical planning efforts.

Based on the conclusions it is recommended to continue to pursue Alternative 4 (C12 and C13 Canal Interconnect Project) in conjunction with Broward County. While the project will provide relatively low WUP withdrawal credit, the project should result in improved water quality in the canals and is very low cost operationally, hence sustainable. The City should continue to track Florida indirect potable reuse efforts into the Floridan Aquifer, e.g., the City of Hollywood, for future water supply considerations beyond this study period.

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WA11 Climate Change Strategies

11.1 Introduction

The potential consequences of climate change are raising concerns about the sustainability of the City's water supply system. South Florida's low topographic relief, unique hydrology compared to other regions of the continent, and the significant seasonal variability of precipitation, leaves it especially vulnerable to the potential impacts of climate change. Although water resources throughout South Florida are among the most heavily managed in the world via South Florida Water Management District (SFWMD) operations, it is important that water supply purveyors consider how potential impacts from a changing climate including rising seas may influence their ability to meet future customer needs.

Primary issues associated with climate change in South Florida include the following:

- Coastal saline intrusion, and reduction in coastal stormwater release capacity, due to sea level rise combined with variable rainfall/recharge;
- Changes in tropical storm and hurricane intensity and frequency, which in combination with sea level rise may cause increased storm surge and vulnerability to coastal ecosystems, real estate, and public and private infrastructure;
- Possible changes in rainfall and evaporation patterns, with resulting variations in frequency and magnitude of droughts and/or flooding.

Climate change issues have been a concern for coastal water utilities in the past and are increasing in importance due to data confirming acceleration of sea level rise. Scientists, engineers, and other staff at SFWMD have been particularly involved with monitoring climate change issues, and have completed comprehensive assessments of technical challenges and possible management implications of climate change on South Florida. Findings and results from the SFWMD work provide relevant information about how climate change may impact the City's water supply operations.

11.2 Risks and System Vulnerabilities

11.2.1 Sea Level Rise and High tide

Data from National Oceanic and Atmospheric Administration (NOAA), measurements made at Key West between 1846 and 1992 indicated that sea level rose at a rate of approximately 0.09 inches per year (in/year), with evidence for a change from approximately 0.07 in/year before 1925 to approximately 0.11 in/year afterwards. In the last five years, sea level rose at a rate of approximately 0.34 in/year. Recent sea level rise projections for South Florida (SFRCCC Draft, 2015) include estimated rises above the 1992 reference level: 1) from 6 to 10 inches by 2030; 2) from 14 to between 26 and 34 inches by 2060; and 3) from 31 to as high as 81 inches by 2100. Sea level rise projections less than the low end of these ranges result from scenarios assuming significant reductions in greenhouse gas emissions, while projections at the high end reflect assumed greenhouse gas emissions remain at current level resulting in massive glacial melting.

Primary risks resulting from sea level rise, especially an accelerated rise, include saline intrusion of the Biscayne Aquifer. In addition, sea level rise in combination with extreme high tide events and/or major storm surge reduces and/or eliminates stormwater gravity discharges to tide via SFWMD control structures.

Historical saline intrusion throughout South Florida likely resulted from a combination of sea level rise, lower groundwater elevations in response to construction of the SFWMD regional

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drainage system, and water withdrawals in excess of natural recharge near coastal wellfields. Compared to the Prospect Wellfield, the eight currently active production wells at the Dixie wellfield are closest to saline water, and are thus more vulnerable to enhanced future saline intrusion than other City production wells.

Gravity discharge at some SFWMD control structures is already an issue at some locations, particularly in Miami-Dade County. SFWMD considers the control structures located in the vicinity of Fort Lauderdale to be high risk with regard to their ability to discharge by gravity during periods of peak tides and/or storm-related surge. Anticipated future sea level rise is expected to exacerbate the gravity discharge condition.

11.2.2 Extreme Weather Events

South Florida will remain at risk to extreme weather events such as tropical storms, hurricanes, and extended periods of intense rainfall. Projections for more frequent occurrence of such events and/or increased intensity compared to historical conditions warrant preparation to adapt to such projections.

The location of the City's Biscayne Aquifer wellfields relatively far inland reduces the risk of impacts from storm surge impacts. An item of concern involves the possibility of saline storm surge overtopping and getting behind SFWMD control structures resulting in saline water infiltration to the shallow aquifer. Such a drastic flooding event has a potential to adversely impact water quality withdrawn by City wellfields.

Intense rainfall events, whether or not associated with tropical storms or hurricanes, may cause flooding in the vicinity of City wellfields. King tides, 3 feet above normal, for example, may result in water quality impacts to production wells if not properly sealed to prevent surface water infiltration. Site inspection of Prospect Wellfield indicated cracks in concrete well pads and heavy rusting and pitting of above-ground casing in many wells, which could promote surface water infiltration during flood events.

11.2.3 Temperature and Rainfall

Increased evapotranspiration (ET) resulting from rising temperatures can increase water supply demand, especially due to greater irrigation needs, assuming that rainfall does not increase sufficiently to offset higher rates of ET. Typically, future water supply demand is determined based on historical usage combined with population projections. Current projections indicate that the City has sufficient Water Use Permit (WUP) allocations and capacity from their Biscayne Aquifer wellfields and water treatment plants (WTPs) to meet their 20-year water supply demands. Such projections include an assumed reduction in finished water per capita use rates from historical values greater than 200 gallons per person per day (gpcd) to 170 gpcd by 2028. As of 2014, this water consumption level goal has been met.

Should a combination of future ET rates and reduced rainfall lead to demand greater than currently anticipated, the possibility exists that the City's current WUP allocation may be reached sooner than anticipated. Unfortunately, projections about future temperature and rainfall conditions in South Florida are uncertain. Model predictions of global and regional climate models evaluated by SFWMD suggest that either increases or decreases in rainfall patterns compared to historical conditions may occur. Consequently, it is difficult if not impossible at this point to identify whether future climate change will adversely impact future water demand.

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WUP allocations assume a 1-in-10 year drought return frequency, and annual rainfall totals approximately 80% of historical averages. Water shortage rules are implemented for conditions more severe than those occurring during 1-in-10 year drought events. Increased severity and frequency of drought conditions in the future would likely result in more frequent and potentially more stringent water restrictions than those instituted historically.

In conclusion, water demand may increase, in particular for irrigation, due to potential higher ET rates in combination with reduced rainfall. Predictions of potential future rainfall and ET changes are highly uncertain, as increased and/or reduced rainfall may vary over annual and seasonal time frames. Consequently, the possibility exists that increased rainfall, proportionally greater than potential ET increases from temperature changes, may result in reduced irrigation demand.

11.3 Strategies

Approaches to mitigate adverse impacts from more frequent and severe droughts, and/or increased demand due to higher ET and less rainfall should focus on irrigation practices, since irrigation demand represents a substantial demand component. Promoting xeriscape and irrigation efficiency principles represent an appropriate course of action. Other water conservation practices are discussed and recommended in **Section WA9**.

Prudent planning should focus on collecting and evaluating data involving water usage and population projections to assess future demand. Flexibility in water supply sources may add increased resistance to climate driven demand increases. Updated demand projections occur every five years as part of the SFWMD water supply planning process. More frequent analysis and update should occur as warranted, considering the uncertainties with climate change projections, and whether City water customers will reduce per capita usage consistent with long term goals.

The SFWMD G-54 Control Structure is located approximately 1.5 miles southwest of the Dixie Wellfield. Limited discharge from the G-54 structure during a major storm or high tide event would promote a flooding risk that could impact the Dixie Wellfield. SFWMD implemented procedures to assess options to modify control structures to mitigate elevated downstream water levels. Current options focus on installing pumps for use when gravity drainage cannot occur or are ineffective at regulating downstream water levels. Additionally, options to move the G-54 approximately 2-miles downstream from its current location have been considered. Seaward relocation of the G-54 would likely reduce the risk of flooding impacts on the Dixie wellfield. The feasibility of moving the G-54 appears highly uncertain, due to complicating factors such as high cost as well as ocean access restrictions to entities located downstream of the existing structure.

SFWMD interpretation of the location of the landward extent of saline intrusion indicated minor landward advancement of the saline interface between 2009 and 2014 in portions of Broward County. Ongoing monitoring by the City through the Saline Intrusion Monitoring (SALT) Program has yielded no evidence of saltwater intrusion into production zones of the City's existing Biscayne Aquifer wellfields. However, monitoring results from wells located near the Dixie Wellfield, in combination with the inferred location of the saline interface along a canal approximately 3,500 feet to the southwest, suggest enhanced vulnerability to future saline intrusion.

The City participated in the development and application of a Saltwater Intrusion Modeling project with Broward County and the USGS, to evaluate threats to the City wellfields. Preliminary results (subject to change and not to be cited prior to publication) have been presented by County staff, and detailed findings are anticipated to be published in November or December 2015. Model simulations evaluated potential future saline migration in response to three different rates of sea level rise for a 50-year period. The rates used correspond to the sea-level rise projections selected by the Southeast Florida Regional Climate Change Compact Technical Ad hoc Work Group (2011) and identify the total rise in sea level after 50 years for modified National Research Council (NRC) sea-level rise rates I, II, and III are 0.77, 1.40 and 3.03 feet, respectively. Model simulations also evaluated whether moving the G-54 Structure seaward would have a positive impact on reducing future saline intrusion risk in the vicinity of the Dixie wellfield.

The removal of freshwater in response to I&I can contribute to saltwater intrusion due to its impact on reducing the volume of freshwater that would otherwise flow toward the ocean. City plans to greatly reduce I&I will mitigate this contribution to saltwater intrusion.

The planned joint implementation of the C-12 and C-13 Canal Interconnect Project with Broward County will redirect C-13 Canal flows that otherwise would be discharged to tide and potentially quality as an offset to enable increased Biscayne Aquifer withdrawals from City wellfields. The magnitude of potential offsets would have to be estimated with complex groundwater modeling and was estimated at 0.1 MGD for planning purposes. The C-12 and C-13 Canal Interconnect Project will also theoretically improve water quality in the C-12 Canal.

11.4 Conclusions and Recommendations

Risks to the City's water supply system associated with potential climate change and sea level rise include the following:

- Saline intrusion risk to the City's Biscayne Aquifer wellfields, the magnitude of risk dependent primarily on the rate of sea level rise. The Dixie wellfield's close location seaward of the G-54 Control Structure appears more vulnerable than the Prospect Wellfield;
- Restricted stormwater gravity discharge through the SFWMD Control Structures during extreme high tides and/or major storm events. Limited discharge would promote wellfield flooding that may cause impaired water quality due to surface water infiltration into improperly sealed production wells. This is less of a potential issue at the Dixie Wellfield compared to the condition of the wells at the Prospect Wellfield. Seven of the eight wells in the Dixie wellfield are located on elevated concrete structures approximately four feet above the ground surface;
- As mentioned in **Section WA10**, operation of the C12/C13 interconnect may facilitate enhanced discharge of regional system flows to tide. This will lower water table elevations in the area, which will reduce potential flooding associated with extreme climatic events;
- Increased water demand, in particular for irrigation, due to higher ET rates in combination with reduced rainfall. Demand increases significantly greater than that currently estimated for 2035 could require request for additional allocation sooner than currently authorized in the City's WUP, however, climate change projections regarding future precipitation trends are uncertain;
- Hurricanes damaging water supply facilities;
- Fortunately, the Peele-Dixie WTP uses membrane treatment which can effectively decrease the low levels of salt that could possibly impact the wellfield after a catastrophic storm surge or tidal flooding event.

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Measures the City can take to address impacts to the water supply system due to potential climate change and sea level rise include the following:

- Review findings of the USGS/Broward County variable density modeling study. Combine modeling results with ongoing monitoring to apply existing model to perform simulations specific to City wellfield operations (Estimated modeling costs = $75,000 - $100,000);
- Perform subsurface investigation and if needed install additional monitoring well(s) south of the Dixie wellfield (Estimated construction costs = $25,000 to $75,000 per well, estimated capital costs = $75,000 - $150,000 per well);
- Assess and implement as needed production well improvements to prevent potential surface water infiltration in the event of flooding events (Estimated costs = $230,000 per well for wellhead replacement; $450,000 per well for total well replacement - see **Section WA.5.A.3.b** for details).
- Monitor customer per capita usage annually to compare with long-term reduction goals and 2035 demand estimates. Evaluate need for additional water allocations if long-term demands increase significantly above current estimates (assumed costs borne by existing City personnel); and Plan and implement further hurricane hardening measures for water supply facilities.
- Implement conservation methods that reduce per capita usage below the planned 170 gallons per day rate; methods recommended in Section WA9 include:
    - Continue to fund current water conservation programs
    - Ozone Laundry Program
    - Unidirectional Flushing Plan
    - Water Smart Home Program
    - Strategic Water Auto Flushing (SWAF) Program
    - Energy Performance Contracting Program
    - Automated Metering Infrastructure
    - Green Lodging Program
    - Individual Water Metering
- The City complies with all regulations; short term improvements at the Fiveash WTP should include potentially qualifying for 4-log virus inactivation to reduce reporting requirements in the event of positive bacteriological sampling of the wellfields.
- Continue the City's rate structure and increasing the revenue stream to prepare for climate change, while minimizing fund transfers to other City departments.
- While moving major water infrastructure is not needed in the 20-year planning period, certain fire hydrants prone to flooding could be relocated if access and maintenance becomes an issue.
- Continue with joint implementation of the C-12 and C-13 Canal Interconnect Project with Broward County. Redirection of C-13 Canal flows that otherwise would be discharged to tide could potentially be applied for as an offset to enable increased Biscayne Aquifer withdrawals from City wellfields. The magnitude of potential offsets would have to be estimated with complex groundwater modeling and was estimated at 0.1 MGD for planning purposes. The C-12 and C-13 Canal Interconnect Project will also theoretically improve water quality in the C-12 Canal.

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WA12 Lime Sludge Evaluation

The City of Fort Lauderdale's (City) Fiveash Water Treatment Plant (WTP) currently uses lime softening technology in its treatment process, which creates a byproduct known as lime sludge. Lime sludge is created after treating the water to remove hardness and consists primarily of precipitated calcium carbonate ($CaCO_3$) and magnesium hydroxide ($Mg(OH)_2$). Several alternatives exist for disposal of this byproduct with different costs for each method. The City's alternatives for lime sludge disposal are evaluated below, as well as options for improving current treatment practices and potentially reducing the amount of lime sludge produced.

12.1 Current Standards and Practices

The City's Fiveash Water Treatment Plant (Fiveash) is a 70 million gallon per day (MGD) facility which uses quicklime to achieve a target pH of 9.0 - 9.5 in its treatment process. Currently, Fiveash uses approximately 50,000 dry pounds (lb)/day of quicklime which produces, on average, 125,000 lb/day of spent lime sludge solids. The lime sludge also contains small amounts of a polymer used in the treatment process to help separate the lime sludge.

Lime sludge from Fiveash's treatment process is removed from the facility's hydrotreators and fed into an onsite sludge holding tank. From the holding tank, the lime sludge is pumped to the "Prospect Wellfield Sludge Pit," which is a lagoon with an east cell and a west cell each capable of holding approximately 375,000 cubic yards (CY) of lime sludge. When capacity is approached in one of the cells, the flow is switched to the other cell, and the full cell dries for 1-2 years, then excavation and disposal is contracted out utilizing the lowest bidder for removal of the sludge. The City had been utilizing the west cell since October 9, 2009, but determined on November 17, 2015 that the west cell was full, and switched flow of lime sludge into the east cell. The sludge from the west cell will be contracted and disposed of in the 2017 or 2018 fiscal year.

12.1.1 Industry Practices

A limited survey of utilities in Florida that employ lime softening in their water treatment process was performed to determine current industry practices for reuse or disposal of lime sludge from WTPs. Utilities contacted included the following:

- Miramar
- Hollywood
- Pompano Beach
- Sunrise
- North Miami Beach
- FKAA J. Robert Dean WTP
- Deerfield Beach
- Lakeland
- Palm Coast
- Gainesville
- Brevard County
- St. Augustine
- Collier County
- Daytona
- St. Petersburg

Utilities were polled regarding lime sludge quantities being produced, de-watering methods employed, reuse/disposal practices and potential issues involved. Some of the surveyed entities employ processes that differ from the City of Fort Lauderdale. The City of Hollywood, for example, uses a spiractor process, which creates a bead-like product. The CUS Master Plan Team conducted additional literature reviews to collect further data on current lime sludge management practices outside the State of Florida.

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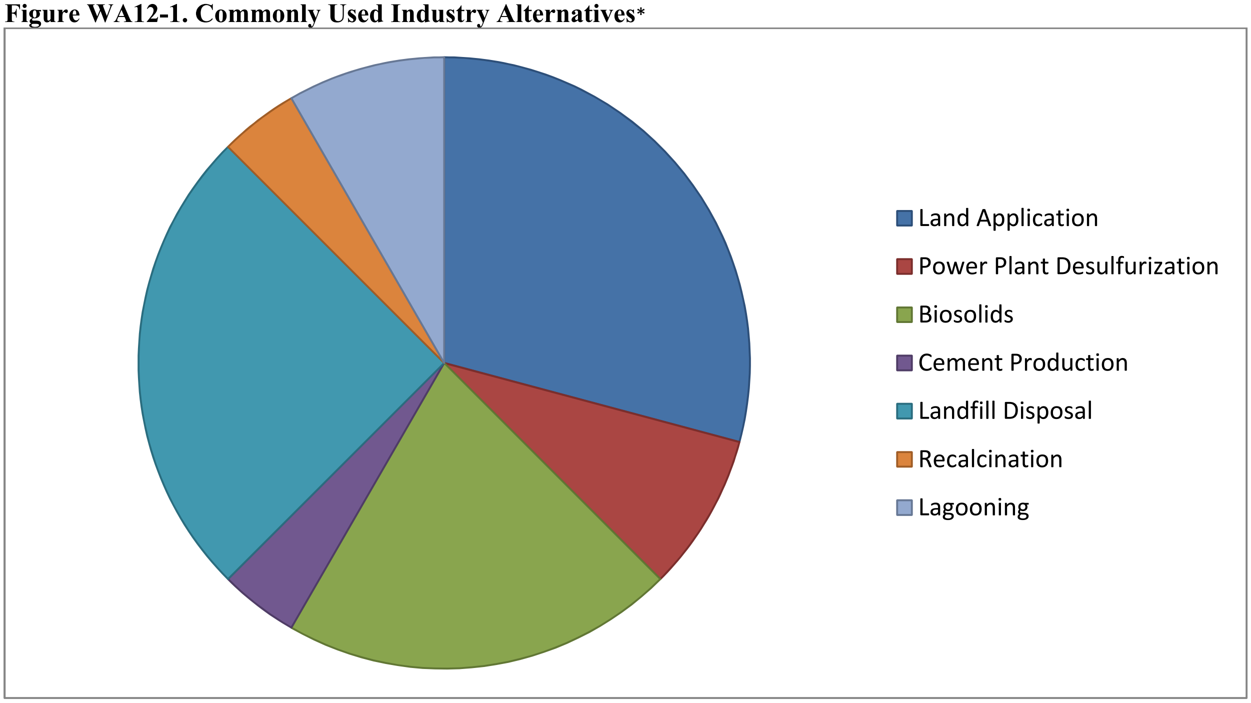
A summary of the current lime sludge management investigation is presented in **Figure WA12-1**. The Florida utilities survey indicated the two most commonly used practices for residual reuse/disposal are land application and landfill disposal. Other methods of reuse/disposal found in Florida included use for electric power flue gas desulfurization (FGD) scrubbing, combining with treated wastewater biosolids, cement production, and the City's current method of lagoon dewatering prior to contracted excavation and disposal.

Figure WA12-1. Commonly Used Industry Alternatives*



*Graph based on data collected from Florida water treatment plants surveyed.

12.1.2 Regulatory Requirements

According to the Guidance for Land Application of Drinking Water Treatment Plant Sludge from the Florida Department of Environmental Protection (FDEP), it has been determined that beneficial land application of lime sludge from drinking water systems is not expected to create any significant threat to public health or the environment. For this reason, no additional regulation or approval by the FDEP is required prior to reuse or disposal. The FDEP recommends that "lime sludge be applied at a rate no greater than 9 dry tons per acre per year in order to minimize movement of metals into the environment." However, the land application of the lime sludge (sludge) must meet the following three general criteria:

I. The lime sludge must not be a hazardous waste;

II. The use of the lime sludge must not cause violations of applicable Department ground water or surface water standards and criteria; and

III. The lime sludge must not cause fugitive dust emissions or objectionable odors, or create a public nuisance.

Additionally, local regulations for lime sludge disposal were considered. It was determined through the Department of Pollution Prevention, Remediation and Air Quality Division for Broward County that no local regulations exist in addition to those set by the State, although certain land application practices may require licensure or permitting.

12.2 Alternative Lime Sludge Disposal Methods

Based on the current lime sludge disposal/reuse practices investigated, the following alternatives were developed and analyzed with a focus on their feasibility and sustainability.

12.2.1 Landfill Disposal/Reuse

Landfill disposal is one of the most common practices in Florida for lime slurry disposal. Broward County Solid Waste and Recycling and North Dade Landfill are two (2) local landfills that can potentially make use of lime sludge as a soil amendment in intermediate cover, though this not currently practiced. In general, landfills do not accept stockpiled lime sludge unless it is dried to greater than 50 percent solids by volume, since landfills need to minimize the amount of leachate generated. The WTPs normally assume the cost of drying, loading and transporting of the lime sludge plus any tipping fees at the landfill. Therefore, it was assumed landfill disposal requires limes sludge to be a minimum of 60 percent dry.

Reuse of the lime sludge as soil amendment for landfills would be environmentally sustainable and can potentially provide a reliable source of clean material and the opportunity for Leadership in Energy and Environmental Design (LEED) credits. Materials and Resources (MR) credits are a type of LEED credit focused on preserving energy and minimizing waste. Using lime residuals could qualify the user for the following MR credits.

- MR 4.1 - Recycled Content, 10%
- MR 4.2 - Recycled Content, 20%Potential
- MR 5.2 - Regional Materials, 10%

12.2.2 Combine with Biosolids

Lime sludge is used by some utilities and biosolids processing companies to help stabilize and sanitize biosolids generated from wastewater treatment processes. Biosolids processing companies sometimes use patented technologies for recycling, land fertilization and soil stabilization applications. The combining with biosolids alternative can potentially be cost efficient if transportation and equipment handling logistics are successfully managed. However, the logistical challenges involved in coordinating with the biosolids process at GTL would likely constitute a cumbersome effort. Challenges include potential intermittent demand for the lime sludge and long term viability of the individual biosolids processing companies. Combining with the City's biosolids processing involves transporting the lime sludge to the GTL and combining prior to the dewatering process. Combination of biosolids with lime sludge at the farm was not considered, as the combination needs to occur prior to dewatering, and would require additional infrastructure at the farm. The combination would increase the capacity needs for the biosolids dewatering and disposal processes, and would effectively increase the lime sludge disposal and monitoring requirements to that of biosolids.

12.2.3 Direct Agricultural Land Application

One of the most common practices by utilities in Florida for lime sludge use/disposal is land application, which beneficially reuses the spent lime residuals as a soil amendment for agricultural land application. Since the FDEP determined that lime does not pose significant threat to the environment, agricultural land application of lime sludge can be a desirable alternative due to its economic and ecological advantages in crop production. Lime can help farmers create optimum

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soil conditions. Plants use the calcium in the lime to build cell walls and grow roots, which results in stronger plant growth. A study from a water treatment plant in Adersheim, Germany revealed that lime raises the pH value in soils which can improve plants ability to absorb nutrients, leading to a more efficient use of commercial fertilizers containing ingredients such as nitrogen, potash and phosphorous. Challenges for this method of reuse/disposal include a potentially intermittent demand of lime sludge due to weather dependency or crop timing and proximity and willingness of land owners available to take the product. Lime sludge would not be beneficial to most soils in South Florida, as the soil pH is already relatively high. Additionally, South Florida agricultural acreage has historically been on the decline due to continued urbanization. Thus, limiting the available farmland for application and increasing costs for hauling outside of the surrounding area.

12.2.4 Brick and Cement Additive

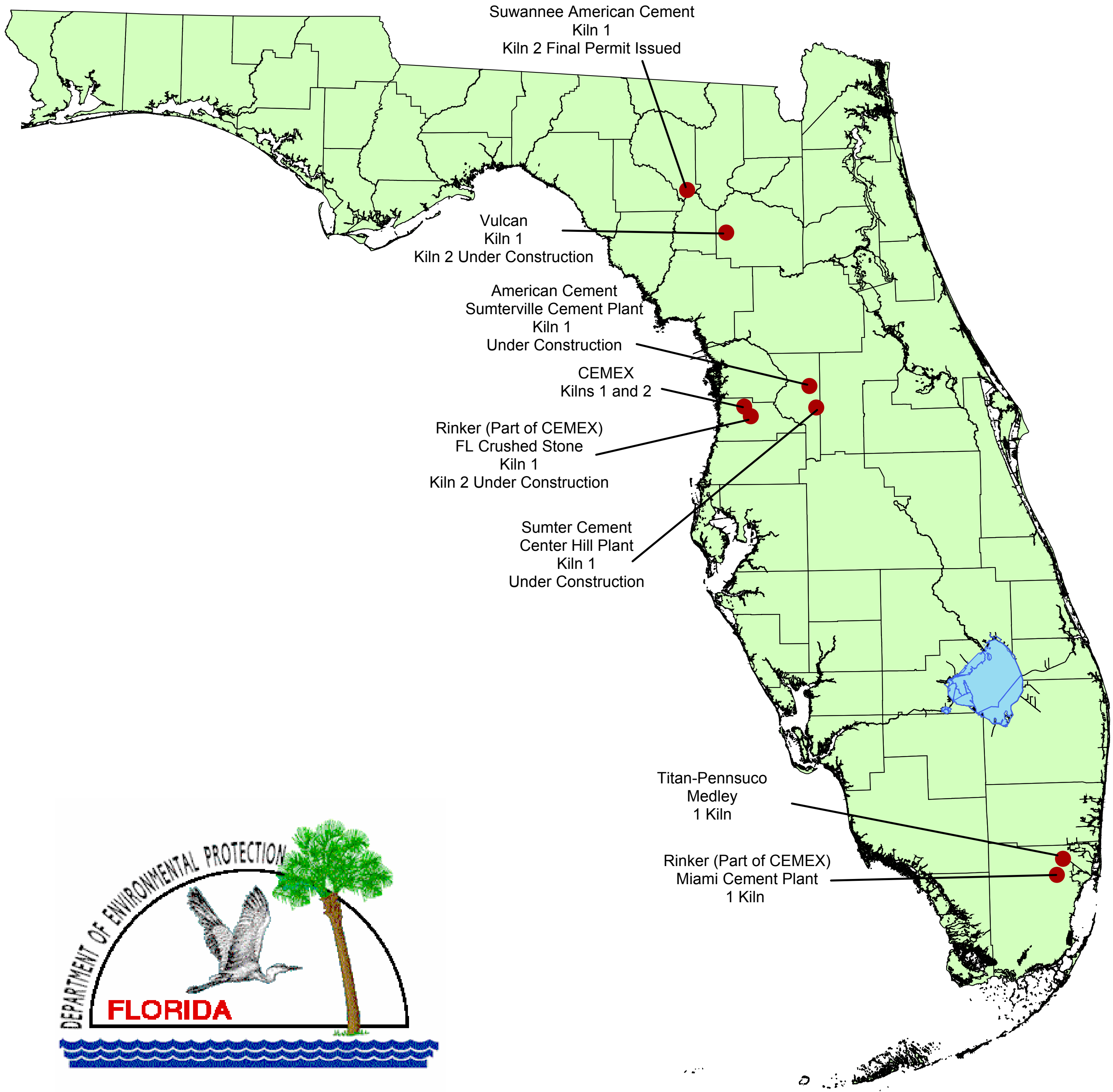
Use as an additive in brick and cement production is a relatively new alternative for recycling dried lime sludge. Gainesville Regional Utilities (GRU) has successfully used this approach according to telephone interviews and a report published by the Florida Water Resources Journal (FWRJ). GRU was able to carry out this effort effectively by coordinating transportation and management of quantities (contracted hauling trucks to provide 40 percent of stockpiled material to the cement plants over a period of 12 days).This effort also required the cement kiln to obtain certain FDEP permits to add new material (lime sludge) in the quarry and the raw materials as well as adjustments to monitoring practices.

The closest cement kilns to Fort Lauderdale are CEMEX Miami Cement Plant and Tarmac Pennsuco Cement, both located in Dade County. These facilities are located approximately 30 to 40 miles from Ft Lauderdale. **Figure WA12-2** displays the locations of cement kilns located within the state of Florida provided by FDEP. The main challenges are transportation logistics (distance, time, and costs) and the condition of lime sludge produced from Fiveash matching the needs of the cement kilns. Cement kilns typically require the lime sludge to be dewatered and dried to 60 to 80% solids. Additional research is required in order to evaluate the use of wet lime sludge in providing the correct water content/fines ratio necessary to create concrete. Limitations may be imposed depending on the type of polymer and levels of magnesium and silica in the lime residuals. Cement kiln reuse can become a very feasible alternative, if these challenges can be effectively managed and coordinated with the cement plants, as proven by GRU.

The cement reuse alternative is environmentally sustainable as it provides the cement kilns with a reliable source of relatively clean material and the potential of marketing the final product as LEED product. Using lime residuals could qualify the user of the material for MR credits as well. These credits include the following:

- MR 4.1 - Recycled Content, 10%
- MR 4.2 - Recycled Content, 20%
- MR 5.2 - Regional Materials, 10%

Figure WA12-2 Florida's Cement Kilns



Updated: August 2007

12.2.5 Power Plant Flue Gas Desulfurization

Ground limestone is typically applied to the flue in coal-fired power generators to prevent the release of sulfur gases (SOx) that contribute to the formation of “acid rain”. The “wet scrubbing” process involves solid/liquid lime sludge put in contact with flue gas, where the $CaCO_3$ absorbs and reacts with SOx gases. Researchers at Iowa State University have found that sulfur dioxide removal was more effective when using lime sludge than ground limestone. Currently, the City of Lakeland, the City of Cocoa, and Brevard County employ this practice in which the lime sludge is hauled to the Orlando Utilities Commission (OUC) Stanton Energy Center power plant in East Orange County. GRU discontinued this disposal method as its nearby power plants decreased their demand due to switching to dry scrubbers, which precludes the need for lime sludge. Typically, only coal fired power plants employ wet scrubbing technology.

Figure WA12-3 provides a map of power plants located throughout the State of Florida provided by FDEP and was utilized in identifying the four (4) closest power generation facilities to the City of Fort Lauderdale. Each of the four (4) power plants were contacted in reference to their use of lime at their facility, none of which use or can use spent lime for the following reasons.

- Florida Power & Light (FPL) Lauderdale (North Plant) – Is a Gas/Oil Plant and does not employ the use of lime in its scrubbers.
- FPL Port Everglades (South Plant) – The old plant was demolished in 2013, and is being replaced by a natural gas fired plant that is due to come on line by summer 2016. The new plant will not employ the use of lime in its scrubbers.
- Wheelabrator North Broward – Facility will be closing down.
- Wheelabrator South Broward – Uses dry scrubbers instead of wet scrubbers which will not accommodate the use of lime sludge.

This option as a whole may not be sustainable due to EPA regulations encouraging utilities to generate more energy with less dependency on coal and to harness carbon-free energy in the future. Many coal-fired power plants in Florida have already begun the process of converting to natural gas boilers. The regulatory changes could eventually force the shut down or limit the use of coal-fired power plants which in turn will reduce or eliminate the need for wet scrubbers and the use of lime sludge at power plants.

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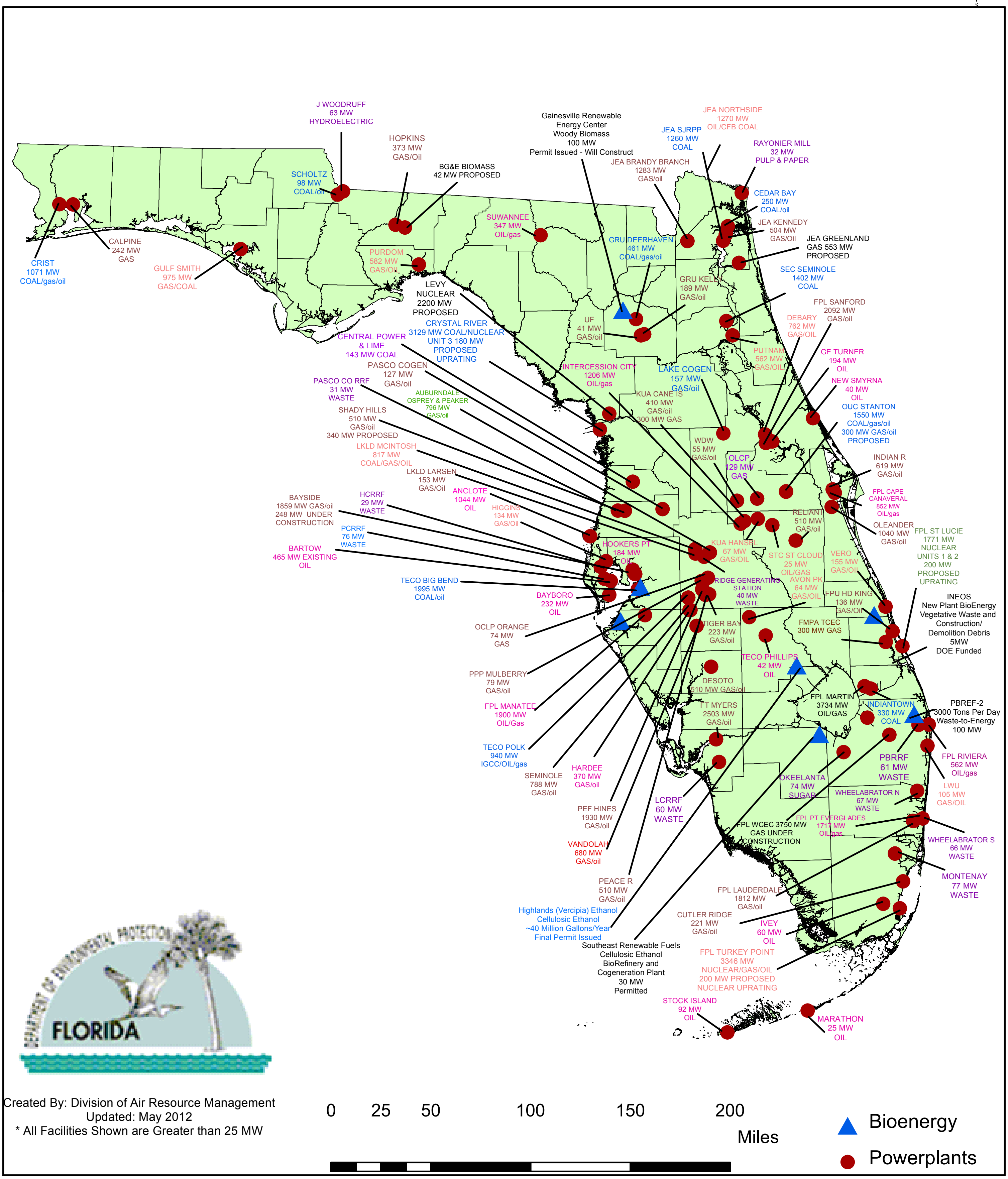
Figure WA12-3 Florida's Power Plants & Bioenergy Projects



12.2.6 Reverse Osmosis WTP Post – Treatment

Reverse Osmosis (RO) WTP post-treatment may be defined as a treatment processes that occurs downstream of synthetic membrane processes. The demineralized water is "stabilized" to protect downstream pipelines and storage facilities, usually by blending with mineralized finished water or adding lime, calcite (mineralized calcium carbonate), or caustic to prevent corrosion of concrete-lined surfaces. All RO plants have a need for post stabilization, but relatively few utilize the addition of calcium carbonate to truly stabilize the finished water. One of the calcium carbonate addition methods, calcite contactors (St. Lucie West, Florida and Blue Hills, Bahamas) has been proven to cost effectively, adequately stabilize finished RO waters. When lime or calcite calcium carbonate reacts with acidified demineralized water, the solution is then re-mineralized with calcium hardness and carbonate alkalinity. The process would replace the calcite with spent lime sludge from Fiveash. For this alternative to be feasible, the residual organic carbon present in the lime would need to be fixed or removed. This process has not been tested or implemented by a water treatment plant to Reiss Engineering’s knowledge; further research would be required. Research would involve testing color and metal concentrations at Fiveash, and measuring the impact of the lime sludge on the water quality at Peele-Dixie. It is also likely that this change to the stabilization process would require a permit modification in order to implement. The process would be environmentally sustainable since there is a need for stabilization of the Peele-Dixie WTP finished water.

Lime sludge could address critical factors for calcite use in the RO plants which depend on the availability of limestone approved by NSF International (NSF). Other factors need to be taken into consideration for the use of lime sludge in this application such as lime sludge’s head loss characteristics, total organic carbon content, polymer content and storage and feed design characteristics. These considerations would affect the viability of this conceptual alternative and according to the available knowledge base has not been implemented in any water treatment plant.

12.2.7 Ecological Enhancement

Eutrophication is the process by which a lake becomes rich in dissolved nutrients as a result of point and nonpoint pollutant sources and can be a major cause of the loss of natural lake ecosystems throughout the world. Eutrophication can cause unwanted high plant and algae bloom growth and can kill off aquatic life. Research has identified calcium carbonate to be an excellent phosphate binder reducing up to 70% of the phosphates in a given sample of water. Since the lime sludge is a reliable source of clean material, it can potentially be a feasible source of calcium carbonate to ecologically enhance compromised lakes and canals. Due to the application logistics, it might not be economically feasible and the demand will be intermittent since ecological enhancement will be subject to site specific conditions. It is not known at this time if any lime softening WTPs are employing this option.

12.2.8 Onsite Lime Regeneration

Lime regeneration, or recalcination, is a process in which spent lime is placed into a rotary kiln and heated to approximately 2,000 degrees Fahrenheit (F) where it is then converted into calcium oxide (CaO) and carbon dioxide (CO2). The recalcination process dissolves magnesium (Mg) from the lime softening residuals and leaves the carbon dioxide which is used for carbonation of lime softening residuals and pH adjustment. Additionally, dewatering is required before sludge is placed into the rotary kiln.

Section WA12 accepted December 16, 2016.

The recalcination process could not only provide the City with a new alternative for disposal, but reduce the amount of lime purchased for treatment as well. Significant energy is necessary to heat the spent lime to the required temperature; thus, conflicting with the City's plans for a 20% energy reduction by the year 2020. Additional space would need to be allocated for a rotary kiln, as well as additional operational staffing, air treatment, and regulatory compliance activities. The relatively small amount of lime sludge produced at the Fiveash WTP further reduces the viability of this option.

12.2.9 Alternative Disposal Comparison

Table WA12-1 compares the cost and feasibility of alternative lime sludge disposal methods. Capital costs are based on the installation of drying/thickening devices required for each alternative. Feasibility rankings are based on demand, hauling cost, equipment required, energy cost, and space allocation. For the feasibility scale, a scoring of 5 black circles represents the highest (excellent) ranking; 1 black circle represents the lowest (poor) ranking.

Table WA12-1. Alternative Disposal Methods Comparison

Alternative	Advantages	Disadvantages	Estimated Capital Cost	Estimated Annual O&M	Feasibility Scale
Contracted Disposal (Currently In-Use)	• An established system is already in place • Minimal extra management and logistical effort needed	• Is not environmentally sustainable • Cost of contracting the removal and disposal	$2,025,000	$20,000[1]	●●●●○
Landfill Disposal	• As reuse, it is environmentally sustainable • Potential for LEED credits	• Requires additional thickening/drying • WTP still assumes cost for disposal • Greater than 50% solids by volume	$2,400,000	$140,000	●●●●○
Combine with Biosolids	• Potential savings in disposal cost • Environmentally sustainable if used for land application	• No local Bio-solids facilities that make use of this alternative • Potential intermittent demand for facilities employing this alternative • May require additional thickening	$1,900,000	$90,000	●●○○○
Direct Land Application	• Environmentally sustainable. • Potential for reduction in disposal cost.	• Intermittent demand. • Requires additional thickening/dewatering.	$2,400,000	$140,000	●●●●○
Brick & Cement Additive	• Environmentally sustainable • Potential for LEED credits	• Requires additional thickening/dewatering. • No immediate, local interest. • Between 60% to 80% dry solids	$2,400,000	$140,000	●●●○○
Power Plant Desulfurization	• Potential for reduction in disposal cost • Additional dewatering may not be required	• No local power plants can make use of this alternative • This alternative is slowly being phased out	$0	$0	●○○○○
RO Post Treatment	• Environmentally sustainable. • Potential for reduction in disposal cost	• Additional thickening/dewatering may be required. • No local facilities employ the use of this alternative	$2,400,000	$140,000	●○○○○
Ecological Enhancement	• Environmentally sustainable. • Potential for reduction in disposal cost	• Intermittent demand. • May require additional thickening	$1,900,000	$90,000	●●○○○
Lime Regeneration	• Reduction in disposal cost • Savings in lime purchased for treatment	• Additional thickening/dewatering would be required • Large increase in energy use for rotary kiln	$5,600,000[2]	$480,000	●●●○○

[1]Cost estimation derived running two active 32.2 HP pumps non-stop yearly based on an average electrical rate of $0.08/kWh.
[2]This cost will be partially offset by not having to purchase as much lime.

Section WA12 accepted December 16, 2016.

12.3 Treatment Alternatives

Reducing the amount of lime introduced in the treatment process can in turn, reduce the amount of lime sludge produced by the City. The Fiveash WTP makes use of pebble quicklime as part of their water softening process. Currently, the lime is stored in a silo at the facility where it is fed into slakers via screw conveyors where water is added creating a lime slurry through a process called slaking. Two (2) 2,000 pound per hour (pph) and two (2) 4,000 pph slakers produce the lime slurry which is then fed through an open channel trough system where it is then added to the hydrotreators and precipitates out hardness and adjusts pH levels. Alternatives to this process were examined to identify potential lime reduction methods. Currently, the City is operating efficiently from a lime usage standpoint. Potential improvements utilizing the existing Fiveash treatment process (enhanced lime softening) to the color removal efficiency could increase lime usage and resulting lime sludge quantities. The nanofiltration treatment option would eliminate lime sludge generation, but has the disadvantage of utilizing more water supply due to the nanofiltration recovery requirements. Other challenges for nanofiltration include the cost of additional energy and chemicals, and the lack of available space to house the filter structures.

The City has been practicing volume minimization by minimizing the lime addition and softening at relatively lower pH to save the expense of recarbonation. Further minimization efforts to be pursued include reducing the amount of solids/sludge being sent back to the Fiveash WTP's recovery basin to reduce the recovery basin cleanup requirements and limit the impact of recovery return on color and treatment in the hydrotreaters. The impacts of solids minimization on lime sludge generation is expected to be relatively small given the City's efforts to date, but nonetheless worthwhile as it saves lime purchasing and disposal costs.

12.3.1 Split Flow Treatment

One alternative to reduce the introduction of lime into the treatment process would be to divert a portion of the water flow around the lime treatment and reintroduce it further downstream via a process known as split flow treatment. This process reduces the amount of lime used by treating only a portion of the water being processed.

In the split treatment process, lime would be added based on the flow entering the hydrotreators and not the bypass stream. The treated flow from the hydrotreators typically does not require recarbonation as there is typically enough alkalinity and carbon dioxide in the bypass stream to react with the excess lime. The treated and bypass streams would then need to be mixed and passed into an additional settling basin to further precipitate out calcium carbonate. If further non-carbonate hardness reduction (such as calcium sulfate, $CaSO_4$, or magnesium chloride, $MgCl_2$) is required, sodium carbonate (Na_2CO_3) can be added to the influent of the final mixing stage to precipitate out the additional hardness. After the final mixing and settlement the mixed stream would then pass to the recarbonation basin for final pH adjustment and then continue the treatment process as before.

Potential issues may exist with this process as it is normally used for water with lower magnesium concentrations. The appropriate pH levels may be acquired with this process but slightly harder water could occur, as well as increased color. The City must maintain color below acceptable levels; as additional color could potentially become a water quality issue. Additionally, space for new mixing and settling basins would need to be considered as well as capital cost for the installation of the tanks.

Section WA12 accepted December 16, 2016.

12.3.2 Lime Feed Improvements

In 2009, the City evaluated their need for improvements to the Fiveash lime feed system, investigating the lime feed systems of three (3) nearby lime softening facilities; the John E. Preston WTP, J. Robert Dean WTP, and Margate WTP. A report with a list of recommendations was compiled based on information obtained through the evaluation. The recommendations of the 2009 study have yet to be implemented and still provide a valid option for potentially reducing the amount of lime used and in turn reducing the amount of spent lime.

The City's current method of introducing lime into the system has created issues which have contributed to the use of excess lime as well as increased turbidity and poor water color. When the lime is exposed to the humidity it begins to absorb moisture from the atmosphere and begins sticking together causing clogging or bridging in the system which in turn disrupts the flow from the lime hoppers to the slakers.

The 2009 evaluation found that each of the three facilities recently installed new lime slakers, lime slurry storage tanks, pumps, and piping to introduce the lime into the treatment system. Adding new slakers and dilution tanks would ensure better mixing of lime and reduce the risk of clumping. Replacing or making improvements to the lime hoppers would also be necessary to reduce bridging. This reduction in lime build up would help eliminate the introduction of excess lime into the slakers, providing a more consistent distribution. Furthermore diluting the lime in tanks and using variable speed pumps as well as a new conveyance system to the hydrotreators would allow for the automated introduction of lime and potentially cut down on excess lime use. Reducing lime usage and controlling the ups and downs would also minimize the calcification of the filter media which in turns requires the replacement of filters in shorter cycles. Reducing lime usage also will reduce calcification of the downstream filters further minimizing operational efforts and cost. The CUS Master Plan team recommends this improvement, because it would be highly beneficial to the efficiency of the lime process, regardless of the selected lime sludge disposal method. These changes should also produce a savings in the amount of lime used at the facility, though the exact quantity cannot easily be identified prior to installation, due to numerous variables throughout the process.

12.3.3 Treatment Alternative Comparison

Table WA12-2 compares cost and feasibility for alternative treatment methods. Capital costs are based on the installation of equipment required for each alternative. Feasibility rankings are based on equipment required, space allocation, and energy cost. For the feasibility scale, a scoring of 5 black circles represents the highest (excellent) ranking; 1 black circle represents the lowest (poor) ranking.

Section WA12 accepted December 16, 2016.

Table WA12-2. Treatment Alternative Comparison

Alternative	Advantages	Disadvantages	Estimated Capital Cost	Estimated Annual O&M Cost	Feasibility Scale
Split Flow	• Potential reduction in lime used for treatment.	• Additional space required for mixing and settling basins. • Increase in energy cost. • Potential increase in treated water color.	$8,200,000	$95,000	●●○○○
Lime Feed Improvements	• Potential reduction in lime used for treatment. • Potential reduction in turbidity. • Controlling the ups/downs reduces filter calcification, as well as cleaning of the flumes and other lime feed system areas.	• Additional space required for new components. • High initial capital cost.	$4,000,000	Minimal increase in annual O&M cost	●●●●○

12.3.4 Redundancy in the System

There are physical constraints that will need to be addressed for the placement of new lime sludge processing equipment. Additional facility improvements are required to accommodate the equipment needed to improve the lime feed system. Such changes would include updating the fluoride system to provide more space and updates to the facilities instrumentation and controls.

The City currently has limited redundancy built in to its lime disposal process. The system consists of one sludge storage tank and three (3) 350 gpm sludge pumps, two (2) active and one (1) in reserve. Lime sludge is pumped into a single pipeline of varying sizes that discharges into a lagoon at the Prospect Wellfield. The pipeline is continuously in use to minimize build up caused by varying pipe sizes, so even when sludge is not being pumped, water is pumped to keep the line active. Additionally, the pipeline is the only source of transmission to the lagoon and creates a single point of failure; therefore, if this pipeline were to fail, the City would have no means for disposal of their lime sludge. In order to ensure proper operation for the disposal of lime sludge it is necessary for the City to include some form of redundancy within the system. Adding a standby lime thickener would allow the City to tanker the lime sludge to the sludge lagoon as a backup. The City could set up a contract with a hauler to provide redundancy in the event of emergency.

12.3.5 Vacuum Drying with Contracted Disposal

Several treatment facilities in South Florida make use of vacuum dryers to dry their spent lime and have it hauled for daily disposal. One source of redundancy would be the addition of a vacuum dryer followed by contract transportation as a primary source for disposal, and leaving the current pipeline to the lagoon as a backup, or vice versa. Vacuum dryers take previously thickened lime sludge and further dry the material to a range of 80-95 percent solids. With the addition of a vacuum dryer, the City could gain greater control over the percent solids in their spent lime and potentially develop alternative means of lime sludge disposal. Vacuum drying requires sludge thickening prior to utilization, additional space requirements, and added energy cost that may not be economically feasible for the City.

In addition to the vacuum dryer, a gravity thickener tank would be required to thicken the lime sludge in order to reduce its volume before entering the dryer. A gravity thickener tank also could recover most of the treated water that is currently used to transport the lime sludge to the lagoons. Both the gravity thickener and the vacuum dryer will increase the City's energy consumption, which may be counterproductive in achieving the City's energy savings goal. Additionally, the City will still have to contract out the disposal of the lime sludge, but now on a daily/weekly basis.

12.3.6 Gravity Thickening with Contracted Disposal

A lime sludge gravity thickener added to the Fiveash WTP could allow for another alternative source of redundancy. This option would leave the current lagoon process as the primary means of disposal and establish a gravity thickener accompanied by contracted hauling as the source for redundancy. Should the pipeline to Prospect Wellfield incur any problems, valves could redirect flow to a gravity thickener where the sludge could be thickened to approximately 30-40 percent solids, from there the thickened lime sludge would then be temporarily be disposed of via contracted hauling until such time that pipeline repairs could be effected.

Additionally, for this alternative, the CUS Master Plan Team recommends that the existing pipeline to Prospect Wellfield be replaced/rehabilitated with a new single sized 8-inch pipeline via pipe bursting, to reduce clogging caused by the alternating pipe sizes that currently exist.

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Adding a gravity thickener tank and a new single sized 8-inch pipeline to Prospect Wellfield would incur a significant capital cost for installation with the benefits of renewed infrastructure, higher water efficiency and contract hauling for redundancy.

12.3.7 Parallel Disposal Pipe

Another source for improved redundancy for the disposal of lime sludge would be the addition of a new sludge pump along with a with a single size 8-inch pipe running in parallel to the existing disposal line. By adding the new pump and line the City would have the option to run one line open while the other is maintained or shutdown due to an emergency. This option would allow for future lime sludge disposal capacity by establishing the ability to handle increased flow from the Fiveash WTP. Additionally, this option would have minimal impact in regards to operations and maintenance as well as energy cost, since the new pump and line would be used as a redundant system and only under existing conditions. Using existing abandoned pipes as casings for new runs of lime disposal pipe would reduce the cost of a new pipeline significantly. City Engineering staff evaluated the water atlas and found a route with roughly 80% of the distance covered by abandoned water mains ranging in size from 18 to 30 inches in diameter. Additionally much of the route is in long runs of straight pipe. The City should study this plan further to determine feasibility.

12.3.8 Redundancy Alternatives Comparison

Table WA12-3 compares the cost and feasibility for redundancy alternatives. Capital costs are based on the installation of equipment required for each alternative. The feasibility ranking is based on equipment required, space allocation, hauling cost, and energy cost. For the feasibility scale, a scoring of 5 black circles represents the highest (excellent) ranking; 1 black circle represents the lowest (poor) ranking.

Table WA12-3. Redundancy Alternatives Comparison

Alternative	Advantages	Disadvantages	Estimated Capital Cost	Estimated Annual O&M Cost	Feasibility Scale
Vacuum Drying and Contract Hauling	• Source of redundancy in spent lime disposal. • Minimizes amount of water hauled.	• Requires thickening prior to drying. • Increased energy cost to dry and contract haul. • Requires daily contracted hauling.	$4,300,000	$120,000 + Contract Hauling	●●●○○
Gravity Thickening and Contract Hauling	• Source of redundancy in spent lime disposal. • Reduces amount of water pumped/hauled.	• Additional space required. • Contracted hauling required. • Increased energy cost to contract haul.	$2,000,000	$30,000 + Contract Hauling	●●●●○
Parallel Pipe	• Source of redundancy in spent lime disposal. • No additional energy cost	• High capital cost. • Periodic lagoon cleaning. • Lower water efficiency.	$4,900,000	No additional O&M Cost	●●●●●

Section WA12 accepted December 16, 2016.

12.4 Lime Sludge Evaluation Summary

Several options exist for lime disposal with varying costs and degrees of feasibility. Options like ecological enhancements and land applications may prove to be cost efficient but the need for sludge can fluctuate greatly. Other options like nanofiltration treatment and brick and cement additives could prove to be costly in terms of capital equipment and operations. Some options are simply not feasible due to a lack of need or availably near the City of Fort Lauderdale like desulfurization of flue gases from power plants, bio-solids land application and soil amendment. For these reasons, it is recommended that the City continue their current practice of lagooning and hauling when the lagoon reaches capacity in the short term. For the long term it is recommended that the City begin negotiations with the local landfills (for soil cover amendment) and the two nearest cement kilns for reuse. While cement kiln reuse requires sludge drying, it also increases Fiveash treatment efficiency and is a “green”, sustainable approach to handling the lime. Other lower demand lime sludge reuse options such as for dry wall production could be utilized with the dried sludge. Also, and depending on the Fiveash color removal process selected, nanofiltration treatment is a viable alternative to eliminate lime sludge generation, albeit with its higher energy cost and reduced water efficiency (85% vs. 97% for lime softening).

The CUS Master Plan Team also recommends that the City create redundancy for their lime sludge disposal with either the addition of a parallel pipe to the sludge lagoon or a gravity thickener and contract hauling. Both alternatives would meet the need for redundancy and both have pros and cons. The estimated capital cost for adding the parallel pipe is $4,900,000, with minimal additional O&M cost. The estimated capital cost for adding a gravity sludge thickener is $2,000,000, with as needed contract hauling costs and supernatant return pumping.

Finally, the CUS Master Plan Team recommends improvements be made to the lime feed system. Improvements to the lime feed system will help to minimize excess lime use which will in turn reduce the amount of lime sludge produced from Fiveash WTP. Updating the system may also correct other issues with water quality such as color, and turbidity. These improvements have already been forecasted in the 2016-2020 Fort Lauderdale CIP. The estimated cost for the lime feed system improvements is $4,000,000. Further investigation into the lime feed system improvements may reduce cost if other processes or equipment is utilized.

12.5 Community Investment Plan

Community Investment Plan (CIP) project identification was a joint effort of City staff input, engineering analysis, strategic City initiative compliance, and previous program evaluation. Proposed lime sludge CIP projects are listed in **Section WA7.** The higher capital cost option was input into the CIP to allow either option to be selected.

Section WA12 accepted December 16, 2016.

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WA13 Energy Conservation

13.1 Introduction

As part of its Sustainability Action Plan (2013), the City of Fort Lauderdale (City) set goals to reduce power consumption 20% by the year 2020. This task evaluates methods of saving energy throughout the water system, including energy usage associated with the raw water wellfields, the water treatment systems and plant facilities, and the distribution system facilities. These methods include replacing equipment and implementing operational/maintenance changes; evaluating potential energy savings for building envelopes (mechanical, electrical, and plumbing) and site lighting; and utilizing renewable energy or alternative fuels.

After assessing the viability of implementing each of the alternatives, the CUS Master Plan Team provides recommendations for meeting the City's energy reduction goals. These recommendations are summarized in a 20-year Community Investment Plan (CIP) Table.

13.2 City Water Supply System

To provide potable water service to the City's service area, the City owns and operates two (2) water treatment plants (WTPs) that treat Biscayne Aquifer well water and provide water service through the City's water distribution system. The Fiveash Water Treatment Plant (Fiveash WTP) is located in the north part of the City and is served by the Prospect Wellfield located northwest of the plant approximately two miles. The Peele-Dixie Water Treatment Plant (Peele-Dixie WTP) is located in the southwest portion of the City and is served by the Dixie Wellfield located approximately one mile northwest of the WTP. Facilities include both a lime softening WTP, which is currently out of operation, and a nanofiltration membrane WTP.

The City's potable water distribution system consists of approximately 784 miles of water mains and two (2) remote storage and re-pump stations, the Poinciana Park Water Tank/Pump Station and the Northwest 2nd Avenue Water Tank/Pump Station.

Table WA13-1 lists the components of the water supply system and the average electrical usage in kilowatt hours (kWh) for the last two (2) years.

Table WA13-1. Average Electrical Usage (kWh) for the City's Water Supply System

Component	2013-2014 Average (kWh)	Percentage of System Total
Fiveash WTP		
Wellfield	5,863,414	20%
Plant	14,929,248	50%
Total	**20,792,662**	**70%**
Peele-Dixie WTP		
Wellfield	2,949,840	10%
Plant	5,656,070	19%
Total	**8,605,910**	**29%**
Distribution System	**194,930**	**1%**
System Total	**29,593,502**	**100%**

Section WA13 accepted February 17, 2017.

Based on the total water production from each plant during 2013 and 2014, **Table WA13-2** shows the total energy usage per 1000 gallons of water produced.

Table WA13-2. City's Total Energy Usage per 1000 Gallons of Water Produced.

WTP	Finished Water Produced 2013 (MG)	kWh/1000 Gal Finished Water Pumped 2013[1]	Finished Water Produced 2014 (MG)	kWh/1000 Gal Finished Water Pumped 2014[1]
Fiveash WTP	11,645	1.80	11,169	1.85
Peele-Dixie WTP	1,387	3.7	2,520	3.70

[1] Based on Total kWh for both the Wellfield and the WTP.
[2] MG = Million Gallons.

13.3 Fiveash Water Treatment Plant

The City's largest WTP is the Charles W. Fiveash WTP, with a design capacity of 70 million gallons per day (MGD). The plant is located in northwest Fort Lauderdale and draws its raw water from the Prospect Wellfield, which is fed from the surficial Biscayne Aquifer.

13.3.1 Prospect Wellfield

13.3.1.1 Description

Raw water is fed to the Fiveash WTP through twenty-nine (29) active production wells near Prospect lake that were constructed from 1969 through 2006 (see **Figure WA13-1**). A combination of 42-inch raw water transmission mains (some portions older and some portions newer) transmit the raw water from the Prospect Wellfield to the Fiveash WTP.

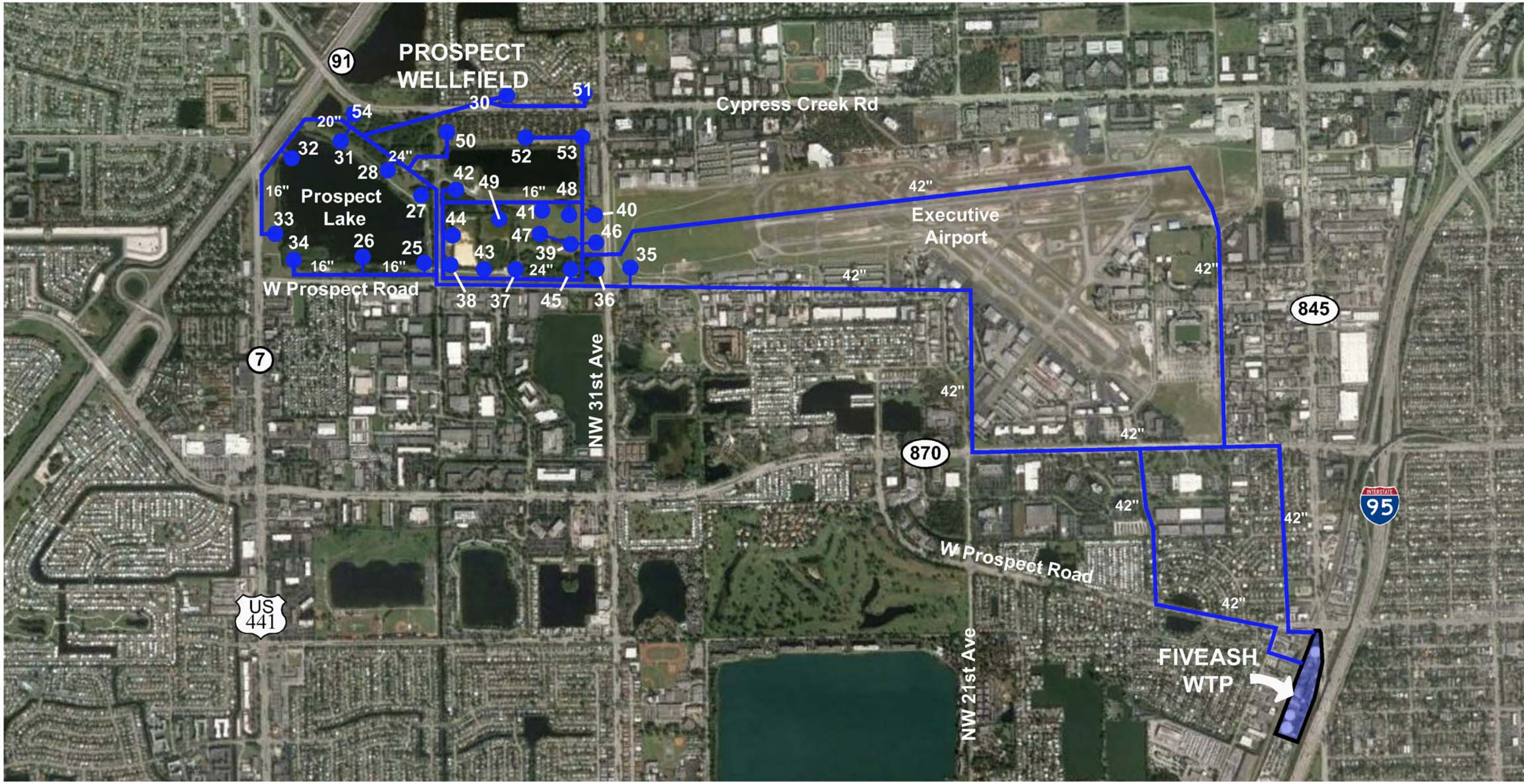
As shown in **Table WA13-1**, the combined total power consumption of the twenty-nine (29) wells is approximately 5,863,414 kWh per year based on an average of power-company billing records for the years 2013 and 2014. This equates to an energy cost of approximately $469,000 per year based on the current electrical rate of $0.08/ kWh.

All well pumps are 3-stage, vertical turbine pumps equipped with 100-horsepower (HP) motors, (with the exception of Well 27 which has a 75-HP motor). The well pumps have pumping capacities of approximately 3.03 MGD each which equates to a total wellfield capacity of approximately 88 MGD. According to operations personnel, the combination of wells operated at any given time are manually selected based on raw water quality.

For the Prospect Wellfield, structural and mechanical issues are addressed in **Section WA5.A**, electrical issues are addressed in **Section UW3**, and I&C/SCADA issues are discussed in **Section UW2**.

13.3.1.2 Equipment Replacement

Testing and replacement of wellfield electrical equipment recommended in **Section UW3** will help identify/reduce energy losses associated with the system due to failing wiring and other electrical components.



LEGEND

●	WELL
—	RAW WATER TRANSMISSION LINES
US 441	US ROUTE
7	STATE ROUTE
870	CITY ROUTE
95	INTERSTATE ROUTE

Graphic Scale in Feet
0 1500' 3000'

N

DWG: R:\Projects\134001-P FtLauderdale CUSMP\Design\Drawings\PreliminaryDesign\134001 Fiveash Well Location Map.dwg

RE

CITY OF FT. LAUDERDALE
FIVEASH WATER TREATMENT PLANT
WELL LOCATION MAP

FIGURE WA13-1

Replacing older, low-efficiency motors with high-efficiency motors can reduce operating costs at the Prospect Wellfield. Motors fabricated prior to 1997 are standard efficiency motors that have significantly lower efficiencies than high or premium efficiency motors produced after 1997.

Most of the well pump motors are pre-1997 and have been repaired multiple times. The CUS Master Plan Team recommends that any well pump motors in operation for 12 hours or more per day be replaced with high/premium efficiency motors (based on a payback period of 7 years or less). This could be done in conjunction with the replacement of the "across the line" starters with energy saving, reduced voltage starters as recommended in **Section UW3.** Based on an estimated eighteen (18) well pumps that operate 12 hours per day or more, **Table WA13-3** shows the estimated project costs, the estimated annual energy savings, and the payback period for replacing the low-efficiency motors with higher efficiency motors.

Table WA13-3. Recommended Motor Replacements

Pump Name	Horsepower (HP)	Operation (Hours/day)	Estimated Project Cost[1] ($)	Estimated Annual Savings[2] ($)	Simple ROI (Years)
Prospect Wellfield Well Pump Motors (18)	100	12	205,452	27,774	7

[1] Based on motor cost plus 1 man-day and $50 travel for 5 - 40 HP; 2 man-days, $50 travel, and $500 crane for 50-200 HP; 3 man-days, $100 travel, and $1000 crane for 350 - 600 HP; $280/man-day; includes 30% contingency and 10% non-construction costs.

[2] Based on an 8% efficiency improvement for 5 - 40 HP; 5% efficiency improvement for 50-200 HP; 2% efficiency improvement for 350 - 600 HP and $0.08/KWh.

13.3.1.3 Operational Changes

No operational changes for the well system are recommended to reduce energy.

13.3.1.4 Use of Renewable Energy or Alternative Fuels

The motor loads at the individual wells are too large for renewable energy sources such as wind or solar energy to be feasible for generating sufficient power. Based on the small amount of energy utilized at the wellfield for lighting and controls, no significant energy savings are anticipated if renewable energy systems for these electrical loads are provided.

Alternate fuels for the emergency power generators providing backup power to the wells, which currently run on diesel fuel, include natural gas, LP gas, and biodiesel. If natural gas is available, relying on another utility (such as a gas company) during emergencies is usually not preferred. The use of LP gas to fuel emergency generators is not common based on the high operating costs. These costs can be attributed to the significant amount of LP gas that must be used to generate power versus lower quantities of diesel.[1] The life span (rated hours) for LP gas powered generators are also usually much less than for diesel generators.[1]

Most emergency generator manufacturers now honor equipment warranties for generator engines run on biodiesel blends with up to 5% biodiesel (B5), with some engines also approved to run on blends up to 20% (B20). Storage of biodiesel blends has and continues to be an issue for intermittent use due to oxidation, moisture absorption, growth of microbes, and sediment formation.2,3,4 While biodiesel is considered a renewable, clean energy source, using biodiesel blends for an emergency generator fuel source requires extensive testing and the addition of additives to prevent damage to the generator engine. While specific standards are in place for biodiesel, the quality of biodiesel blends available is inconsistent.[4]

13.3.2 Water Treatment Plant Processes

The Fiveash WTP processes include the following:

a. Pretreatment Aeration
b. Lime Softening Total Organic Carbon (TOC) Removal
c. Chemical Treatment and Filtration
d. Clearwell and Transfer Pumps
e. Ground Storage Tanks and High Service Pumping
f. Sludge Management

As shown in **Table WA13-1**, the combined total power consumption for the Fiveash WTP is approximately 14,929,248 kWh per year based on average of power-company billing records for the years 2013 and 2014. This equates to an energy cost of approximately $1,194,000 per year based on an average electrical rate of $0.08/kWh.

The total HP of all pumps on site is 5,777 HP, with the high service pumps accounting for approximately 80% of the total pump HP.

Section UW3 addresses replacement of older electrical equipment at the Fiveash WTP based on safety/reliability issues. Replacing aging electrical equipment will ultimately reduce energy consumption by eliminating voltage losses through old electrical connections and aging wire insulation.

13.3.2.1 Pretreatment Aeration

13.3.2.1.1 Description

The Prospect Wellfield well pumps deliver raw water from the active production wells into two (2) aeration basins. The aeration basins remove excess carbon dioxide and hydrogen sulfide from the raw water by passing large quantities of air through the water to strip away the excess gases.

The pretreatment aeration system includes two (2) 75-HP centrifugal blowers and perforated PVC pipes located at the bottom of the aeration basins that act as coarse bubble diffusers.

13.3.2.1.2 Equipment Replacement

Sections WA5, WA5B and **WA8** identify the aeration blowers as equipment that needs to be replaced within the next 5 years due to the age and condition of the equipment. Replacing the existing blowers with new high-efficiency turbo blowers can reduce aeration energy costs. Turbo blower systems are typically VFD-driven and are approximately 10-20% more efficient than centrifugal blower systems. The majority of this increased efficiency can be attributed to the turbo blowers' ability to vary air flow based on the air requirements.

The estimated payback period for installing turbo blowers is based on the difference in cost between installing replacement centrifugal blowers versus turbo blowers divided by the annual energy cost savings. The estimated incremental cost to replace the two (2) existing centrifugal blowers with new high-efficiency turbo blowers is approximately $100,000.

With one (1) 75-HP centrifugal blower operating 24 hours per day, the estimated annual energy cost is $39,210 based on $0.08/kWh. **Table WA13-4** shows the estimated project costs, the estimated annual energy savings based on a 15% efficiency improvement, and the simple return on investment (ROI) for replacing the existing blowers.

Replacing the existing perforated PVC diffusers with fine bubble diffusers will also reduce aeration energy costs by improving the dissolved gas removal efficiency. Smaller, slower-moving bubbles with more surface area in contact with the water will allow greater contaminant removal with less air. The estimated project cost to replace the coarse bubble diffusers with fine bubble diffusers is approximately $70,000.

Typical energy savings achieved by converting from coarse bubble diffusers to fine bubble diffusers for oxygen transfer or dissolved gas removal can be 50% or more (Xylem Technical Manual and multiple other sources). **Table WA13-4** shows the estimated project costs, the estimated annual energy savings based on a 25% reduction of air requirements after installing high-efficiency blowers, and the simple ROI for replacing the coarse air bubble diffusers.

Table WA13-4. Cost Analysis for Installing High-Efficiency Blower and Diffusers

Alternative	Estimated Project Cost ($000)	Estimated Annual Savings ($000)[2]	Simple ROI (Years)
Replace (2) 75-HP Blowers with High-Efficiency Blowers	100[1]	5.9[2]	16
Replace Perforated PVC Diffusers with Fine Bubble Diffusers	70	8.3[3]	8
Both Alternatives	160	14.2	11[4]

[1] Project cost difference between replacing blowers with centrifugal blowers and turbo blowers.
[2] Based on an estimated 15% reduction of power costs.
[3] Based on an estimated 25% reduction in air requirements.
[4] Higher efficiency diffusers would allow the use of smaller turbo blowers, increasing the system's energy savings and further and decreasing the payback time.

Although the payback period is in excess of 10 years, the CUS Master Plan Team recommends replacing the existing blowers with high-efficiency turbo blowers and installing fine bubble diffusers. The energy savings for installing fine bubble diffusers are potentially twice what is used to determine the payback period, and can significantly contribute to the City's goal of reducing energy consumption by 20% by the year 2020. The additional CIP money is accounted for in **Section WA8**.

13.3.2.1.3 <u>Operational Changes</u>

No operational changes for this process were identified which would reduce energy consumption.

13.3.2.1.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.3.2.2 Lime Softening

13.3.2.2.1 Description

There are four (4) hydrotreater units that receive water from the aeration basins and soften the water by chemical addition and clarification. On average, at least three (3) of the hydrotreaters are routinely in operation, with the last hydrotreater used solely during peak flow hours and for redundancy.

There are four (4) 2-HP motors which drive mixers in the hydrotreaters and four (4) recirculation pumps with two (2) 7.5-HP motors and two (2) 15-HP motors.

Processing of sludge generated by the hydrotreaters is discussed in the Sludge Management section below.

13.3.2.2.2 Equipment Replacement

The advantages of replacing older, low-efficiency motors with high-efficiency motors is discussed in **Section WA13.3.1.2** above. **Table WA13-5** shows the pre-1997 motors associated with the hydrotreaters, the estimated project costs, the estimated annual energy savings, and the payback period for replacing the low-efficiency motors with higher efficiency motors.

Table WA13-5. Recommended Motor Replacements

Pump Name	Horsepower (HP)	Operation (Hours/day)	Estimated Project Cost ($)[1]	Estimated Annual Savings ($)[2]	Simple ROI (Years)
Recirc #1	7.5	12	1,722	235	7
Recirc #2	7.5	12	1,722	235	7
Recirc #3	15	12	2,276	447	5
Recirc #4	15	12	2,276	447	5

1. Based on motor cost plus 1 mechanic-day and $50 travel; $280/mechanic-day; includes 30% contingency and 10% non-construction costs.
2. Based on a 8% efficiency improvement for 5 - 40 HP, 5% efficiency improvement for 50-200 HP and a 2% efficiency improvement for 350 - 600 HP and $0.08/KWh.

The CUS Master Plan Team recommends replacing the motors that were constructed pre-1997 with high/premium efficiency motors having a payback period of 7 years or less to reduce pumping energy costs. As a result, the CUS Master Plan Team recommends replacing the motors on all recirculation pumps with high/premium efficiency motors within the next five years.

13.3.2.2.3 Operational Changes

No operational changes for this process were identified which would reduce energy consumption.

Section WA13 accepted February 17, 2017.

13.3.2.2.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.3.2.3 Chemical Injection, Recarbonation, and Filtration

13.3.2.3.1 Description

Once the water has undergone lime softening, a controlled dose of chlorine (7-7.5 mg/L) is added to the water for disinfection as it flows to one (1) of three (3) recarbonation basins. The purpose of the recarbonation basins is to reduce the pH and reintroduce carbonate (for stability) into the process water by injecting carbon dioxide. Currently, the recarbonation system is not in use. Ammonia is also added at this stage for formation of chloramines.

After chemical treatment in the recarbonation basins, the water flows through one (1) of twenty-two (22) sand/anthracite gravity filters for final filtration. Filter backwash is transported to the washwater diversion structure, where the diversion structure separates sludge from the backwash water. The sludge goes to a sludge holding tank/pump station and ultimately the Prospect Wellfield sludge disposal lagoon. The supernatant water is then pumped to the hydrotreaters for re-treatment.

13.3.2.3.2 Equipment Replacement

The advantages of replacing older, low-efficiency motors with high-efficiency motors is discussed in **Section WA13.3.1.2** above. **Table WA13-6** shows the pre-1997 motors associated with the chemical injection and filters, the estimated project costs, the estimated annual energy savings, and the payback period for replacing the low-efficiency motors with higher efficiency motors. The City is in the process to replace all 4 chlorine injector pumps and operations personnel developed a new process that does not require the use of the injection pumps. The injection pumps are used as a back up system only and would not impact operations cost.

Table WA13-6. Recommended Motor Replacements

Pump Name	Horsepower (HP)	Operation (Hrs./day)	Estimated Project Cost[1] ($)	Estimated Annual Savings[2] ($)	Simple ROI (Yrs.)
Surface Wash #1[3,4]	20	0.5	2,665	22	121
Surface Wash #2[4]	30	0.5	3,862	29	133
Backwash Motor #2	150	12	16,047	2,224	7
Washwater Transfer #1	75	8	8,596	755	11
Washwater Transfer #2	75	8	8,596	755	11
Washwater Transfer #3	75	8	8,596	755	11

[1] Based on motor cost plus 1 man-day and $50 travel for 5 - 40 HP; 2 man-days, $50 travel, and $500 crane for 50-200 HP; 3 man-days, $100 travel, and $1000 crane for 350 - 600 HP; $280/man-day; includes 30% contingency and 10% non-construction costs.
[2] Based on an 8% efficiency improvement for 5 - 40 HP; 5% efficiency improvement for 50-200 HP; 2% efficiency improvement for 350 - 600 HP and $0.08/KWh.
[3] The City is currently in process of replacing the Surface Wash Pump #1 due to the current pump's inability to provide reliable pressure on a constant basis.

[4] Surface wash pumps run for 5 minutes per filter with 2 filters per shift for a total of ~30 minutes per day of run time.

The CUS Master Plan Team recommends replacing the motors that were constructed pre-1997 with high/premium efficiency motors having a payback period of 7 years or less to reduce pumping energy costs. As a result, the CUS Master Plan Team recommends replacing the backwash pump #2 motor with a high/premium efficiency motor within the next five years. Repair & Replacement (R&R) costs presented in **Section WA8** also include replacing the washwater transfer pump motors with high/premium efficiency motors when the existing motors fail.

13.3.2.3.3 Operational Changes

No operational changes for this process were identified which would reduce energy consumption.

13.3.2.3.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.3.2.4 Clearwell and Transfer Pumps

13.3.2.4.1 Description

The filter effluent discharges into Clearwells 1 and 2, which are connected to the other clearwells. Transfer pumps push water into the ground storage tanks from Clearwells 3 and 4. Back wash water pumps withdraw from Clearwell 3. High Service Pumps 6 through 11 pull from Clearwell 6 or the transfer pipe from the ground storage tanks. High Service Pumps 12 through 16 pump only from Clearwell 5. High Service Pumps 4 and 5 pump only from Clearwell 1. The three ground storage tanks (GSTs) are interconnected with transfer pumps. There are four (4) transfer pumps, two (2) with 150-HP motors and two (2) with 100-HP motors. All motors are low efficiency motors manufactured prior to 1997.

The transfer pumps are fixed speed pumps in a lead/lag1/lag2/lag3 configuration that operate at a discharge pressure of approximately 20 pounds per square inch (psi).

13.3.2.4.2 Equipment Replacement

The advantages of replacing older, low-efficiency motors with high-efficiency motors is discussed in **Section WA13.3.1.2** above. **Table WA13-7** shows the transfer pumps with pre-1997 motors, the estimated project costs, the estimated annual energy savings, and the payback period for replacing the low-efficiency motors with higher efficiency motors.

Section WA13 accepted February 17, 2017.

Table WA13-7. Recommended Motor Replacements

Pump Name	Horsepower (HP)	Operation (Hours/day)	Estimated Project Cost ($)[1]	Estimated Annual Savings ($)[2]	Simple ROI (Years)
Transfer Motor #1	150	12	16,047	2,224	7
Transfer Motor #2	150	12	16,047	2,224	7
Transfer Motor #3	100	12	11,414	1,543	7
Transfer Motor #6	100	12	11,414	1,543	7

[1] Based on motor cost plus 1 mechanic-day and $50 travel for 5 - 40 HP; 2 mechanic-days, $50 travel, and $500 crane for 50-200 HP; 3 mechanic-days, $100 travel, and $1000 crane for 350 - 600 HP; $280/mechanic-day; includes 30% contingency and 10% non-construction costs.

[2] Based on an 8% efficiency improvement for 5 - 40 HP; 5% efficiency improvement for 50-200 HP; 2% efficiency improvement for 350 - 600 HP and $0.08/KWh.

The CUS Master Plan Team recommends replacing the motors that were constructed pre-1997 with high/premium efficiency motors having a payback period of 7 years or less to reduce pumping energy costs. As a result, the CUS Master Plan Team recommends replacing the motors on all transfer pumps with high/premium efficiency motors within the next five years.

13.3.2.4.3 Operational Changes

No operational changes for this process were identified to reduce energy consumption.

13.3.2.4.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.3.2.5 Ground Storage Tanks and High Service Pumping

13.3.2.5.1 Description

There are three (3) ground storage tanks (GSTs) on-site. GST No. 1 has a capacity of 5 MG and is located on the north side of the property. GSTs No. 3 and 4 have a capacity of 5 MG and 7 MG, respectively, and are located on the south side of the property.

There are thirteen (13) high service pumps (HSPs) that provide finished water to the distribution system. Seven (7) of the pumps are electric-motor driven, three (3) are combination electric-motor and diesel-engine drive pumps, and three (3) are diesel-engine driven only. All HSP electric motors are 350-HP, except for the combination pumps which have 600-HP motors.

Currently, the Fiveash WTP high service pumps pull from both the clearwells and the ground storage tanks before pumping finished water into the distribution system. These high service pumps operate at a target pressure of approximately 80 psi. The GST discharge pipes also have "strike-down" valves that open when the level in the clearwells is below the minimum setpoint. Backflow of water from the GST to the clearwell creates issues for chemical feed dosing particularly chloramination and can result in hydraulic short circuiting and increased water age in the GST; recommendations were provided to resolve this issue in **Section WA5B**.

The high service pumps at the Fiveash WTP are constant speed pumps operated manually as system pressures increase or decrease (no automation), which makes maintaining a constant discharge pressure from the Fiveash WTP to the distribution system challenging. **Figure WA13-2** shows the pressure variations of the discharge pressures at the Fiveash WTP during normal demand.

13.3.2.5.2 Equipment Replacement

Section UW3 includes recommendations for installing VFDs on two (2) of the HSPs, while **Section UW2** includes more automation programming recommendations to allow for reliable control of the HSP operation. Both recommendations will save energy by allowing the HSPs to operate at a much smaller variation in operating pressures at the plant. These alternatives will also allow coordination of the Fiveash WTP plant flows with the plant flows from the Peele-Dixie WTP. With the energy cost to produce water at the Peele-Dixie WTP twice the cost of producing water at the Fiveash WTP, controlling flow from the plants is critical to reducing energy costs.

The advantages of replacing older, low-efficiency motors with high-efficiency motors is discussed in **Section WA13.3.1.2** above. **Table WA13-8** shows the HSPs with pre-1997 motors, the estimated project costs, the estimated annual energy savings, and the payback period for replacing the low-efficiency motors with higher efficiency motors.

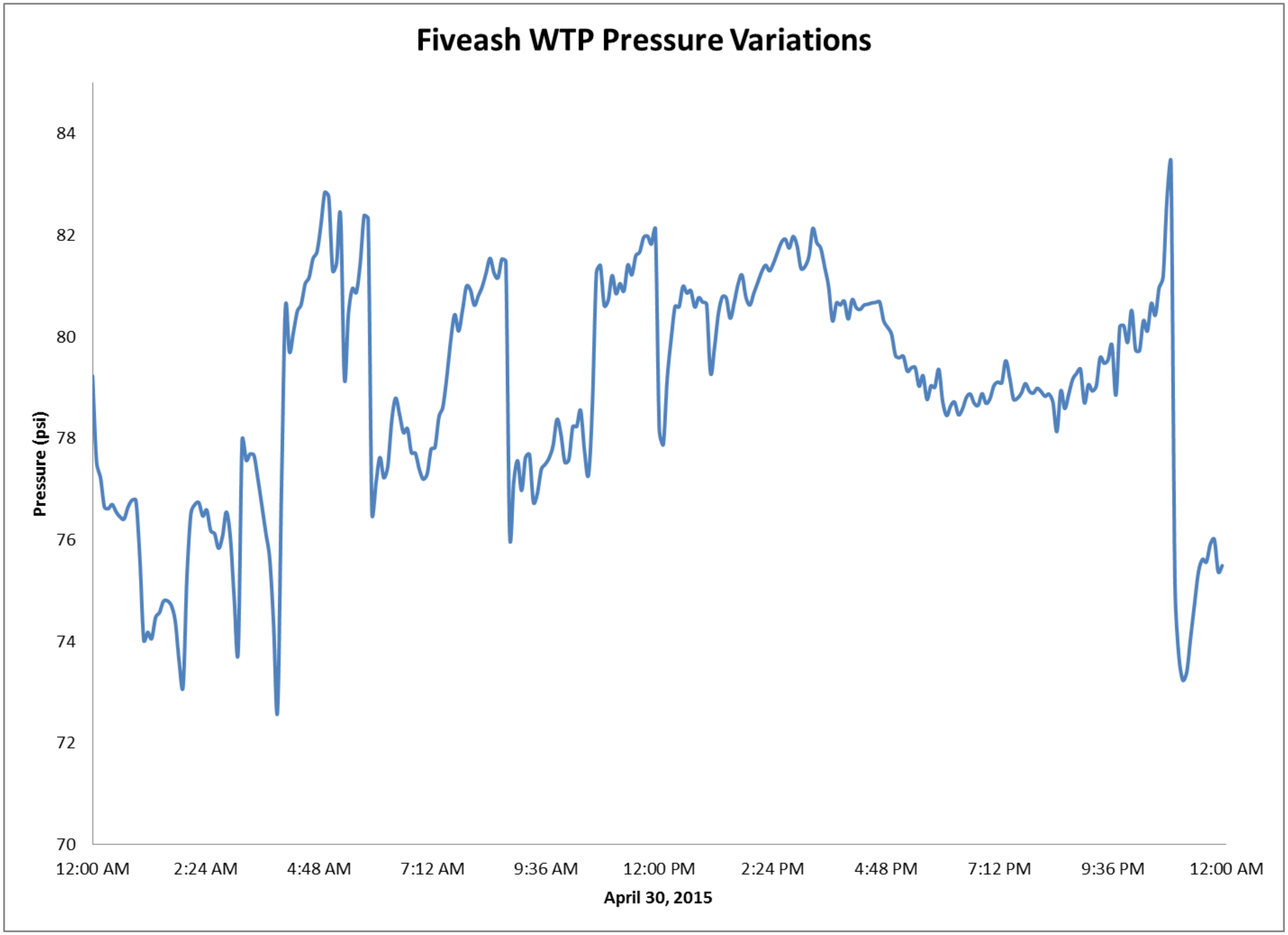
Table WA13-8. Recommended HSP Motor Replacements

Pump Name	Horsepower (HP)	Operation (Hours/day)	Estimated Project Cost[1] ($)	Estimated Annual Savings[2] ($)	Simple ROI (Years)
South High Service #9	600	3	49,964	644	78
South High Service #10	600	3	49,964	644	78
South High Service #11	600	3	49,964	644	78
South High Service #12	350	12	32,804	1,502	22
South High Service #13	350	12	32,804	1,502	22
South High Service #14	350	12	32,804	1,502	22
South High Service #15	350	12	32,804	1,502	22
South High Service #16	350	12	32,804	1,502	22

[1] Based on motor cost plus 1 mechanic-day and $50 travel for 5 - 40 HP; 2 mechanic-days, $50 travel, and $500 crane for 50-200 HP; 3 mechanic-days, $100 travel, and $1000 crane for 350 - 600 HP; $280/mechanic-day; includes 30% contingency and 10% non-construction costs.

[2] Based on an 8% efficiency improvement for 5 - 40 HP; 5% efficiency improvement for 50-200 HP; 2% efficiency improvement for 350 - 600 HP and $0.08/KWh.

Figure WA13-2. Fiveash WTP Pressure Variations



Section WA13 accepted February 17, 2017.

The CUS Master Plan Team recommends replacing the motors that were constructed pre-1997 with high/premium efficiency motors having a payback period of 7 years or less to reduce pumping energy costs. As a result, no HSP motors are recommended to be replaced within the next five years with high/premium efficiency motors. R&R costs presented in **Section WA8** include replacement of the motors with high/premium efficiency motors when the existing motors fail.

13.3.2.5.3 Operational Changes

Section WA5 includes the CUS Master Plan Team recommendation to provide piping modifications in order to eliminate short-circuiting between the GSTs and the clearwells.

13.3.2.5.4 Use of Renewable Energy or Alternative Fuels

The CUS Master Plan Team identified no potential uses of renewable energy or alternative fuels for this process.

13.3.2.6 Sludge Management

13.3.2.6.1 Description

Sludge accumulated in the hydrotreaters and the filter washwater diversion structure is drained into a sludge holding tank, where it is pumped to the City's two bermed sludge storage and drying cells at the Prospect Wellfield.

13.3.2.6.2 Equipment Replacement

The CUS Master Plan Team did not identify any equipment replacements for this process to reduce energy costs.

13.3.2.6.3 Operational Changes

No operational changes for potential energy savings were identified.

13.3.2.6.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.3.3 Building Envelope

The building envelope components evaluated include the following:

a. Architectural
b. HVAC
c. Solar Water Heating Panels
d. Interior Lighting
e. Exterior Site Lighting

13.3.3.1 Architectural

Significant amounts of energy are typically expended in older buildings due to inefficiencies in the building insulation system and exterior windows. Typical items that are evaluated as part of an "energy audit" include the following:

- Roof Insulation Properties
- Roof Reflective Properties
- Ceiling Insulation Properties
- Window Insulation Properties and Shading co-efficiencies

The CUS Master Plan Team recommends performing a full building envelope energy audit within the next three years to determine building improvements which can assist the City in achieving a 20% energy reduction by the year 2020. Improvements relating to the above building properties are eligible for FP&L rebates (see FP&L programs discussed further in the report).

13.3.3.2 HVAC

The Fiveash WTP has approximately 85 tons of air conditioning equipment operating within the plant, not including miscellaneous wall units feeding various offices. All of the units are traditional condenser/air handler systems with ductwork. An evaluation of the economics of converting the HVAC systems to geothermal heat pumps is discussed below.

Heat pumps using a boiler/cooling tower system are generally more efficient than conventional fan coil systems. Geothermal heat pumps, which use the constant temperature of the earth/groundwater to provide a heat sink/source for air conditioning/heating systems, can save between 25% and 50% on HVAC energy costs compared to conventional systems.[8,9,10] This section of the report evaluates the economics and other factors for replacing the existing systems with geothermal heat pump systems.

There are three (3) common types of geothermal heat pump systems as follows:

1. Horizontal Closed Loop
2. Vertical Closed Loop
3. Vertical Open Loop

All of the systems use heat exchangers and cooling/heating loops to provide heat loss (for AC) and heat gain (for heating) in the circulating water. Types of heat exchangers and cooling/heating loops include Horizontal Closed Loop, Vertical Closed Loop, and Vertical Open Loop. The City will most likely select Vertical Open Loop because the Biscayne Aquifer is very productive and the water is of sufficient quality.

A Vertical Open Loop system uses a number of supply wells which feed a heat exchanger within a building and discharge the heated groundwater to either the surface, a body of water, or return wells. Due to environmental concerns, Florida no longer allows open loop systems that discharge water to surface waters. This report anticipates that the supply water will be discharged back to the aquifer where the water was withdrawn. The supply and discharge wells must be located far enough apart so that the heated discharge water does not get pulled up by the supply wells.

Table WA13-9 shows the area requirements of the different systems.

Table WA13-9. Geothermal Heat Pump Systems' Area Requirements

Type System	Approx. Linear Ft of Piping Required[1]	Approx. Area Required
Horizontal Closed Loop	25,500 lf[1]	1.2 Acres[2]
Vertical Closed Loop	29,750 lf[3]	0.3 Acres[4]
Vertical Open Loop	N/A[5]	.011 Acres[6]

[1] Based on 150 lf supply and return piping per ton.
[2] Based on 400 lf runs with 2 ft. spacing between runs.
[3] Based on 175 lf supply and return piping per ton.
[4] Based on 10 ft. deep vertical loops in 100 lf runs with 2 ft. spacing between runs.
[5] Open loop systems use groundwater flow from wells.
[6] Based on two wells (One for withdrawal and one for discharge)

For the amount of air conditioning required at Fiveash (85 tons) and the large area required for the horizontal closed loop system, the only types of systems which appear to be feasible are the vertical closed loop and the open loop system.

Vertical closed loop systems are the most expensive to install based on the challenges with installing the vertical loops. Furthermore, the operating costs are approximately the same for both systems. For the purposes of this report, only an open loop system is considered. While some open areas exist on the Fiveash site, underground utilities will make installation of the closed loop system difficult and expensive.

The only land requirements for an open loop system are 10 feet x 10 feet areas for the supply and discharge wells and room to install the piping to the wells.

Open loop systems require approximately 1.5 to 2 gallons per minute (GPM) of source water per ton of cooling capacity (Geothermal Design), which means Fiveash would need supply wells producing approximately 170 GPM (and return wells with 170 GPM disposal capacity). Three (3) supply wells producing approximately 85 GPM each and three (3) return wells (1 of each for redundancy) are anticipated. The total cost of installing open loop geothermal heat pump systems at Fiveash is estimated to be $3,000/ton, plus the costs for constructing the wells and installing well pumps at $10,000 for each supply well, and $6,000 for each return well for a total cost of $303,000.

The amount of energy currently used at Fiveash for HVAC purposes is not known, which limits the estimation of energy savings and calculation of payback periods for installing the geothermal systems. The CUS Master Plan Team recommends replacing existing air conditioning units with open loop geothermal systems as they fail. This reduces the investment to the difference between the cost of a new condenser/air handler unit and the cost of a new open loop geothermal system. Two (2) of the supply and disposal wells can initially be drilled (second well for redundancy) with the other wells constructed as needed. **Section WA8** includes R&R costs for replacing HVAC units.

Other sources of "heat sinks" for basic water-to-air heat exchange for a heat pump system were also considered. They include the incoming raw water and the effluent leaving the plant. Installing heat exchangers around portions of the piping to transfer heat from the heat pump piping is also a viable energy saving alternative. Adding heat to the raw water is a disadvantage, unless it could be shown that the heat addition is negligible or is rapidly radiated away through the tankage and underground piping. Due to the expansiveness of the Fiveash

WTP, the high number of existing underground utilities, and the various locations of the existing systems, an estimated cost for this alternative is not provided.

The CUS Master Plan Team recommends the City pursue small-scale demonstrations of the alternate “heat sink” sources to determine the viability of replacing the traditional air conditioner systems with heat pumps. A survey of all HVAC systems including locations and sizes of units would be performed during the demonstration testing.

13.3.3.3 Solar Water Heating

Heating water using solar energy has been used for many years. Solar water heaters were commercially available as early as 1902 (U.S. Department of Energy). There are many different types of solar water heaters in existence today. For instance, existing tanks can be retrofitted with a solar heating system, or a new specially designed water heater tank can be installed that uses a heat exchanging coil within the tank for the solar heated water and an electric heating element for auxiliary heating. Water from the solar collector plates (which contain the small tubing that water or other fluid is streamed through to absorb heat from the sun) can be recirculated through the tank heat exchanger coil to heat the water in the tank. For retrofits, an exterior heat exchanger can be mounted on the existing tank between the tank drain and pressure relief openings.

The Fiveash WTP has a 50-gallon and a 120-gallon hot water heater serving the facility. Based on the fact that most solar water heater retrofit systems are for tanks smaller than 120 gallons, only costs to replace the existing heaters with new solar water heaters (with collector plates) is considered. The estimated project cost of replacing the 120-gallon water heater tank at Fiveash is $30,000 based on equipment costs of approximately $13,000 and a 30% labor factor and a 20% contingency (no non-construction costs). The estimated project cost of replacing the 50-gallon water heater tank at Fiveash is $6,000 for the tank system with a 30% labor factor and a 20% contingency (no non-construction costs).

The amount of energy currently used at Fiveash for water heating purposes is not known which limits estimation of energy savings and calculation of payback periods for installing the solar water heating systems. The CUS Master Plan Team recommends replacing existing water heaters with solar water heaters as they fail. This reduces the investment to the difference between the cost of a new conventional water heater and the cost of a new solar heating system. Installing a de-superheater on the air conditioning system can provide “free” hot water and help the air conditioner system by shedding heat.

13.3.3.4 Interior Lighting

The City is in the process of changing existing interior building lighting systems to use LED lamps (reported to be approximately 40% complete).

Installing a lighting control system which automatically turns lights on and off based on motion sensors was considered. The Fiveash WTP staff proactively practices elements of the City’s Environmental & Sustainability Management System which includes being responsible for turning lights off when leaving rooms, etc. Also, there are certain lights which need to remain on for safety purposes. Based on the above information, installing lighting control systems is not anticipated to save any significant amounts of energy.

13.3.3.5 Energy Recovery/Reduction Devices

Other energy recovery/reduction devices that can impact a facility's energy use include the following:

1. Energy Recovery Ventilators
2. Demand Controlled Ventilation
3. Thermal Energy Storage
4. Electronically Commutated Motors (ECM) for Direct Expansion Air Conditioning (DX) Systems

The cost of retrofitting air conditioning units with these devices is considered significant for the amount of energy (and money) saved. For Fiveash WTP, all of the air conditioning is planned to be replaced in the Reliability Upgrades Project. The DX system air is cooled directly by the refrigerant. Piping the refrigerant long distances can be costly and not always feasible, and therefore, DX systems are normally used for smaller buildings or rooms. ECM motors should meet the latest HVAC codes and the City's HVAC efficiency standards.

13.3.3.6 Exterior Site Lighting

There are approximately 200 exterior light fixtures at the plant ranging from 50 to 400 watts. Plant personnel indicate that approximately 40% of the fixtures have been converted from high pressure sodium or metal halide to LED. Based on an average fixture wattage of 175 watts, the total current site lighting power requirement for non-LED lights is approximately 17.5 KW. The wattage requirements for LED lights would be approximately 40% to 60% lower than the existing lighting. **Table WA13-10** shows the estimated current power consumption for the existing non-LED site lighting and the estimated reduced power consumption using LED fixtures. A lighting study could reduce wasted light and result in uniform fixtures and should be performed in conjunction with major site lighting changeout projects.

Table WA13-10. Site Lighting Energy Comparison

Lighting System	Total KW	Hours/Day	kWh/Year	$/Year[1]
Existing Metal Halide/High Pressure Sodium	17.5	12	91,980[2]	$7,358
LED	8.8[3]	12	38,544[2]	$3,084

1. Based on $.08/kWh
2. Includes 20% ballast draw
3. Anticipates a minimum of 50%-watt reduction requirements

Conversions from high pressure sodium and metal halide lamps can be accomplished by either replacing the entire fixture or by installing a retrofit package in each fixture. The retrofit package should have separate ballast and bulb components, and a fan to cool the electronics. **Table WA13-11** shows the options of installing new fixtures versus installing retrofit packages in each fixture.

Table WA13-11. Cost Difference Between New LED Fixtures Versus Retrofit Kits

Option	Estimated Cost per Fixture ($)	Estimated Total Cost ($000)	Expected Savings per Year ($000)	ROI (Years)
Replace 100 Fixtures	1100	110	4.3	25
Install 100 Retrofits	450	45	4.3	10

The disadvantage of installing the retrofit packages is that there are issues encountered with older fixtures in fair to poor condition. Based on the age of the fixtures, it is recommended to budget sufficient money to completely replace the fixtures in order for the system to last throughout the 20-year planning period. Replacing the fixtures within the next 5 years will help the City in achieving the goal of 20% energy reduction by 2020.

13.3.3.7 Site Water Usage

No equipment replacements or operational changes were identified which would reduce potable water usage at the Fiveash WTP. Minimize the need for irrigation by using xeriscape principles. Where irrigation is necessary, use raw water instead of finished.

13.3.4 Recommendations

In addition to recommendations included in other sections of the report, the CUS Master Plan Team recommends the following:

1-5 years:

- Replace motors on eighteen (18) well pumps at Prospect Wellfield.
- Replace motors on hydrotreater Recirculation Pumps #1, #2, #3, and #4 with high efficiency motors.
- Replace motor on Backwash Pump #2 with a high efficiency motor.
- Replace motors on Transfer Pumps #1, #2, #3, and #6 with high efficiency motors.
- Complete replacements of site lighting with LED fixtures.
- Perform small scale demonstration of alternative sources of heat pump “heat sinks” such as the raw water main or the piping to the distribution system.
- Perform a building envelope energy analysis to identify potential modifications which can save HVAC energy.

6-10 years:

- Replace motors on eleven (11) well pumps at Prospect Wellfield.

13.3.5 Cost Summary

Table WA13-12 below lists the estimated costs (in 2015 dollars) for the recommended Fiveash WTP energy improvements.

Table WA13-12. Prospect Wellfield/Fiveash WTP Energy Recommendations

Project Description	1-5 Year Cost	6-10 Year Cost
Incremental cost to add high efficiency blowers and fine bubble aeration when replacing pretreatment aeration system.	$160,000	--
Replace motors on (18) well pumps.	$205,000	--
Replace motors on (11) well pumps	--	$126,000
Replace motors on hydrotreater Recirculation Pumps #1, #2, #3, and #4 with high efficiency motors.	$8,000	--
Replace motor on Backwash Pump #2 with a high efficiency motors.	$5,000	--
Replace motors on Transfer Pumps #1, #2, #3, and #6 with high efficiency motors.	$55,000	--
Complete replacements of site lighting with LED fixtures.	$110,000	--
Perform small scale demonstration of alternative sources of heat pump “heat sinks” such as the raw water main or the piping to the distribution system.	$25,000	--
Perform a building envelope energy analysis to identify potential modifications which can save HVAC energy.	4,000	--
Total	**$572,000**	**$126,000**

13.4 Peele-Dixie Water Treatment Plant

The City operates the Walter E. Peele-Dixie Water Treatment Plant, providing drinking water to the southern portion of the City’s service area. The Peele-Dixie WTP was originally constructed in 1926, as a lime softening plant and replaced with a nanofiltration plant in 2008 built adjacent to the old plant. The Peele-Dixie WTP maintains a Florida Department of Environmental Protection (FDEP) permitted treatment capacity of 12 MGD. The plant is located in southwest Fort Lauderdale and draws its raw water from the Dixie Wellfield, which is fed from the surficial Biscayne Aquifer.

13.4.1 Dixie Wellfield

13.4.1.1 Description

In 2008, the City installed eight (8) new raw water wells into the Dixie Wellfield and abandoned the existing wells. The new well pumps have capacities of approximately 2.5 MGD each, which equates to a total wellfield capacity of approximately 20 MGD. The South Florida Water Management District (SFWMD) Water Use Permit (WUP) limits the maximum daily withdrawal to 15 MGD, which is sufficient to produce 12 MGD of finished water through the membrane treatment system. A 30-inch water main transmits the raw water from the wellfield to the Peele-Dixie WTP, as shown in **Figure WA13-3**.

The combined total power consumption of the eight (8) active production wells is approximately 2,949,840 kWh per year based on average of power-company billing records for the years 2013 and 2014, as shown in **Table WA13-1**. This equates to an energy cost of approximately $236,000 per year based on the average electrical rate of $0.08/kWh. All well pumps are 100-HP, 3-stage vertical turbine pumps that pump into the raw water transmission system. Currently there are no means to monitor the raw water transmission system pressure.

13.4.1.2 Equipment Replacement

Well pumps and motors, upon end of service life, should be replaced with high efficiency equipment as part of the City's water repair and replacement program described in **Section WA8**. Similarly, the air conditioning system used at the emergency generator building to keep the controls cool should be replaced with higher efficiency equipment upon end of service life. A budget of $30,000 is included to address energy efficiency in the Dixie Wellfield.

13.4.1.3 Operational Changes

No operational changes for the wellfield system are recommended to reduce energy costs, however, the City could add raw water transmission pressure monitoring to help optimize wellfield energy operations and identify malfunctions or partially closed valves.

13.4.1.4 Use of Renewable Energy or Alternative Fuels

The motor loads at the individual wells are too large for renewable energy sources such as wind or solar energy to be feasible for generating sufficient power. Based on the small amount of energy utilized at the wellfield for lighting and controls, no significant energy savings are anticipated if renewable energy systems for these electrical loads are provided. Solar or alternative power could be used to power the emergency generator building air conditioning system. **Section WA13.3.1.4** above addresses the use of alternative fuels for emergency generators.

13.4.2 Water Treatment Plant Processes

The Peele-Dixie WTP is currently permitted by the FDEP to treat 12 MGD. For calendar year 2014, the Peele-Dixie WTP treated an annual average day of 8.1 MGD of groundwater, producing 6.9 MGD of finished water. The plant recovers 85% water as permeate, while the remaining 15% concentrate water is disposed of into an underground deep injection well. The Peele-Dixie WTP is designed to allow for an expansion for an additional 6 MGD of membrane treatment skids.

As shown in **Table WA13-1**, the combined total power consumption for the Peele-Dixie WTP is approximately 5,656,070 kWh per year based on average of power-company billing records for the years 2013 and 2014. This equates to an energy cost of approximately $452,000 per year based on the current electrical rate of $0.08/kWh. The Peele-Dixie WTP processes include:

a. Cartridge Filtration Pretreatment
b. RO/NF Hybrid System
c. Post Treatment
d. Clearwell and Transfer Pump System
e. Finished Water Storage and Distribution
f. Concentrate Disposal

The following sections address potential energy savings for each of the treatment processes.

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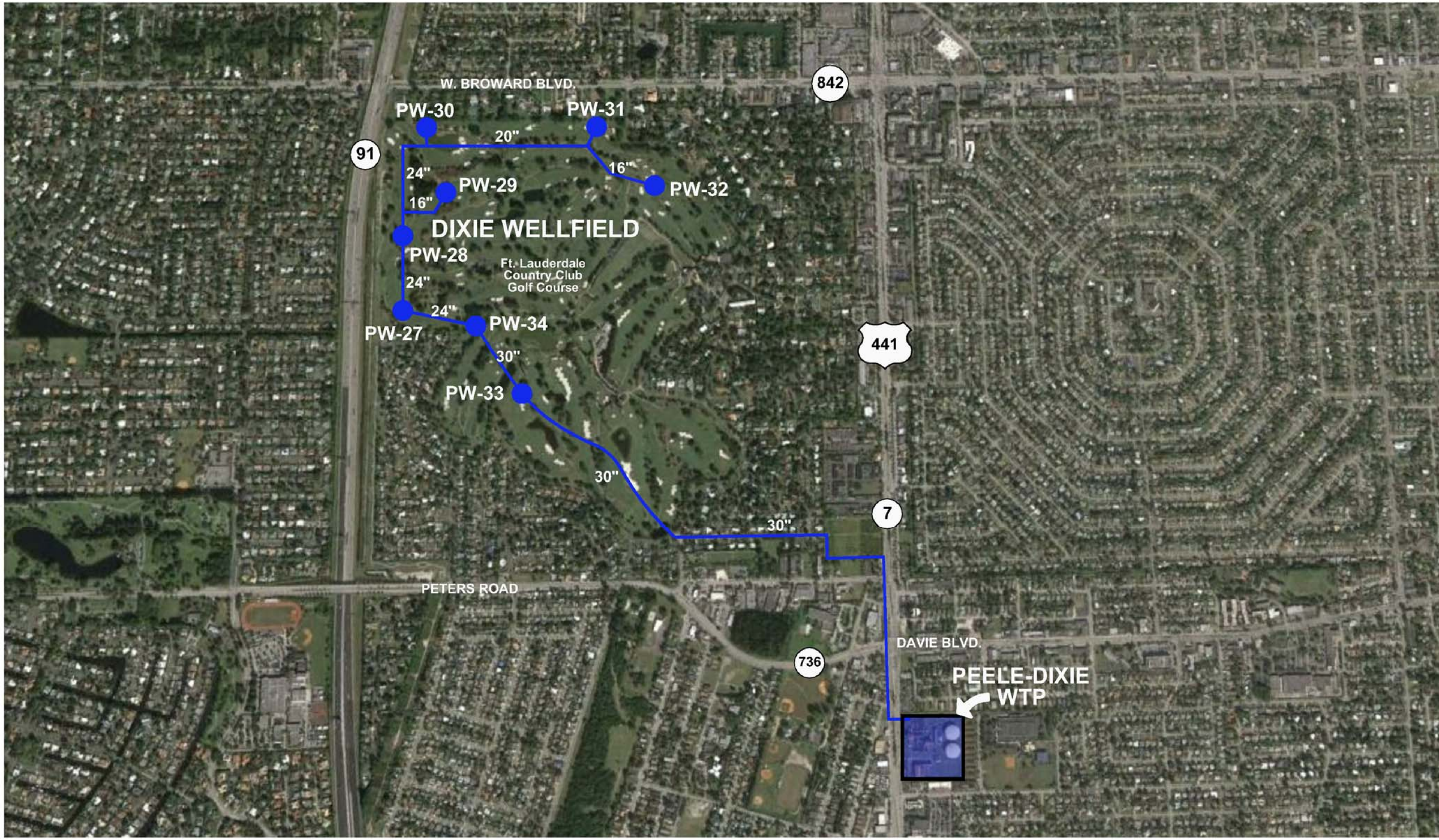


LEGEND

WELL

RAW WATER TRANSMISSION LINES

US ROUTE

7 STATE ROUTE

Graphic Scale in Feet

0 1000' 2000'

N

CITY OF FT. LAUDERDALE
PEELE-DIXIE WATER TREATMENT PLANT
WELL LOCATION MAP

FIGURE WA13-3

DWG: R:\Projects\134001-P FtLauderdale CUSMP\Design\Drawings\PreliminaryDesign\134001 Peele Dixie Well Location Map.dwg

13.4.2.1 Pretreatment

13.4.2.1.1 Description

Pretreatment includes straining, which removes sand and other large particulates, chemical addition, and cartridge filtration. Sulfuric acid and antiscalant are added to the raw water to protect the membrane elements from scaling, while the cartridge filters protect the membrane elements from clogging with small particles.

13.4.2.1.2 Equipment Replacement

No equipment replacements for this process were identified which would reduce energy consumption.

13.4.2.1.3 Operational Changes

No operational changes for this process were identified which would reduce energy consumption.

13.4.2.1.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.4.2.2 RO/NF Hybrid System

13.4.2.2.1 Description

After pretreatment, the water is pumped to the four (4) membrane treatment skids for removal of hardness elements (calcium, magnesium, iron, etc.). Water softening is the primary function of the membrane system since the TDS of the raw water is relatively low.

The system operates at a recovery rate of 85% and each skid includes a dedicated 300-HP vertical turbine pump equipped with a VFD to pump water to the membrane units. The current inlet operating pressure of the membrane system is approximately 125 psi.

This inlet pressure has gradually increased since 2008 when the new membranes required inlet pressure of 100 psi. Cleaning the membranes is having minimal impact on the performance of the units. Replacing the membranes is currently part of the City's CIP.

13.4.2.2.2 Equipment Replacement

The current membrane system inlet operating pressure of 125 psi is high for softening applications based on other membrane softening facilities in Boca Raton, Hollywood, and Deerfield Beach. Replacing the existing membranes at Peele-Dixie with more conventional softening membranes can significantly reduce energy. Lowering the inlet operating pressures to approximately 75 psi can reduce the energy costs for the Peele-Dixie WTP as much as 16%.

While replacing the membranes is currently a City CIP project, the CUS Master Plan Team recommends performing a membrane pilot test to determine the lowest energy membrane suitable to meet the City's water quality goals.

13.4.2.2.3 Operational Changes

Maintaining a consistent permeate water quality that meets water quality goals is critical to reducing energy costs. A 1% variation in the TDS of the product water can have as much as a 17% impact on the system's power usage. The CUS Master Plan Team recommends performing an operational study to evaluate the RO system controls and provide better automation to maintain a consistent quality of product water.

13.4.2.2.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.4.2.3 Post Treatment

13.4.2.3.1 Description

Post treatment includes degasification and chemical addition. Prior to the degasifiers, the water is treated with sodium hypochlorite to control sulfide oxidation and to prevent biogrowth on the degasifiers. After the degasification, sodium hypochlorite and ammonia are added in the clearwell to create chloramines for disinfection. Sodium hydroxide and a corrosion inhibitor are also added to the water to lower the pH and corrosivity of the finished water.

13.4.2.3.2 Equipment Replacement

No equipment replacements for this process were identified to reduce energy consumption.

13.4.2.3.3 Operational Changes

While no energy saving concepts were identified for this system, the importance of monitoring the chemicals being fed into the system is critical to maintaining the integrity (and lower pressure requirements) of the membranes. The installation of very accurate flow measurement instruments (such as Yokagawa magnetic flow meters) on the discharge of the chemical feed systems can not only provide accurate flow measurement, but can also provide reliable flow failure indication and inventory monitoring. No further operational changes for this process were identified which would reduce energy consumption.

13.4.2.3.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.4.2.4 Clearwell and Transfer Pump System

13.4.2.4.1 Description

Once the RO treatment system permeate passes through the degasifiers, it flows into a clearwell and is then pumped to the GSTs with transfer pumps. There are three (3) 60-HP transfer pumps equipped with VFDs that transfer the finished water into the GSTs.

13.4.2.4.2 Equipment Replacement

No equipment replacements for this process were identified which would reduce energy consumption.

13.4.2.4.3 Operational Changes

No operational changes for this process were identified to reduce energy consumption.

13.4.2.4.4 Use of Renewable Energy or Alternative Fuels

The large, flat operations building roof would be ideal for solar panels. Solar photovoltaics could be cost effective for small loads during the day. The City should investigate obtaining a grant to implement solar power supplementation at the Peele Dixie WTP in the short term. The CUSMP recommends significant alternative energy implementation for the 15-20 year planning horizon.

13.4.2.5 Finished Water Storage and Distribution

13.4.2.5.1 Description

The transfer pumps discharge finished water into the two (2) 4-MG GSTs that operate in parallel. Finished water is pumped to the distribution system by the HSP station. The HSPs include five (5) 250-HP vertical turbine pumps, each with a capacity of 6 MGD. The normal system operating pressure is approximately 65 to 70 psi. Currently, two (2) of the pumps are controlled by VFDs and three (3) of the pumps are fixed speed pumps with reduced voltage starters (soft starters). **Figure WA13-4** shows the minor pressure variations in the Peele-Dixie WTP operating pressure during normal demands.

13.4.2.5.2 Equipment Replacement

No equipment replacements for this process were identified to reduce energy consumption.

13.4.2.5.3 Operational Changes

No operational changes for this process were identified to reduce energy consumption.

13.4.2.5.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

13.4.2.6 Concentrate Disposal

13.4.2.6.1 Description

The membrane treatment units currently recover 85% water as permeate, while the remaining 15% concentrate water is disposed of into an underground deep injection well. The concentrate is pumped to the injection well by four (4) 50-HP pumps. The discharge pressures of the pumps were compared to the pressures at the injection well, and no excessive head loss was identified.

13.4.2.6.2 Equipment Replacement

No energy reducing equipment replacements for this process were identified.

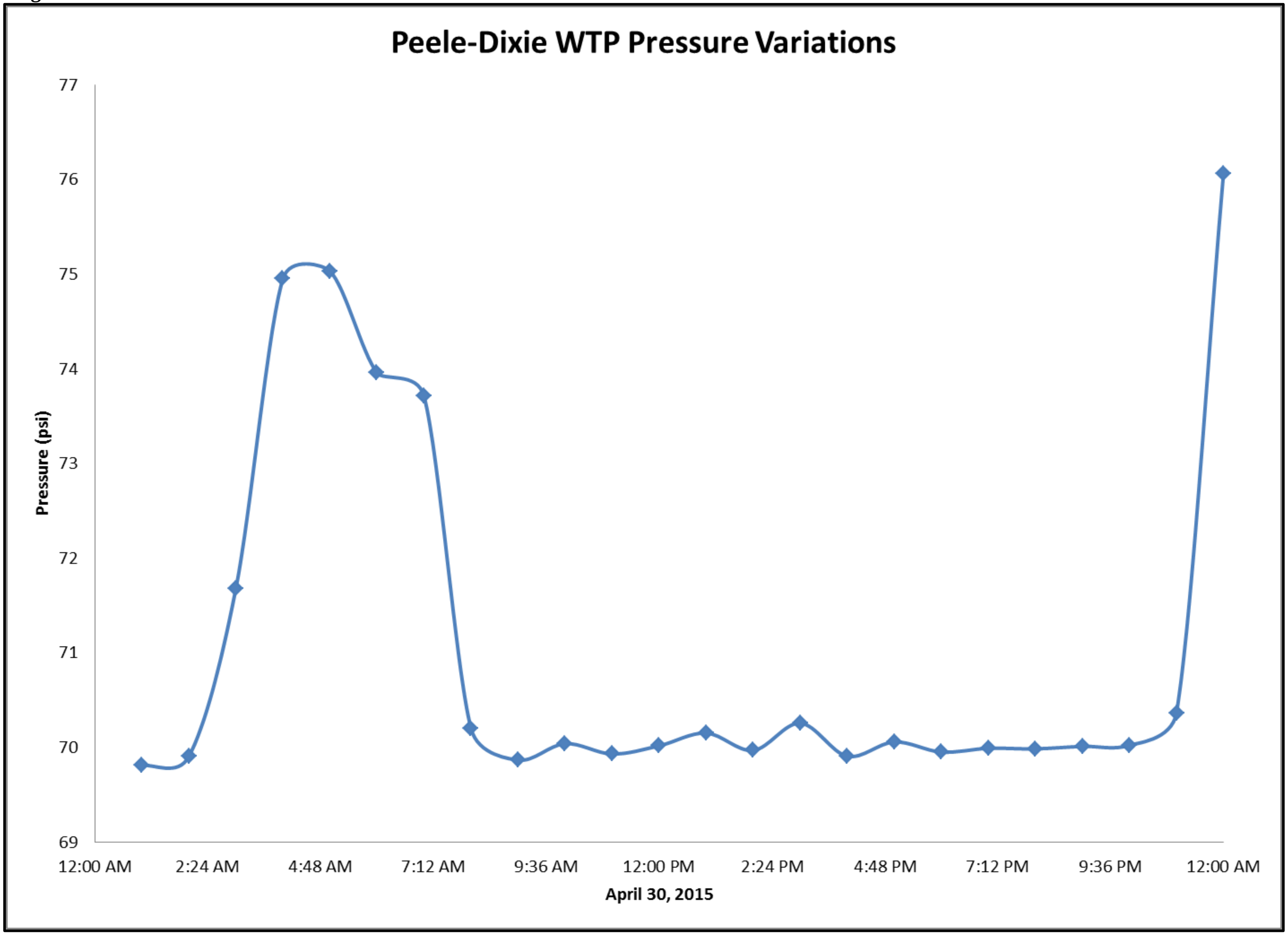
13.4.2.6.3 Operational Changes

No energy reducing operational changes for this process were identified.

13.4.2.6.4 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels were identified for this process.

Figure WA13-4. Peele-Dixie WTP Pressure Variations



13.4.3 Building Envelope

The building envelope components evaluated include the following:

a. Architectural
b. HVAC
c. Solar Water Heating
d. Interior Lighting
e. Exterior Site Lighting

13.4.3.1 Architectural

Based on the age of the buildings, no issues with energy losses due to inefficient insulation properties for the roof, ceiling, or windows are anticipated.

13.4.3.2 HVAC

The Peele-Dixie WTP has approximately 102 tons of air conditioning equipment operating within the plant, including miscellaneous wall units feeding various offices. All of the units are conventional condenser/air handler systems with ductwork. An evaluation of the economics of converting the HVAC systems to geothermal heat pumps is discussed below.

Section WA13.4.3.2 above presents background information on geothermal heat pump systems. **Table WA13-13** shows the area requirements of the different systems.

Table WA13-13. Geothermal Heat Pump Systems' Area Requirements

Type System	Approx. Linear Ft of Piping Required[1]	Approx. Area Required
Horizontal Closed Loop	30,600 lf[1]	1.4 Acres[2]
Vertical Closed Loop	35,700 lf[3]	0.4 Acres[4]
Vertical Open Loop	N/A[5]	0.011 Acres[6]

[1] Based on 150 lf supply and return piping per ton.
[2] Based on 400 lf runs with 2 ft. spacing between runs.
[3] Based on 175 lf supply and return piping per ton.
[4] Based on 10 ft. deep vertical loops in 100 lf runs with 2 ft. spacing between runs.
[5] Open loop systems use groundwater flow from wells.
[6] Based on two wells (One for withdrawal and one for discharge)

For the amount of air conditioning required at Peele-Dixie and the large area required for the horizontal closed loop system, the only types of systems which appear to be feasible are the vertical closed loop and the open loop system.

Vertical closed loop systems are the most expensive to install based on the challenges with installing the vertical loops. However, the closed loop systems have less operating costs versus the open loop systems due to smaller pumps recirculating the cooling water. For the purposes of this report, only an open loop system is considered. While some open areas exist on the Peele-Dixie site, underground utilities will make installation of the closed loop system difficult and expensive.

Section WA13 accepted February 17, 2017.

The only land requirements for an open loop system are 10 feet x 10 feet areas for the supply and discharge wells and room to install the piping to the wells. Open loop systems require approximately 1.5 to 2 GPM of source water per ton of cooling capacity (Geothermal Design), which means Peele-Dixie would need supply wells producing approximately 200 GPM (and return wells with 200 GPM disposal capacity). Three (3) supply wells producing approximately 100 GPM each and three (3) return wells (1 of each for redundancy) are anticipated. The total cost of installing open loop geothermal heat pump systems at Peele-Dixie is estimated to be $3,000/ton, plus the costs for constructing the wells and installing well pumps at $10,000 per supply well, and $6,000 per return well for a total cost of $354,000.

The amount of energy currently used by the Peele-Dixie WTP for HVAC purposes is not known, which limits estimation of energy savings and calculation of payback periods for installing the geothermal systems. The CUS Master Plan Team recommends replacing existing air conditioning units with open loop geothermal systems as they fail. This reduces the investment in the difference between the cost of a new condenser/air handler unit and the cost of a new open loop geothermal system. Two (2) of the supply and disposal wells can initially be drilled (second well for redundancy), with the other wells constructed as needed.

Other sources of “heat sinks” for basic water-to-air heat exchange for a heat pump system were also considered, including the incoming raw water, the finished water leaving the plant and the concentrate stream down the deep injection well. Installing heat exchangers around portions of the piping to transfer heat from the heat pump piping is also a viable energy saving alternative. Due to the expansiveness of Peele-Dixie, the high number of existing underground utilities, and the various locations of the existing systems, an estimated cost for this alternative is not provided.

The CUS Master Plan Team recommends the City pursue small-scale demonstrations of the alternate “heat sink” sources to determine the viability of replacing the traditional air conditioner systems with heat pumps. A survey of all HVAC systems including locations and sizes of units would be performed during the demonstration testing.

13.4.3.3 Solar Water Heating

As discussed in **Section WA13.4.3.3** above, solar water heating has been used to save energy for many years. Peele-Dixie has a 50-gallon hot water heater that currently serves the facility. Although there are retrofit systems available, only costs to replace the existing heaters with new solar water heaters (with collector plates) is considered. The estimated project cost of replacing the 50-gallon water heater tank at Peele-Dixie is approximately $6,000 for the tank system with a 30% labor factor and a 20% contingency (without non-construction costs).

The amount of energy currently used at Peele-Dixie for water heating purposes is not known which limits estimation of energy savings and calculation of payback periods for installing the solar water heating systems. Installing a de-superheater could provide “free” hot water while easing the load on the A/C system by shedding heat to the water. The CUS Master Plan Team recommends replacing existing water heaters with solar water heaters as they fail. This reduces the investment in the difference between the cost of a new conventional water heater and the cost of a new solar heating system.

13.4.3.4 Interior Lighting

The City is in the process of changing existing interior building lighting systems to use LED lamps (reported to be approximately 50% complete).

Section WA13 accepted February 17, 2017.

Installing a lighting control system which automatically turns lights on and off based on motion sensors was considered. The Peele-Dixie WTP staff proactively practices elements of the City's Environmental & Sustainability Management System which includes being responsible for turning lights off when leaving rooms, etc. Also, there are certain lights which need to remain on for safety purposes. Based on the above information, installing lighting control systems is not anticipated to save significant energy.

13.4.3.5 Energy Recovery/Reduction Devices

Other energy recovery/reduction devices that can impact a facility's energy use include the following:

1. Energy Recovery Ventilators
2. Demand Controlled Ventilation
3. Thermal Energy Storage
4. ECM Motors for DX AC Systems

The cost of retrofitting the air conditioning units with these devices is considered significant for the amount of energy (and money) saved. As the technologies improve and more grants/rebate incentives are offered, these technologies can be evaluated in the future upon replacement.

13.4.3.6 Exterior Site Lighting

There are approximately 150 exterior high pressure sodium or metal halide light fixtures at the plant ranging from 50 to 400 watts. According to plant personnel, approximately 50% of the light fixtures have already been changed to LED. Based on an average fixture wattage of 175 watts, the total current site lighting power requirement for non-LED lighting is approximately 13 KW. The wattage requirements for LED lights would be approximately 40% to 60% lower than the existing lighting requirement. **Table WA13-14** shows the estimated current power consumption for the existing non-LED site lighting and the estimated reduced power consumption using LED fixtures. A lighting study could reduce wasted light, and result in uniform fixtures.

Table WA13-14. Site Lighting Energy Comparison

Lighting System	Total KW	Hrs./Day	kWh/Yr.	$/Yr.[1]
Existing Metal Halide/High Pressure Sodium	13	12	68,328[2]	$5,466
LED	6.5[3]	12	28,470[2]	$2,278

1. Based on $.08/KWhr
2. Includes 20% ballast draw
3. Anticipates a minimum of 50%-watt reduction requirements

Conversions from high pressure sodium and metal halide lamps can be accomplished by either replacing the entire fixture or by installing a retrofit package in each fixture. The retrofit package should have separate ballast and bulb components and a fan to cool the electronics. **Table WA13-15** shows the options of installing new fixtures versus installing retrofit packages in each fixture.

Table WA13-15. Cost Difference Between New LED Fixtures Versus Retrofit Kits

Option	Estimated Cost per Fixture ($)	Estimated Total Cost ($000)	Expected Savings per Year ($000)	ROI (Years)
Replace 75 Fixtures	1100	82.5	3.2	25
Install 75 Retrofits	450	33.8	3.2	11

The disadvantage of installing the retrofit packages is that there are issues encountered with older fixtures in fair to poor condition. Based on the age of the fixtures, it is recommended to budget sufficient money to completely replace the fixtures in order for the system to last throughout the 20-year planning period. Replacing the fixtures within the next 5 years will help the City in achieving the goal of a 20% energy reduction by 2020.

13.4.3.7 Site Water Usage

No equipment replacements or operational changes were identified to reduce potable water usage at the Peele-Dixie WTP.

13.4.4 Recommendations

In addition to recommendations included in other sections of the report, the CUS Master Plan Team recommends the following:

1-5 years:

- Complete replacements of site lighting with LED fixtures.
- Perform small scale demonstration of alternative sources of heat pump "heat sinks," such as the raw water main, finished water piping to the distribution system or concentrate discharge.

13.4.5 Cost Summary

Table WA13-16 below lists the estimated costs (in 2015 dollars) for the recommended Peel-Dixie WTP energy improvements.

Table WA13-16. Dixie Wellfield/Peele-Dixie WTP Energy Recommendations

Project Description	1-5 year Cost
Complete replacements of site lighting with LED fixtures.	$82,500
Perform small scale demonstration of alternative sources of heat pump "heat sinks," such as the raw water main, finished water piping to the distribution system or concentrate discharge.	$25,000
Total	**$107,500**

13.5 Distribution System

13.5.1 Description

The City's distribution system consists of two remote storage and repump facilities and approximately 750 miles of distribution pipeline. **Figure WA4-1** in **Section WA4** illustrates the existing potable water system. The two remote (distribution) storage and pump stations, Poinciana Park Water Tank and Pump Station and the Northwest 2nd Avenue Water Tank and Pump Station, have a nominal distribution water storage total of 2.5 MG. The City replaced the Poinciana Park Storage Tank and Pump Station in 2006, and rehabilitated the 2nd Avenue pump station in 2012.

The Northwest 2nd Ave Water Tank and Pump Station is located at 625 Northwest 2nd Ave, Fort Lauderdale, FL. The pumping station currently has one horizontal split case, 200-HP pump. This pump station was upgraded in 2012 which included replacement of the existing pump with a higher capacity pump, replacement of piping from the street to the tank and associated electrical and control improvements.

The Poinciana Park Water Tank and Pump Station is located at 2011 Southeast 4th Avenue, Fort Lauderdale, FL. The pumping station contains two pumps. Both pumps are horizontal split case, 150-HP pumps equipped with VFDs. The Poinciana Park Water Tank and Pump Station use diesel fuel for the backup power generator.

The combined total power consumption of the pump stations is approximately 194,930 kWh per year based on averages of power-company billing records for the years 2013 and 2014, as shown in **Table WA13-1**.

Average system pressures range from approximately 53 psi to 85 psi. However, system pressures in the Harbor Beach area are among the lowest in the system during peak demand periods. During high irrigation hours (approximately 3:00 am to 7:00 am), the operating pressures at the WTPs must be increased significantly to maintain minimum pressures in the Harbor Beach area.

The Harbor Beach area experiences a pressure drop between the pressure sustained at Fiveash WTP and the pressure entering into Harbor Beach. Distribution system mapping and modeling do not show limiting hydraulics for Harbor Beach, which concludes that there is a problem out in the distribution system, such as a closed valve. The City investigated this issue and has tentatively resolved the issue by reopening closed valves.

13.5.1.1 Equipment Replacement

Identifying and correcting the hydraulic issues with the distribution system in the Harbor Beach area will save energy. Reducing the need for the Peele-Dixie WTP operating pressure to be increased approximately 20 psi above the average operating pressure during peak demand periods could reduce the WTP operating cost by as much as 4%. No other equipment replacements for the distribution system were identified which would reduce energy consumption.

13.5.1.2 Operational Changes

No operational changes for the distribution system were identified to reduce energy consumption.

13.5.1.3 Use of Renewable Energy or Alternative Fuels

No potential uses of renewable energy or alternative fuels for the distribution system were identified for this process.

13.5.2 Recommendations

In addition to recommendations included in other sections of the report, the CUS Master Plan Team recommends the following:

***1-5 years*:**

- Identify hydraulic issues with the distribution system in the Harbor Beach area (this has been tentatively resolved by the City). Make an additional tie-in to better feed the area and minimize the 6 and 8-inch pipe bottlenecks.

Table WA13-17 summarizes the costs for the distribution system recommendations.

Table WA13-17. Distribution System Energy Recommendations

Project Description	1-5 year Cost
Investigate/identify distribution system hydraulic issues at Harbor Beach. Make an additional tie-in to better feed the area and minimize the 6 and 8-inch pipe bottlenecks.	$50,000
Total	**$50,000**

13.6 Water System Cost Summary

Table WA13-18 below lists the estimated costs (in 2015 dollars) for the recommended Potable Water System energy improvements.

Table WA13-18. Water System Energy Recommendations

Location	1-5 year Cost	6-10 year Cost
Prospect Wellfield Improvements	$205,000	$126,000
Fiveash WTP Improvements	$367,000	--
Dixie Wellfield Improvements	$30,000	--
Peele-Dixie WTP Improvements	$107,500	--
Water Distribution Improvements	$50,000	--
Total	**$759,500**	**$126,000**

13.7 Estimated Energy Savings

The current total energy cost for both the WTPs and the potable water distribution system is approximately $2,367,480 per year. **Table WA13-19** below shows the recommendations for years 1-5 and the estimated total energy savings for the WTPs and the associated potable water distribution system associated with each project.

Table WA13-19. Recommendations and Estimated Energy Savings for the Potable Water System

Recommendation	Estimated Total Annual Energy Savings (kWh)	Estimated Total Annual Energy Cost Savings ($)[1]
Replace motors on (18) well pumps at Prospect Wellfield.	347,175	27,774
Replace motors on hydrotreater Recirculation Pumps #1, #2, #3, and #4 with high efficiency motors.	17,050	1,364
Replace the motor on Backwash Pump #2 with a high efficiency motor.	29,564	2,224
Replace motors on Transfer Pumps #1, #2, #3, and #6 with high efficiency motors.	94,175	7,534
Complete replacements of Fiveash WTP site lighting with LED fixtures.	53,750	4,300
Complete replacements of Peele-Dixie WTP site lighting with LED fixtures.	40,000	3,200
Total	581,700	46,400

[1] Based on $.08/KWhr

$46,000 in savings is only about 2% of the $2,367,480 water system average annual energy bill. A reasonable effort of implementing conservation will only result in approximately 2% energy savings. The goal of 20% energy reduction may not be possible for the water system. This indicates that the water utility is well managed and the staff has been committed to saving energy.

13.8 Rebate/Tax Credit Programs

13.8.1 Business Energy Efficiency Rebates

FP&L offers rebates for installation of energy-saving devices, systems, or materials. The following are applicable program incentives:

a. Ceiling Insulation - $0.15/Sq. Ft.
b. Roof Insulation - $0.05/Sq. Ft.
c. Window Treatments – Up to $1.00/Sq. Ft. depending on shading coefficients
d. Energy Recovery Ventilators – Up to $415/KW reduced
e. Thermal Energy Storage – Up to $580/KW reduced
f. Demand Controlled Ventilation – Up to $600/KW reduced
g. ECM Motors for DX Systems - $100/KW reduced

13.8.2 Business Tax Credits

Federal tax credits are available for installation of geothermal heating systems and solar water heating systems until December 31, 2016. A tax credit of 10% is available for geothermal heat pump systems and a tax credit of 30% is available for solar water heating systems installed by commercial businesses.

13.8.3 Rate Structures

No FP&L rate structure programs more beneficial than the rate structures currently in place were identified.

13.9 References

1. http://emergencypower.com/support/generator-buying-guide/270-propane.htm
2. http://www.eia.gov/biofuels/issues-trends/pdf/bit.pdf
3. http://www.afdc.energy.gov/fuels/biodiesel-blend.htm
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WA14 Risk Assessment & Alternatives Analysis

14.1 Existing Water Facilities

The City's potable water system includes two water treatment plants (WTP) with associated wellfields, a distribution system consisting of approximately 750 miles of pipelines, 34 interconnects, a 1 million gallon (MG) elevated tank and pump at Northwest 2nd Avenue, and a 2 MG ground storage tank and pump station at Poinciana Park.

The larger of the two WTPs is the Charles W. Fiveash WTP (Fiveash WTP), which has a 70 million gallons per day (MGD) design capacity. The reduced, effective capacity of the Fiveash WTP is approximately 55 mgd because of hydraulic, process and raw water supply limitations. The smaller WTP is the recently upgraded Walter E. Peele-Dixie Nanofiltration WTP (Peele-Dixie WTP), which is rated at 12 mgd design capacity.

High service pumping and storage systems at the Fiveash and Peele-Dixie WTPs supply the distribution system and operate to maintain system pressure. The finished water is pumped from storage tanks and delivered directly to homes and businesses in the City of Fort Lauderdale, Wilton Manors, Oakland Park, Sea Ranch Lakes, Lauderdale-by-the Sea, Davie, Dania Beach, Port Everglades Authority, North Lauderdale, as well as portions of east Tamarac and Broward County.

14.2 High Risk and Single Points of Failure

14.2.1 Water Treatment Plants Single Points of Failure

Single points of failure are critical plant components, which, if failure occurs, could result in the shutdown of the WTP. Treatment components evaluated in this study consist of pumps, cartridge filters, piping, instrumentation, chemical injection, electrical feeds, and control valves. Most of the assets involved in treatment have redundancy, and the systems have a backup for operation and maintenance. Single points of failure include instrumentation that is critical to system operation such as flow meters or pressure indicators/transmitters upstream of the strainer. The flow meters and pressure indicators/transmitters are essential especially to nanofiltration and reverse osmosis operations at Peele-Dixie WTP. If a single pressure indicator fails to readout or provides an incorrect value, the programmable logic controller (PLC) system would operate based on incorrect readings, which could cause serious damage to the treatment plant system or result in a shutdown.

Single points of failure include assets without redundancy, which have one pipeline connection to the system and are important to the plant operation.

For the Fiveash WTP, the single points of failure include:

- Ground Storage Tank No.1 (North Tank, 5 MG)
- Sludge holding tank mixer
- PLC for the lime sludge pump station
- PLC for the dry polymer batch system
- Lime Sludge pipeline
- Hydrotreator feed valves and aeration basin drain valves
- Washwater Recovery Pipeline

Section WA14 accepted February 7, 2017.

Single points of failure for Peele-Dixie WTP include:

- Static mixer
- Sulfuric acid storage and feed system
- Scale inhibitor storage and feed system
- Aqueous ammonia storage and feed system
- Sodium hypochlorite storage and feed system
- Sodium hydroxide storage and feed system
- Corrosion inhibitor storage and feed system
- Fluoride storage and feed system
- Clearwell
- Air strippers

Table WA14-1 and **Table WA14-2** summarize the single point of failure assets and their remaining useful life for Fiveash and Peele-Dixie WTPs, respectively.

Table WA14-1. Single Points of Failure for the Fiveash WTP

No.	Asset Description	Useful Life (Yrs.)	Year Purchased/ Rehabilitated	Remaining Useful Life (Yrs.)	Redundancy	Priority
1	Ground Storage Tank 1 (North Tank, 5 MG)	50	1985	20	No	1
2	Sludge Holding Tank Mixer	20	2006	11	No	1
3	PLC for Lime Sludge Pump Station	20	2006	11	No	1
4	PLC for Dry Polymer Batch System	20	2005	10	No	1
5	Washwater Recovery Pipeline	20	1980	1	No	1
6	Lime Sludge Pipeline	50	Pre 1980	0	No	1
7	Aeration Basin Drain Valves	20	1963	0	No	1

Section WA14 accepted February 7, 2017.

Table WA14-2. Single Point of Failure for the Peele-Dixie WTP

No.	Asset Description	Useful Life (Yrs.)	Year Purchased/ Rehabilitated	Remaining Useful Life (Yrs.)	Redundancy	Priority
1	Static Mixer	20	2007	12	No	1
2	Sulfuric Acid Storage and Feed System	10	2007	2	No	1
3	Scale Inhibitor Storage and Feed System	10	2007	2	No	1
4	Aqueous Ammonia Storage and Feed System	10	2007	2	No	1
5	Sodium Hypochlorite Storage and Feed System	10	2007	2	No	1
6	Sodium Hydroxide Storage and Feed System	10	2007	2	No	1
7	Corrosion Inhibitor Storage and Feed System	10	2007	2	No	1
8	Fluoride Storage and Feed System	10	2007	2	No	1
9	Clearwell	30	2007	22	No	1
10	Air strippers	15	2007	6	No	1

14.2.2 Risk Prioritization Criteria

Utilities use asset risk management to evaluate and identify critical system components that drive water treatment processes and distribution system reliability. Major treatment processes and major pieces of equipment are evaluated for redundancy, remaining useful life and their importance to the operation process.

Table WA14-3 and **Table WA14-4** show examples of the asset prioritization according to their remaining useful life, condition, and redundancy for Fiveash WTP and Peele-Dixie WTP respectively.

Table 14-3. Assets Assessment Based on Priority, Redundancy, and Existing Condition for the Fiveash WTP

Item	System	System Priority[1]	Quantity	Redundant	Useful Life (Yrs.)	Year Purchased/ Rehabilitated	Remaining Useful Life (Yrs.)[2]	Condition[2]
Aeration Basin - Blower Motors	Aeration Basin	2	2	Yes (One Back Up)	15	1998	0	Poor
North Aeration Basin 1 - Valves & Valve Operators	Aeration Basin	2	1	No	20	1963	0	Fair
South Aeration Basin 2 - Valves & Valve Operators	Aeration Basin	2	2	No	20	2005	5	Good
Aqueous Ammonia System	Ammonia System	1	1	No	10	2005	1-2	Good
AC Units-Transformer Room & Switch Gear Room	AC Units	3	2	Yes (One Back Up)	15	2015	15	Good
Backwash Motor 2 (150 HP)	Washwater Recovery Basin	3	1	No	20	1980	1	Fair
Backwash Motor 3 (150 HP)	Washwater Recovery Basin	3	1	No	20	1989	3	Good
Backwash Pump 2	Washwater Recovery Basin	3	1	No	20	1980	1	Fair
Backwash Pump 3	Washwater Recovery Basin	3	1	No	20	1989	3	Good

[1]System Priority based on a Scale of 1-3, with 1 being the highest priority and 3 being the lowest priority.
[2]Based on City Operations Staff Opinion and REI cursory inspection.

Table 14-4. Assets Assessment Based on Priority, Redundancy, and Existing Condition for the Peele-Dixie Water Treatment Process

Item	System	System Priority[1]	Quantity	Redundant	Useful Life (Yrs.)	Year Purchased/ Rehabilitated	Remaining Useful Life (Yrs.)[2]	Condition[2]
Air Stripper Fans 1 & 2 (50 HP)	Degasifier System	1	2	Yes (One Back Up)	15	2007	10	Good
Air Stripper Fans Motor 1 & 2 (50 HP)	Degasifier System	1	2	Yes (One Back Up)	20	2007	10	Good
Air Strippers Packing Material	Degasifier System	1	-	-	5	2007	0	Poor
Antiscalant Transfer Pump/Motor (0.5 HP)	Antiscalant	1	1	No	20	2007	10	Good
Aqueous Ammonia Feed System	Ammonia System	1	1	No	10	2007	2[3]	Fair
Aqueous Ammonia Metering Pump	Ammonia System	1	1	No	10	2007	2[3]	Fair
Aqueous Ammonia Storage Tank	Ammonia System	1	1	No	10	2007	2[3]	Fair
Aqueous Ammonia Transfer Pump/Motor 1 & 2 (0.5 HP)	Ammonia System	1	2	Yes (One Back Up)	20	2007	10	Good
Aqueous Ammonia VFD	Ammonia System	1	1	No	10	2007	2[3]	Fair

[1]System Priority based on a Scale of 1-3, with 1 being the highest priority and 3 being the lowest priority.
[2]Based on City Operations Staff Opinion and REI cursory inspection.
[3]Based on useful life calculations.

Risk assessment of WTP assets is based on likelihood of failure of assets and assets' criticality. Remaining useful life of WTP assets, asset condition based on replacement and routine maintenance requirements, and corrosive environment conditions make up the criteria for the likelihood of failure. Size of assets and importance of delivery of safe and reliable service with redundancy are important factors which quantify the consequence of failure. Assets that are crucial to the utility's performance that have no back up and are near or beyond the end of their useful life are given the highest risk ranking for the single point of failure. Key assumptions for this evaluation include the following:

- The existing conditions are based on the City staffs' opinions of known equipment conditions. For unknown conditions, the CUSMP Team recommends an examination and reassessment of assets to determine an accurate condition.
- The remaining useful life of WTP assets are based on City staff's judgment for an estimation of how many more years the equipment is expected to function adequately prior to replacement.
- Installation dates and quantities for WTP assets derive from the Fort Lauderdale Water Master Plan 2007: Renewal and Replacement Requirement Analysis and from City staff's knowledge.

Table WA14-5 demonstrates the categories and weighting factors used to determine the probability of a shutdown. The quantitative risk score in **Figure WA14-1** is a product of the likelihood of failure score times the consequence of failure score. **Table WA14-6** and **Table WA14-7** show examples of risk scores for Fiveash WTP assets and Peele-Dixie WTP assets respectively. **Figure WA14-2** shows the explanation of results from the risk exposure score matrix. The quadrant "D" in **Figure WA14-2** includes assets that have a high risk score between 16 and 25. The high risk assets in quadrant D have high probability and high consequence of failure. The high ranking risk assets require immediate inspection and repair/replacement for reliability response. **Figure WA14-3** shows recommended actions according to the degree of probability and consequence of failure.

Table WA14-5. Risk Prioritization Criteria – Water Treatment Plant Assets

Category	Basis	Weighted %	Low Risk				High Risk
			1	2	3	4	5
Likelihood of Failure	Useful Life Remaining (years)	33%	> 30	15-30	10-14	5-9	< 5
	Rated Condition	33%	Good	--	Fair	--	Poor
	Corrosive Environment	33%	Less corrosive environment	--	Corrosive environment	--	Highly corrosive environment
Consequence of Failure	Size/ Importance	50%	Not in regular use	--	Crucial for operations	--	Crucial for all operations
	Redundancy	50%	Multiple backups	--	One backup	--	No backup

Section WA14 accepted February 7, 2017.

Figure WA14-1. Determination of Significance of Failure (Risk Exposure Matrix), (EPA 2007)

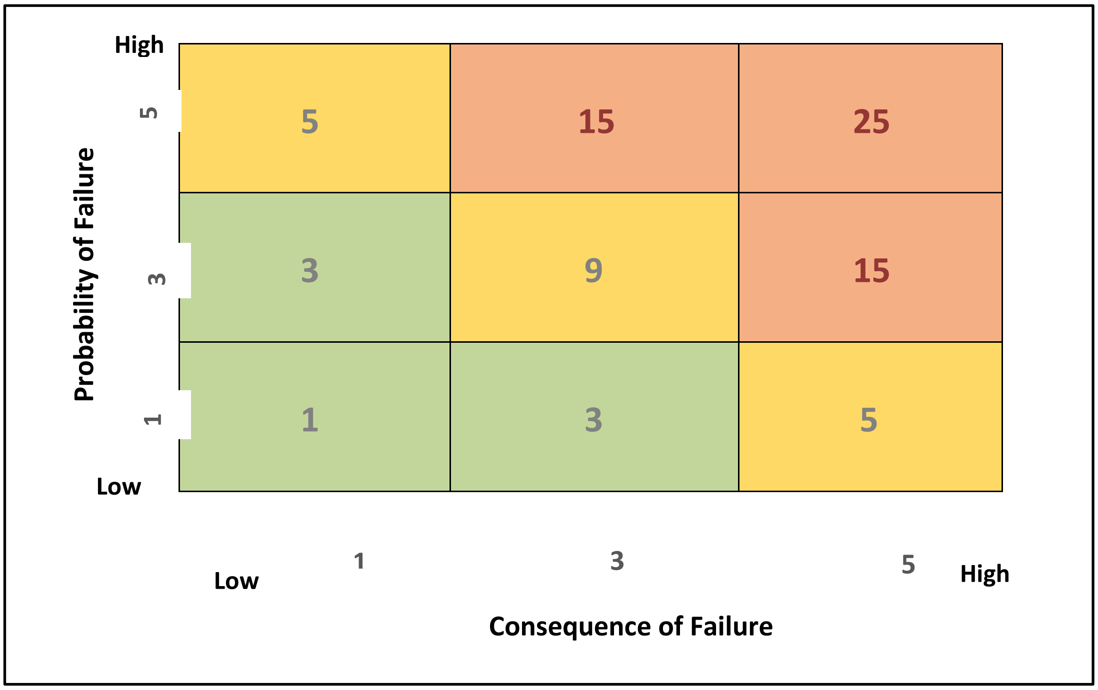


Figure WA14-2. Risk Exposure of Significance of Failure (EPA 2007)

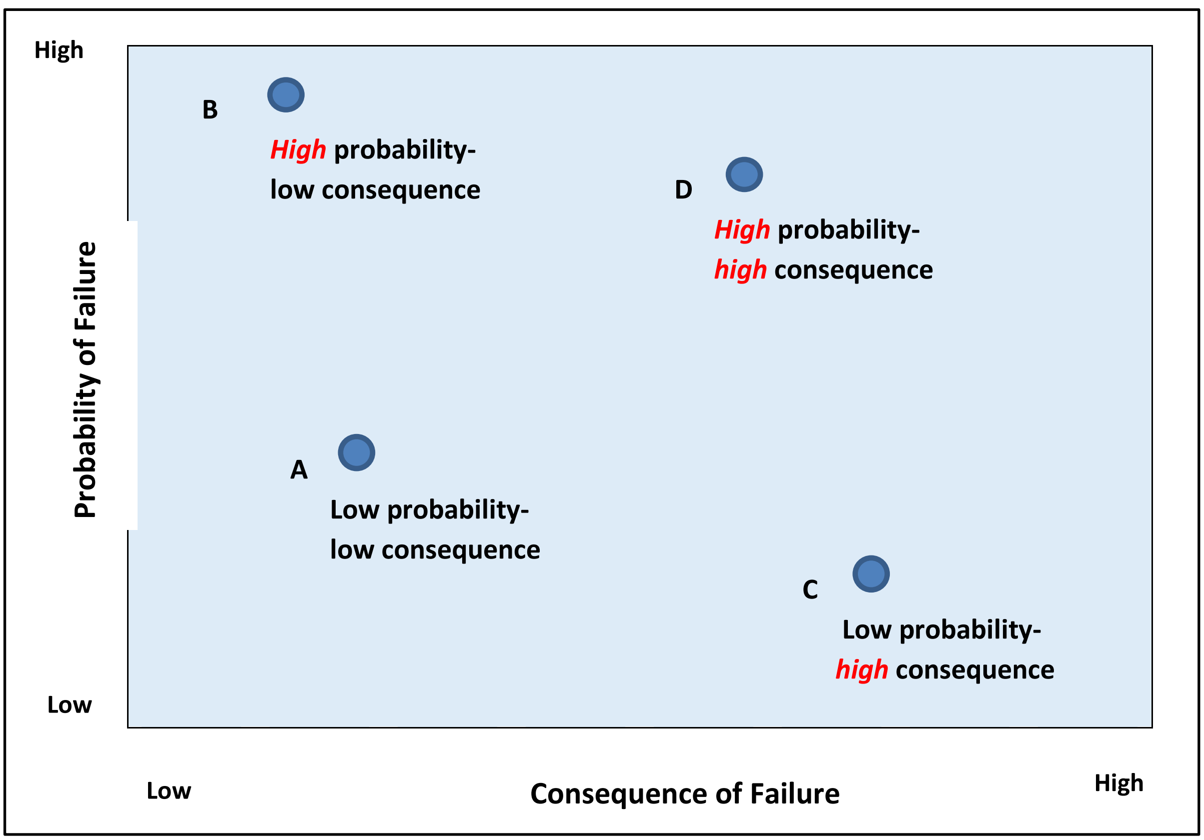
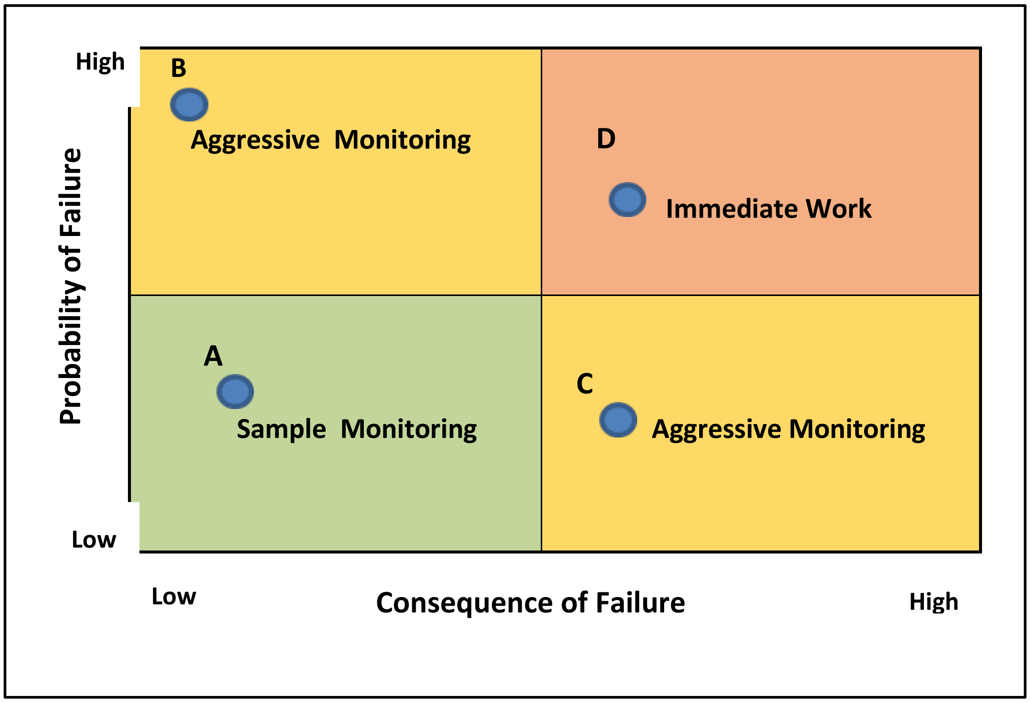


Figure WA14-3. Reliability Response for Risk Exposure (EPA 2007)



Source:
EPA 2007: EPA Asset Management Training Material. *Sustainable Infrastructure Management Program Learning Environment*.

14.2.3 Risk Assessment and Analysis

Much of the equipment and mechanical components of the lime softening system are at the end of their useful life. Spare lime softening treatment unit capacity is not available which limits preventative maintenance to short-term corrective measures. A Fiveash WTP "Reliability Upgrades" is ongoing to replace several key mechanical components and to automate the controls of key plant processes. Phases II and III of the Reliability Upgrades are under design and will be distributed for bid in the near future See **Section WA5.B** for more information.

During the Peele-Dixie WTP site visit, the CUSMP Team was informed that the day storage tanks for sodium hydroxide and sulfuric acid did not hold enough chemical supply to sustain the treatment process for 24 hours. In order to reduce staffing operation costs to refill the tanks twice a day, the CUS Master Plan team recommends additional day storage for the current sodium hypochlorite and sulfuric acid storage-and-feed systems. The installation of additional storage can be incorporated into the expansion of the membrane treatment system, or performed independently.

Based on the risk criteria described in the previous section the samples of assets in each of the plants were given risk scores as shown in **Table WA14-6** and **WA14-7** below.

Table WA14-6. Risk Score for Fiveash Water Treatment Plant Assets

Item	System	Year Purchased/ Rehabbed	Remaining Useful Life[2]	Condition (Good, Fair, Poor)[2]	Corrosive Condition[2]	Likelihood Score[2]	System Priority[2]	Redundancy[2]	Consequence Score[2]	Risk Score[3]
Hydraulic Operated Valve in Transfer Pump Header	Transfer Pump	1983	5	5	3	4.34	5	5	5	22
PCCP Pipe Feeding High Service Pumps[1]	High Service Pump System	1982	5	5	3	4.34	5	5	5	22
Color Polymer System	Polymer System	2009	4	5	5	4.67	5	3	4	19
North High Service Pump Header	High Service Pump System	1963	5	5	3	4.34	5	3	4	17
Southeast High Service Pump Header	High Service Pump System	1990s	5	5	3	4.34	5	3	4	17
Sluice Gates for Clearwell No. 1	Clearwell	1960	5	5	3	4.34	3	5	4	17
Vacuum Priming System 1 & 2	Electrical System	1986	5	5	3	4.34	5	3	4	17
Plant Air Compressor 6	Electrical System	1986	5	5	3	4.34	5	3	4	17
Lime Storage System	Lime Softening System	1960	5	3	5	4.32	5	3	4	17
Aeration Basin 1 - Valves & Valve Operators	Aeration Basin	1963	5	3	5	4.32	3	5	4	17
Hydro Recirculation Pumps 1 & 2 (7.5 HP)	Hydrotreator System	Pre-1990	5	3	5	4.32	5	3	4	17
Hydro Recirculation Pumps 3 & 4 (15 HP)	Hydrotreator System	Pre-1990	5	3	5	4.32	5	3	4	17
Sludge Holding Tank Mixer	Sludge Holding Tank	2006	4	1	5	3.31	5	5	5	17
Lime Blower Motor (480 Volt)	Lime Softening System	2010	4	3	5	3.99	5	3	4	16
Aqueous Ammonia System	Ammonia System	2005	5	1	5	3.64	5	3	4	18
Hydro Washdown Booster Pump (19 HP)	Hydrotreator System	1995	5	3	5	4.32	2	5	3.5	15
Hydro Booster Pump Motor (480 Volt)	Hydrotreator System	1995	5	3	5	4.32	2	5	3.5	15
Aeration Basin - Blower Motors	Aeration Basin	1998	5	5	5	5	3	3	3	15
Chlorine Injector Motor 1,2,3 &4 (480 Volt)	Chlorine System	Varied	5	5	5	5	5	1	3	15

Item	System	Year Purchased/ Rehabbed	Remaining Useful Life	Condition (Good, Fair, Poor)[2]	Corrosive Condition[2]	Likelihood Score[2]	System Priority[2]	Redundancy[2]	Consequence Score[2]	Risk Score[3]
Chlorine Injector Pump 1,2,3 & 4 (10HP)	Chlorine System	Varied	5	5	5	5	5	1	3	15
Filter 1-5, 10, 11, 12, 13, 16-22 Filter Media	Filter System	1990	5	5	5	5	5	1	3	15
Fluoride System	Fluoride System	1980	5	5	5	5	1	5	3	15
Lime Slakers 1, 2, 3 & 4	Lime Softening System	2007	5	5	5	5	5	1	3	15
Sluice Gates for Recarbonation Basin 1 & 2	Recarbonation Basin	1959	5	5	5	5	1	5	3	15
Lime Blower (75 HP)	Lime Softening System	2000	1	3	5	3	5	5	5	15
Ground Storage Tank 1 (5 MG)	Ground Storage Tank	1985	3	3	3	3	5	5	5	15
Coagulant Polymer System	Coagulation System	2015	3	1	5	2.98	5	5	5	15
Transfer Motor 1 & 2 (150 HP, 480 Volt)	Transfer Pump	1983	5	3	3	3.66	5	3	4	15
Transfer Motor 3 & 4 (100 HP, 480 Volt)	Transfer Pump	1991	5	3	3	3.66	5	3	4	15
Transfer Pumps 1 & 2 (150 HP)	Transfer Pump	1983	5	3	3	3.66	5	3	4	15
Transfer Pumps 3 & 6 (100 HP)	Transfer Pump	1991	5	3	3	3.66	5	3	4	15
Aeration Basin By Pass w/ possible passive aeration	Aeration Basin	1963	5	1	5	3.64	3	5	4	15

1: Section WA5B indicated that this pipe is at the end of its useful life

2: See **Table WA14-5** for a scale of values for Condition, Likelihood Score, System Priority, Redundancy, Consequence Score

3: See **Figure WA14-1** for an explanation of the Risk Score.

Table WA14-6 illustrates the Fiveash WTP assets' risk scores that range from 15 to 22 (Assets scoring lower than 15 are not shown in this table). The highest risk scores for the Fiveash WTP are the high service pump headers, the color polymer system, lime storage system, and the PCCP feeding high service pumps. These three assets are critical for the plant operations, have remaining service lives of less than five years, have no redundancy, are in poor condition and are in highly corrosive environments. The color polymer system, high service pump headers and lime storage system are prioritized for replacement and are included as CIP projects in **Table WA14-11**. Please note that these risk scores may not reflect all of the critical needs for individual infrastructure replacement. Rather, this risk score was prioritized based upon the potential to cause shut down of the entire process or loss of plant services.

Table WA14-7. Risk Score for Peele-Dixie Water Treatment Plant Assets

Item	System	Year Purchased/ Rehabbed	Remaining Useful Life	Condition (Good, Fair, Poor)[1]	Corrosive Condition[1]	Likelihood Score[1]	System Priority[1]	Redundancy[1]	Consequence Score[1]	Risk Score[2]
Membrane Cleaning and Flushing System	Reverse Osmosis/Nanofiltration	2007	4	1	5	3.3	5	5	5	17
Sodium Hypochlorite Transfer Pump/Motor 1&2 (5 HP)	Sodium Hypochlorite System	2007	5	2	5	3.96	5	3	4	16
Sulfuric Acid Transfer Pump/Motor 1&2 (3 HP)	Sulfuric Acid System	2007	5	2	5	3.96	5	3	4	16
Aqueous Ammonia Feed System	Ammonia System	2007	4	2	5	3.63	5	3	4	15
Aqueous Ammonia Metering Pump	Ammonia System	2007	4	2	5	3.63	5	3	4	15
Aqueous Ammonia VFD	Ammonia System	2007	4	2	5	3.63	5	3	4	15
Sodium Hydroxide Feed System	Sodium Hydroxide System	2007	4	2	5	3.63	5	3	4	15
Sodium Hydroxide Metering Pump	Sodium Hydroxide System	2007	4	2	5	3.63	5	3	4	15
Sodium Hydroxide VFD	Sodium Hydroxide System	2007	4	2	5	3.63	5	3	4	15
Sodium Hypochlorite Feed System	Sodium Hypochlorite System	2007	4	2	5	3.63	5	3	4	15
Sodium Hypochlorite Metering Pump	Sodium Hypochlorite System	2007	4	2	5	3.63	5	3	4	15
Sodium Hypochlorite VFD	Sodium Hypochlorite System	2007	4	2	5	3.63	5	3	4	15
Sulfuric Acid VFD	Sulfuric Acid System	2007	4	2	5	3.63	5	3	4	15
Aqueous Ammonia Storage Tank	Ammonia System	2007	4	2	5	3.63	5	3	4	15
Sodium Hydroxide Storage Tank	Sodium Hydroxide System	2007	4	2	5	3.63	5	3	4	15

Item	System	Year Purchased/ Rehabbed	Remaining Useful Life	Condition (Good, Fair, Poor)[1]	Corrosive Condition[1]	Likelihood Score[1]	System Priority[1]	Redundancy[1]	Consequence Score[1]	Risk Score[2]
Sodium Hypochlorite Storage Tank	Sodium Hypochlorite System	2007	4	2	5	3.63	5	3	4	15
Sulfuric Acid Feed System	Sulfuric Acid System	2007	4	2	5	3.63	5	3	4	15
Hardware (I&C)	Electrical System	2007	5	3	3	3.63	5	3	4	15
Instrumentation (I&C)	Electrical System	2007	5	3	3	3.63	5	3	4	15
Software (I&C)	Electrical System	2007	5	3	3	3.63	5	3	4	15

[1]Refer to Table WA14-5 for the risk prioritization criteria for the water treatment plan assets.

[2]Refer to Figure WA14-1 for the determination of significance of failure (Risk Exposure Matrix) for risk score

Table WA14-7 demonstrates the Peele Dixie WTP assets' risk scores that range from 15 to 17 (Assets scoring lower than 15 are not shown in this table). The highest risk score for Peele Dixie WTP applies to the components from the chemical feed system such as ammonia, corrosion inhibitor, fluoride, scale inhibitor, sodium hydroxide, sodium hypochlorite, and sulfuric acid. These higher risk assets are in fair condition; however, they are in a highly corrosive environment, have a remaining service life of less than five years, and have some redundancy, such as spare pumps. Please note that the calculated risk scores may not reflect all of the critical needs for individual infrastructure replacement. Rather, this risk score was prioritized based upon the potential to cause shut down of the entire process or loss of plant services.

Section WA14 accepted February 7, 2017.

Assets were categorized by their risk score as they fell within the risk matrix. The risk score categories are defined below:

- *Low probability- low consequence "Sample Monitoring":* The asset is low risk and should be monitored and maintained per typical standards. No other action needs to be taken.
- *High probability- low consequence "Aggressive monitoring":* The asset is at risk and requires aggressive monitoring and rehabilitation or replacement within the planning period.
- *Low probability- high consequence "Aggressive Monitoring":* The asset is at risk and requires aggressive monitoring and rehabilitation or replacement within the planning period.
- *High probability-high consequence "Immediate Work":* The asset is at risk and requires rehabilitation or replacement within the next five years.

14.2.4 Storage Tanks and Pump Stations

14.2.4.1 Single Points of Failure

The potable water distribution system also includes two water storage and repump facilities, one at Northwest 2nd Avenue and one at Poinciana Park. The pump station at Poinciana Park has a bypass 24" water line, which would continue to deliver water from the distribution system in the event of tank or pump station failure. The atlas maps were reviewed to analyze the station at NW 2nd Avenue which showed that the tank can be taken offline and bypassed by the water distribution system, just at potentially lower pressures during peak flow periods. The tank is bypassed during most of the day except when needed during peak hours; therefore, there is no significant risk if the NW 2nd Avenue station or tank were to fail.

14.2.4.2 Condition and Risk Assessment

The City reconstructed the Poinciana Park storage and repump facility in 2007. The station is believed to be in fairly good condition, though control issues with the VFDs at the station have occurred. An emergency generator was installed new during the 2007 construction of the new pump station and ground storage tank. Therefore, it is assumed that the Poinciana Park pump station, including its generator, is in good condition.

The pump station at Northwest 2nd Avenue building was upgraded from 2010-2012 and construction was expected to be completed in 2013. The tank however has not been inspected in ten years, though inspection should occur every five years. The outside of the tank is considered to be unsafe, which has put off the inspection. The tank was also scheduled for rehabilitation when the station was rehabilitated but it was delayed in order to allow development of a design for a decorative painting scheme and color changing light system. The tank is considered to be in poor condition. The City anticipates bidding the decorative painting scheme and lighting system along with the necessary repairs to the water tower by the end of 2016.

The risk of failure of the Poinciana Park pump station is not considered high due to the fairly good condition of the station and the provided bypass. The risk of failure for the Northwest 2nd Ave pump station is considered high due to the poor condition of the tank and need for inspection and rehabilitation. The NW 2nd Ave. pump station can be bypassed though, which decreases the consequences involved in shutdown of the water tower.

Section WA14 accepted February 7, 2017.

14.2.5 Electrical Supply

The existing power distribution system at Fiveash WTP receives normal utility power from Florida Power Lighting (FPL) at 4.16Kv through an on-site utility transformer vault. FPL serves the Fiveash WTP with two (2) 13.2Kv primary feeders, one (1) preferred, and one (1) emergency. Each pair of transformers has an automatic oil immersed transfer switch that switches between the normal and emergency feeder when utility power is lost. The utility transformers in the vault were upgraded within the last 18 months by FPL. Emergency power is derived from two (2) existing 480V, 900 kW emergency diesel generators. A large portion of the electrical system was installed in the 1970s/1980s, and is nearing the end of its useful service life (40-60 years old). There is redundancy in the power distribution system and pumping systems for the high service and transfer pumps such that a single point failure will not prevent Fiveash WTP from delivering water to the distribution system. However, there are concerns with regards to reliability and redundancy in other treatment processes. **Section UW3.2.1 and UW3.2.2** provides a detailed analysis and recommendations regarding the redundancy of the Fiveash WTP electrical system.

Peele-Dixie WTP receives utility power from two pad-mounted utility owned transformers that are served by primary distribution lines along State Road 7. Emergency power is provided through two (2) 1750 kW emergency diesel generators. Under normal operating conditions, Peele-Dixie WTP loads are powered from both utility services, and both generators when utility power is lost. **Section UW3.4.1** affirms that the power supply configuration is redundant, as the entire plant can still operate in the event of failure of one of the electrical power supply components. Much of the electrical equipment at the Peele-Dixie WTP will extend through the 20-year planning period, as the WTP was constructed in 2008 and is relatively new. Therefore, the CUSMP Team does not have recommendations for improvement of the Peele Dixie WTP power supply system at this time.

14.2.6 Distribution System

14.2.6.1 Risk Prioritization Criteria

Risk for utilities asset management purposes is determined by likelihood of failure and consequence of failure. For the distribution system, physical conditions such as the material of the pipe, installation date and level of service requirements for capacity make up the basis for a likelihood of failure score. Sources of information for the likelihood of failure include the City's GIS and the CUS Master Plan team's hydraulic model results. Likelihood of failure criteria and weighting is presented in **Table WA14-8**.

The impact on the City of failure of an asset is measured by the consequence of failure. Size and redundancy are components of consequence of failure. In the City's potable water distribution system, large diameter pipes affect more customers during an outage than smaller pipes. For this reason, the risk assessment of pipes is focused on larger pipelines and assets; however, in the future these criteria can apply to evaluation of all assets. Redundancy is provided if an alternate route, unit or power supply is available. The consequence of failure will be lower for assets with redundancy because an alternate asset is available. Consequence of failure and weighting factors are included in **Table WA14-8**.

Table WA14-8. Likelihood and Consequence of Failure of Pipe

Category	Basis	Weighted %	Low Risk				High Risk
			1	2	3	4	5
Likelihood of Failure	Pipe Material	40%	PVC or HDPE	DIP	Unknown	--	PCCP, VCP, CIP. RCP
	Installation Date	40%	2000 or later	1990-2000	1980-1990, Unknown	1970-1980	Earlier than 1970
	LOS Require-ments[1]	20%	Velocity < 5 fps (Meets LOS requirement)	--	Velocity 5-6 fps (Almost meets LOS requirement)	--	Velocity > 6 fps (Fails LOS requirement)
Consequence of Failure	Pipe Diameter	50%	<24”	--	24” – 36”	--	>36”
	Redundancy	50%	Full Redundancy	--	Partial Redundancy	--	No backup/ redundancy

[1]Level of service assessed from the 2015 Peak Hour Flow (PHF) output.

14.2.6.2 Risk Assessment and Analysis

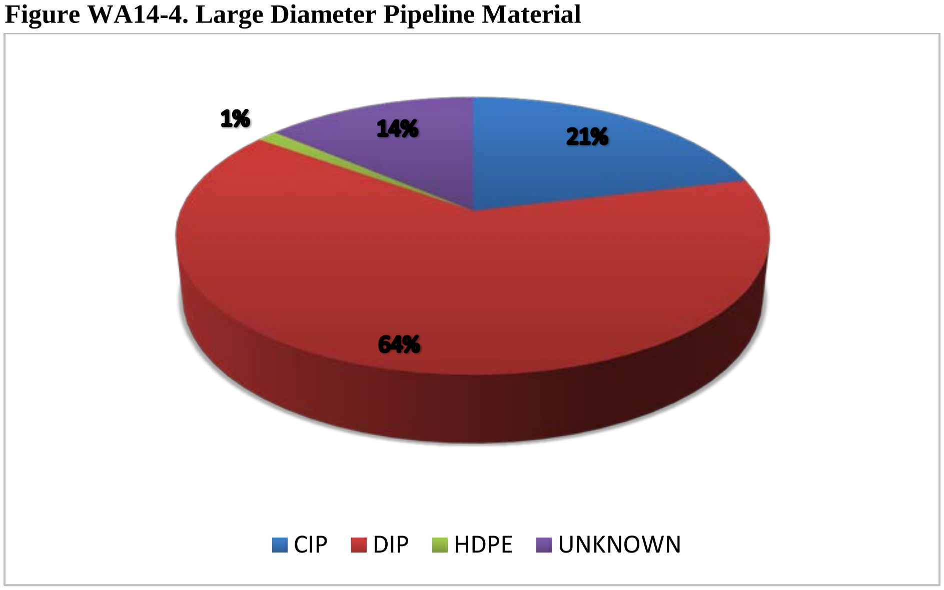
A “risk score” was calculated for the large diameter (24” or greater) distribution pipe using relevant data and the risk assessment criteria identified previously. The risk score categories are defined below:

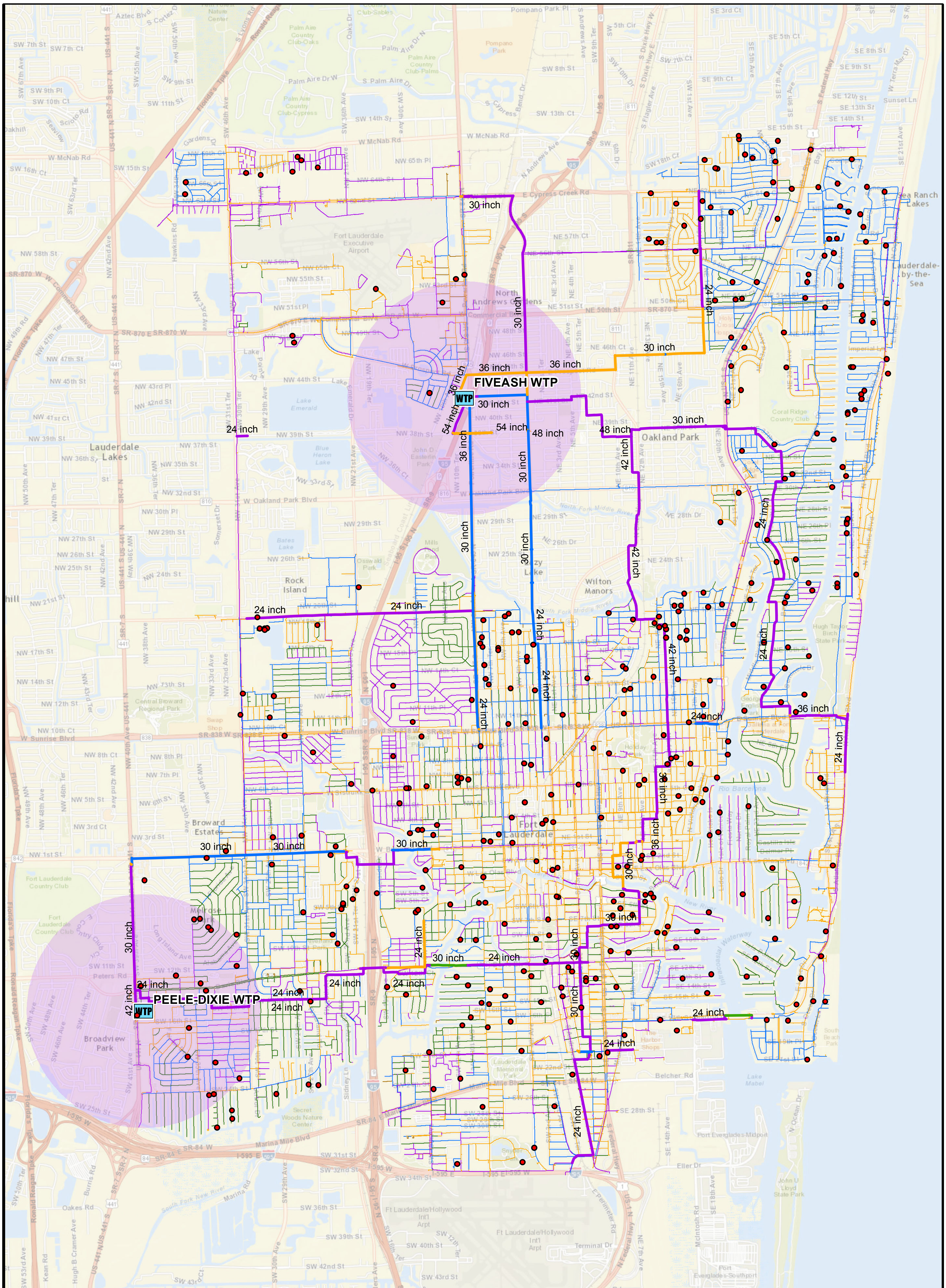
- *Risk Score 1-2 “Low Risk”:* The asset is low risk and should be monitored and maintained per typical standards. No other actions are required.
- *Risk Score 2-3 “Low-Moderate Risk”:* Maintain asset per usual schedule. No other action required.
- *Risk Score 3-4 “Moderate-High Risk”:* The asset is at risk and requires rehabilitation or replacement within the planning period.
- *Risk Score 4-5 “High Risk”:* The asset is at risk and requires rehabilitation or replacement within the next five years.

14.2.6.3 Risk Assessment Results

Figure WA14-4 illustrates that almost two-thirds of the large diameter pipe in the distribution system is ductile iron pipe. A significant portion is cast iron pipe and almost a quarter of the large diameter pipes are of unknown material. Much of the cast iron pipe was installed before 1970. The age of the large diameter potable water pipelines indicates that the City should be budgeting funds to address the most critical of these pipes over the next 20 years. Another consideration is corrosion of pipes. The soil conditions surrounding buried pipe control the external corrosion of pipes. Resistivity of the soil is the main determinant of corrosiveness; low resistivity soils have higher corrosivity. The moisture and salt content of the soil are directly related to the resistivity; therefore, degradation of metallic pipes, including ductile iron pipe (DIP) and cast iron pipe (CIP), could be exacerbated by a higher groundwater table and saltwater intrusion. **Figure WA14-5** presents a map of the City’s potable water distribution system with large diameter pipes in the system categorized by material. The results of the large diameter potable water main rankings are shown in **Figure WA14-6**.

Figure WA14-4. Large Diameter Pipeline Material





Legend

- Water Pipe Breaks (Jan 2010-Jan 2014)
- Water Treatment Plant
- WTP 1-Mile Buffer

Large Diameter Water Main Material

- Unknown
- CIP
- DIP
- HDPE

Water Main Material

- PVC
- HDPE
- DIP
- CIP
- Other
- Unknown

N / E / S / W

0 0.5 1 2 Miles

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PALN
Potable Water System: Large Diameter Pipe Materials

FIGURE WA14-5

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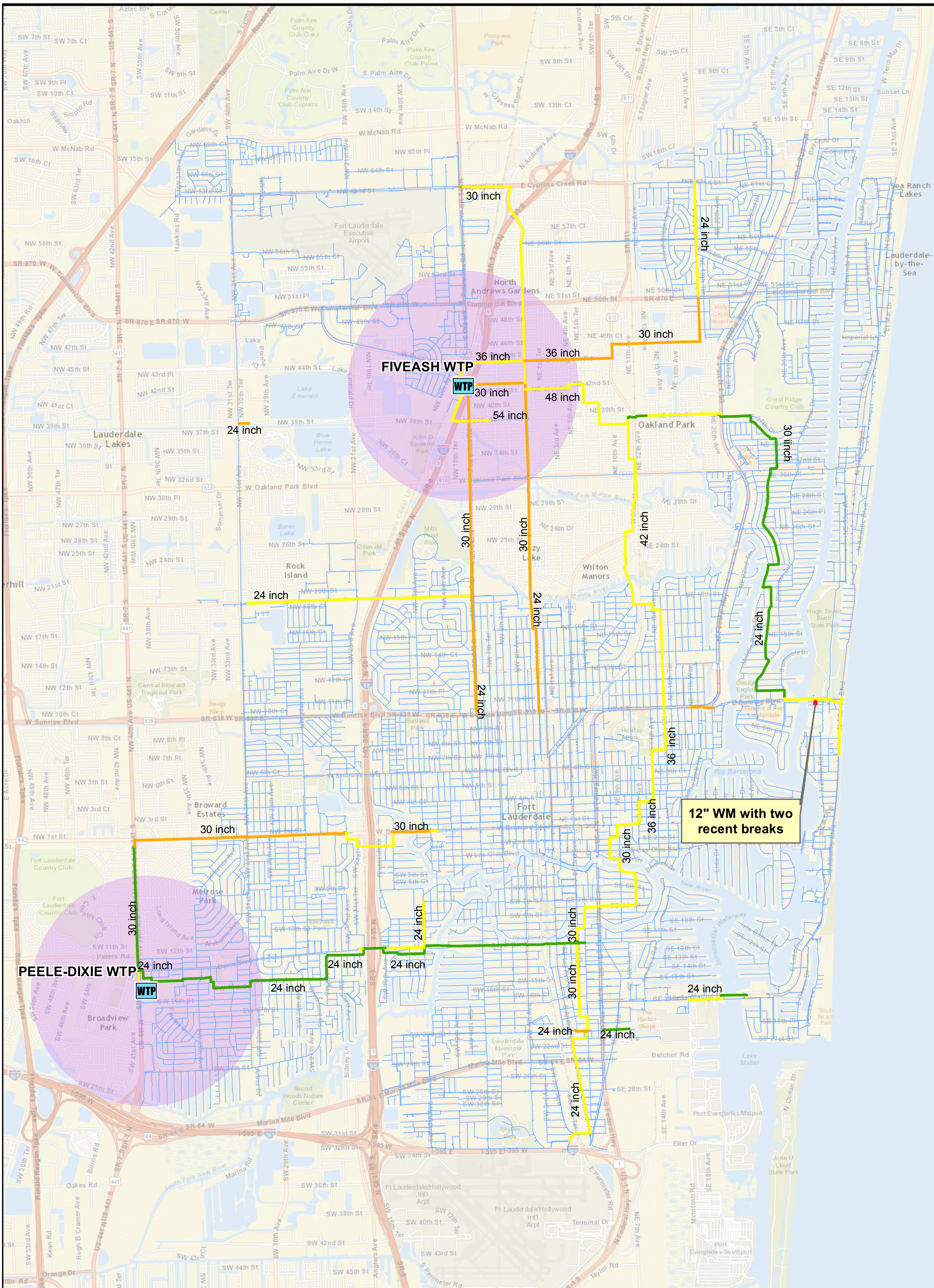

N
W E
S

0 0.5 1 2
Miles

Legend

WTP **Water Treatment Plant**

WTP 1-Mile Buffer

Large Diameter PW Main Risk

Risk Ranking

- Low Risk (1-2)
- Low-Moderate Risk (2-3)
- Moderate-High Risk (3-4)
- High Risk (4-5)

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PALN
Potable Water System: Large Diameter Pipe Risk Ranking

FIGURE WA14-6

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14.3 Interconnects for Water Supply Redundancy

The City of Fort Lauderdale's water distribution system maintains interconnects with nearby municipalities. Through outgoing interconnects, water distributes into wholesale service areas including Wilton Manors, Oakland Park, Sea Ranch Lakes, Lauderdale-by-the Sea, Davie, Dania Beach, Port Everglades Authority, North Lauderdale, portions of east Tamarac and Broward County. Piping materials for the interconnect force mains are DIP, CIP and Polyvinyl Chloride (PVC). Scoring and weighting of the interconnect force mains for physical condition, capacity performance and consequence of failure are similarly developed as explained above. The redundancy scores take into account the number of interconnects that the City has with the user. For example, the Oakland Park interconnects were given a redundancy score of 1 because the City maintains multiple interconnects with this municipality, but Ft. Lauderdale International airport interconnect was given a redundancy score of 5 because there is only one interconnect. **Table WA14-9** presents the prioritization criteria.

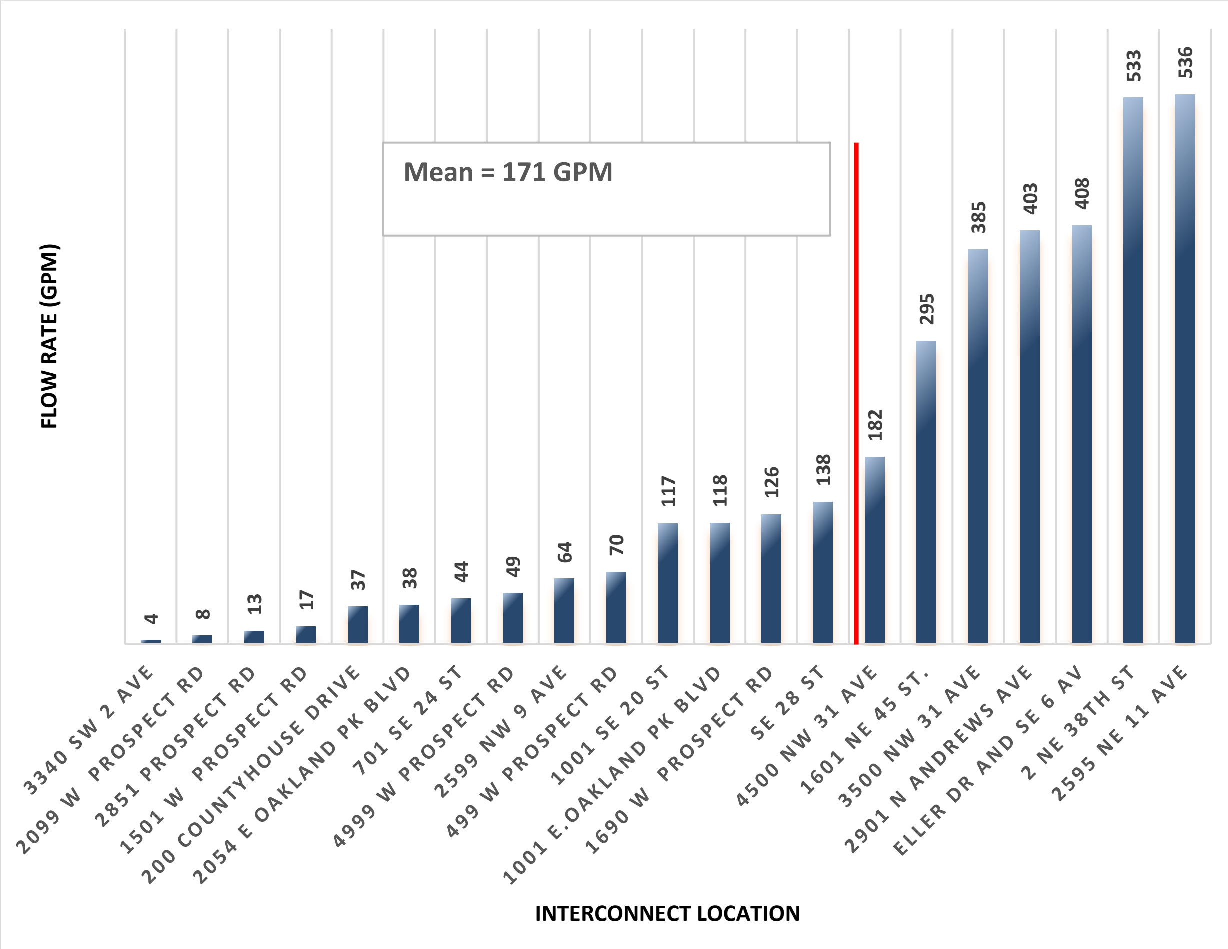
Table WA14-9. Risk Prioritization Criteria – Interconnects

Category	Basis	Weighted %	Low Risk 1	2	3	4	High Risk 5
Likelihood of Failure	Pipe Material	40%	PVC	--	DIP	--	CIP
	Installation Date	40%	2000 or later	1990-1999	1980-1989, Unknown	1970-1979	Earlier than 1970
	LOS Requirements[1,2]	20%	Velocity < 5 fps (Meets LOS requirement)	--	Velocity 5-6 fps (Almost meets LOS requirement)	--	Velocity > 6 fps (Fails LOS requirement)
Consequence of Failure	Population	50%	< 3,000 people per Interconnect	--	3,000-5,000 people per Interconnect	--	> 5,000 per Interconnect
	Redundancy[3]	50%	Full Redundancy	--	One Redundancy	--	No backup/ redundancy

[1]Level of service assessed from the 2015 Peak Hour Demand (PHD) Output.
[2]Scored based on the characteristics of the pipeline at the interconnect.
[3]Scored based on the interconnect itself.

The interconnect information collected from the City and hydraulic model results for flow rate, velocity, customer served, and material type are demonstrated in **Figures WA14-7, WA14-8, WA14-9, and WA14-10,** respectively. The flows for each interconnect were determined from the hydraulic model output results of the 2015 average day demand (ADD) scenario. Some of the interconnects in the Fort Lauderdale area were initially installed in 1952 while others were connected as recently as 2006. **Figure WA14-11** shows the number of interconnects according to installation year. The risk score can be based on material type, interconnect installation date, daily flow rate, velocity, number of customers served and number of back up interconnects.

Figure WA14-7. Water Interconnect Flow Rate



Section WA14 accepted February 7, 2017.

Figure WA14-8. Interconnect Velocity

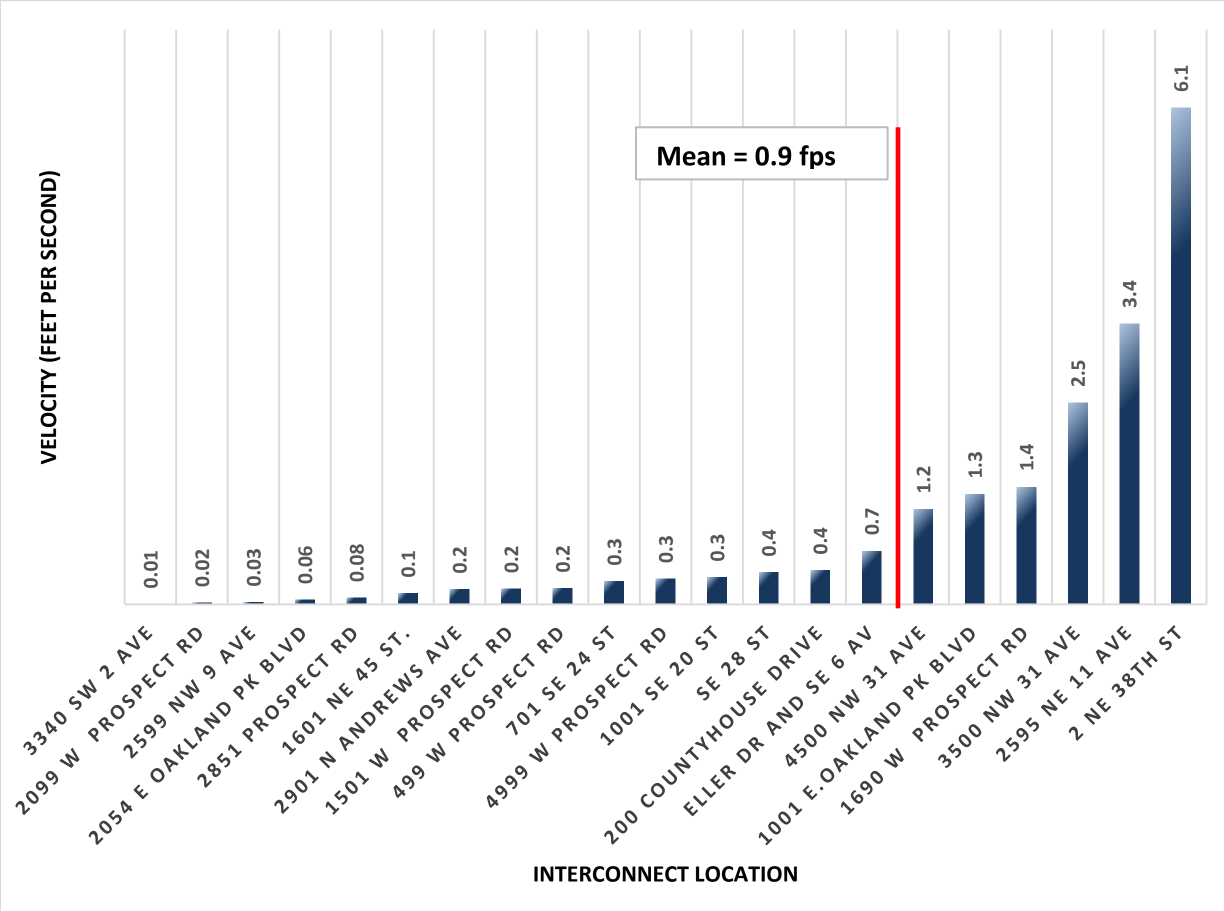
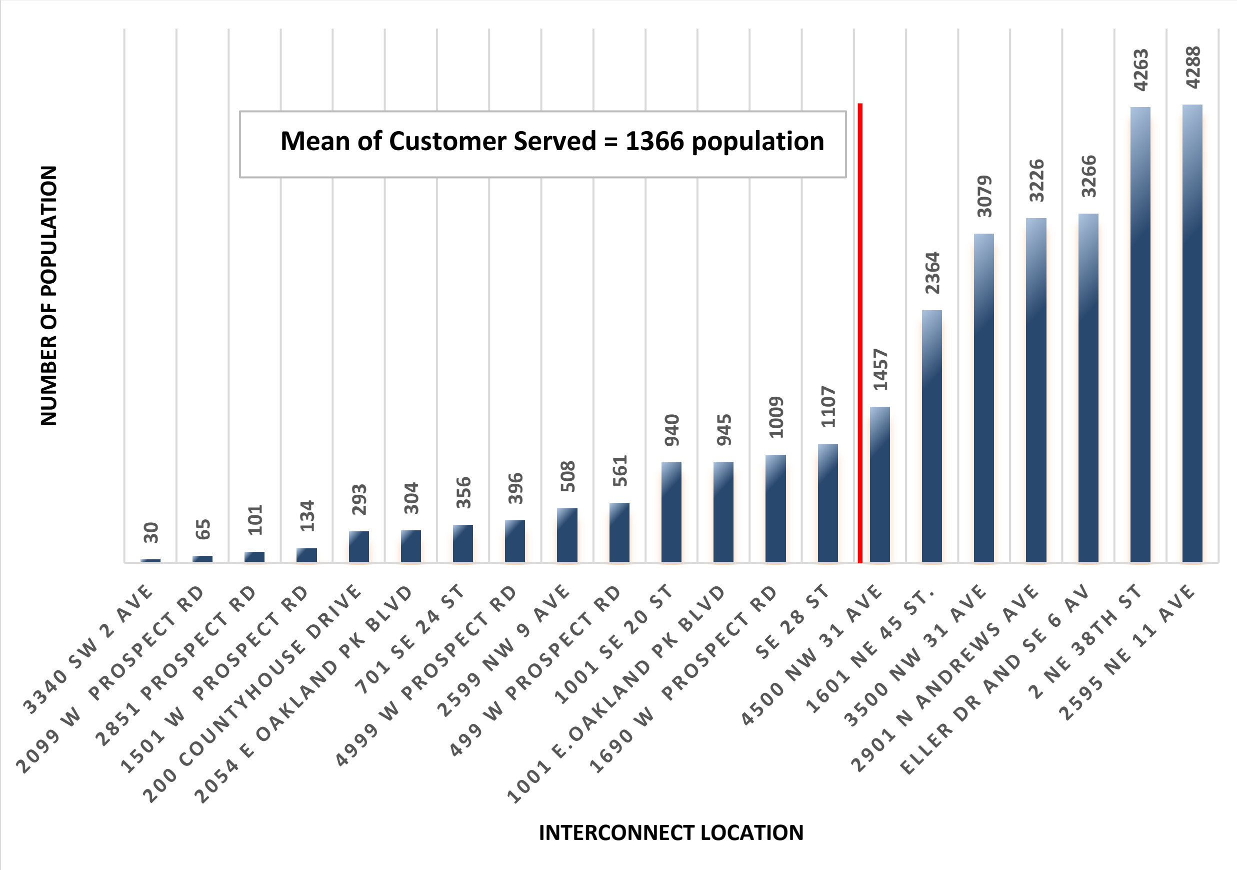
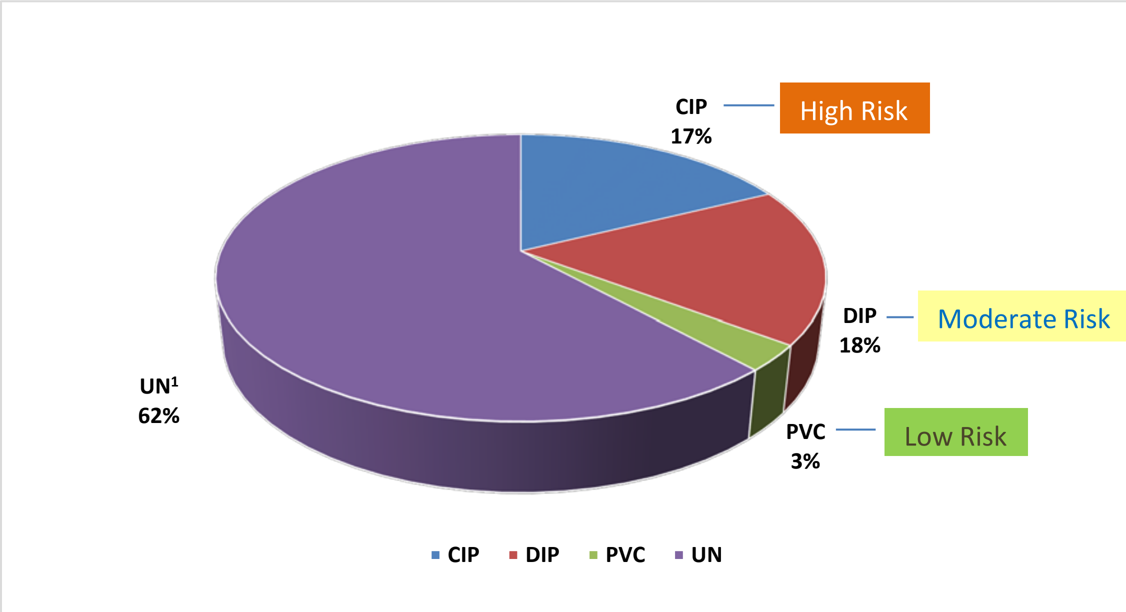


Figure WA14-9. Interconnect Customer Served Population



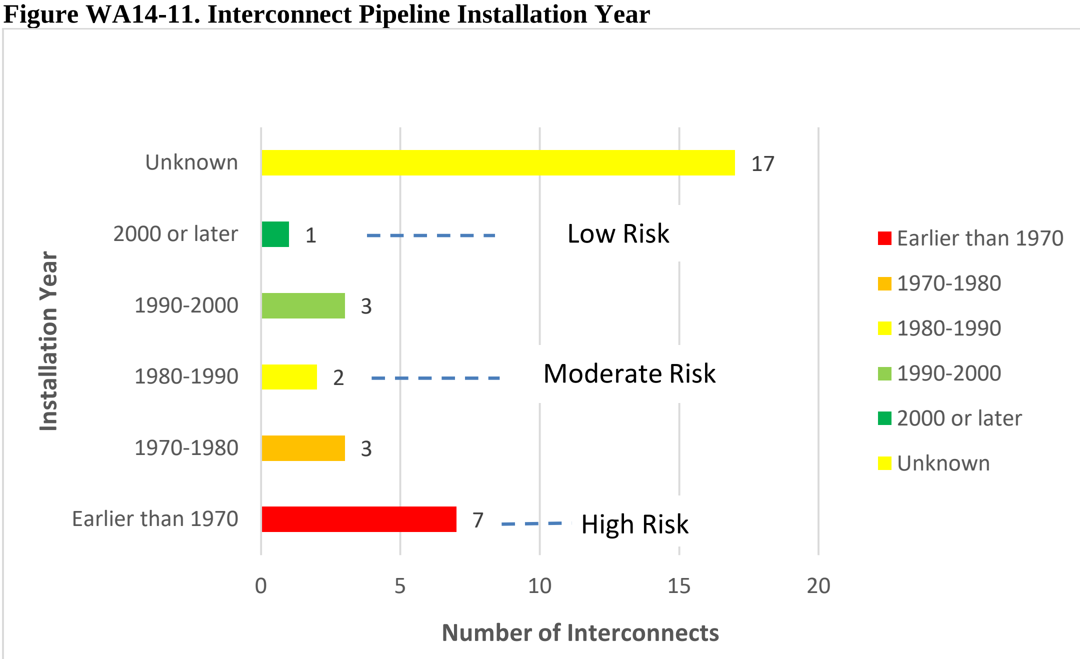
Section WA14 accepted February 7, 2017.

Figure WA14-10. Interconnect Pipeline Material Type



[1]UN = unknown

Figure WA14-11. Interconnect Pipeline Installation Year



Section WA14 accepted February 7, 2017.

Table WA14-10. Risk Score for Interconnects

Interconnect Authority	Interconnect Address	Likelihood Score[1]	Consequence Score[1]	Risk Score[2]
HOUSING AUTHORITY SUNNYLANDHMS	1326 NW 9TH ST	4.2	3.0	12.6
CITY OF TAMARAC	2099 W PROSPECT RD	3.8	3.0	11.4
DIXIE COURT	1006 NW 4 ST	2.6	4.0	10.4
BROADVIEW PARK	2001 SW 40 AVE	2.2	4.0	8.8
FOREST LAKE	UN	2.2	4.0	8.8
CYPRESS CREEK TOLL PLAZA	UN	2.2	4.0	8.8
WILTON MANORS	2901 N ANDREWS AVE	4.2	2.0	8.4
FT. LAUD AIRPORT	3340 SW 2 AVE	2.6	3.0	7.8
COUNTY COURT HOUSE	200 COUNTYHOUSE DRIVE	2.6	3.0	7.8
HOUSING AUTHORITY	1616 NW 24 AVE	2.6	3.0	7.8
CITY OF OAKLAND PARK	2 NE 38TH ST	3.0	2.0	6.0
PORT EVERGLADES	ELLER DR AND SE 6 AV	2.6	2.0	5.2
OAKLAND PARK	NW 26 AVE AND NW 26 CT.	2.6	2.0	5.2
WILTON MANORS SERVICE METER	2595 NE 11 AVE	2.6	2.0	5.2
OAKLAND PARK	3500 NW 31 AVE	2.6	2.0	5.2
TAMARAK LAKES	1501 W PROSPECT RD	2.6	2.0	5.2
TAMARAC	4999 W PROSPECT RD	2.6	2.0	5.2
WILTON MANORS	2599 NW 9 AVE	4.2	1.0	4.2
OAKLAND PARK	1001 E.OAKLAND PK BLVD	4.2	1.0	4.2
OAKLAND PARK	2054 E OAKLAND PK BLVD	4.2	1.0	4.2
OAKLAND PARK	1601 NE 45 ST.	3.4	1.0	3.4
CITY OAKLAND PARK	1600 NW 41 ST	3.0	1.0	3.0
PROSPECT VILLAS	2851 PROSPECT RD	1.0	3.0	3.0
PORT EVERGLADES AUTHORITY	SE 28 ST	2.6	1.0	2.6
PORT EVERGLADES	701 SE 24 ST	2.6	1.0	2.6
PORT EVERGLADES	1001 SE 20 ST	2.6	1.0	2.6
OAKLAND PARK	NW 21 AVE AND NW 26 ST	2.6	1.0	2.6
OAKLAND PARK	499 W PROSPECT RD	2.6	1.0	2.6
OAKLAND PARK	1690 W PROSPECT RD	2.6	1.0	2.6
CITY OF OAKLANDPARK LAKEPOINTE	4500 NW 31 AVE	2.6	1.0	2.6

[1]Refer to **Table WA14-9** Risk Prioritization criteria for interconnects
[2]Refer to **Figure WA14-1** for the determination of significance of failure (Risk Exposure Matrix) for risk score

Table WA14-7 demonstrates the City of Fort Lauderdale interconnects risk scores range from 2.6 to 12.6. The high risk score for interconnects mainly results from the type of pipe material used, year of installation and the level of redundancy. The highest risk score interconnect is located on 1326 NW 9TH St. This interconnect was made from cast iron pipe (CIP) and was in service since 1958. The second highest risk interconnect is located on 2099 W Prospect Rd. This interconnect has no redundancy, was made from CIP and was in service since 1974.

14.4 Summary of Potential Areas of Concern and Recommendations

The purpose of this report is to analyze and evaluate the water treatment system components and the distribution system pipeline and interconnects in terms of risk of failure and reliability in operation. The process developed to guide this effort included:

- Defining critical system components
- Evaluating redundancy of critical system components
- Evaluating the remaining useful life
- Evaluating the environmental condition regarding corrosive activity
- Evaluating piping and interconnects regarding material, flow rate, customers served and remaining useful life
- Identifying single points of failure

The CUS Master Plan team developed risk scores and made recommendations including CIP projects and preventative action, such as monitoring and maintaining the high potential risk areas. These actions will help lessen the potential detrimental impact of failure on system operations and decrease the chance of a system shutdown. The following conclusions resulted from this analysis:

- In order to maintain the City's distribution system, the CUS Master Plan team recommends rehabilitation of prioritized pipeline on a yearly basis. **Section WA7** displays the pipeline rehabilitation/replacement CIP projects that resulted from this study. Overall, the City's potable distribution system has sufficient redundancy. **Figure WA14-12** shows a map of the recommended pipeline CIP projects.
- Redundancy is provided for a majority of the City's interconnects. However, there is only one interconnect with the City of Tamarac, therefore the CUS Master Plan Team recommends that the City should consider a second interconnect.
- The two (2) offsite storage and repump facilities do not represent a significant risk at this time, although the City should proceed with the scheduled restoration of the water tower.
- Peele-Dixie WTP is generally in good condition, due to its recent construction in 2008 and upkeep by City operations staff. The CUS Master Plan team confirmed this visually during a site visit. The CUS Master Plan team recommends that the City continue to periodically monitor and record the condition of Peele-Dixie WTP assets and perform routine maintenance. **Section WA5-C** identifies capacity-related improvements for the chemical storage systems at Peele-Dixie WTP.
- There are components at the WTPs that represent single points of failure to the system; these were identified and prioritized for future capital projects to reduce risk and increase system redundancy. The highest risk components at Fiveash WTP included the lime storage and feed systems. At Peele Dixie, the highest calculated risk was for components such as the aqueous ammonia, scale, and corrosion inhibitor systems.

Section WA14 accepted February 7, 2017.

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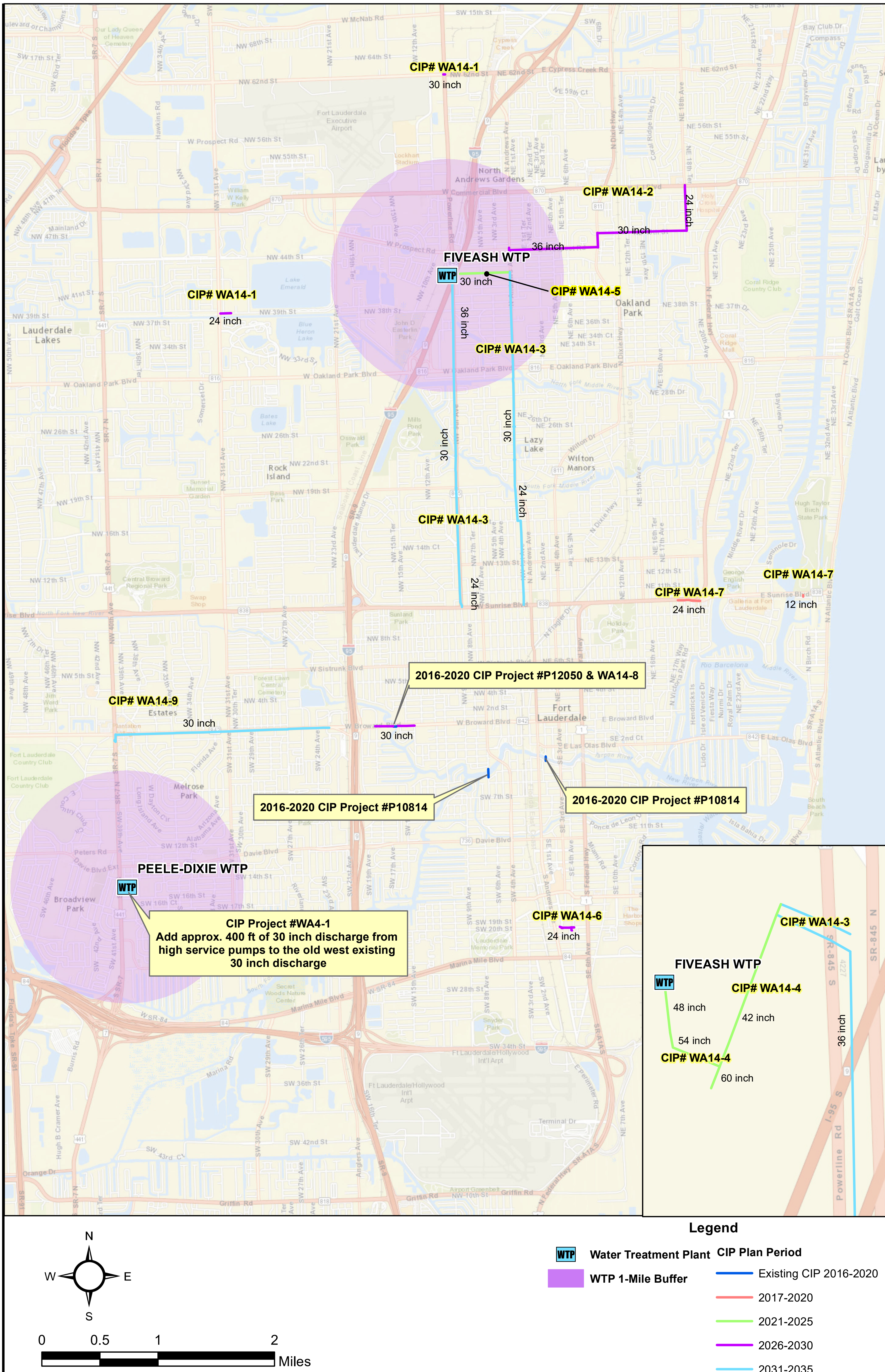

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
Potable Water System: Large Diameter Pipe CIP Projects

FIGURE WA14-12

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WW1 Wastewater Flow Forecast

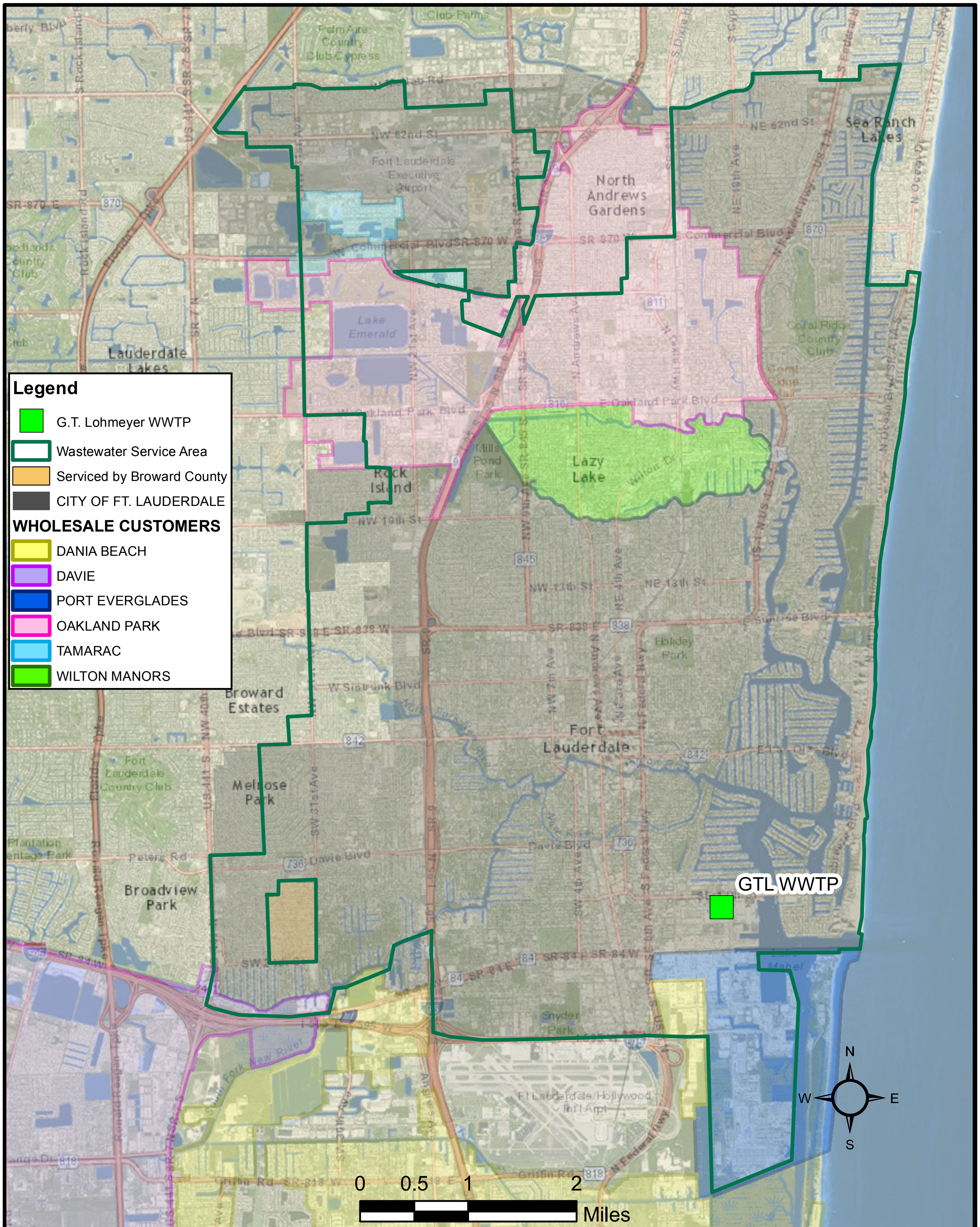
The City owns and operates the George T. Lohmeyer Wastewater Treatment Plant (GTL), which serves the City, Wilton Manors, Oakland Park, Davie, and Port Everglades, as well as parts of Tamarac and unincorporated Broward County. Wastewater flows are projected and evaluated over a 20-year planning period to the year 2035. The purpose of these projections is to evaluate the capacity of the existing wastewater transmission system and to identify the need for wastewater capacity expansion. This section provides a summary of historical flows, along with wastewater flow projections for the years 2020, 2025, 2030, and 2035. Furthermore, the design flows and peaking factors used to evaluate the future needs of the wastewater transmission, treatment, and disposal are confirmed as summarized below.

1.1 Introduction

The City of Fort Lauderdale (City) provides wastewater treatment and disposal services to an estimated 180,000 people in central Broward County. Those within the City of Fort Lauderdale comprise approximately 70 (2008 City Comprehensive Plan) to 80 (City staff estimates) percent of the wastewater service population with the remainder located in portions of unincorporated Broward County, Port Everglades and the Cities of Dania Beach, Davie, Tamarac, Wilton Manors and Oakland Park. According to the Broward County Health department, a maximum of 19,500 people (this number is expected to have decreased in recent years) have onsite wastewater treatment (septic tank) systems, mostly located within the Fort Lauderdale City limits. The City built 42 new pump stations in the Waterworks 2011 program to provide infrastructure to take residents off septic tanks and replace with City sewer service. The Waterworks 2011 program tracked residences in areas to receive new sanitary sewers to ensure that owners connected to the sanitary sewer system and abandoned their septic tanks properly. City code compliance inspectors would cite homeowners that were slow to connect. Delinquent owners were called before a Special Magistrate for enforcement. Florida Statute 381.00655 requires connection to an adjacent sanitary sewer system. The City's wastewater service area is presented in **Figure WW1-1**.

The collected wastewater from the City's service area is treated at the City owned and operated George T. Lohmeyer Wastewater Treatment Plant (GTL). The City also owns and operates the regional wastewater transmission system, as well as the wastewater collection system within its boundaries and a small portion of unincorporated Broward County. The other contributing wastewater collection systems, located outside the City boundaries, are owned and operated by the respective governmental agencies.

Section WW1 accepted March 28, 2016.



CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER SERVICE AREA

FIGURE WW1-1

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1.2 Wastewater Service Area

The City wastewater service area population forecast was compiled and provided by the City based on the latest Census of Population and Housing Publication, the South Florida Water Management District (SFWMD), and the University of Florida's Bureau of Economic and Business Research (BEBR) "Detailed Population Projections by Age, Sex, Race, and Hispanic Origin, for Florida and Its Counties, 2015-2040, With Estimates for All Races" (2014), as well as population projections for the City's Water Service. The City's wastewater service area population, in 5 year increments for the 20-year planning period, is presented in **Table WW1-1**. As shown in **Table WW1-1**, the City's wastewater service area population is expected to grow from approximately 178,640 in 2014 to 213,885 in year 2035; nearly a 20% increase. The increase in population will result in increased wastewater influent flows to the GTL over the planning period, unless City efforts to curtail inflow and infiltration are successful or if the large users further curtail their water use resulting in less wastewater being generated.

Table WW1-1. Wastewater Service Area Population Forecast

Year	Ft. Lauderdale, Unincorporated Broward County	Oakland Park	Wilton Manors	Tamarac and Davie	Total Population
2005	147,319	28,366	12,230	429	188,344
2015	140,717	27,095	11,611	410	179,903
2020	145,429	28,107	11,740	422	185,697
2025	160,108	28,646	11,693	394	200,840
2030	168,078	29,866	11,931	443	210,317
2035	171,240	30,214	11,929	503	213,885

1.3 Historical Wastewater Flows

1.3.1 System-Wide Historical Flows

Wastewater flow is measured continuously by the City at GTL's influent flowmeters adjacent to the pretreatment building. GTL's flow meters are calibrated annually by GTL instrument technicians and assumed accurate. Measured flows are recorded on Monthly Operating Reports by the City and used as the source of data for historical flows for comparison to GTL's current permitted capacity of 56.6 MGD. Historical monthly average daily flow (MADF), 3-month average daily flow (3MADF), and annual average daily flow (AADF), shown in **Appendix WW1-A** and graphically in **Figure WW1-2,** are defined as follows:

- Average Annual Daily Flow (AADF) – The total volume of wastewater flow to the GTL for a year divided by 365.
- Monthly Average Daily Flow (MADF) – The total volume of wastewater flow during a calendar month divided by the number of days in that month.
- Three-Month Average Daily Flow (3MADF) – The total volume of wastewater flow during a period of three consecutive months, divided by the number of days in that three-month period. 3MADF is a rolling average of the current month and the two preceding months and represents seasonal flow to the GTL. The maximum 3MADF that occurs during a calendar year is termed the M3MADF. **The permitted capacity of the GTL WWTP (currently 56.6 MGD) is based on treating the M3MADF.**

The historical wastewater flow data indicates that the highest historical AADF over the last ten years occurred in 2012, with the highest recorded MADF and 3MADF occurring in November of 2011. **Figure WW1-2** shows that historical flows to the WWTP generally increased from 2003 to 2009, and then decreased slightly in 2010 and 2011, before turning up again at the end of 2011. It can also be seen from the data that there is a significant difference between the AADF and the peak flows, indicating that there are large contributions from other factors such as inflow and infiltration (I/I) as documented in previous City planning efforts. The WaterWorks 2011 Program was an effort by the City to rehabilitate the wastewater transmission system through rehabilitation of key transmission force mains and pump stations. The WaterWorks 2011 Program did an excellent job of bolstering transmission reliability and capacity. The City now has a robust network of force mains and pump stations to mitigate and manage the I/I but it still remains a huge burden during major rain and tide events. Based on review of historical data, WaterWorks 2011 efforts did not produce a significant measurable reduction in I/I and hence the City is continuing to turn its focus to this important capacity issue. Often, I/I improvements are not seen until 40% of the repairs are completed. Patching leaks often causes groundwater levels to rise, which allows water to infiltrate through additional leaks and cracks in the system, which were previously above the groundwater table. I/I programs frequently require long term funding commitment through times of low or no visible results before the benefits start showing.

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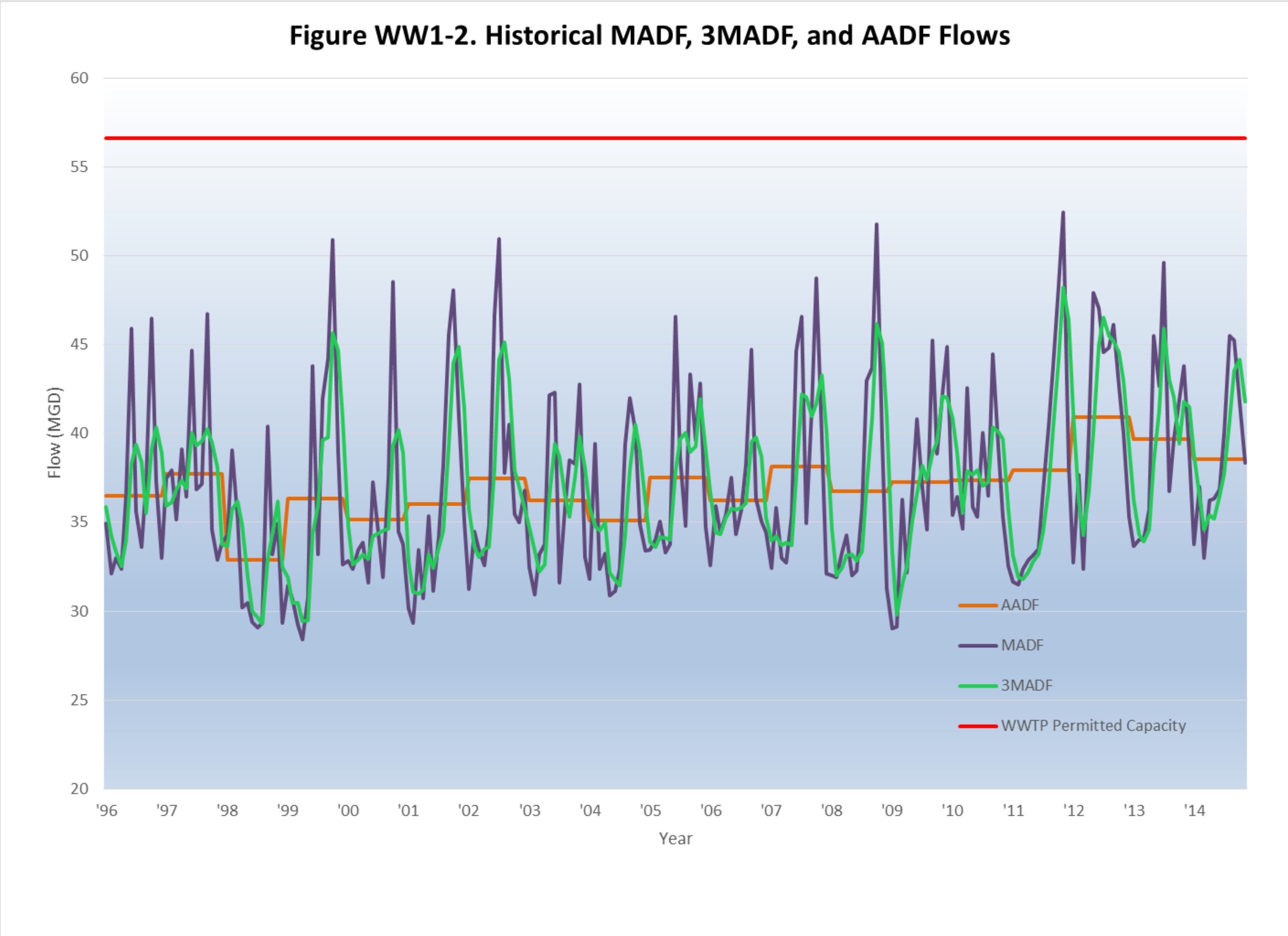

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1.3.2 Variations in Historical Wastewater Flows

In addition to the MMADF and M3MADF analyses, peak flow variations are utilized to assess collection, transmission, treatment, and disposal system capacities. Flow variations are typically expressed in terms of the ratios of maximum-to-average flows in a calendar year and referred to as peaking factors. Of particular interest are the maximum daily flow (MDF) and maximum hourly flow (MHF), which are defined as follows:

- MDF – Largest wastewater flow in a single 24-hour day during a calendar year.
- MHF – Largest wastewater flow in a one-hour period during a calendar year.

The historical peaking factors are compared to average rainfall totals in **Table WW1-2**. The rainfall data for 1996-2005 was obtained from the 2007 Wastewater Master Plan Update, and the rainfall data from 2005-2014 was obtained from the GTL Capacity Analysis Report (CDM, 2015). For a majority of the recorded years, MMADF and M3MADF occurred in September, October, or November; likely a result of the late summer/early fall high rainfall season that increases groundwater level and I/I contributions to the wastewater collection system. The highest M3MADF/AADF peaking factor of 1.27 was experienced in 2011 and the highest MHF/AADF peaking factor was 2.54 occurring in 2003. It should also be noted that over the last 5 years the City has been implementing I/I reduction measures including lining gravity collection pipes, yet as shown in the table below, these efforts and the WaterWorks 2011 Program have not significantly reduced the I/I peaking factors. This is typical for most I/I Programs because a large fraction of repairs must be completed before I/I reduction efforts show significant results.

Table WW1-2. Historical Wastewater Influent Peaking Factors

Year	Rainfall (in)	AADF (MGD)	M3MADF & Month Occurred (MGD)		MHF (MGD)	M3MADF/ AADF	MHF/AADF
1996	72.8	36.51	40.35	November	-	1.11	-
1997	87.1	37.73	40.26	September	-	1.07	-
1998	66.8	32.91	36.18	November	-	1.10	-
1999	81.5	36.34	45.66	October	-	1.26	-
2000	58.2	35.16	40.18	November	79.06	1.14	2.25
2001	27.5	36.02	44.86	November	81.12	1.25	2.25
2002	67.1	37.47	45.11	August	75.58	1.20	2.02
2003	62.8	36.23	39.85	November	92.04	1.10	2.54
2004	58.8	35.09	40.52	October	69.50	1.15	1.98
2005	71	37.51	41.93	November	73.87	1.12	1.97
2006	52	36.21	39.76	October	68.04	1.10	1.88
2007	60	38.12	43.30	November	73.08	1.14	1.92
2008	76	36.75	46.14	October	74.66	1.26	2.03
2009	54	37.24	42.10	November	81.31	1.13	2.18
2010	62	37.36	40.84	January	75.91	1.09	2.03
2011	62	37.91	48.20	November	83.81	1.27	2.21
2012	74	40.93	46.50	July	75.70	1.14	1.85
2013	73	39.67	45.92	July	97.22	1.16	2.45
2014	63	38.61	44.14	October	83.98	1.15	2.18
Maximum Peaking Factor:				-	-	1.27	2.54
Average Peaking Factor:				-	-	1.15	2.12

1.3.3 Historical Per Capita Wastewater Flows

The City calculates unit wastewater flows to normalize flow contributions from the total service area population. Per-capita unit flows allow for comparison to other communities and facilitate assessment of I/I quantities in the system. Note that similar to potable water, the unit per capita flow rate is a “gross” quantity in that commercial, industrial and institutional flows are included. As presented in **Table WW1-3**, the per capita flow rates for the City’s service area ranged from 180 to 230 gpcd from 1988 to 2005. The per capita unit flow rates indicate that the wastewater produced per person increased steadily from 1988 to 1995, but has stayed relatively constant from 1995 to 2005, with minimal fluctuations. With the sewered population dropping by 2010 and slowly climbing up again by 2014, the per capita unit flows are higher due to the lower population and continued, significant contributions from I/I. The sewered population increased due to the additional pump stations that were constructed as part of the Waterworks 2011 program. The accuracy of the per capita flow might also be impacted by methods used to estimate the sewered population. The service area populations were generated by the City’s Urban Design & Planning Division and documented in the 2015 GTL Capacity Analysis Report.

Table WW1-3. Historical Per Capita Wastewater Flows

Year	AADF (MGD)	Sewered Population	Per Capita Flow (gpcd)
1988	32.10	175,097	183
1989	33.33	176,282	189
1990	34.03	177,267	192
1991	35.44	177,386	200
1992	36.27	177,505	204
1993	36.97	177,642	208
1994	39.51	177,743	222
1995	40.68	177,863	229
1996	36.51	180,230	203
1997	37.74	182,590	207
1998	32.91	184,960	178
1999	36.34	187,320	194
2000	35.41	187,491	189
2001	36.02	187,662	192
2002	37.47	187,833	199
2003	36.23	188,004	193
2004	35.09	188,175	186
2005	37.53	188,344	199
2010	37.36	173,586	215
2014	38.61	178,640	216

1.3.4 Base (Sanitary) Wastewater Flow

The base wastewater flow is defined as the sanitary flows generated in the service area that are flushed or drained into the gravity or low pressure collection system. Base (sanitary) wastewater flows are not measured from households and businesses and must be estimated. Base wastewater flows typically range from 60 to 80 percent of the potable water usage depending on the amount of potable water used for irrigation and other outdoor uses not drained to the collection system. Based on the City's 2007 Wastewater Master Plan estimates and the 2015 GTL Capacity Analysis Report Annual Update, the base wastewater flow was estimated to be 100 gpcd currently, trending toward 110 gpcd in the future. The unit base flow is comprised of 70 gpcd from residential customers and 30 gpcd from non-residential (commercial/ industrial/institutional) customers. The non-residential base wastewater flow was estimated in previous City planning documents to increase from 30 gpcd to 40 gpcd in the future based on increased commercial development flow contributions. Understanding that increased use of water saving fixtures should reduce per capita flows these assumptions should be revisited in coming years as relevant supporting data becomes available.

The City's Conservation Pay$ Program reduced an estimated 23,450 gpd in 2014. While the City's water conservation efforts including water efficiency of new construction have significantly reduced potable water use over the last 5 to 10 years, the unit base wastewater flows were held at previously estimated values in this master plan for the following reasons:

a) A significant amount of the water conservation success is likely attributed to reductions in outdoor (irrigation) water use which would not affect wastewater generation,
b) Based on typical potable to wastewater ratios, it is surmised that the City's previous planning documents slightly underestimated historical unit base wastewater flows, and
c) For planning efforts related to capacity evaluations it is prudent to provide a level of conservatism in future flow generation forecasts.

1.3.5 Historical Infiltration and Inflow (I/I)

Infiltration and inflow (I/I) occurs when groundwater or stormwater enters the wastewater collection system through cracks, leaks and illegal connections in the gravity piping, service laterals, or wetwells. I/I has negative impacts on the wastewater system including consuming available hydraulic capacity, creating overflow situations, decreasing treatment efficiency, adding dissolved solids (primarily salt) and increasing energy usage from additional pumping, treatment and disposal. The City has been taking steps to address its significant I/I issue as documented in the previous master plan, capacity analyses and I/I flow monitoring studies. U.S. Environmental Protection Agency (EPA) documents state that average daily per capita flows (excluding major industrial and commercial flows greater than 50,000 gpd each) greater than 120 gpcd indicate excessive I/I. The City's average daily per capita flows were 216 gpcd in 2014, thus meeting the excessive I/I definition. Further, with sanitary flows estimated at 100 gpcd in previous City planning documents, I/I (estimated at 21 MGD in the 2015 GTL Capacity Analysis Report, CDM) comprise approximately 55% of the City's wastewater flow. I/I has demonstrated to be exacerbated by autumnal king tides, which raise surface water levels. In addition, increasing sea level raises groundwater levels impacting I/I. Costal wastewater lift stations have demonstrated greater flow with high tides according to City records.

1.4 Wastewater Flow Forecast

Wastewater flow forecasts were prepared for the 20-year planning period by applying unit base wastewater flows to population forecasts and adding I/I flow. The base wastewater flow includes the sanitary inputs from residential and non-residential (commercial, industrial, public) customers. The estimated unit residential base wastewater flow is 70 gpcd per the 2015 GTL Capacity Analysis Report, and was held constant over the 20-year planning period. The unit non-residential wastewater flow was estimated at 35 gpcd in year 2015 by the 2015 GTL Capacity Analysis Report. The unit non-residential wastewater flow was assumed to increase by 2.5 gpcd every 5 years based in accordance with the previous master plan.

I/I was estimated at 21.0 MGD by the City and projected to remain constant over the 20-year planning period. While the City of Fort Lauderdale has made I/I reduction a priority and makes investments of $3 million annually to rehabilitate its gravity sewer pipes, for conservatism the 21 MGD of I/I contribution was held constant until substantial reductions in I/I can be quantified and forecast by the City as a result of the ongoing I/I program. With a focus on sustainability, the City will continue to address I/I and ready its wastewater collection system for coming issues including climate change, sea level rise and water resource management.

Total wastewater flow forecasts, including residential, non-residential and I/I components, were projected for the 20-year planning period in **Table WW1-4** and graphically in **Figure WW1-3**. Forecasts include AADF and M3MADF. The graph shows a trend of increased growth from 2020-2030, which is due to the projected population increases. The growth begins to level off from 2030-2035 because of the smaller predicted population increase. The M3MADF value is compared to the GTL capacity and was derived from historical flow analysis as 1.27 times AADF. GTL's permitted capacity, based on the M3MADF, is current 56.6 MGD. As shown in

Section WW1 accepted March 28, 2016.

Table WW1-4, the GTL is not expected to exceed this capacity by the year 2035, however, as flows approach the GTL limit certain Florida Department of Environmental Protection (FDEP) capacity related action items will be triggered.

Table WW1-4. Wastewater Flow Forecast

Year	Wastewater Population	Residential AADF (MGD)	Non-Residential ADF (MGD)	I/I Contribution (MGD)	Total AADF (MGD)	M3MADF (MGD)
2015	179,903	12.6	6.3	21.0	39.9	50.7
2020	185,697	13.0	7.0	21.0	41.0	52.0
2025	200,840	14.1	8.0	21.0	43.1	54.7
2030	210,317	14.7	8.9	21.0	44.7	56.7
2035	213,885	15.0	9.6	21.0	45.6	57.9

In accordance with Chapter 62-600.405(8), F.A.C., FDEP requires documentation of timely planning, design and construction of needed expansions be submitted within the schedule as follows:

- If the permitted capacity will be equaled or exceeded within 5 years, planning and preliminary design of the necessary expansion shall be initiated.
- If the permitted capacity will be equaled or exceeded within 4 years, plans and specifications for the necessary expansion shall be prepared.
- If the permitted capacity will be equaled or exceeded within 3 years, a complete construction permit application shall be submitted within 30 days of submittal of the updated capacity analysis report.
- If the permitted capacity will be equaled or exceeded within 6 months, an application for an operation permit for the expanded facility shall be submitted.

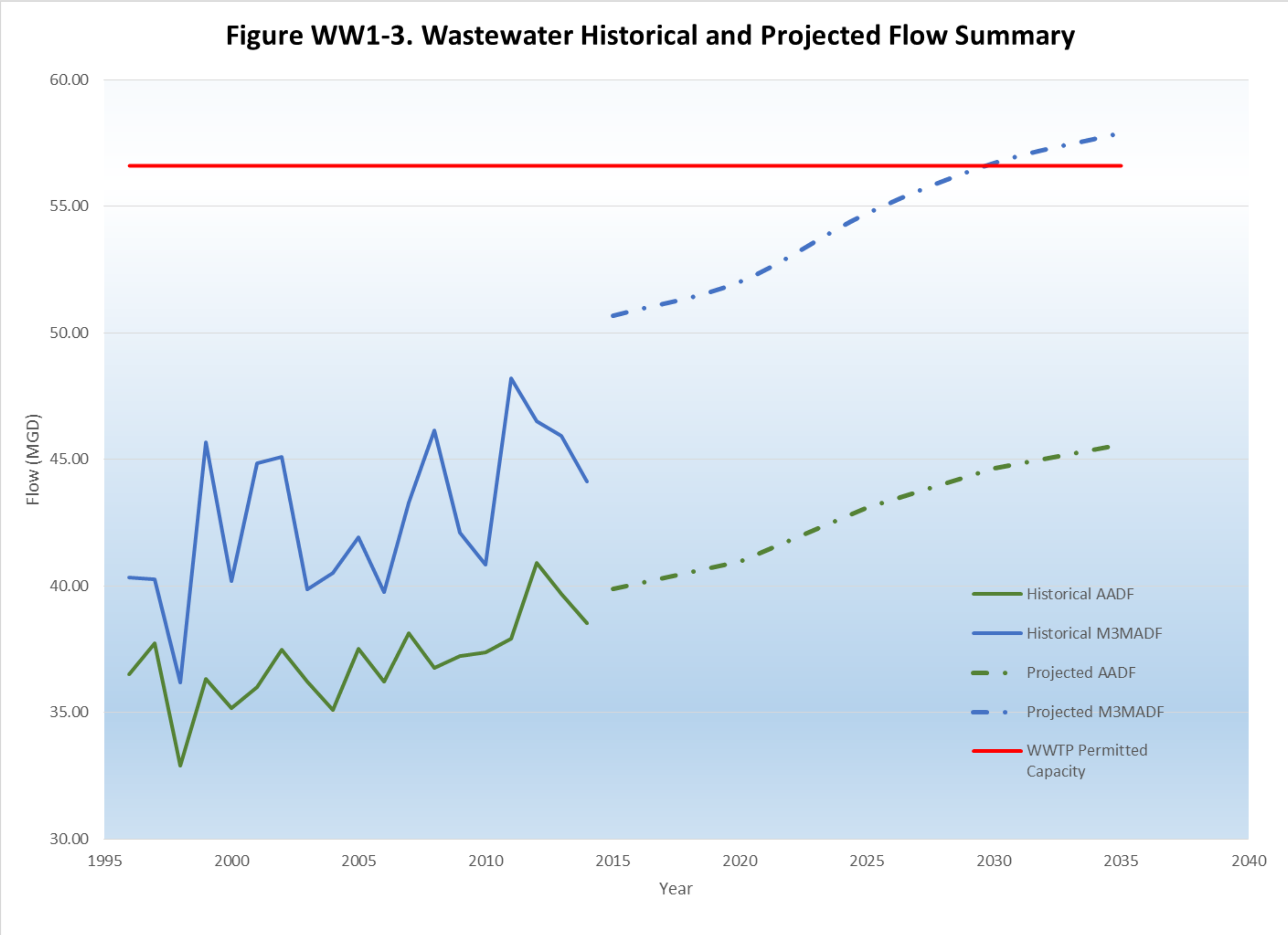
The permitted capacity will not be reached for approximately 10 to 15 years, therefore, the FDEP requirements above do not mandate any action to be taken at this time. Because FDEP requires the design to be started when the capacity will be equaled or exceeded in 5 years, the design for capacity improvements will need to be initiated in 2025 at the latest. A construction permit will need to be submitted by 2027. The City's priority should be to reduce peak flows to the GTL by continuing its I/I abatement program, requiring large users to reduce I/I and identifying individual unit processes that could physically limit achieving the GTL's permitted capacity.

However, according to the projections in **Section WW8**, the GTL effluent flow could exceed the normal operating MHF injection well (IW) capacity beginning in 2019 under emergency conditions or during integrity testing. Therefore, the City will need one (1) additional IW to meet MHFs, unless influent flows to GTL are reduced. The opportunity to reduce influent resides in reducing I/I flow, which is estimated to be 50% of the average plant influent.

It typically takes approximately 18 to 24 months to place a Class I IW and associated dual-zone monitoring well into service once the permittee submits a construction permit application to FDEP for processing. Unless I/I can be significantly reduced, the CUSMP Team recommends that the process of IW design and permit application preparation begin in January 2017 to ensure the additional disposal capacity is in place by the beginning of 2019.

Effluent disposed of via the new IW would be required to be treated to high level disinfection standards unless the new IW were also utilized for disposal of a non-hazardous industrial waste stream. The City currently disposes of only municipal wastewater effluent treated to secondary standards. If the City used a new IW for disposal of industrial wastewater and treated effluent, FDEP would require the City to treat the effluent to secondary standards, which is the level of treatment currently provided by GTL. FDEP would then classify the new well as a Class I Industrial injection well and would require an injection liner inside the final casing of the well. The addition of a new IW would not affect the current level of treatment requirements of effluent disposed via the existing IWs. Therefore, given the costs and lack of available space to construct plant facilities associated with treating effluent to high level disinfection standards, it is recommended that the new IW be permitted for disposal of both secondary treated effluent and a non-hazardous industrial waste stream to allow the Class I Industrial well classification. The source of this non-hazardous industrial waste stream has not yet been identified; however, landfill leachate has been used as industrial waste in such application. There is uncertainty of cost in this alternative, such as the cost of the pipelines required to convey such non-hazardous industrial flows. The CUSMP Team recommends the City to further investigate and identify such potential non-hazardous industrial waste contributors, as the need for an additional injection well is inevitable unless the City can significantly reduce I/I flow.

The City's continued economic success depends on maintaining capacity at GTL for development. Reduction of I/I, especially in the face of increasing groundwater levels with climate change, increasing sea level rise and predicted increased frequency of extreme precipitation events, is critical to maintain capacity. Diversion of wastewater flows to a new scalping water reclamation facility to produce public access reuse is another option to decrease flows to the GTL. Reclaimed water reuse is beneficial because it conserves water, and effectively reduces the amount of treated wastewater injected into GTL deep-injection wells. However, the implementation of reuse incurs new costs because it requires additional infrastructure (new treatment capacity, pumps, storage facilities, and pipelines), as well as additional energy expenditures to treat and pump the reclaimed wastewater. Wastewater reuse requires an investment of a higher level of treatment in order for the wastewater to be in compliance for its intended reuse, and also requires user agreements and permits. Wastewater reuse is most commonly used for irrigation. A problem with this is that during rainy periods irrigation demands decrease while the flows to the treatment plant and need to dispose of reuse increases. The wastewater reuse can be injected into wells to be used as a saltwater intrusion barrier, which would be of higher value because of the water use permit (WUP) offset/credit.



Section WW1 accepted March 28, 2016.

1.5 Wastewater Flow Forecast Conclusions

Based on the wastewater flow forecast evaluation, the Master Plan Team drew the following conclusions:

- The City's wastewater flow is projected to increase approximately 5 MGD of AADF over the next 20 years, resulting in a M3MADF in excess of GTL's 56 MGD capacity.
- Infiltration and inflow (I/I) accounts for approximately half (21 MGD) the City's 40 to 45 MGD AADF.
- Reducing I/I by 25% is the more environmentally responsible and cost effective option because it would preclude the need to expand the GTL especially considering renewal of collection infrastructure than wastewater treatment plant expansion. This is a feasible goal if the City can invest 2.5-5 million dollars in reducing I/I each year, consistent with the CIP projects indicated in **Section WW4**. Realization of this goal involves a collaborative effort with the large users, who also need to make investments to reduce their wastewater flows to GTL. Investments in rehabilitating pipeline to reduce I/I will have a relatively short return on investment (ROI). See **Section WW4** for more detail on the cost-benefit analysis of reducing I/I within the wastewater system.

Appendix WW1-A

Table WW1-A-1. Wastewater Historical Flows

Year	Month	MADF (MGD)	3MADF (MGD)	ADF (MGD)
1996	Jan.	34.93	35.88	36.508
	Feb.	32.13	34.22	
	March	32.99	33.35	
	April	32.39	32.50	
	May	36.51	33.96	
	June	45.91	38.27	
	July	35.62	39.35	
	August	33.60	38.38	
	Sept.	37.24	35.49	
	Oct.	46.48	39.11	
	Nov.	37.32	40.35	
	Dec.	32.99	38.93	
1997	Jan.	37.49	35.93	37.734
	Feb.	37.91	36.13	
	March	35.16	36.85	
	April	39.10	37.39	
	May	36.42	36.89	
	June	44.65	40.05	
	July	36.87	39.31	
	August	37.17	39.56	
	Sept.	46.74	40.26	
	Oct.	34.58	39.49	
	Nov.	32.89	38.07	
	Dec.	33.86	33.77	
1998	Jan.	34.27	33.67	32.905
	Feb.	39.04	35.72	
	March	35.24	36.18	
	April	30.22	34.83	
	May	30.44	31.97	
	June	29.38	30.01	
	July	29.08	29.63	
	August	29.33	29.26	
	Sept.	40.42	32.94	
	Oct.	33.18	34.31	
	Nov.	34.92	36.17	

Year	Month	MADF (MGD)	3MADF (MGD)	ADF (MGD)
	Dec.	29.35	32.48	
1999	Jan.	31.45	31.91	36.341
	Feb.	30.67	30.49	
	March	29.25	30.45	
	April	28.39	29.43	
	May	30.76	29.46	
	June	43.77	34.31	
	July	33.21	35.91	
	August	41.92	39.63	
	Sept.	44.19	39.77	
	Oct.	50.87	45.66	
	Nov.	38.97	44.68	
	Dec.	32.65	40.83	
2000	Jan.	32.86	34.83	35.159
	Feb.	32.36	32.62	
	March	33.43	32.88	
	April	33.84	33.21	
	May	31.57	32.95	
	June	37.26	34.22	
	July	34.38	34.40	
	August	31.93	34.52	
	Sept.	37.54	34.62	
	Oct.	48.53	39.33	
	Nov.	34.48	40.18	
	Dec.	33.74	38.91	
2001	Jan.	30.17	32.80	36.019
	Feb.	29.34	31.08	
	March	33.44	30.98	
	April	30.75	31.17	
	May	35.36	33.18	
	June	31.12	32.41	
	July	34.19	33.56	
	August	38.25	34.52	
	Sept.	45.54	39.33	
	Oct.	48.04	43.94	
	Nov.	41.01	44.86	
	Dec.	35.03	41.36	
2002	Jan.	31.26	35.77	37.468

Year	Month	MADF (MGD)	3MADF (MGD)	ADF (MGD)
	Feb.	34.46	33.58	
	March	33.43	33.05	
	April	32.56	33.48	
	May	34.86	33.62	
	June	46.62	38.01	
	July	50.92	44.13	
	August	37.79	45.11	
	Sept.	40.48	43.07	
	Oct.	35.46	37.91	
	Nov.	34.99	36.98	
	Dec.	36.78	35.74	
2003	Jan.	32.48	34.75	36.231
	Feb.	30.96	33.40	
	March	33.21	32.21	
	April	33.74	32.64	
	May	42.14	36.36	
	June	42.32	39.40	
	July	31.60	38.69	
	August	35.75	36.56	
	Sept.	38.52	35.29	
	Oct.	38.29	37.52	
	Nov.	42.75	39.85	
	Dec.	33.04	38.02	
2004	Jan.	31.83	35.87	35.095
	Feb.	39.43	34.76	
	March	32.39	34.55	
	April	33.23	35.02	
	May	30.88	32.17	
	June	31.11	31.74	
	July	32.39	31.46	
	August	39.41	34.30	
	Sept.	41.98	37.93	
	Oct.	40.17	40.52	
	Nov.	34.91	39.02	
	Dec.	33.41	36.16	
2005	Jan.	33.43	33.92	37.511
	Feb.	34.03	33.63	
	March	35.04	34.17	

Year	Month	MADF (MGD)	3MADF (MGD)	ADF (MGD)
	April	33.27	34.12	
	May	33.74	34.02	
	June	46.58	37.86	
	July	38.72	39.68	
	August	34.78	40.02	
	Sept.	43.33	38.94	
	Oct.	39.64	39.25	
	Nov.	42.84	41.93	
	Dec.	34.73	39.07	
2006	Jan.	32.56	36.71	36.212
	Feb.	35.93	34.41	
	March	34.41	34.30	
	April	35.41	35.25	
	May	37.49	35.77	
	June	34.32	35.74	
	July	35.71	35.84	
	August	38.21	36.08	
	Sept.	44.72	39.55	
	Oct.	36.33	39.76	
	Nov.	35.02	38.69	
	Dec.	34.43	35.26	
2007	Jan.	32.42	33.96	38.121
	Feb.	35.80	34.22	
	March	32.98	33.73	
	April	32.74	33.84	
	May	35.38	33.70	
	June	44.64	37.59	
	July	46.58	42.20	
	August	34.93	42.05	
	Sept.	41.35	40.95	
	Oct.	48.71	41.66	
	Nov.	39.83	43.30	
	Dec.	32.09	40.21	
2008	Jan.	32.00	34.64	36.747
	Feb.	31.90	32.00	
	March	33.31	32.40	
	April	34.26	33.16	
	May	32.01	33.19	

Year	Month	MADF (MGD)	3MADF (MGD)	ADF (MGD)
	June	32.26	32.84	
	July	35.75	33.34	
	August	42.96	36.99	
	Sept.	43.68	40.80	
	Oct.	51.78	46.14	
	Nov.	39.75	45.07	
	Dec.	31.30	40.94	
2009	Jan.	29.02	33.36	37.238
	Feb.	29.12	29.81	
	March	36.28	31.47	
	April	32.16	32.52	
	May	36.84	35.09	
	June	40.80	36.60	
	July	36.90	38.18	
	August	34.56	37.42	
	Sept.	45.24	38.90	
	Oct.	38.83	39.54	
	Nov.	42.24	42.10	
	Dec.	44.88	41.98	
2010	Jan.	35.40	40.84	37.362
	Feb.	36.45	38.91	
	March	34.63	35.50	
	April	42.55	37.88	
	May	35.87	37.68	
	June	35.30	37.90	
	July	40.04	37.07	
	August	36.50	37.28	
	Sept.	44.48	40.34	
	Oct.	39.29	40.09	
	Nov.	35.29	39.69	
	Dec.	32.54	35.71	
2011	Jan.	31.64	33.16	37.915
	Feb.	31.50	31.89	
	March	32.36	31.83	
	April	32.86	32.24	
	May	33.14	32.79	
	June	33.51	33.17	
	July	36.78	34.48	

Year	Month	MADF (MGD)	3MADF (MGD)	ADF (MGD)
	August	40.33	36.87	
	Sept.	43.82	40.31	
	Oct.	48.32	44.15	
	Nov.	52.46	48.20	
	Dec.	38.27	46.35	
2012	Jan.	32.76	41.16	40.929
	Feb.	37.65	36.22	
	March	32.39	34.26	
	April	39.98	36.67	
	May	47.90	40.09	
	June	47.03	44.97	
	July	44.58	46.50	
	August	44.85	45.48	
	Sept.	46.10	45.17	
	Oct.	42.69	44.54	
	Nov.	39.97	42.92	
	Dec.	35.28	39.31	
2013	Jan.	33.65	36.30	39.671
	Feb.	34.03	34.32	
	March	33.99	33.89	
	April	35.70	34.57	
	May	45.47	38.39	
	June	42.68	41.28	
	July	49.62	45.92	
	August	36.76	43.02	
	Sept.	39.68	42.02	
	Oct.	41.87	39.44	
	Nov.	43.80	41.79	
	Dec.	38.79	41.49	
2014	Jan.	33.74	38.78	38.605
	Feb.	36.99	36.50	
	March	33.00	34.57	
	April	36.25	35.41	
	May	36.31	35.19	
	June	36.83	36.46	
	July	39.97	37.70	
	August	45.47	40.76	
	Sept.	45.21	43.55	

Year	Month	MADF (MGD)	3MADF (MGD)	ADF (MGD)
	Oct.	41.73	44.14	
	Nov.	38.35	41.77	
	Dec.	39.42	39.83	

WW2 Wastewater Hydraulic Model Update

2.1 Hydraulic Model Update Summary

Hydraulic modeling is an important tool used for design, planning, and operation of wastewater transmission and collection systems. Various input data fed the creation of the wastewater hydraulic models including the City's Geographical Information Systems (GIS) data, as-built drawings, atlas maps, and previous planning efforts. The CUS Master Plan Team constructed three (3) hydraulic models, including a model of the entire pressurized transmission system (Pressure Model) and two sub-areas of the City's gravity collection system (Gravity Models). The two Gravity Models' sub-areas were the Downtown Regional Activity Center and the Central Beach Alliance Area. Construction of the wastewater hydraulic models involved pre- and post-processing of the existing data, establishment of existing and future flows, and scenarios' determination. The last and most important step in the construction of the new wastewater hydraulic models was to discuss the models' output with City staff to provide a cursory confirmation of actual field conditions. This section documents the models' update and Section WW3 presents results from the hydraulic modeling simulations.

2.2 Pressure Model Construction

2.2.1 Pressure Model Structure

The wastewater hydraulic model is composed of *nodes*, which represent a specific point within the modeling network, and *links*, which relate and connect nodes. The nodes correspond to features such as wetwells and pumps in the City's wastewater transmission system, and the links correspond to pipes. A pipeline intersection is comprised of two (2) or more links connected to a single node. Innovyze's InfoWater® software was used to construct the Pressure Model. The City's pressure system consists of approximately 186 City pump stations, and three re-pump stations. The pump stations generally have submersible duplex or triplex pumps located within a wetwell that collects and stores the wastewater. The City also has wetwell/drywell type stations with non-submersible pumps. In the Pressure Model, pump *nodes* represent submersible pump stations, which *link* to a storage *node* such as a tank or reservoir. The three re-pump stations are aboveground stations that directly connect to pressurized piping to provide in-line pressure boosting. Pump nodes and pipe links represent the re-pump stations in the Pressure Model. The City also receives flow from several "large users", which were represented by a flow demand placed on a node.

2.2.2 Gravity Model Structure

Innovyze's InfoSWMM® software is the software platform for the Gravity Models. The Gravity Models simulate the City's collection system and are composed of *nodes* and *links*. Nodes include pumps, sewer manholes, wetwells, and outfalls. Outfalls in the Gravity Models represent wetwells in the system, which is the location where wastewater flows leave the gravity system and enter the pressurized transmission system. Links are gravity (non-pressurized) collection pipes. The CUS Master Plan Team utilized GIS data, digital elevation model (DEM), and as-built drawings to construct the Gravity Models.

2.2.3 Pre-Processing and Post-Processing of Data

Prior to converting the information into model elements, pre-processing of GIS information coordinated a unique identification (ID) key common to the models and the GIS elements. The wastewater hydraulic model utilizes unique IDs on all elements to maintain database integrity.

Section WW2 accepted April 11, 2016.

GIS unique IDs transfer or combine to create unique IDs for every model element. The unique IDs allow linkage of GIS data and the Water Model elements, facilitating faster model updates. Following transfer of data from the City's GIS to the models, post-processing of the GIS data was required to verify connectivity and add modeling information such as unique modeling IDs, descriptions, pump curves, queries for construction of various scenarios, and initial control settings. The CUS Master Plan team verified suction and discharge piping configurations with City-provided as-built drawings. City utility GIS personnel constructed the wastewater GIS base map proficiently, facilitating successful transfer to the hydraulic model. The CUS Master Planning Team used network connectivity tools to ensure all network structural elements required for hydraulic simulations were successfully connected. The InfoWater® elevation extractor tool, DEM topographic data and as-built information contributed elevations to the Model. The Model assigns roughness coefficients, either Hazen-Williams "C factors" or Manning's Coefficient "n", to pipes according to the pipe material and/or diameter as explained in **Section WW3**. For each pump station, the Pressure Model used pump head versus flow curves provided by the City to approximate flows from the stations into the pressurized transmission network.

2.2.4 Demand Allocation

The CUS Master Plan Team utilized Water Meter data provided by the City in order to determine demands for the wastewater model. The CUS Master Plan Team converted flows at each meter location to wastewater values, using the City's pump station basin shapefile to spatially allocate the meter flows to a pump station basin. That is, the flowmeter demand was allocated to each node based on the corresponding geographical location of the demand to the node. It is also important to note that many pump stations in the City's wastewater system send flow to neighboring larger pump stations, which then convey their combined flow into the pressurized transmission network. Thus, the demand from the smaller station is assigned to the neighboring pump station that connects to the transmission system. The CUS Master Plan Team assumed that domestic wastewater production equals approximately 70% of water usage plus wet weather inflow and infiltration (I/I) flows. For the large users, flows were developed based on the City's historical master meter monthly flow data for the last five years. Large user flows were placed on a node representing the interconnect between the City and the large user. Approximated wastewater demands in the collection system allowed for spatial allocation to the closest node to represent the amount of flow coming from that specific area.

2.3 Model Verification and Use

The newly constructed hydraulic models produced results including the pressure, velocity, and pumping capacity of the wastewater transmission and collection system. The CUS Master Plan Team met with City staff to discuss the model results and identify areas that conflicted with the pressure and velocity conditions seen in the field. In some cases, the CUS Master Plan Team adjusted flows and other parameters in order to increase the accuracy of the Models. The City also identified planned improvements to the system for incorporation into the Models. Because the City requested brand new Models rather than an update of previous efforts, the CUS Master Plan team recommends that the Models be verified against field flow and pressure data in order to calibrate the Models with actual conditions. The City can use the wastewater hydraulic models in the future to determine preliminary design parameters for new projects, such as pipe or pump sizing.

WW3 Wastewater Collection and Transmission Hydraulic Evaluation

3.1 Existing Facilities

The City of Fort Lauderdale (City) provides wastewater treatment and disposal services to an estimated 180,000 people in central Broward County[1]. Those within the City of Fort Lauderdale comprise approximately 70 (2008 City Comprehensive Plan) to 80 (City staff estimates) percent of the wastewater service population with the remainder located in portions of unincorporated Broward County, Port Everglades and the Cities of Dania Beach, Davie, Tamarac, Wilton Manors and Oakland Park (Large Users). The City's wastewater collection system is subdivided into two systems:

- Central Regional Transmission System – collectively owned by the City and Large users; transmits wastewater flows from the Large User collection and transmission systems to the George T. Lohmeyer Wastewater Treatment Plant (GTL). The Central Regional Transmission System consists of two (2) re-pump stations, Large User billing meters, and approximately 23.5 miles of force main.
- City Collection and Transmission System – City owned gravity collector pipes (368 miles), manholes and service laterals, 186 pump stations, 3 repump stations and 135 miles of pressurized force main.

The connections to the Large Users are monitored through City owned and operated master meters, typically located just downstream of the respective Large Users' master pump stations. The City's collection and transmission flows directly to the GTL and is metered there along with the regional flow. **Figure WW3-1** shows the existing wastewater collection and transmission systems.

Most of the City's collection system pipes are over 50 years old and are reaching the end of their service lives. The City has a program of structurally lining its gravity collection system pipes and annually invests approximately between $3,600,000 and 7,500,000 per year on gravity system rehabilitation projects. The City's transmission system was upgraded over the last 10 years as part of Waterworks 2011 by rehabilitating key lift stations, constructing 43 new pump stations, new force mains and gravity mains to service the City's previously un-sewered areas, which was approximately 40% of the City in year 2000, and replacing key force mains.

[1]Source: Capacity Analysis Report Annual Update George T. Lohmeyer Regional Wastewater Treatment Plant (2015)

Section WW3 accepted February 3, 2017.

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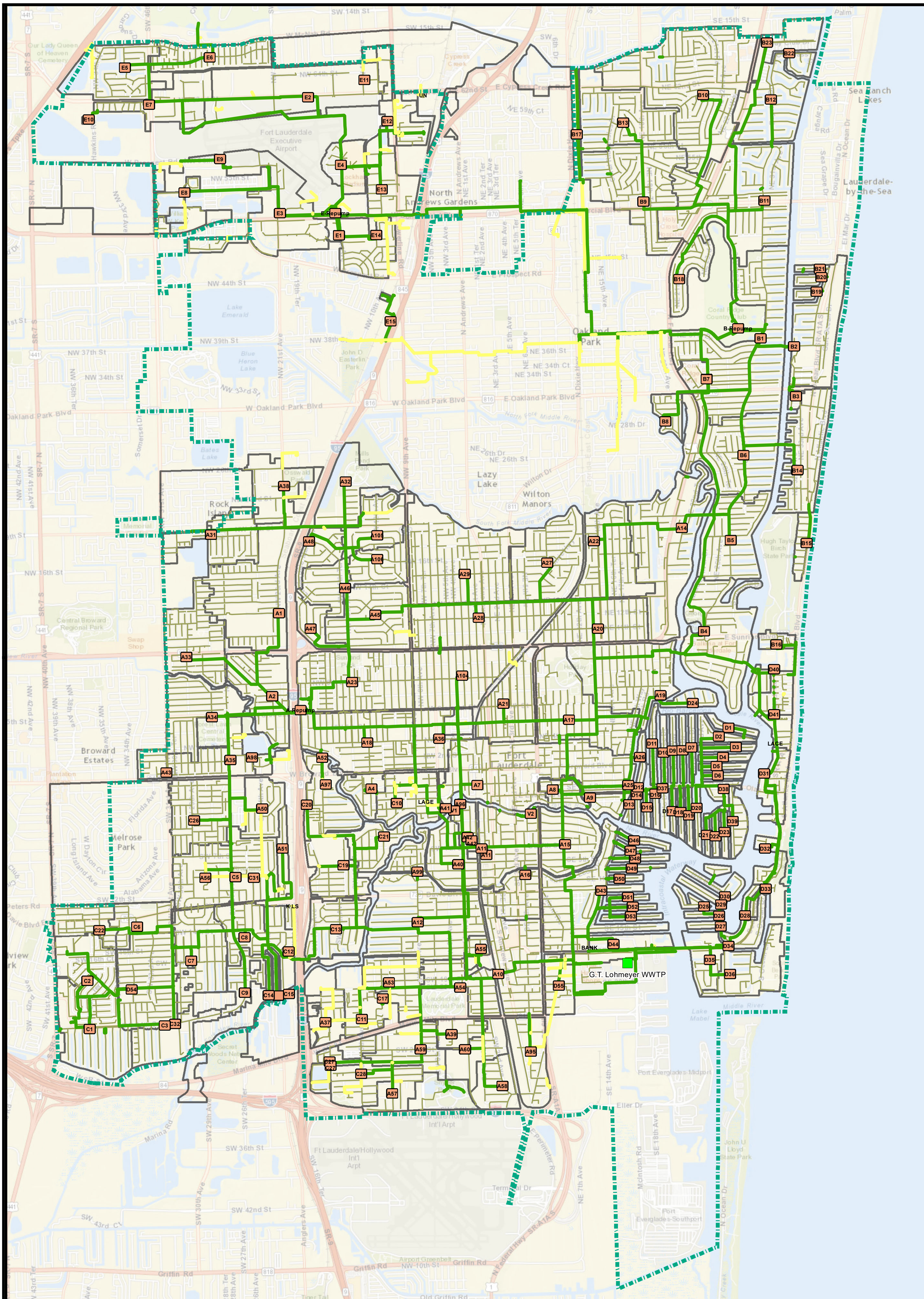

Legend

- GTL
- WW Service Area
- Force Main
- Owner
- *Private
- Gravity Main
- Pump Station Basins

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

FIGURE WW3-1

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3.2 Collection and Transmission System Service Criteria

Service criteria for the wastewater collection and transmission systems were utilized based on City standards, industry practice and previous City planning efforts. Service criteria are applied to engineering calculations including hydraulic modeling to identify areas of need. **Table WW3-1** presents the service criteria used to evaluate the components of the City's wastewater collection and transmission systems. Hazen-Williams pipe roughness coefficients are variables that are entered into the hydraulic models to calculate headloss due to friction. The Hazen-Williams pipe roughness coefficients were estimated based on the size and material of the respective pipe, as presented in **Table WW3-2**.

Table WW3-1. Hydraulic Design Criteria

System Component	Criteria
Transmission (Pump Station and Force Main)	
Maximum Velocity (Forced MHF[1])	5 fps[2]
Minimum Velocity (N-1 Pumps On)	2 fps[2]
Hazen Williams Friction Coefficient (C)	100 – 125 See Table 6-2 below
Maximum Transmission Pressure (Forced MHF[1])	40 psi[3]
Maximum Velocity (N-1 Pumps On)	8 fps[2]
Booster Pump Suction Lock-out Pressure	25 psi[3]
Collection (Gravity and Low Pressure)	
Manholes and Pipes	-Meet minimum slopes -Not surcharging -No overflows

[1] MHF = Maximum Hourly Flow and includes rainfall derived I/I
[2] fps = foot per second
[3] psi = pound per square inch

3.3 Collection and Transmission System Hydraulic Models

A pressurized transmission system hydraulic model and two collection system gravity flow hydraulic models were constructed based on available information including GIS data, as-builts, City staff input, etc. The transmission hydraulic model (transmission model) includes the pressurized pump stations and force mains, while the two collection system hydraulic models (gravity models) encompass the A-7 and Central Beach Alliance basins' gravity mains. The peak flow conditions used for the hydraulic models are discussed below.

Table WW3-2. Hydraulic Design Criteria

Diameter (inches)	Material								
	PVC	DIP	CIP	HDPE	PCCP	VCP	RCP	ACP	Other
2	120	-	-	120	-	-	-	-	115
3	120	110	-	120	-	100	-	-	115
4	120	110	100	120	-	100	-	120	115
6	120	110	100	120	-	100	-	120	115
8	120	110	100	120	-	100	110	120	115
10	120	110	100	120	-	100	110	120	115
12	120	110	100	120	-	105	110	120	115
14	120	110	100	120	-	105	110	120	115
16	120	110	100	120	-	105	110	120	115
18	120	110	100	120	110	105	110	120	115
20	125	115	105	125	110	110	115	125	115
24	125	115	105	125	110	110	115	125	115
30	125	115	105	125	115	110	115	-	115
36	125	115	105	125	115	-	115	-	115
42	-	120	110	-	120	-	120	-	115
48	-	120	110	-	120	-	120	-	115
54	-	120	110	-	120	-	120	-	115

The flow conditions in the transmission and gravity models are defined as follows:

- Average Daily Flow (ADF): Average daily flow is the total annual flow for a given year averaged by the number of days in a year. ADF includes customer-generated sanitary flows and inflow and infiltration (I/I) associated with dry periods and rainfall events.

- “Dry” Maximum Hourly Flow (dMHF): represents peak wastewater flows during a “dry” weather (non-rainfall) condition. The dMHF includes groundwater that infiltrates the collection system from the normal or dry weather ground water tables. dMHF does not include significant rainfall-derived inflow and infiltration (RDI/I). The system dMHF peaking factor of 1.3 was estimated and utilized based on recent dry flow data to the GTL WWTP.

- “Wet” Maximum Hourly Flow (MHF): represents the wet wastewater system peak flows during a significant rainfall event. The MHF was calculated by adding the Rainfall Derived I/I (RDI/I) to the dMHF. MHFs were input for each gravity node or pump station to generate a “Forced Flow” run used for identifying transmission force main capacity issues. The total MHF peaking factor has historically ranged from 2.2 to 2.5 over the last 10 years. For this master plan a MHF peaking factor of 2.2 times the ADF was used; an increase over the 2.13 used in the previous master plan. It was judged that the 2.5 peak hour flows occurred infrequently and would result in overly conservative conclusions.

- N-1 Pumps On: represents the City regional transmission-connected pumps operating (on) with wholesale and private stations contributing a forced MHF. For a City pump station with “N” total pumps, the N-1 run included all but the largest pump operating in the pump station simultaneously. N-1 Pumps On flow conditions were used to identify pump stations with insufficient capacity or head conditions, and estimate the capacity of the transmission system.

In addition to system dMHF and MHF peaking factors, individual pump station peaking factors were estimated. To account for variability of pump station capacity, individual peaking factors were scaled based on the capacity of the pump station. The dMHF peaking factors assigned to each station are shown in **Table WW3-3**. This stratification of peaking factors resulted in an average dMHF peaking factor that was comparable to peak GTL inflow data during dry months. MHF peaking factors were estimated by adding unit RDI/I flow to the individual pump stations' dMHF values.

Table WW3-3. Pump Station Basin Peaking Factor

Pump Station Basin ADF (MGD)	dMHF Peaking Factor (dMHF/ADF)	MHF Peaking Factor (MHF/ADF)
< .25	1.34	dMHF + Basin RDI/I
.25-.50	1.30	dMHF + Basin RDI/I
.50- 1.0	1.25	dMHF + Basin RDI/I
> 1.0	1.20	dMHF + Basin RDI/I

With the method described above, the flow conditions used in the hydraulic models are presented below in **Table WW3-4**.

The Rainfall-derived I/I (RDI/I) component of the hydraulic model was evaluated in various ways according to the availability of information. RDI/I flows were retrieved from the *2014 Infiltration & Inflow Study* where applicable. For pump stations not rehabilitated and not included in that study, the I/I flow component from the 2007 Master Plan Update was assumed. For pump stations that were not included in the previous master plan, a default rate of 0.0027 gallon per minute per foot of gravity piping (the average RDI/I rate from the Wastewater Master Plan 2007 Update) was multiplied by the length of gravity piping within the pump station basin, as determined from GIS analysis. Total peak flow for each station was developed using the RDI/I component and adjusted using the latest GTL peak flow data provided by the City.

Table WW3-4. Model Flow Conditions

Hydraulic Model Scenario	Time	Flow Condition	Hydraulic Model Output (mgd)
Transmission Model			
Existing dMHF	2015	dMHF	52.67
Existing MHF	2015	MHF	87.21
Future dMHF	2035	dMHF	59.17
Future MHF	2020	MHF	89.68
Future MHF	2025	MHF	94.20
Future MHF	2035	MHF	99.59
N-1 Pumps On	2015	"N-1" pumps running for each station	119.00
Gravity Model: A7 (Downtown)			
Existing MHF	2015	MHF	3.96
Future MHF	2035	MHF	5.15
Gravity Model: Central Beach Alliance			
Existing MHF	2015	MHF	3.52
Future MHF	2035	MHF	3.60

In order to assess the accuracy of the estimated flows for each pump station, the overall flow was compared to historical wastewater influent data to the GTL WWTP. The overall flow from the transmission model was approximately 87 MGD for the MHF scenario. During the 2014 wet season, the peak influent flows to the plant ranged from about 60 mgd to 80 mgd. This comparison demonstrates the validity of the assumptions that were made for the purpose of the hydraulic model.

The wastewater transmission and collection models were constructed from the City's latest GIS data and input with current flow information. The transmission hydraulic model could benefit from field calibration. Hydraulic calibration of the transmission model would include developing and executing a field data collection protocol, then adjusting hydraulic model inputs and operations to match field data. Calibration can verify the hydraulic model structure and improve its predictive accuracy.

3.4 Collection System

3.4.1 Collection Level of Service Needs

The A-7 and Central Beach Alliance gravity systems were hydraulically modeled and checked for capacity. A future goal of the City is to hydraulically model the gravity system in its entirety. To assist with the gravity system not modeled, gravity segments with known capacity issues during rain events were identified based on historical performance. As the City's topography is relatively consistent, gravity mains are generally short runs at minimum slope. The collection system hydraulic modeling also identified areas with less than design gravity pipe slopes possibly due to settling issues. Inadequate gravity pipe slopes result in surcharge conditions in the hydraulic models. Surcharge occurs when the level of water in a sewer manhole is higher than the top of the inflow pipe, indicating that the gravity piping downstream of the manhole is overloaded above its design capacity.

To alleviate gravity piping capacity issues, the City is already proceeding with the New Pump Station and Gravity System Re-Routing Project (A-7 Project) and in planning stages for the Central Beach Alliance new Pump Station D-41 Project. The A-7 Project includes re-routed gravity piping, a new pump station (A-13) and a short force main segment and tie-in. The A-7 Project will redirect approximately 1 mgd of flow to pump station A-13 from A-7. The planned Pump Station D-41 similarly includes a re-routed gravity main, a new pump station and a short force main segment. Based on these initiatives, the A-7 hydraulic model was run in existing and future conditions with the new pump station (A-13) in place and the gravity flow diverted. The gravity hydraulic models were run with the existing pipeline configuration in the “existing” scenarios and with the new pump stations and pipes in the “future” scenarios. The hydraulic modeling output identified gravity system pipes not meeting the level of service for Downtown and for the Central Beach Alliance basins under existing conditions as presented in **Figure WW3-2** and **Figure WW3-3.**

The other gravity system level of service needs identified by City staff is associated with surcharging manholes during peak rainfall/flow events. The Central Beach Alliance Area is often surcharged at Terramar Street and Bayshore Drive where the flow from D-41 recirculates into the gravity system for D-40. The CUS Master Plan team recommends that the five (5) 10-inch connections between the parallel pipes along Birch Road from Windamar Street to Vistamar Street be removed to prevent this recirculation. The gravity trunk line along East Las Olas Boulevard also has known seasonal surcharging and should be considered extreme needing immediate evaluation and planning. The current flows will not support any future development in this area without very near future improvements. Pipe rehabilitation, possibly pipe bursting to upsize and I/I abatement including private and City lateral replacements are potential solutions.

The future condition (Year 2035) hydraulic models’ scenarios were performed to represent growth in the City’s downtown Regional Activity Center (RAC), and Central Beach Alliance basins. The future hydraulic modeling confirms that the flow diversion and new pump stations will address the majority of the capacity issues with these systems. Due to gravity pipe slope configurations, the hydraulic models predict that surcharging will occur in the future based on the inadequate gravity pipe slopes during peak flow events. The future condition hydraulic model output for the Central Beach Alliance is shown in **Figure WW3-4**. As shown in the Figure, the existing 10-inch connections between the parallel gravity pipelines on Birch Road need to be removed in order to prevent recirculation of flow. Closing off the connection will allow flow on the west side of Birch Road to flow north to Pump Station D-40, and flow in the east gravity pipeline along Birch Road will flow south to Pump Station D-41. It is necessary to construct the new Pump Station D-41 to provide enough capacity to accept the present flows (including I/I and future redevelopment) before the existing interconnects between Pump Stations D-40 and D-41 can be removed. The design is about 80% complete and the City plans to bid and award the project to construct the Pump Station D-41 replacement before the end of 2016.

It should be noted that surcharging does not lead to a manhole overflow, and that many gravity systems function adequately in a surcharging condition during extreme flow events. Therefore, the CUS Master Plan Team does not recommend future capacity related improvements for the A-7 and Central Beach Alliance gravity systems beyond the flow diversion, recirculation prevention, and new pump stations. It is recommended as part of the subsequent R&R section to rehabilitate these gravity pipes, manholes and service laterals and, if possible, to address inadequate gravity pipe slopes during this rehabilitation.

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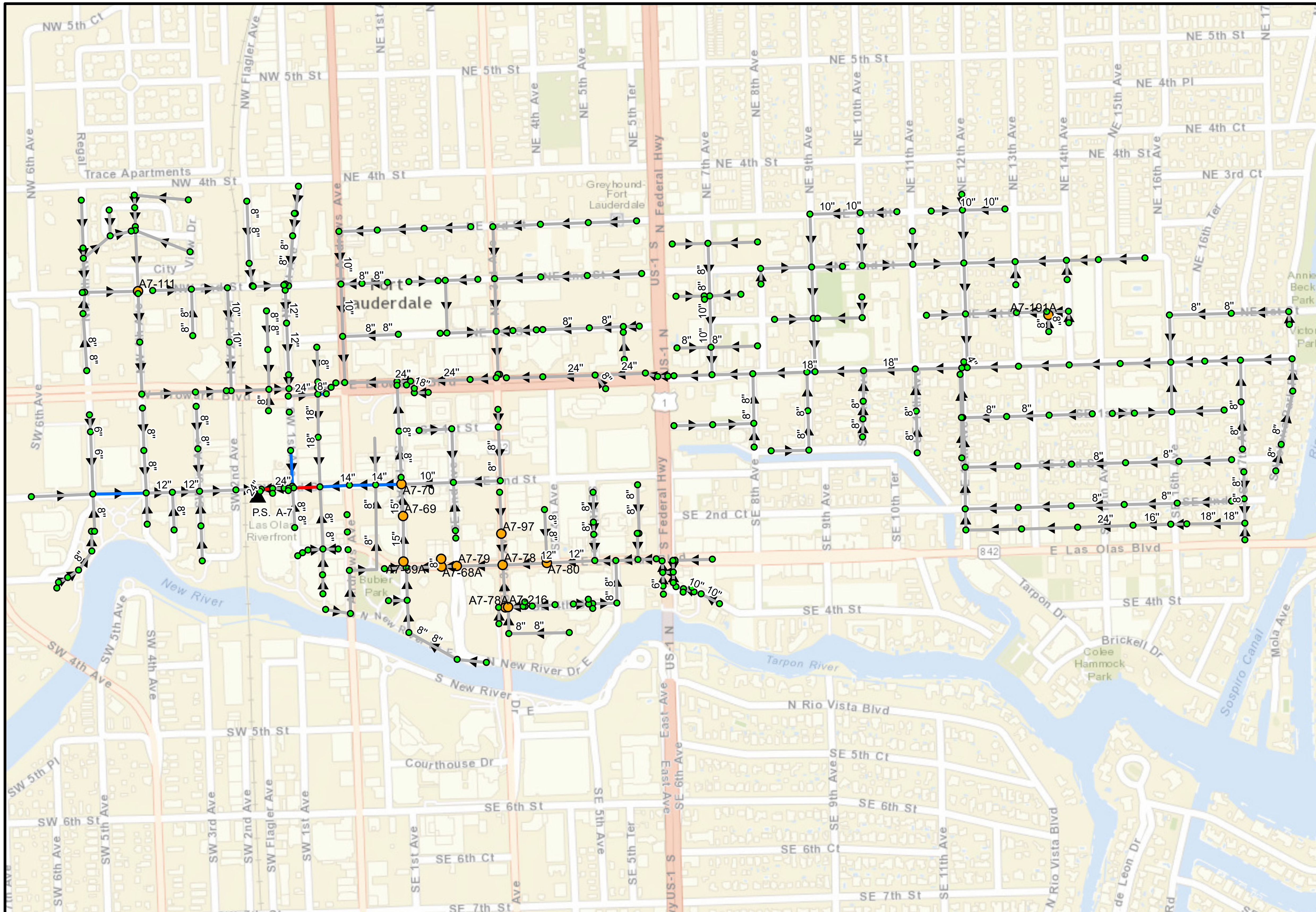


N
W
E
S

0 500 1,000
Feet

LEGEND

▲ Pump Station

Flow Direction

Manhole

- Below Link Crown
- Surcharged
- Overflow

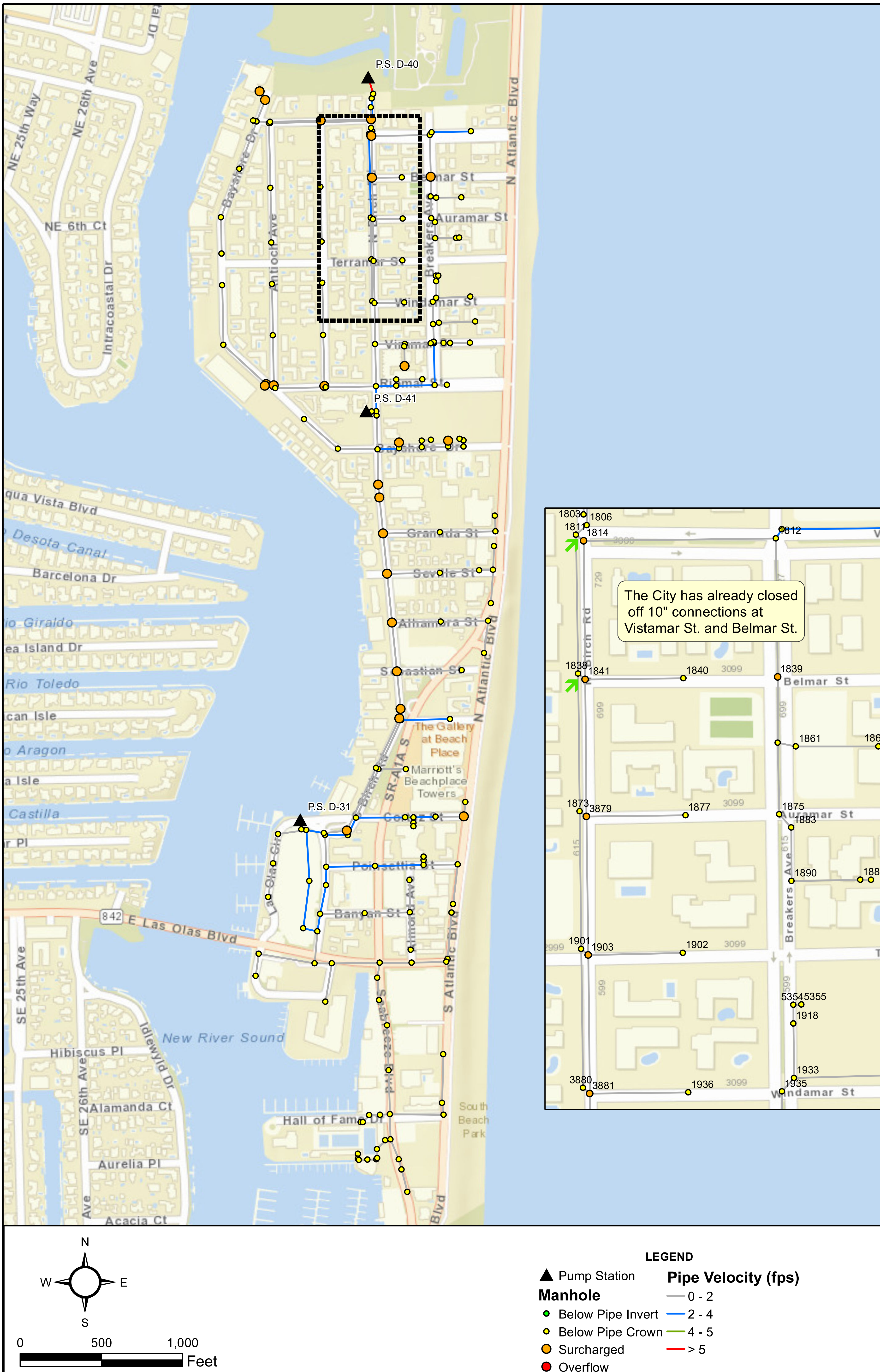
Gravity Pipe Velocity (fps)

- 0 - 2
- 2 - 4
- 4 - 5
- > 5

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER COLLECTION SYSTEM A7 (DOWNTOWN) 2015 MAX HOUR FLOW OUTPUT

FIGURE WW3-2

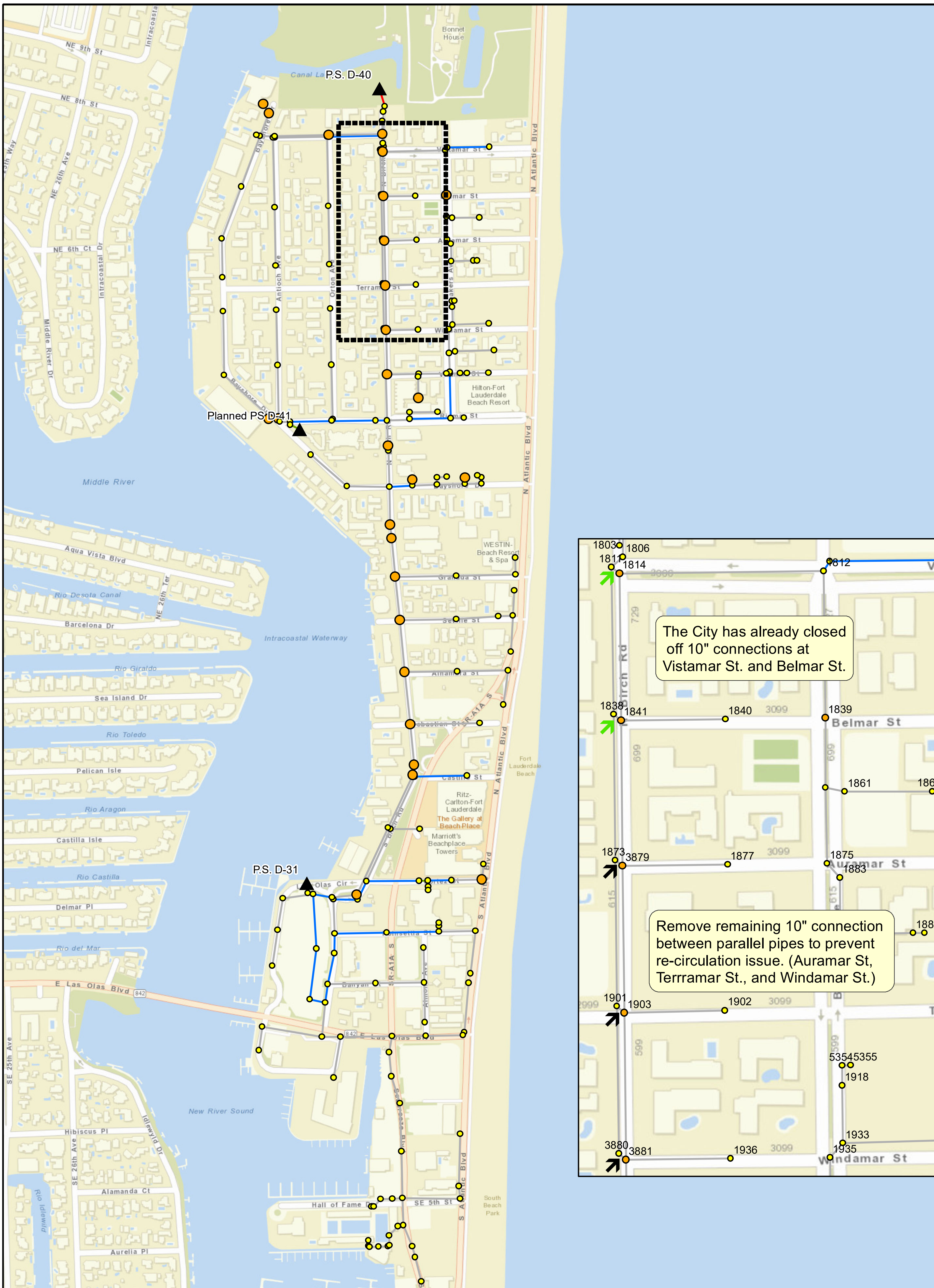
G:\0gis\134001 - FTL Master Plan_MXDs\A-7 Gravity Model\WPHF Existing A-7 Gravity System.mxd



CITY OF FT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER COLLECTION SYSTEM CENTRAL BEACH ALLIANCE 2015 MAX HOUR OUTPUT

FIGURE WW3-3

G:\0gis\134001 - FTL Master Plan_MXDs\WW3 and WW6\Central Beach Alliance hydraulic Model Existing Results.mxd



N
W E
S

0 500 1,000
Feet

LEGEND

▲ Pump Station

Manhole*
- Below Pipe Invert
- Below Pipe Crown
- Surcharged
- Overflow

Pipe Velocity (fps)
- 0 - 2
- 2 - 4
- 4 - 5
- > 5

*Manholes are labeled with the ObjectID from the GIS data provided by the City.

CITY OF FT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER COLLECTION SYSTEM: CENTRAL BEACH ALLIANCE 2035 (FUTURE) MAX HOUR FLOW OUTPUT

FIGURE WW3-4

G:\0gis\134001 - FTL Master Plan_MXDs\WW3 and WW6\Central Beach Alliance hydraulic Model Proposed results v2.mxd

3.5 Transmission System

3.5.1 Transmission Level of Service Needs

The wastewater transmission system is comprised of pump stations and pressurized force main pipes. The wastewater transmission system was analyzed using a GIS-based hydraulic model, under both existing and future system scenarios to evaluate capacity. A two-step approach was used to evaluate transmission capacity:

1. “Forced Flow”- In this scenario, the pumps were turned off. The estimated flow for each pump station node was set and “forced” through the system. The forced flow scenario simulated the theoretically existing and future peak flows in the system flowing through transmission pipes. It allowed the capacity of large force mains and other piping to be evaluated.

2. “N-1 Pumps On” – In this scenario, each pump station had the total number of pumps (N) minus one, turned on. N-1 is typically referred to as “firm” capacity. This scenario allows the sizing and hydraulic performance of the pumps to be analyzed.

Upgrades were identified for pump stations or portions of the transmission system not meeting service criteria under the future scenarios, and subsequently identified as prioritized capital projects.

3.5.1.1 Pump Station Capacity Analysis

The “N-1 Pumps On” scenario was simulated with existing and future force main configurations. The flow output of each pump station for both scenarios was compared to the 2035 forced MHF, and presented **Table WW3-5.** “N-1 Capacity” is the ratio of “N-1 Pumps On” hydraulic model scenario flow output to calculated design flows for each pump station. This “N-1 Capacity” ratio indicates potential level of service capacity issues with individual pump stations. The N-1 Capacity ratio is used as a pump capacity indicator to identify weaker or under-sized pump stations, as shown by ratios lower than 75%. Conversely, high N-1 Capacity ratios can indicate potential over-sized pumps. All pump stations not included in **Table WW3-5** are tributary pump stations that are not directly connected to the transmission main and therefore do not affect the hydraulic analysis. However, flows from the tributary pump stations were accounted for at the receiving pump stations that are directly connected to the transmission main.

Section WW3 accepted February 3, 2017.

Table WW3-5. Pump Station Capacity

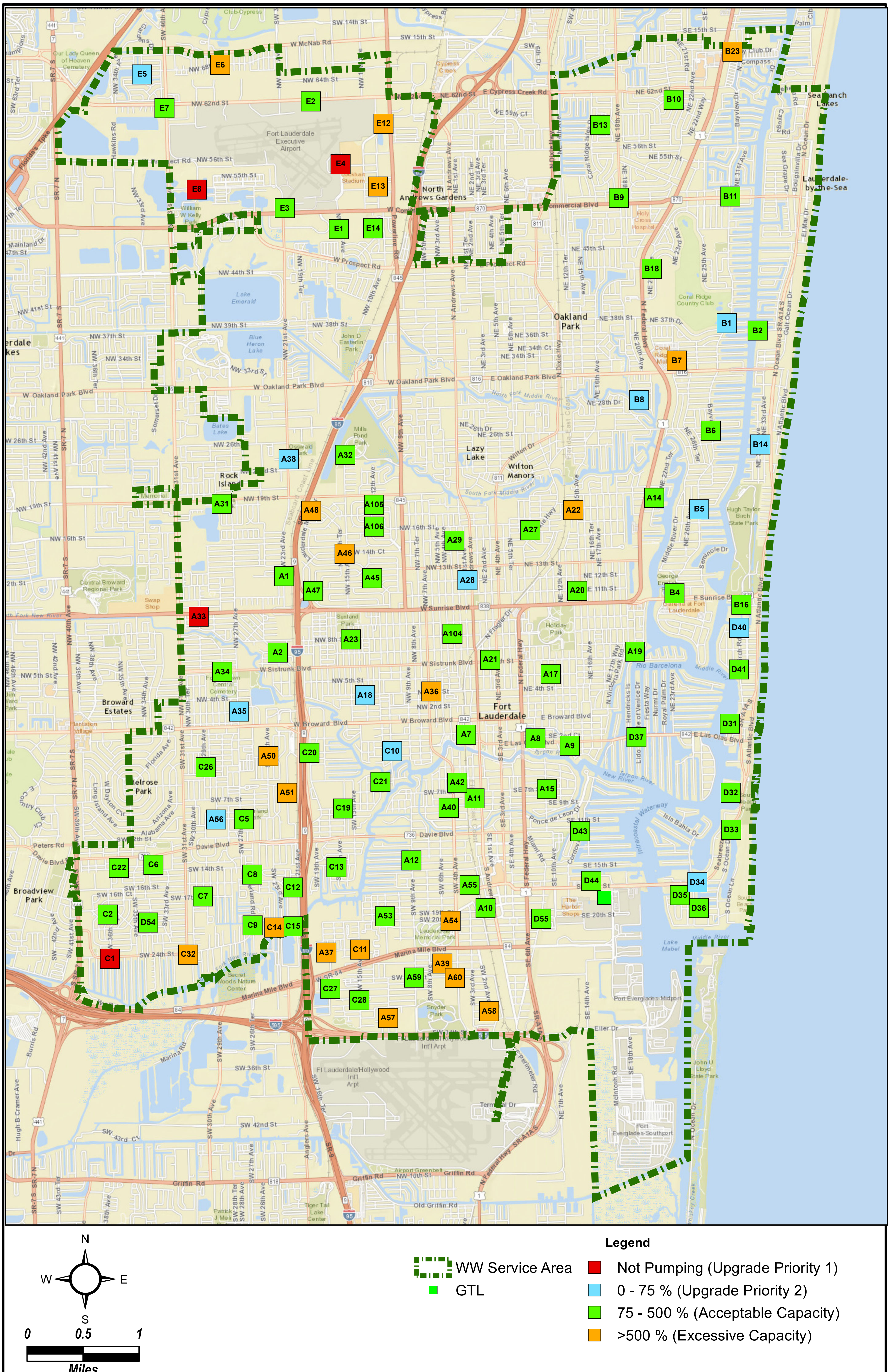
Pump Station Area				
A	B	C	D	E
Upgrade Priority 1 (Not pumping in hydraulic model)				
A33	--	C1	--	E4, E8
			Total No. of Priority 1 Pump Stations:	**4**
Upgrade Priority 2 (1%-75%)				
A28, A38, A56	B1, B14, B5, B8	C10	D34, D40	E5
			Total No. of Priority 2 Pump Stations:	**11**
Acceptable Capacity (75%-500%)				
A1, A10, A104, A105, A106, A11, A12, A14, A15, A17, A19, A2, A20, A21, A23, A27, A29, A31, A32, A34, A40, A42, A45, A47, A53, A55, A59, A7, A8, A9, A18, A35	B10, B11, B13, B16,B18, B2, B4, B6, B9	C12, C13, C15, C19, C2, C20, C21, C22, C26, C27, C5, C6, C7, C8, C9, C28	D31, D32, D33, D35, D36, D37, D41, D43, D44, D54, D55	E1, E14, E2, E3, E7
			Total No. of Stations "Acceptable Capacity":	**73**
Excessive Capacity (>500%)				
A22, A36, A37, A39 A46, A48, A50, A51, A54, A57, A58, A60	B23, B7	C11, C14, C32	--	E6, E12, E13, E16
			Total No. of Stations "Excessive Capacity":	**21**

The “N-1” Capacity evaluation groups pump stations into four individual categories:

1. Upgrade priority 1 pumps: pumps that are not able to operate in the model due to the high head.
2. Upgrade priority 2 pumps: pumps that have an “N-1” Capacity of 1% - 75% indicate that the pump station likely operates with “N” both pumps on during peak flow events and limited redundancy.
3. Pumps with acceptable capacity: Pumps with an “N-1” Capacity of 75% - 500% indicates that the pump stations have enough capacity to operate sufficiently without the spare pump “on”. All pumps running at the same time likely only occurs during severe weather conditions.
4. Pumps with excessive capacity. Pumps with an “N-1” Capacity of more than 500% indicates that the pump station is oversized and is unlikely to operate with “N” pumps on at the same time. Several of the larger stations are equipped with variable frequency drives that can adjust the speed of the pump as needed. Oversized stations could be considered for downsizing to reduce power costs and maintenance.

The pump stations with categorized analysis results are presented in **Figure WW3-5.**

Section WW3 accepted February 3, 2017.



CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER TRANSMISSION SYSTEM: PUMP STATION 2035 CAPACITY EVALUATION- WITHOUT IMPROVEMENTS

FIGURE WW3-5

3.5.1.2 Force Main Capacity Analysis

The force main capacity was analyzed in the "Forced Flow" scenario with maximum hour flow (MHF) condition, representing a worst-case flow during a rainfall event. The force main pipes' output was compared with the level of service criteria: velocity and pressure. The hydraulic evaluations' output under existing and future conditions for the MHF scenario is presented in **Figure WW3-6 - WW3-9** respectively**.** The output for the dMHF under existing and future flow conditions is presented in **Figure WW3-10** and **Figure WW3-11** respectively.

As shown in the figures, most force mains have acceptable velocity (2 – 5 fps) in the Forced Flow scenarios indicating that the transmission force mains are robustly sized and for the most part meet level of service standards. In the worst case scenario (MHF Forced Flow), several force mains had velocities higher than 5 fps presented in **Table WW3-6.**

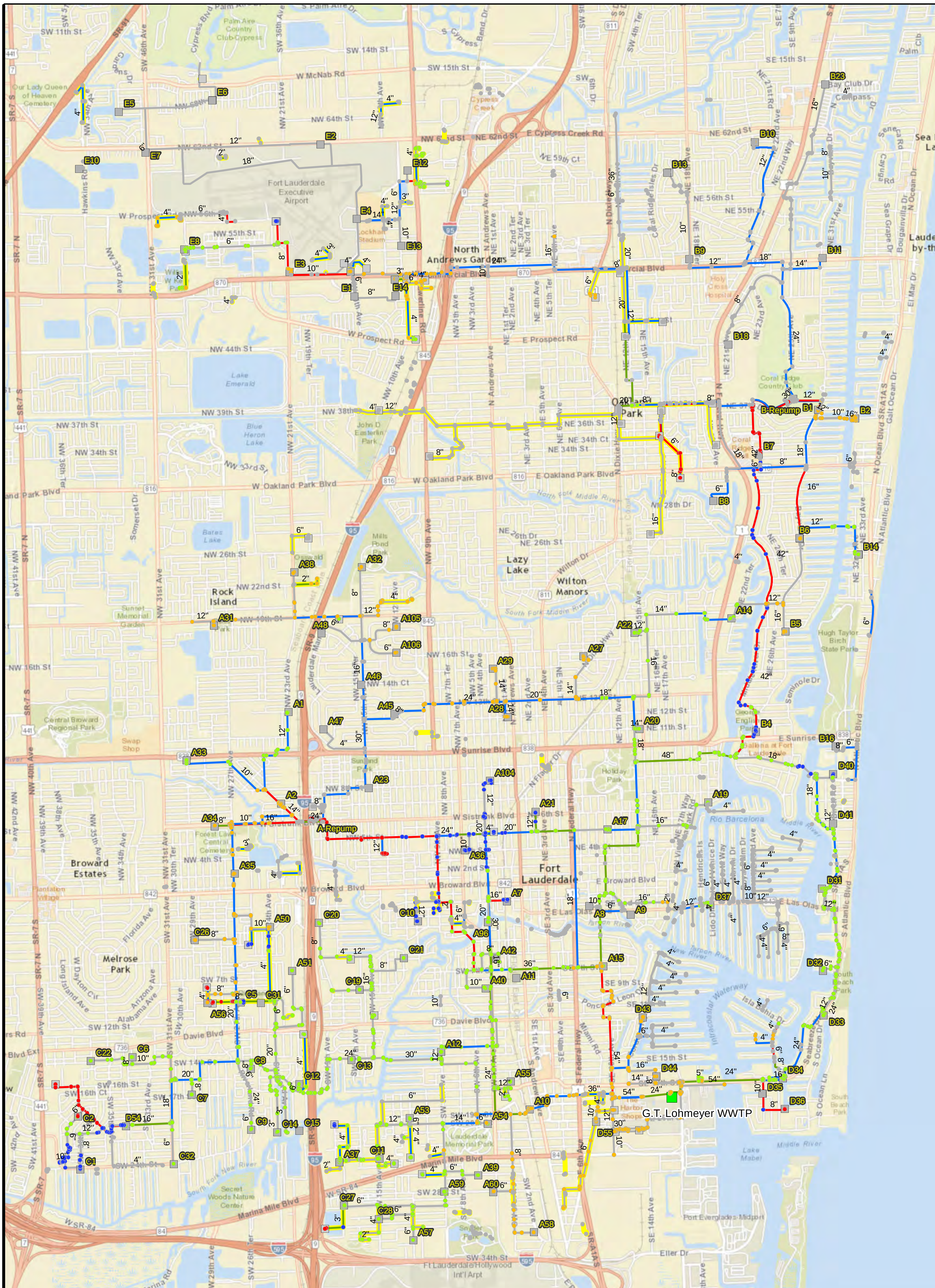
Table WW3-6. Force Mains Exceeding 5 fps

Street Name	Diameter (Inches)	Length (ft)
NW 21st Terrace	8	930
NW 21st Avenue	8	1,910
W Commercial Boulevard	8	2,300
SE 19th Place	8	850
SE 23rd Avenue	8	650
SE 23rd Avenue	10	560
SW 16th Street	12	878
Fairfax Drive	12	2,470
SW 35th Avenue	12	220
SW 20th Court	12	550
NW 22nd Road	12	1,850
SW 2nd Street	12	250
Bayview Drive including part in Coral Ridge Country Club	12	1,470
W Sistrunk Boulevard	14	440
W Sistrunk Boulevard	16	2,625
SW 2nd Street	16	600
Bayview Drive (South of E Oakland Park Blvd)	16	2,550
A-Repump Discharge Pipe (Along W Sistrunk Boulevard)	30	850
NW 19th Avenue	30	660
NW 5th Street	30	4,310
NW 9th Avenue	30	2,650
SW 2nd Avenue	30	470
SW 8th Avenue	30	1,200
Coontie Court	30	470

Street Name	Diameter (Inches)	Length (ft)
River Crossing (Between Cooley Avenue and SW 5th Street)	30	560
SW 5th Street	30	500
SW 6th Avenue	30	680
SW 7th Street	30	300
B-Repump Discharge Pipe	42	2,100
NE 25th Terrace	42	1,150
NE 35th Drive	42	180
NE 26th Avenue	42	1,440
E Oakland Park Boulevard	42	270
Middle River Drive	42	11,600
Bayview Drive (Near Pump Station B-4)	42	950
E Sunrise Boulevard	42	480
SE 9th Avenue	54	1,830
SE 10th Street	54	320
Ponce De Leon Drive	54	450
SE 12th Street	54	350
SE 10th Avenue	54	3,200

Velocities in excess of service criteria levels indicate potential capacity issues with the force mains. High velocities also generate higher head losses and potential severe water hammer (surge) pressures that are undesirable. The CUSMP team made recommendations to resolve high velocity and pressure issues by upsizing or paralleling force main pipes to increase capacity and lower Forced Flow hydraulic model velocities. The proposed transmission level of service projects are presented in the end of this section.

The dMHF (non-rainfall peak) Forced Flow scenarios indicate no velocity or pressure issues with the only exceptions being the Tamarac wholesale connection and the Peele Dixie well water alternate discharge force main. This conclusion supports that the force main level of service issues identified are associated with rainfall events and the resulting I/I. Transmission R&R needs, as opposed to capacity related improvements, are identified in **Section WW10**.



LEGEND

PRESSURE
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40
- Pump Station
- GTL

Pipe Velocity
- 0 - 2
- 2 - 4
- 4 - 5
- > 5

Owner
- *Private

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

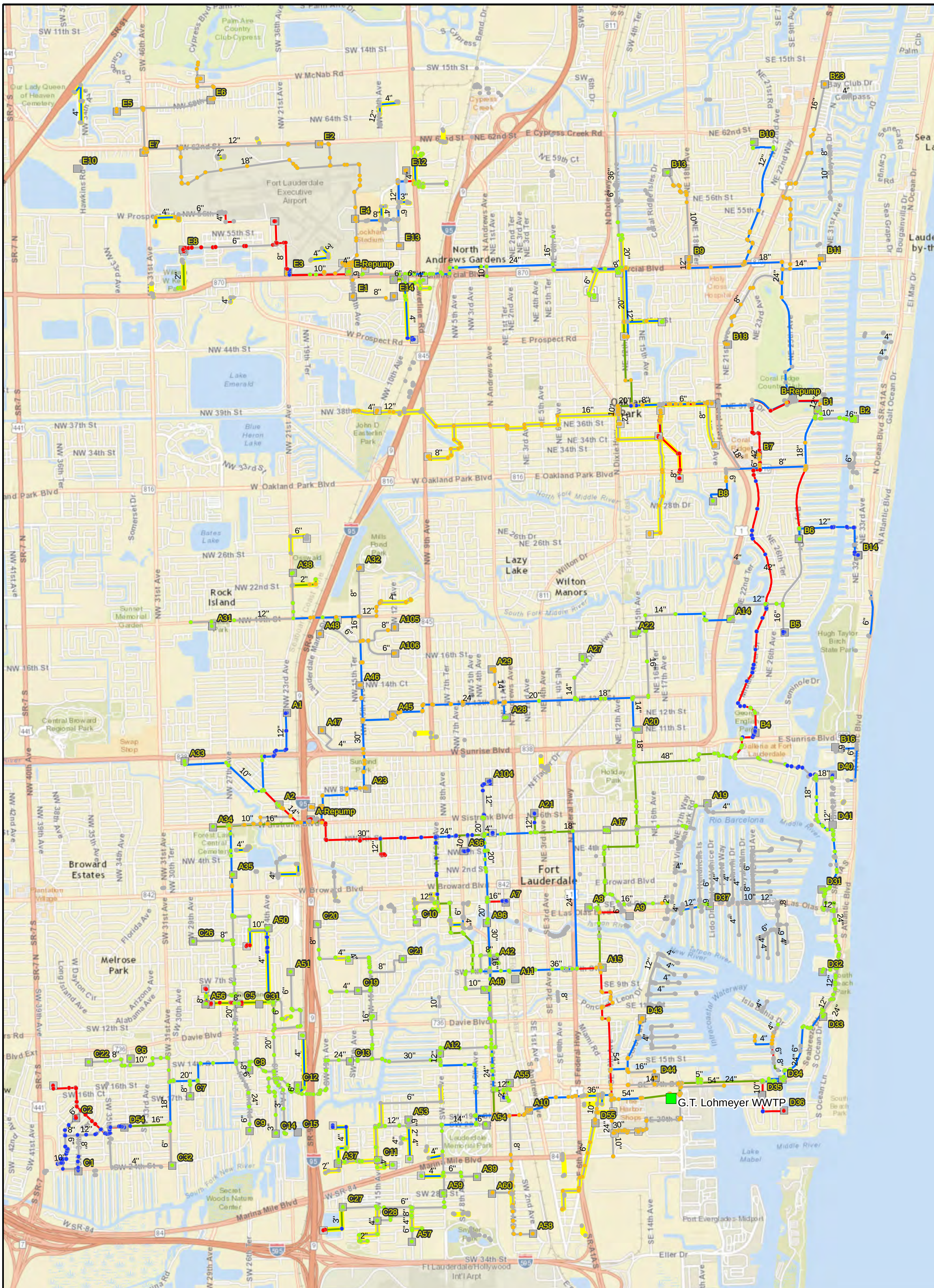
N
W E
S

0 0.5 1
Miles

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER TRANSMISSION SYSTEM: 2015 (EXISTING) MAX HOUR, FORCED FLOW OUTPUT

FIGURE WW3-6

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Forced Flow_Existing 072115.mxd



LEGEND

N
W E
S

0 0.5 1
Miles

Junction Pressure (psi)
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40
- Pump Station
- GTL

Pipe Velocity (fps)
- 0 - 2
- 2 - 4
- 4 - 5
- > 5

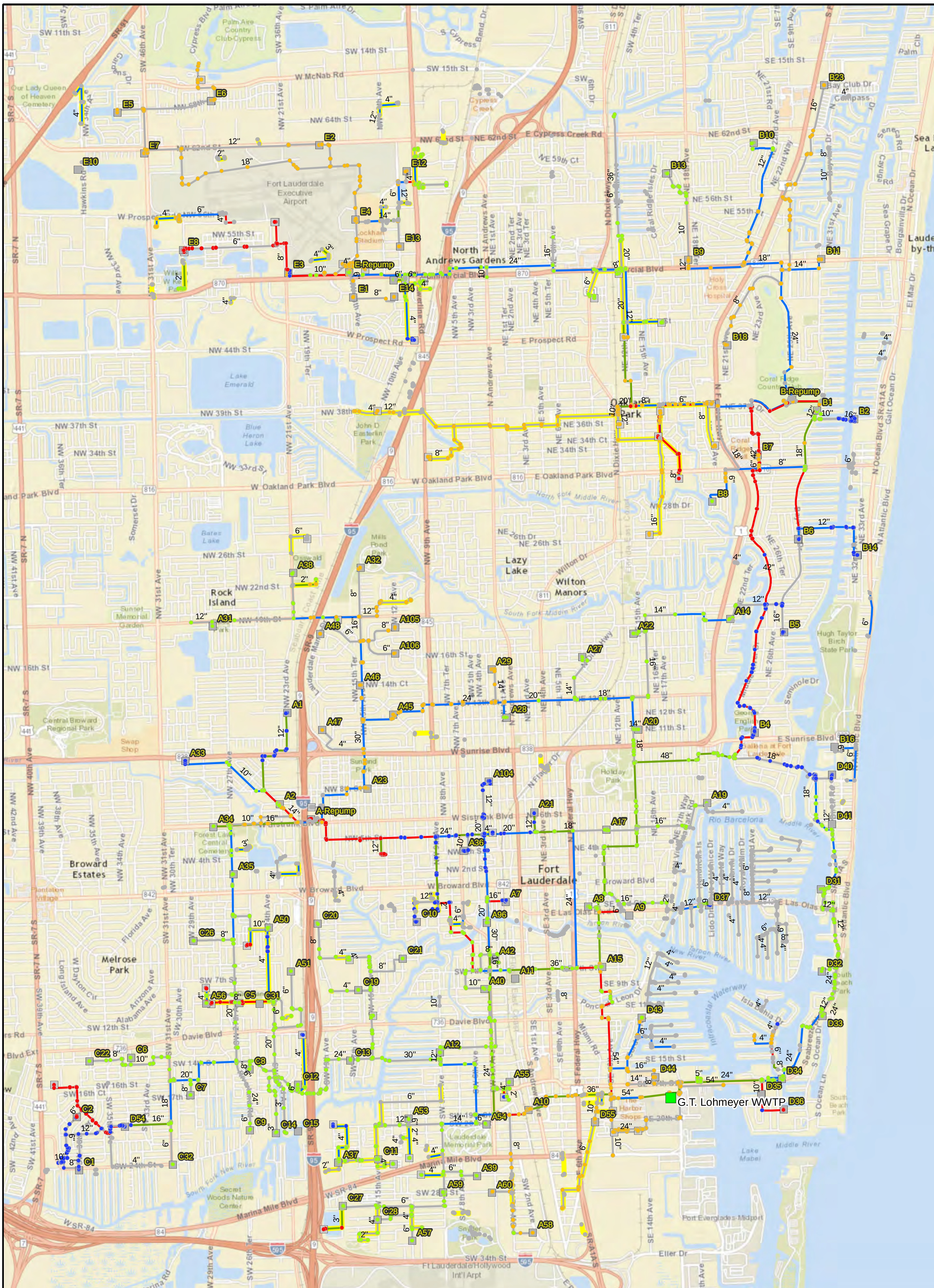
Owner
- *Private

*Privately owned forcemains are not part of the City's transmission system. The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER TRANSMISSION SYSTEM: 2020 (FUTURE) MAX HOUR, FORCED FLOW OUTPUT

FIGURE WW3-7

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Flow future 2020 No Improvements.mxd



LEGEND

N
W E
S

0 0.5 1
Miles

GTL

Junction Pressure (psi)

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40
- Pump Station

Pipe Velocity (fps)

- 0 - 2
- 2 - 4
- 4 - 5
- > 5

Owner

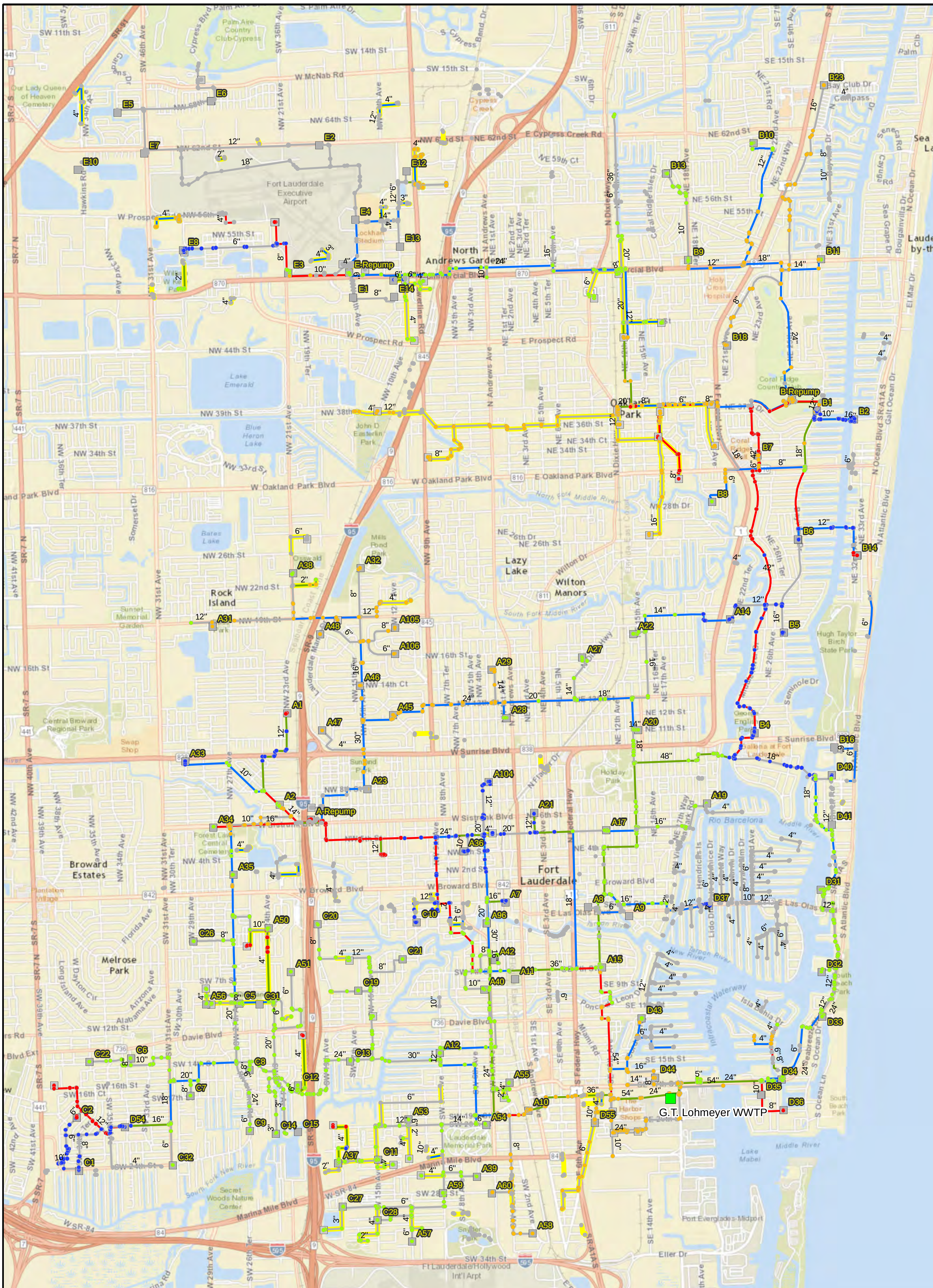
- *Private

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER TRANSMISSION SYSTEM: 2025 (FUTURE) MAX HOUR, FORCED FLOW OUTPUT

FIGURE WW3-8

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Flow future 2025 No Improvements.mxd



LEGEND

Junction Pressure (psi)	Pipe Velocity (fps)	Owner
0 - 10	0 - 2	*Private
10 - 20	2 - 4	
20 - 30	4 - 5	
30 - 40	> 5	
> 40		
Pump Station		
GTL		

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

N
W E
S

0 0.5 1

Miles

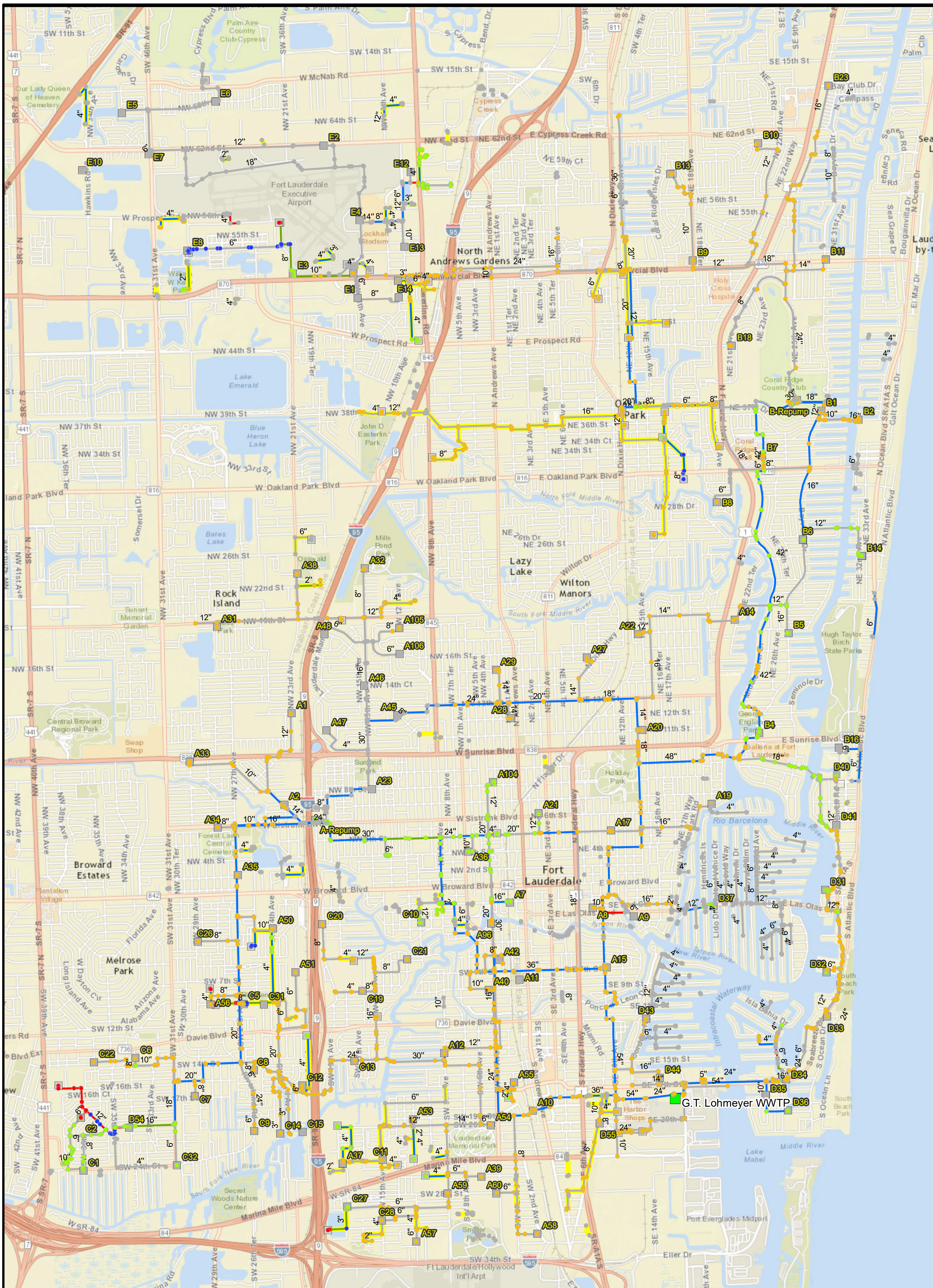
CITY OF FT. LAUDERDALE

COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

WASTEWATER TRANSMISSION SYSTEM: 2035 (FUTURE) MAX HOUR, FORCED FLOW OUTPUT

FIGURE WW3-9

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Flow future 2035final V2.mxd



N
W E
S

0 0.5 1

Miles

LEGEND

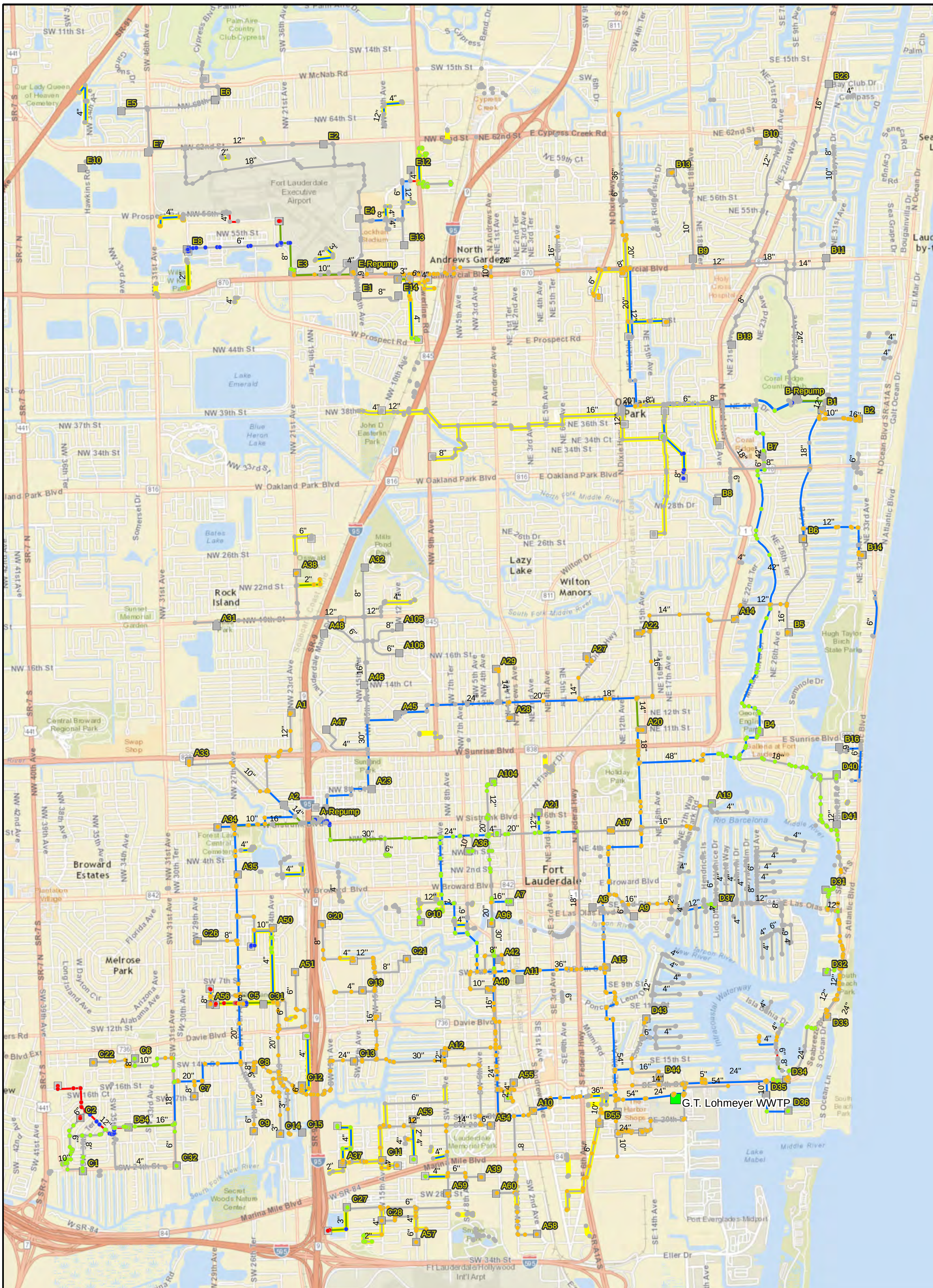
Junction Pressure (psi)	Pipe Velocity (fps)	Owner
0 - 10	0 - 2	*Private
10 - 20	2 - 4	
20 - 30	4 - 5	
30 - 40	> 5	
> 40		
GTL		
Pump Station		

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER TRANSMISSION SYSTEM: 2015 (EXISTING) DRY MAX HOUR, FORCED FLOW OUTPUT

FIGURE WW3-10

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Forced DRY Flow_Existing.mxd



N
W E
S

0 0.5 1

Miles

LEGEND

Junction Pressure (psi)
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40
- Pump Station
- GTL

Pipe Velocity (fps)
- 0 - 2
- 2 - 4
- 4 - 5
- > 5

Owner
- *Private

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER SYSTEM: 2035 (FUTURE) DRY MAX HOUR, FORCED FLOW SCENARIO

FIGURE WW3-11

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Flow DRY future 2035final.mxd

3.6 Wastewater Collection/Transmission Hydraulic Evaluation Summary

The CUS Master Plan Team developed the following conclusions from the wastewater transmission and collection hydraulic evaluation:

- The CUS Master Plan team constructed updated hydraulic models to represent the City's transmission and collection systems, which are powerful tools for capital planning, operational optimization and R&R/maintenance prioritization.
- The City's wastewater transmission system is a robust system with adequate present and future infrastructure capacity and built in reliability.
- The CUS Master Plan team identified the level of service needs, as summarized in **Table WW3-7**, pertaining to high velocity force mains, sewer basins with historical issues, and pump station capacities.
- Rainfall derived inflow and infiltration (RDI/I) almost exclusively accounted for level of service needs; dry weather maximum hourly flows (dMHF) resulted in very few issues.
- The quantitative I/I analysis, and hence individual pump station peaking factors, was based on limited and outdated data; additional rainfall event data should be collected to improve the station peak flow inputs.

Table WW3-7. Summary of Transmission and Collection Level of Service Issues

System Component	Level of Service Criteria	Actions to Comply
Force Mains	MHF Forced Flow Velocity <5 fps	Force Main Upsize; Flow Diversions
Pump Station Discharge Pressures	Junction Pressure < 40 psi	Force Main Upsize; Flow Diversions
Pump Station "N-1" Capacity	Pump Station Output >75% of Design Flow	Pump Upgrade
High RDI/I or N-RDI/I	Severe or Extremely Severe	Sewer Basin Rehab including gravity pipes, laterals and manholes

Community Investment Program (CIP) project identification was a joint effort of City staff input, engineering analysis, strategic City initiative compliance, and previous program evaluation. Proposed wastewater collection and transmission level of service CIP projects are listed in **Section WW9. Figure WW3-12** illustrates the transmission and collection CIP projects conceived to alleviate level of service issues in the system. The hydraulic model was re-run with the proposed pipeline improvements and the resulting output displayed in **Figure WW3-13 – WW3-15 and Figure WW3-16**. **Figure WW3-17** displays the pump station CIP projects based on level of service needs.

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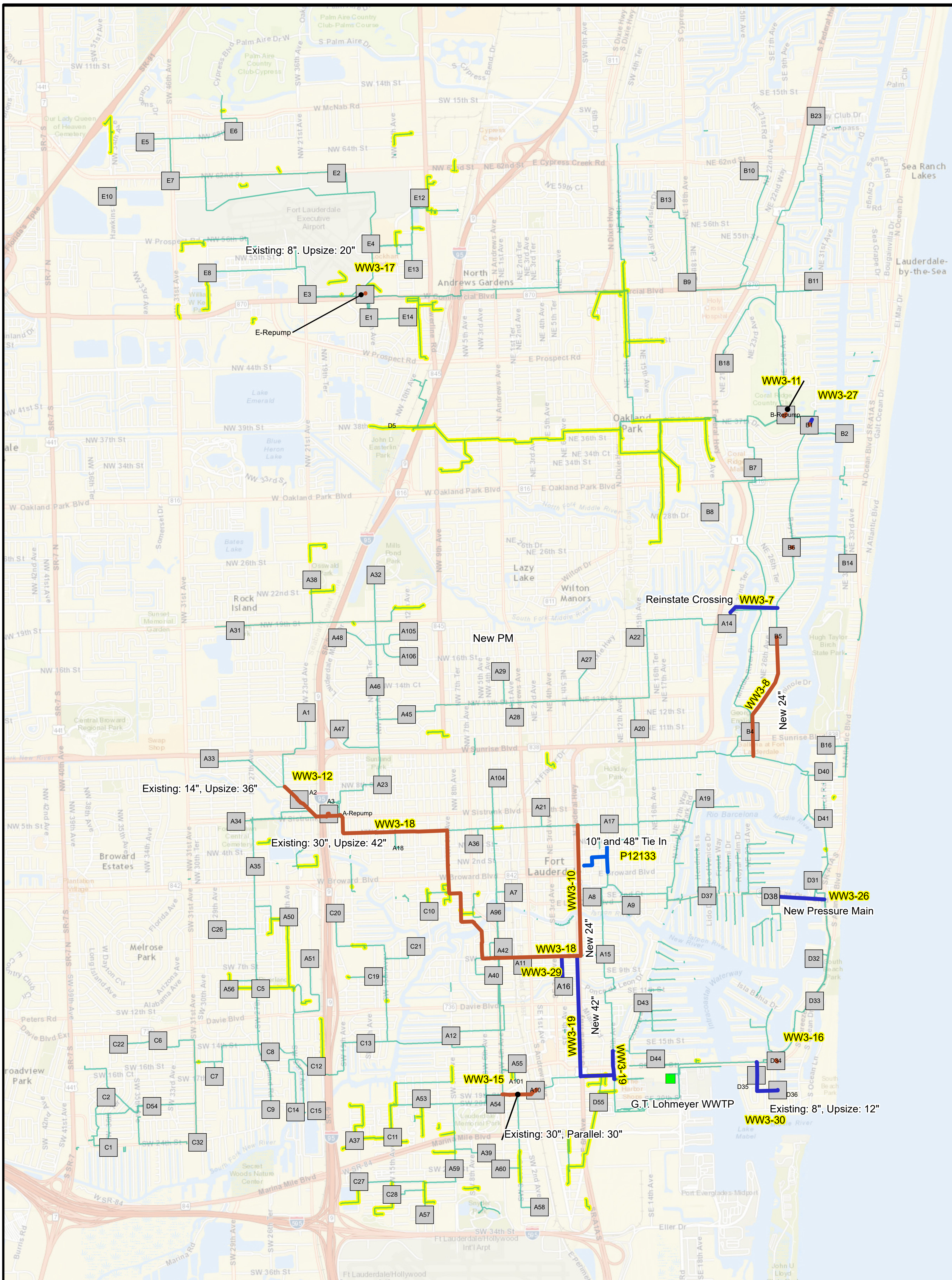


N
W E
S

0 0.5 1
Miles

LEGEND

CIP Project (Pipeline)

Short Term Improvement (0-5 years)

Long Term Improvement (> 5 years)

Pump Station

Existing Pressurized Pipe

GTL

Owner

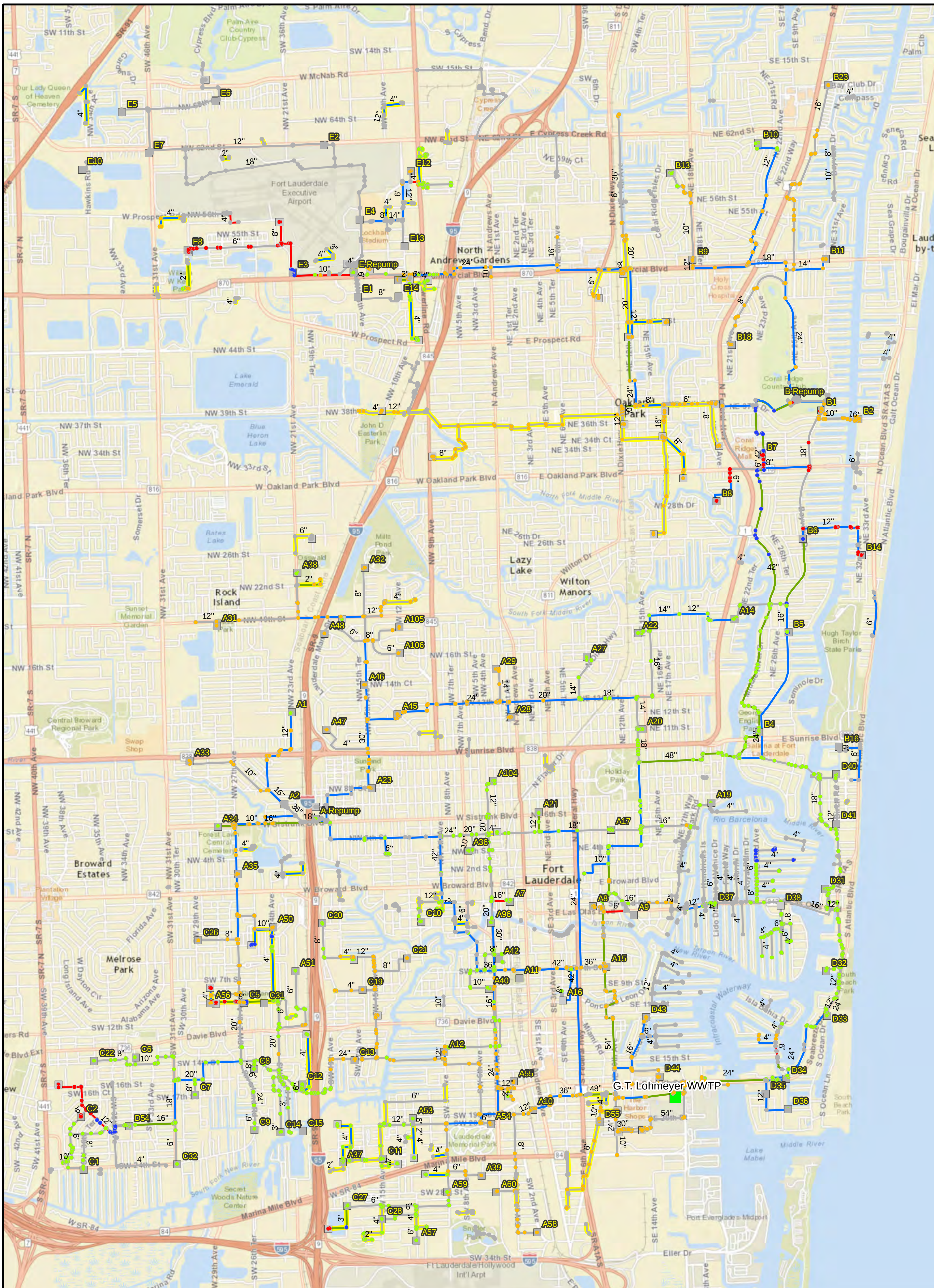
*Private

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER SYSTEM: LEVEL OF SERVICE (LOS) CAPACITY IMPROVEMENT PROJECTS

FIGURE WW3-12

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW CIP Projects_final V2.mxd



N
W E
S
0 0.5 1
Miles

LEGEND

Junction Pressure (psi)
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40
- Pump Station
- GTL

Pipe Velocity (fps)
- 0 - 2
- 2 - 4
- 4 - 5
- > 5

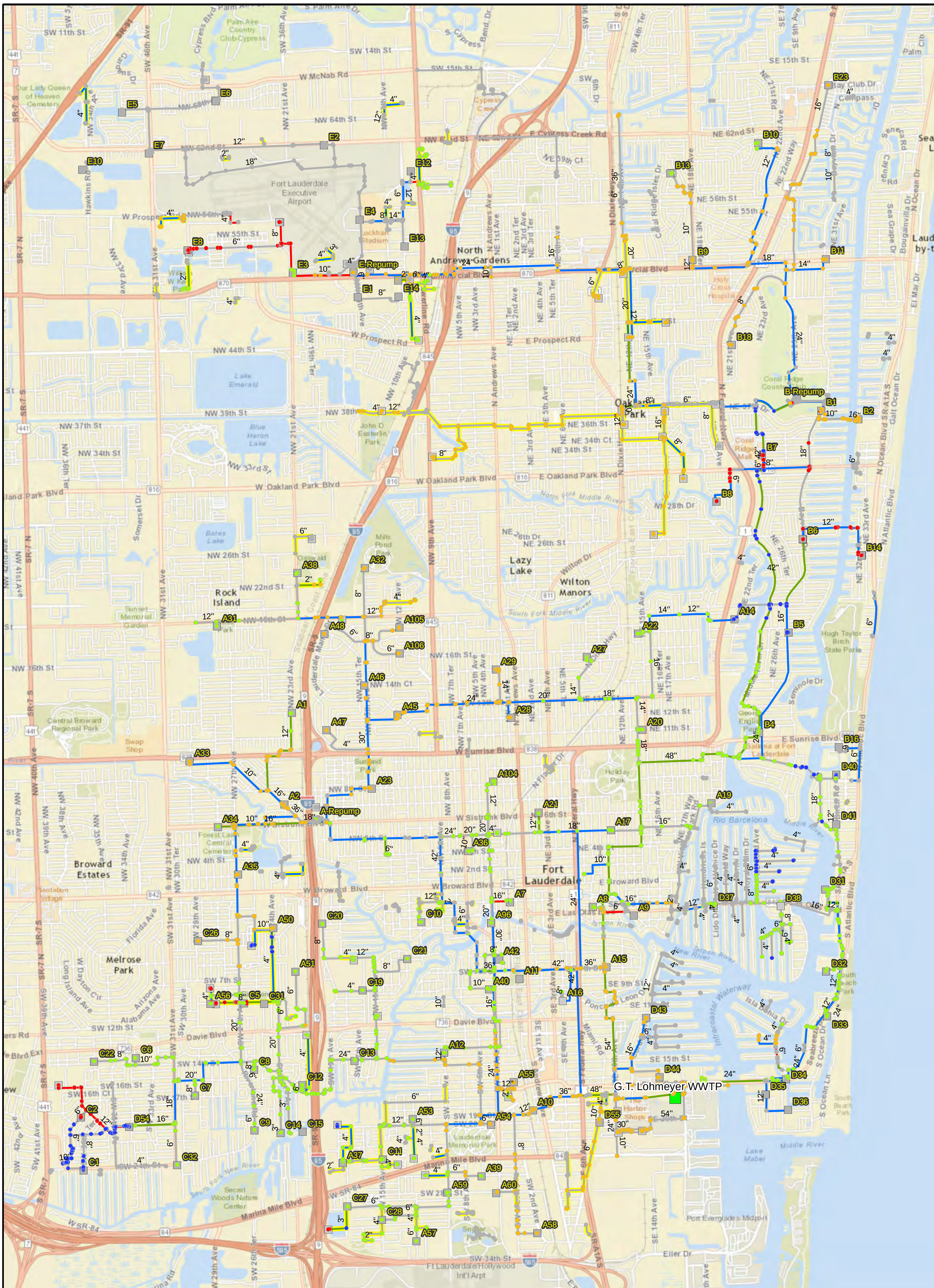
Owner
- *Private

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER SYSTEM: 2020 (FUTURE) MAX HOUR, FORCED FLOW SCENARIO WITH IMPROVEMENTS

FIGURE WW3-13

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Flow future 2020 W IMPROVEMENTS.mxd



LEGEND

Junction Pressure (psi)
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40
- Pump Station
- GTL

Pipe Velocity (fps)
- 0 - 2
- 2 - 4
- 4 - 5
- > 5

Owner
- *Private

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

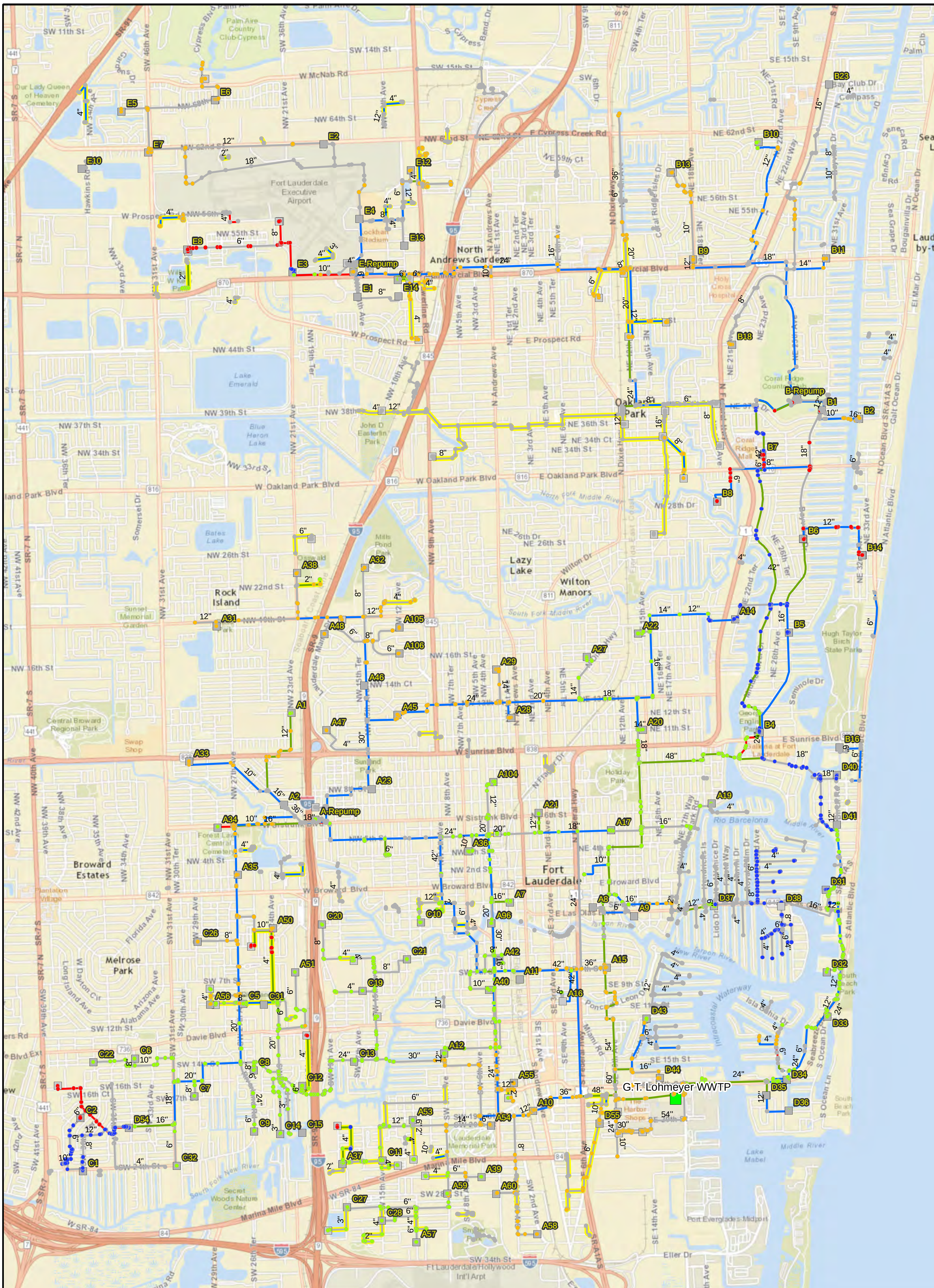
N E S W

0 0.5 1 Miles

CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER SYSTEM: 2025 (FUTURE) MAX HOUR, FORCED FLOW SCENARIO WITH IMPROVEMENTS

FIGURE WW3-14

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Flow future 2025 W IMPROVEMENTS.mxd



N W E S

0 0.5 1

Miles

LEGEND

Junction Pressure (psi)	Pipe Velocity (fps)
0 - 10	0 - 2
10 - 20	2 - 4
20 - 30	4 - 5
30 - 40	> 5
> 40	**Owner**
Pump Station	*Private
GTL	

*Privately owned forcemains are not part of the City's transmission system.The wastewater flow from the private areas is transmitted through interconnections into the City's transmission system and is treated by GTL WWTP.

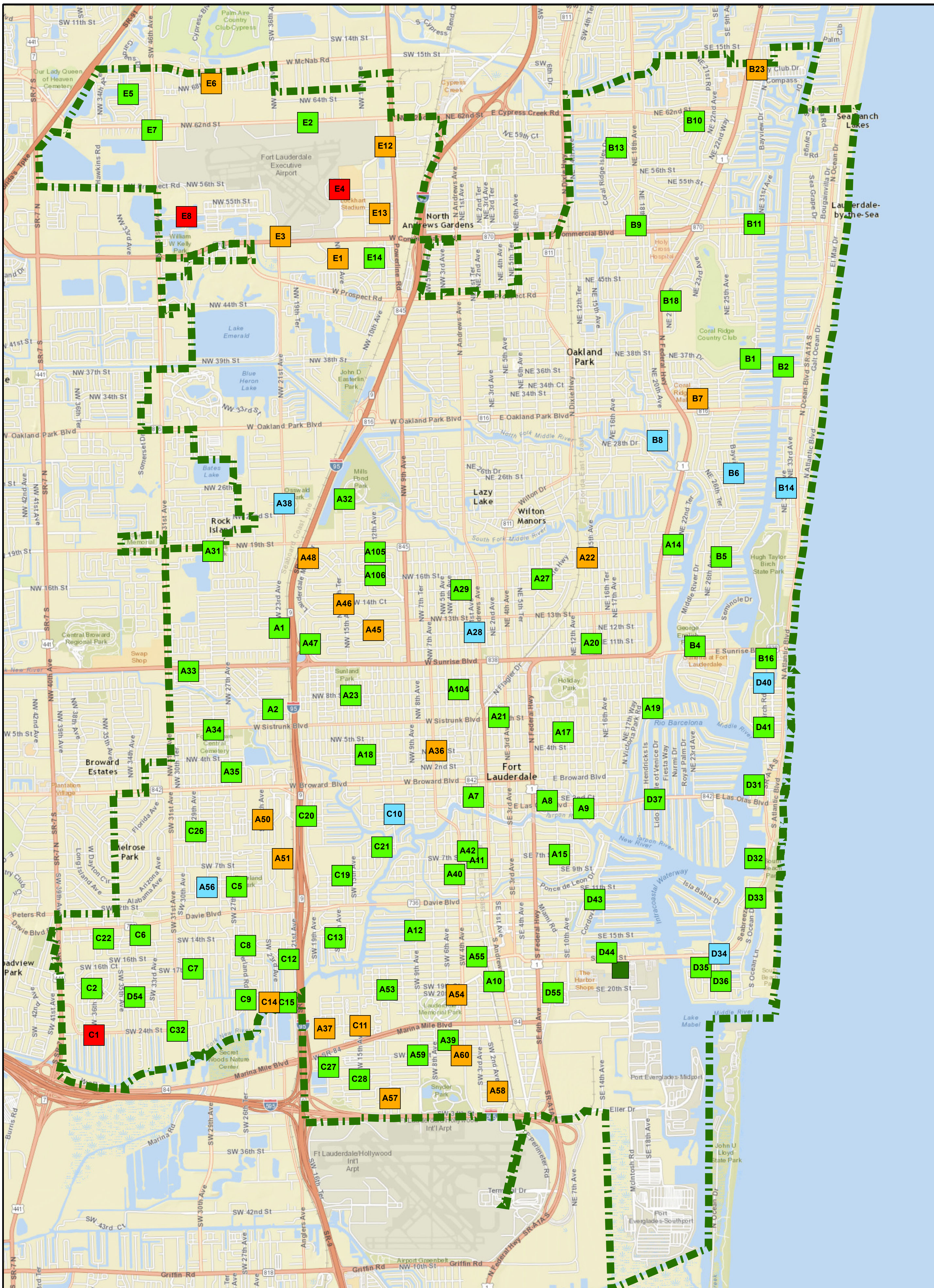
CITY OF FT. LAUDERDALE

COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

WASTEWATER SYSTEM: 2035 (FUTURE) MAX HOUR, FORCED FLOW SCENARIO WITH IMPROVEMENTS

FIGURE WW3-15

G:\0gis\134001 - Fort Lauderdale CUSMP_MXDs\WW3 and WW6\WW3\WW_Model_Flow future 2035final W IMPROVEMENTS.mxd



N
W E
S

0 0.5 1
Miles

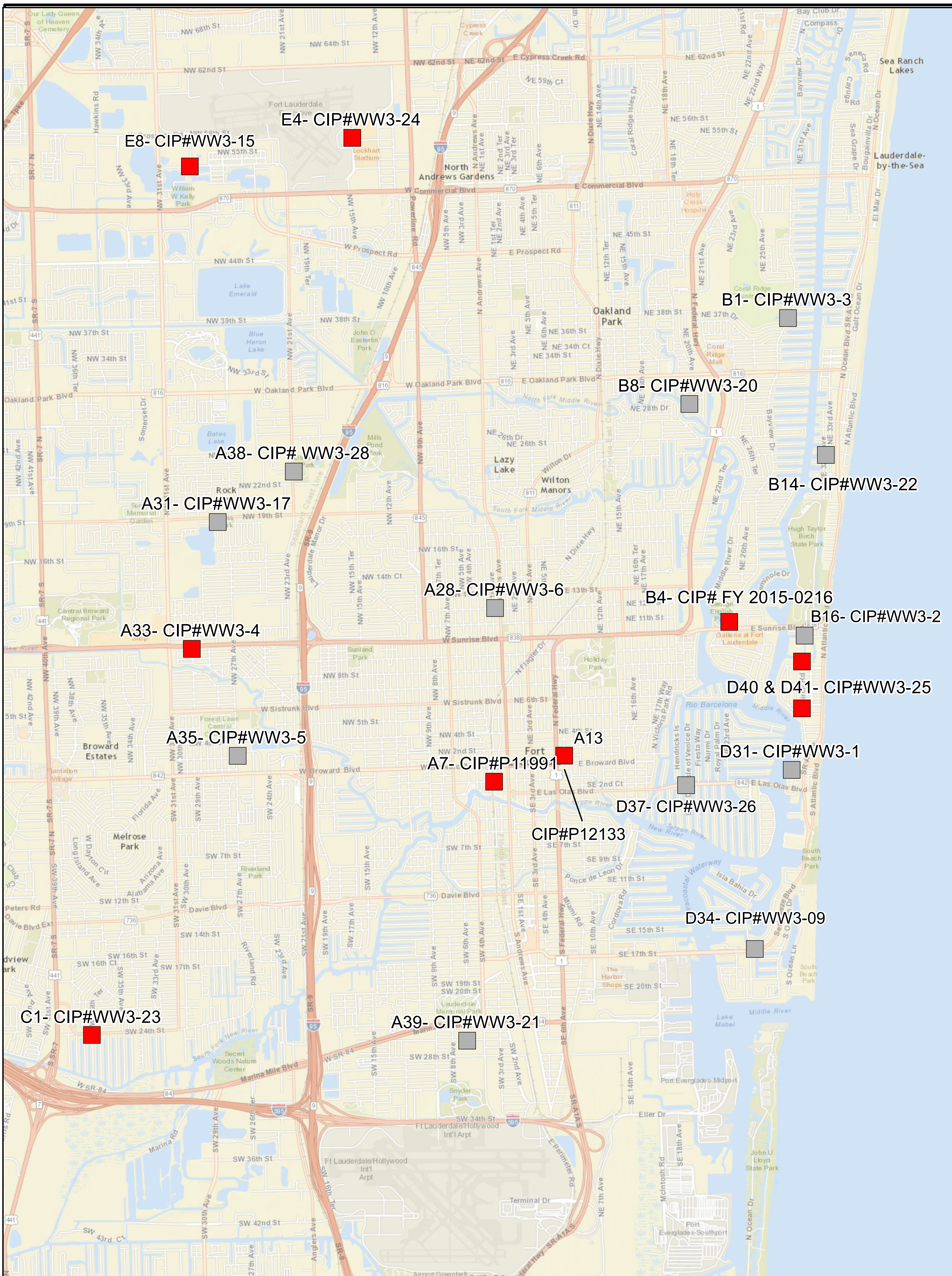
LEGEND

- Not Pumping (Upgrade Priority 1)
- 0 - 75 % (Upgrade Priority 2)
- 75 - 500 % (Acceptable Capacity)
- >500 % (Excessive Capacity)
- WW Service Area
- GTL

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER TRANSMISSION SYSTEM: PUMP STATION 2035 CAPACITY EVALUATION: WITH IMPROVEMENTS

FIGURE WW3-16

G:\0gis\134001 - FTL Master Plan_MXDs\WW3 and WW6\WW_Model_Flow Comparison 2035 with Improvements.mxd



N
W E
S
0 0.5 1
Miles

LEGEND

Pump Station "N-1" Capacity

- Upgrade Priority 1
- Upgrade Priority 2

*Upgrade includes replacement of impellers or pumps with new models of sufficient capacity. Also includes all relevent equipment and eletrical work.

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER SYSTEM: PUMP STATION CAPITAL PROJECTS

FIGURE WW3-17

G:\0gis\134001 - FTL Master Plan_MXDs\WW3 and WW6\WW_PS CIP Projects v2.mxd

WW4 I/I Prioritization Update

4.1 Introduction

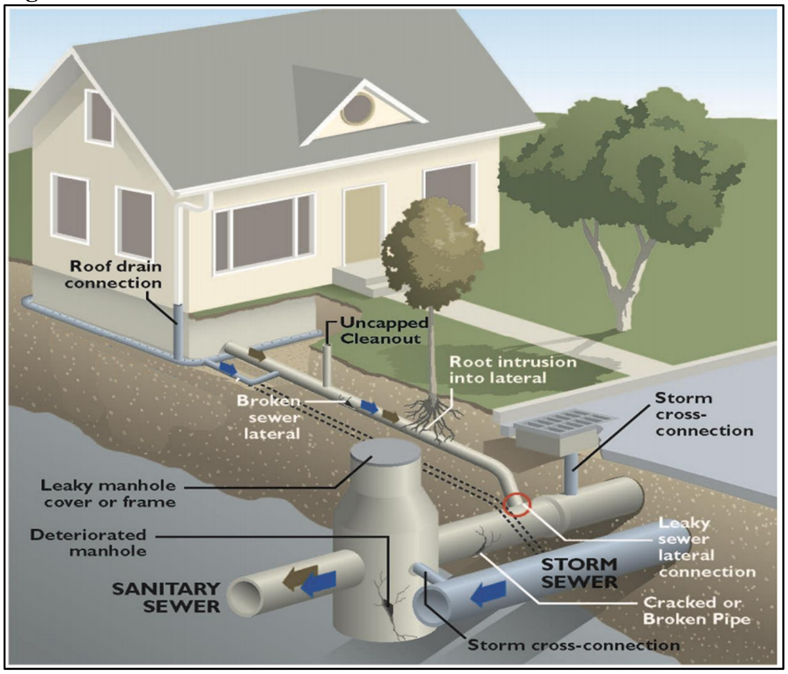
Most of the City's gravity collection system was constructed primarily of vitrified clay piping over 50 years ago with some pipes laid on wooden pipe supports or "bridges" as was the method at the time. Over time, the wooden supports rotted away, and along with soil settling, have propagated cracks in the inflexible, brittle clay pipes. Vitrified clay pipe also came in short segments and required many joints. Gasket materials used at the time were not as durable as those currently used and gradually deteriorated. There were no watertight means of adding laterals to existing sewer system and the effort often cracked the sewer pipe. The City has also targeted removal of Orangeburg gravity and service lateral pipe (also known as "fiber conduit", an outdated, problematic material that absorbs moisture and deforms under pressure) and backyard gravity pipes from its system due to service life and access issues. Along with service lateral and brick manhole deterioration and a high groundwater table, these issues have contributed to a high amount of infiltration and inflow (I/I) to the wastewater flowing through the City's collection pipes, pump stations, force mains and treatment facility.

Moreover, rising sea level and the intensified strength and frequency of King Tides will further amplify I/I flows. King Tides have caused severe flooding and restricted access along much of the City's coastal areas. In combination with the I/I prioritization efforts in this section that include tidally influenced areas, **Section WW13** further evaluates and provides recommendations to mitigate the projected sea level rise and the increasingly austere King Tide events.

The inflow portion of I/I (mostly due to rainfall) refers to water other than sanitary flow that enters a sewer system from sources which include, but are not limited to, roof leaders, manholes and pump station access doors, broken cleanouts, yard drains, local area drains, drains from low lying areas, cross connections between storm sewers and sanitary sewers, catch basins, cooling towers, stormwaters, surface runoff, or drainage. Inflow does not include, and is distinguished from, infiltration. The infiltration portion of I/I refers to groundwater (water found underground in the cracks and spaces in soil, sand, etc.) entering a sewer system through defective pipes, manhole casings, unsealed pipe joints and connections, and wet wells. Rising sea level and King Tides have become major infiltration contributors to total I/I. Some inflow connections are illegal, such as connecting a roof leader/drain to the sanitary system or opening a cleanout to drain a yard/parking lot after a rainfall event. **Figure WW4-1** shows the sources of I/I in a typical sewer system.

Section WW4 accepted December 16, 2016.

Figure WW4-1. I/I Sources



(Source: The New Zealand Water & Wastes Association, Infiltration & Inflow Control Manual Volume I, 2015)

4.2 I/I Impact Analysis

I/I contributions to the City's wastewater collection system during the high rainfall season create significant additional flow that consumes available capacity at the City's George T. Lohmeyer Wastewater Treatment Plant (GTL). More importantly, inflow contributions from large rainfall events have historically stressed the capacity of the City's infrastructure for short periods. Infiltration contributions to total I/I have recently increased due to a rising sea level and the more frequently occurring King Tide events. Both undesirable I/I contributions result in fluctuating influent sewer load and increased annual operating expenses. Impacts of I/I on the City's system include:

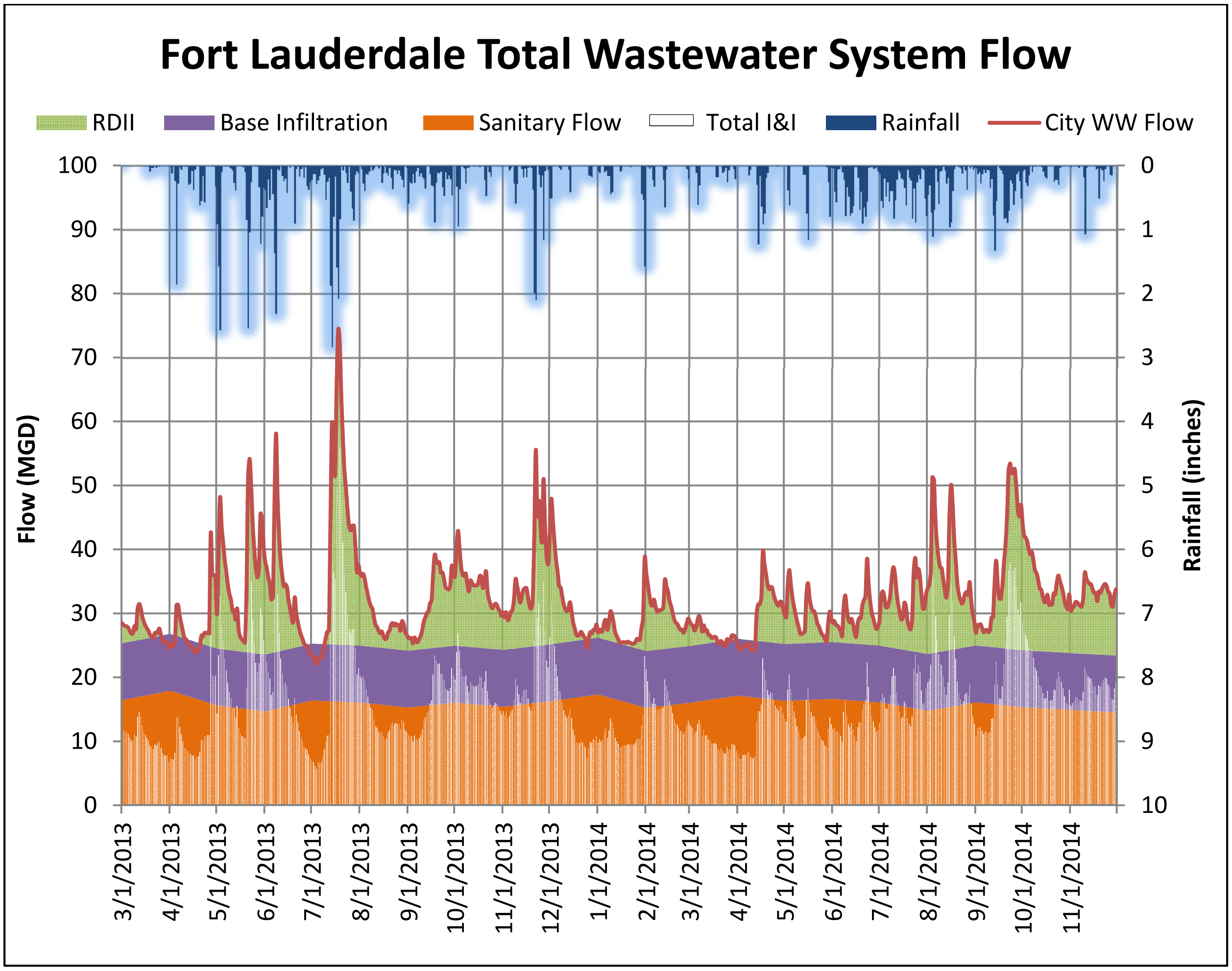
- Electrical costs to pump the fluid by the 186 pump stations
- Wear and tear of the impellers, motors, etc. on the 186 pump stations as well as on the elbows and transition pieces of the various piping systems
- Reducing the capacity of the system via depositing of grit/sand/etc. on the bottom of the pipes
- Increasing the chloride levels (well over 1,000 parts per million) thus needing advanced treatment options in order to facilitate reuse. This increases the capital cost as well as the operating costs (electricity being a major component)
- Electrical costs at GTL for the internal pumping, effluent pumping, generation of oxygen, etc.
- Wear and tear of impellers, motors and equipment within GTL
- Reducing or challenging the capacity of the plant systems: grit chambers, pipes and reactors filled up with sand and grit
- Additional chemical usage including hydrogen peroxide and chlorine
- Diluted constituents increasing the difficulty to meet the 90% reduction requirements at GTL
- Needing to expand GTL up to and including a 6th injection well

Section WW4 accepted December 16, 2016.

Historically, the City has performed rehabilitation projects to reduce I/I flow. Limited field studies were also performed to evaluate the effectiveness of the rehabilitation projects. The historical findings are summarized in this section.

The I/I contribution is a significant portion (more than 50%) of the total system flow. I/I typically is 20% - 60% of the system flow. EPA considers unit flows above 120-gallon per capita day (gpcd) to have excessive I/I: the City's unit flows are currently over 200 gpcd. **Figure WW4-2** shows the constituents of wastewater system flow from 2013 – 2014 compared to daily rainfall in the City. The analysis covers 2013 – 2014 for the available water billing data.

Figure WW4-2. Fort Lauderdale Total Wastewater System Flow 2013 – 2014



(Rainfall Data Source: National Weather Service (NWS))

Section WW4 accepted December 16, 2016.

The following definitions are used to define the various influent contributions to GTL:

1. Plant Influent - Plant influent is the total flow that enters GTL with large users (City of Oakland Park, Wilton Manors, Port Everglades, etc.). The daily influent data is recorded by flow meters and recorded by the City SCADA system. The daily influent data includes flow contributed by all large users. In order to analyze the flow generated within the City of Fort Lauderdale, all of the large user flows were deducted from the total recorded plant influent, which is presented in the figure.

2. Sanitary Flow (SF) - Sanitary flow is defined as the component of wastewater, which includes residential, commercial, institutional, and industrial sewage and specifically excludes infiltration/inflow. On average about 60 to 90 percent of the per capita water consumption becomes wastewater (Metcalf & Eddy, 2003). Based on a review of the City's potable water consumption data and the previous master plan, 70% return rate is used in this section to evaluate sanitary flow.

$$\mathrm{SF} = \text{Water Consumption x } 70\%$$

3. Total I/I - Total I/I (MGD) is the quantity of water from both infiltration and inflow without distinguishing the source.

$$\text{Total I/I} = \text{Plant Influent} - \text{Sanitary Flow}$$

Base Infiltration (BI) - BI is the flow resulting from groundwater infiltrating into the sewer not associated with rainfall events. BI occurs year-round and is also referred to as groundwater infiltration (GWI). BI is part of Total I/I, and includes I/I contribution from the rising sea level and King Tide events. BI cannot be measured directly but is estimated indirectly from flow data. The previous 2001 and 2013 I/I studies both used 80% of observed minimum dry weather flow as BI. However, more recent research has suggested that this method is least preferred (ADS, 2014). In this evaluation, BI is estimated using the Stevens-Schutzbach equation, which is reported to be more accurate in basins yielding flows comprised of more than 20% BI (Mitchell, etc., 2007). The Stevens-Schutzbach equation is as follows:

$$\mathrm{BI} = \frac{0.4 \times \mathrm{MDF}}{1 - 0.6 \times (\frac{\mathrm{MDF}}{\mathrm{ADF}})^{\mathrm{ADF}^{0.7}}}$$

MDF - Minimum Daily Flow rate (2013-2014)
ADF - Average Daily Flow rate (2013-2014

The MDF and ADF, with the large users deducted, from 2013 to 2014 SCADA data, is 22 MGD and 32 MGD respectively. These values were then used to calculate a BI of 8.89 MGD and compared to an assumption made in previous studies that the BI is 80% of the overserved minimum dry weather flow, 17.6 MGD. Using 17.6 MGD as base infiltration yields a sanitary flow of approximately 5 MGD, which is low for the City. Therefore, the Stevens-Schutzbach equation is assumed to be more accurate.

Section WW4 accepted December 16, 2016.

4. Rainfall-derived inflow and infiltration (RDI/I) - RDI/I is the increased portion of water flow in a sanitary sewer system that occurs during and after a rainfall. RDI/I is usually calculated by subtracting average dry weather flow from measured wet weather flow. Rationally, average dry weather flow is comprised of sanitary flow and BI. In this report, RDI/I is calculated by subtracting BI from Total I/I.

$$\text{RDI/I} = \text{Wet weather flow} - \text{average dry weather flow or RDI/I} = \text{Total I/I} - \text{BI}$$

5. Normalized rainfall-derived inflow and infiltration (N-RDI/I) - N-RDI/I (gallon/ foot/inch) is RDI/I divided by the length of sewer pipe in a pump station basin and by the amount of rainfall within each respective basin. N-RDI/I allows comparison of RDI/I during differing magnitude precipitation events.

The CUSMP Team performed a detailed wastewater flow analysis by applying the definitions and calculations described above. **Figure WW4-2** shows the breakdown of daily plant influent from March 2013 to November 2014. The analysis covers 2013 – 2014 due to the limited water billing data available.

Overall, the system's influent correlates closely with rainfall events, which is indicative of a high amount of inflow. The peak flow during wet weather conditions exceeds 80 MGD. More than half of the average influent to the GTL plant is I/I flow. The City is addressing I/I with an annual repair and replacement (R&R) budget to rehabilitate gravity pipes, service laterals and manholes to help maintain an acceptable level of service.

Collection system repair and replacement (R&R) needs were identified through a combination of City Distribution & Collection (D&C) staff knowledge, engineering analyses and risk assessment. Collection system R&R projects typically include gravity pipe lining, manhole rehabilitation, manhole lid liners, service lateral rehabilitation and RDI/I monitoring and identification efforts. R&R efforts were prioritized to minimize risk and reduce RDI/I contributions to optimize hydraulic condition in the collection system.

4.3 Identification

Ideally, I/I evaluations should be based on monitored flow data. While two previous City flow monitoring efforts were reviewed, this study used available runtime data and pump curve information to evaluate present conditions. After reviewing historical rainfall data, the CUSMP Team selected January 2012, March 2013, and February 2014 as "dry months"; August 2012, July 2013, and September 2014 are selected as "wet months" for analysis. The CUSMP Team assumed that the pumps are delivering 80% of the designed flow rate while running. Monthly pump runtime data and the assumed pump flow rate are used to estimate individual sewer basin flow for dry months and wet months. The 80% assumption then was verified by comparing the total calculated monthly pump flows to the City monthly average influent (large users deducted). With the dry month flows and wet month flows, RDI/I and N-RDI/I are calculated using the equations mentioned above.

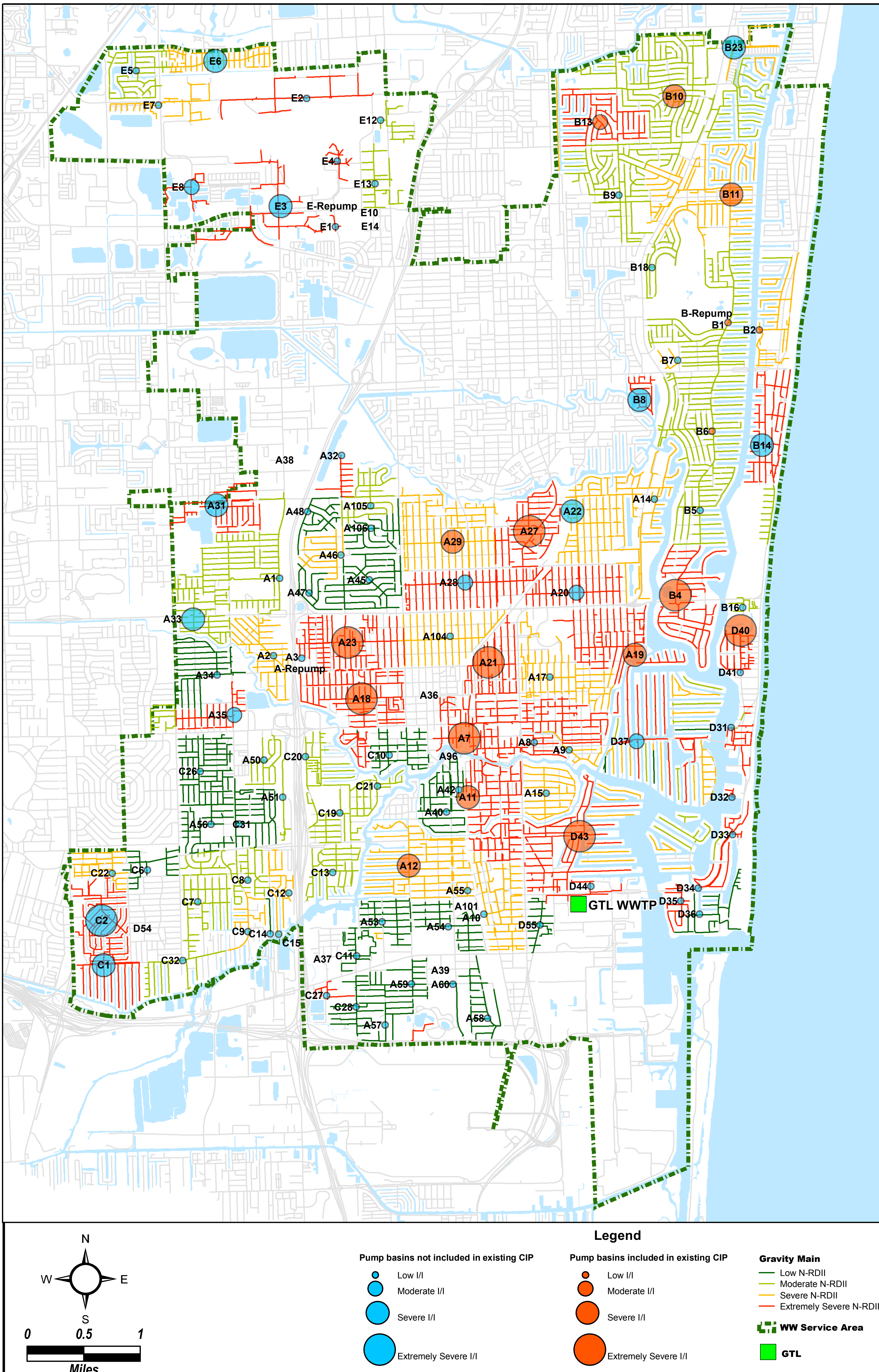
The resulting, calculated 3-year average RDI/I and N-RDI/I values are distributed in the following bins as presented in **Figure WW4-3** and detailed in **Appendix WW4-1**:

- **Extremely Severe I/I**: sewer basins with average annual I/I greater than 1.0 mgd.
- **Severe I/I**: sewer basins with annual average I/I between 0.7 and 1.0 mgd.
- **Moderate I/I**: sewer basins with annual average I/I between 0.55 and 0.7 mgd.
- **Low I/I**: sewer basins with annual average I/I between less than 0.55 mgd.

Figure WW4-3 graphically represents RDI/I volume by the size of the pump stations' circles. N-RDI/I is represented by the color of the gravity mains with red being extremely severe and green being low. Higher N-RDI/I can be an indicator of severe physical deterioration of wastewater collection infrastructure. Based on the analysis of sewer basins included in the City's current project lists and newly identified areas, the sewer basins were categorized into the following four target priority levels:

- **Priority 1 Target Areas**: Sewer basins located in the low lying (King Tide-susceptible) areas defined in **Figure WW11-3** and **Figure WW11-5** or with Extremely Severe I/I.
- **Priority 2 Target Areas**: Sewer basins with Severe I/I.
- **Priority 3 Target Areas**: Sewer basins with Moderate I/I.
- **Priority 4 Target Areas**: Other sewer basins included in the City's current Community Investment Plan (CIP).

Section WW4 accepted December 16, 2016.



CITY OF FT. LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER SYSTEM: SEWER BASIN I/I EVALUATION

FIGURE WW4-3

R:\Projects\134001-P FtLauderdale CUSMP\Study-Report\Draft_Report\2.0 Wastewater\WW.4 I&I Prioritization\WW I&I Severity0901.mxd

4.4 Previous Effort Summary

In the 2014 I/I monitoring study, a total of 12 rehabilitated pump station basins were evaluated using flow monitors and rain gauges. **Table WW4-1** compares the two studies completed previously in 2001 and 2013, which shows the percent difference in BI and RDII of each station to evaluate whether there was improvement from the rehabilitation efforts on the pump station basins.

Table WW4-1. 2001 to 2013 N-BI and N-RDI/I Comparison for Flow Monitored Basins

Basin	N-BI $_{2001}$	N-BI $_{2013}$	% N - BI	N - RDI/I 2001	N - RDI/I 2013	% N – RDI/I
	(gpd/in-mi)	(gpd/in-mi)	(%)	(gal/LF/in)	(gal/LF/in)	(%)
A-11-0	10080	9799	-3%	17.7	3.65	-79%
A-12-1	11746	5541	-53%	12	1.56	-87%
A-12-2	59995	7461	-88%	88.1	1.59	-98%
A-12-3	17	1056	6124%	0.1	0	-100%
A-17-1	4114	7424	80%	7.9	3.26	-59%
A-17-2	2468	1098	-55%	8.9	2.19	-75%
A-20-1	5970	2848	-52%	14.7	2.28	-84%
A-20-2	2690	2109	-21%	9.2	1.71	-81%
A-23-1	2261	4552	102%	6.5	1.51	-77%
A-23-2	5099	4882	-4%	4.1	1.23	-70%
A-27-1	6578	2569	-61%	11.3	1.39	-88%
A-27-2	6888	6880	0%	18.9	3.6	-81%
A-27-3	5999	6522	8%	23.7	3.69	-84%
A-29-1	6423	5985	-7%	9.3	2.03	-78%
A-29-3	10817	2321	-79%	8.2	1.71	-79%
A-29-4	5533	3263	-41%	6.1	2.08	-66%
A-29-5	-	2467	-	-	4.16	-
B-04-1	8678	4870	-44%	3.1	1.19	-62%
B-04-2	6712	19589	192%	18.4	0	-100%
B-10-1	3191	3076	-4%	12.7	2.14	-83%
B-10-2	677	1059	56%	3.6	0.6	-83%
B-10-3	606	748	23%	7.5	0	-100%
B-11-1	3066	3244	6%	13.8	0.88	-94%
B-11-2	2702	8841	226%	12.4	6.44	-48%
B-14-1	3900	6464	65%	11	1.62	-85%
B-14-2	8133	8203	1%	5.6	2.31	-59%
D-37-1	3991	3186	-20%	6.4	4.76	-26%

Note:
1. N-BI = BI (gpd) / (Pipe Diameter (in) * Pipe Length (mi))
2. % N-BI: (N-BI $_{2013}$ - N-BI $_{2001}$)/ N-BI $_{2001}$
3. % N-RDI/I: (N-RDI/I $_{2013}$ - N-RDI/I $_{2001}$)/ N-RDI/I $_{2001}$
4. N-RDI/I in the previous studies was calculated based on measured flow during the rainfall events. N-RDI/I in this study was calculated based on the average daily flow from the monthly pump runtime and pump curve.

Section WW4 accepted December 16, 2016.

According to the City's most recent flow study, the 12 surveyed pump station basins that have undergone rehabilitation experience similar levels of N-BI (A-12 is not taken into consideration) and significantly reduced N-RDI/I after rehabilitation. The firm that conducted the City's flow testing (ADS) indicated that caution should be used in this comparison, as drastic differences in rainfall totals and rainfall intensities were observed between the two comparative study periods. Also, the total GTL influent has not significantly decreased as a result of these rehabilitation efforts. The rehabilitation efforts employed by the City during this period, pipe lining and public lateral lining, typically reduces BI more than RDI/I (City of St. Petersburg Maximo Pilot Study). Repairs to deeper gravity pipes and laterals intuitively reduces more infiltration associated with groundwater than inflow associated with rainfall runoff. This can explain why N-BI is reduced by the City's rehabilitation efforts without significant reduction in RDI/I. Therefore, accurate and consistent flow monitoring is required to better evaluate the change in I/I due to basin rehabilitation and a concerted effort will be required, also including inflow mitigation strategies, to reduce GTL I/I going forward.

4.5 I/I Control Plan

Due to extensive I/I contributions to the GTL influent identified in this analysis, there is an excellent opportunity to defer the cost of expanding the GTL plant by reducing I/I flow. Inflow is more closely related to peak flows than infiltration from pipes that are constantly under the water table. Minimizing inflow into the collection system can help reducing peak flows, which causes plant damage or potential sewage overflows (Bloetscher, etc., 2014). I/I enters the wastewater system from three primary sources: collection lines, manholes, and service laterals. I/I from service laterals is typically reported to be 20% - 80% of the total I/I flow. (Strand Associates Inc., 2006; MCES, 2004; WEF, 1994) for wastewater utilities. A comprehensive I/I Control Plan is developed in this section to achieve significant reduction, with inflow reduction being the priority. Field testing will be applied to better quantify I/I quantities and evaluate the City's ongoing rehabilitation efforts. The CUSMP Team recommends salinity monitoring in areas that are near salt-water bodies because the salt water infiltrates the ground water and can eventually enter the wastewater force mains. The salinity monitoring can benefit the City by determining which pump stations that will need rehabilitation due to high I/I from the salt water bodies, not rainfall. The City can adjust the I/I Control Plan accordingly to future rehabilitation efforts. It should be noted that Stage 2 is already underway and will continue to proceed throughout this effort. The 5-stage plan is presented below:

Stage 1. Field Testing and Inflow Removal

- Purpose: To locate and repair inflow defects, improve the I/I quantity estimates for each sewer basin using the recommended key performance indicators (KPIs, e.g. RDI/I, N-RDI/I, etc.) and establish accurate baseline flows.
- Actions:
  a. Smoke test Priority 1 areas to locate and repair inflow defects.
  b. Install manhole lid liners and cleanout plugs in Priority 1 and flood prone areas.
  c. Perform flow and salinity monitoring during dry period high tides and flow monitoring shortly after significant rainfall events to target specific areas (SCADA pump runtime, station flow and rainfall monitoring program recommendations will be discussed in WW5).
  d. Perform engineering analysis (calculate inflow for each station) and update I/I prioritization list and the I/I Control Plan.
  e. Ensure City GIS staff is tracking I/I improvements; for example, add fields designating if a lid liner has been installed on a manhole, etc.

Section WW4 accepted December 16, 2016.

Stage 2. Contractor Sewer Basin Rehabilitation

- Purpose: Renew collection system infrastructure and reduce I/I.
- Actions:
  a. Perform 30% sewer basin rehabilitations of gravity mains (pipe length), manholes (number) and service laterals (pipe length).
  b. In the future, perform 80% sewer basin rehabilitations of gravity mains (pipe length), manholes (number) and service laterals (pipe length).
  c. Ensure City GIS staff is tracking I/I improvements; for example, add fields designating if a main or lateral has been lined, etc.

Stage 3. City Lateral Rehabilitation Crew

- Purpose: Maximize the I/I reduction per dollar spent by self-performing some of the lateral rehabilitation in-house.
- Actions:
  a. Obtain management and elected official approval.
  b. Identify internal champion.
  c. Procure equipment, hire or re-assign staff and train staff.
  d. Implement City lateral rehabilitation.

Stage 4. I/I Monitoring and Analysis

- Purpose: To assess the impact of the works undertaken and help prioritize future I/I mitigation efforts.
- Actions:
  a. Perform engineering analysis to summarize I/I mitigation impacts, reevaluate the I/I Control Plan, and re-prioritize sewer basin rehabilitation.
  b. Monitor pump stations' flow for a dry period and a peak precipitation period of 12 weeks or until 3 to 4 suitable rainfall events have been recorded.
  c. Perform annual engineering analysis to analyze collected data and evaluate I/I reduction by equation: Level of Reduction = (KPIpre – KPIpost) / (KPIpre)
  d. Update the I/I Control Plan with resulting calculations, conclusions, and adjusted prioritizations.

Stage 5. Private-Side Lateral Rehabilitation

- Purpose: To address private-side lateral I/I contributions.
- Actions:
  a. Develop and propose ordinances to address deficient private-side service laterals including requiring inspection and code compliance upon property sale.
  b. Discuss with elected officials and citizens the best way to fund and accomplish private lateral rehabilitation.
  c. Execute private lateral rehabilitation.

The I/I Control Plan is also summarized below in **Table WW4-2**.

Table WW4-2. I/I Control Plan

Year	I/I Control Plan		
	In-house City Efforts	**Field/Consulting Engineering**	**Contract Work**
2016-2020	• SCADA improvement (flow and runtime, as detailed in WW5) • Develop service lateral ordinances • Research lateral lining equipment, assign champion	• Priority 1 smoke testing • Collect & analyze flow data • Verify A7, A18, D40 and D43 rehabilitation • A7, A18, D40 and D43 flow testing • Re-prioritize future I/I projects • Perform A7 and A18 post-rehabilitation analysis	• Sewer Basin rehabs as scheduled • Priority 1 manhole lid liner installation • Install cleanout plugs in low-lying areas
2021-2025	• Acquire lateral lining equipment and staff, train • Perform in-house service lateral CCTV inspection and lining • Perform in-house manhole lid liner and service lateral cleanout plug installation	• Annual data review and engineering analysis • Collect & analyze flow data • Re-prioritize future I/I projects • Priority 2 and 3 smoke testing • Priority 2 and 3 mobile flow testing	• Step up sewer rehabs to 80% • Priority 2 and 3 sewer basin rehabs
2020-2035	• Re-evaluate and re-prioritize • Address private-side laterals	• Re-evaluate and re-prioritize	• Continue Priority 1, 2 and 3 rehabs

4.6 Predicted I/I Reduction

A significant number I/I projects have been analyzed by researchers, hence, there is a robust knowledge base upon which to make reliable predictive estimates of I/I reduction levels achieved from different intensities of untargeted system rehabilitation. The following prediction was based on data published by Carne (2013) summarizing the percentage of public system rehabilitated vs maximum reduction in RDI/I. The predicted reduction was adjusted to better represent I/I conditions in Florida and is presented below in **Table WW4-3**. Of particular interest is the conclusion that unless at least 40% of the total piped system within a sewer basin is rehabilitated, there is no guarantee of reducing RDI/I significantly.

Table WW4-3. I/I Reduction vs. Total System Rehabilitation

% of Total Public System Rehabilitated	Maximum Reduction in RDI/I (%)	Reduction in BI (%)
100	50	Up to 70
80	30	Up to 60
60	15	Up to 40
40	0	Up to 20

Based on the estimated reduction ratios and total sewer basin I/I flows, the predicted I/I reduction of each sewer basin is calculated and presented in **Appendix WW-4.1** for the various levels of rehabilitation. **Table WW4-4** shows the predicted reduction of RDI/I at different levels of rehabilitation of the Priority 1- 4 sewer basins.

Table WW4-4. Predicted I/I Reduction in Priority Areas

Prioritization	Total I/I Reduction (mgd)		
	60% Rehab.	80% Rehab.	100% Rehab.
1	3.99	6.42	8.34
2	1.12	1.85	2.52
3	0.92	1.51	2.01
4	0.18	0.33	0.50
Total	**6.22**	**10.11**	**13.38**

4.7 Cost/Savings Estimate

The field work cost estimate is performed based on empirical construction unit cost ($/foot) and gravity pipe length in each sewer basin, which is calculated in GIS. The following unit costs used in this estimate and the estimated cost for rehabilitating each prioritized sewer basin is listed below as shown in **Table WW4-5** and **Table WW4-6**.

Table WW4-5. Rehabilitation Unit Cost

Item	Cost	Unit
Lining	$35 - $100	/ft.
Gravity Main CCTV	$4.50	/ft.
Service Lateral CCTV	$270.00	Each
Cleanout Plugs	$70.00	Each
Storm Water Disconnection	$10,000.00	Each
Manhole Lid Liner	$90.00	Each
Manhole Chimney Seal	$400.00	Each
Manhole Rehab	$2,000.00	Each
Flow Test (dry & wet)	$600.00	Each
Contractor Repair Service Lateral (per pipe)	$4,000.00	Each
City Repair Service Lateral In-house (per pipe)	$2,500.00	Each
Smoke Test	$0.55	/ft.
Engineering Analysis	$0.20	/ft.
Point Repair and Excavation	$10,000.00	Each

Table WW4-6. Estimated Rehabilitation Cost

Prioriti-zation	Estimated Cost			
	Engineering Service	Total City Self-perform	Total Contractor	Total (Eng. In-house, Contractor)
1	$ 1,406,255	$31,092,605	$20,237,769	$52,736,628
2	$ 1,365,517	$41,265,833	$19,015,624	$61,646,974
3	$ 756,628	$15,365,652	$10,667,845	$26,790,124
4	$ 700,048	$16,805,697	$9,614,730	$27,120,476
Total	**$ 4,228,447**	**$104,529,787**	**$59,535,968**	**$168,294,202**

1. Engineering service includes data analysis, re-prioritization, smoke test, control plan update, rehabilitation projects effectiveness evaluation, etc.
2. City self-perform projects include service lateral CCTV inspection, service lateral lining, install manhole lid liners and cleanout plug installation
3. Contractor projects include storm water disconnection, gravity main CCTV inspection, gravity main lining, manhole rehabilitation, etc.
4. The CUSMP Team assumed 10 point repairs per basin; 20% of service laterals need point repair
5. The CUSMP Team added 10% program management cost and 25% contingency to the estimated project cost

The cost of lining each service lateral is estimated to be $2,500 if the City performs it with in-house labor. The cost for contractor service lateral replacement is $3,500 to $5,000 each. There are 14,019 connections in the Priority 1 & 2 areas according to the water billing database. The cost of CCTV service lateral inspection in Priority 1 & 2 areas is $3,785,130. The service lateral CCTV inspection program pays for itself as long as it identifies 1,515 laterals or more are in satisfactory operating condition and do not need immediate rehabilitation. It is noted that

"Orangeburg" pipe material laterals should be targeted initially. The total rehabilitation cost can be reduced if the City chooses to purchase equipment and self-perform service lateral CCTV inspection and lining in-house. It should be mentioned that self-performance of CCTV inspection and lining in-house requires staff, training, equipment, materials, and a learning curve to become cost effective. It would require a dedicated I/I team to perform this effort and the City would have to commit to make this happen financially and physically.

Based on predicted I/I reduction mentioned above and empirical operation and maintenance cost (treatment per 1000 gallon: $1.80 and pumping per 1000 gallon: $0.08), the following savings are estimated and presented in **Table WW4-7.**

Table WW4-7. Estimated Savings due to I/I Reduction

Items	Savings		
	60% Rehab.	80% Rehab.	100% Rehab.
Estimated Savings due to Predicted I/I Reduction			
• RDII Reduction (mgd)	6.22	10.11	13.38
• Cost per treated 1000 gallon	$ 1.80	$ 1.80	$ 1.80
• Cost per pumped 1000 gallon	$ 0.08	$ 0.08	$ 0.08
• Treatment Savings per Year	$ 4,084,000	$ 6,645,000	$ 8,790,000
• Pumping Savings per Year	$ 179,000	$ 290,000	$ 384,000
Total Savings Per Year	$ 4,262,000	$ 6,934,000	$ 9,173,000
• Priority 1 Subtotal	$ 2,738,000	$ 4,400,000	$ 5,719,000
• Priority 2 Subtotal	$ 767,000	$ 1,272,000	$ 1,729,000
• Priority 3 Subtotal	$ 606,000	$ 992,000	$ 1,324,000
• Priority 4 Subtotal	$ 126,000	$ 228,000	$ 345,000
Estimated I/I Control Field Work Cost (Non-R&R)			
Total Non-R&R Cost Per Year	$20,050,000		
• Priority 1 Subtotal	$6,454,000		
• Priority 2 Subtotal	$6,914,000		
• Priority 3 Subtotal	$3,393,000		
• Priority 4 Subtotal	$3,291,000		

1. Treatment cost $1.80/1000 gallon is provided by City staff.
2. Pump energy cost $0.08/1000 gallon is calculated based on the following assumption: average 90 feet head, 90% motor efficiency, 40% pump efficiency, $0.10/kwh energy cost.
3. Treatment savings = treatment cost/1000 gal * gallons of I/I reduced; Pumping savings = pumping cost/1000 gal * gallons of I/I reduced.
4. Cost includes all inspection, testing and engineering analysis, exclusive of R&R cost such as lining.

Based on the cost and saving analysis performed, the payback period is presented below in **Table WW4-8** (based on the assumption of 80% rehabilitation). It should be noted that most of the I/I improvements are categorized as R&R needs as much of the collection system has reached the end of its service life. Therefore, the payback period would be much shorter considering only I/I targeting efforts.

Table WW4-8. Payback Period

Prioritization	Payback Period[1,2,3] (years)
1	0.58
2	2.16
3	1.32
4	5.73

1. The payback period is calculated by dividing the non-R&R cost (only inspection and engineering analysis cost) by the annual savings.
2. Non-R&R cost is used in this estimate to reflect the effectiveness of investment made only to reduce I/I.
3. The CUSMP Team took the cost of adding a deep injection well ($10,525,000) into consideration as annual savings. Because the reduction of I/I flow can help the City avoid the need for an additional deep injection well as indicated in **Section WW8**.

4.8 Capital Improvement Projects

According to the analysis shown above, a list of CIP projects was prepared and presented in **Section WW9**. Currently, the City is spending approximately $3,000,000 every year on I/I reduction. The CUSMP Team recommends the City to raise the annual I/I budget to approximately $5,000,000-$6,000,000 to achieve significant I/I reduction.

4.9 Reference

1. Ann-Marie Gustafsson, Lars-Goran Gustafsson, Stefan Ahlman, etc., Modeling Rainfall Dependent Infiltration and Inflow (RDII) in a separate sewer system in Huddinge, Stockholm
2. Paul S. Mitchell, Patrick L. Stevens, and Adam Nazaroff, Quantifying base infiltration in sewers – A Comparison of Methods and a Simple Empirical Solution, 2007. Link: http://www.adsenv.com/sites/adsenv.com/files/repository/white%20papers/wef_determining%20base%20infiltration%20in%20sewers%20wef%20coll%202007final.pdf (Last accessed 1/5/2016)
3. The New Zealand Water & Wastes Association, Infiltration & Inflow Control Manual Volume I - Overview, Background, Theory, 2nd Edition, March 2015
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5. Steve Carne, Cost-effective and Reliable Inflow-Infiltration Reduction - Have They Got It Right Down-Under?, 2013
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8. Strand Associates, Inc., Report for Sanitation District No.1 of Northern, Kentucky – Inflow and Infiltration from Private Property.
9. Water Environment Federation and American Society of Civil Engineers. 1994. *Existing Sewer Evaluation & Rehabilitation*, WEF Manual of Practice FD-6. Alexandria, VA.
10. Metropolitan Council Environmental Services, Inflow/Infiltration Task Force Report, May 2004.
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WW5 I/I Monitoring

5.1 Background

Due to the age of the wastewater collection system and the high elevations of the water table in the City of Fort Lauderdale (City), infiltration and inflow (I/I) are major contributors of wastewater influent flows to the City's George T. Lohmeyer Wastewater Treatment Plant (GTL). As estimated in **Section WW4**, approximately 50-60% of GTL's influent flows are I/I. Reducing I/I reduces collection system pumping costs as well as treatment system and maintenance costs. The City is currently spending approximately $5,000,000 every year to rehabilitate collection system components to mitigate I/I flow based on recommendations in the City's Sustainability Action Plan (2011). In order to determine the effectiveness of the rehabilitation efforts, it is imperative to implement practical methods that quantitatively evaluate any reductions of I/I achieved. Furthermore, monitoring I/I fluctuations can also differentiate the effectiveness of the various types of rehabilitation and provide direction for future project prioritization. The purpose of this section is to review available technologies used to monitor pump station flows and to recommend a method to quantify reductions in I/I flow at pump stations.

5.2 Existing Flow Measurement Technologies

5.2.1 Pressure Flow

Pressure flow monitoring is permanent and is preferable for systems that utilize pump stations and force mains to collect and transmit flow. The two (2) most common methods of measuring pressure flows for wastewater-pumping systems are magnetic flow meters (mag meters) and Doppler type ultrasonic flow meters. The installation requirements of both types of flow meters make retrofitting existing pump systems with flow meters difficult. Based on current research, experience, and the number of municipal WWTPs and pump stations using them, mag meters are proven to be the most accurate/suitable for use in raw domestic wastewater.

A magnetic flow meter or mag meter requires a minimum of five (5) pipe diameters upstream and three (3) pipe diameters downstream-unobstructed straight runs of piping to maintain proper accuracy. In most cases, existing collection system wastewater pump stations (WWPSs) do not have sufficient room between the station valve vault and the edge of pavement to install mag meters either in a vault or above ground. Meters require vaults and installing vaults in the paved streets are to be avoided. Re-piping the entire pump station with the pump discharge piping aboveground can provide adequate room for installation of a mag meter. However, re-piping is usually impractical. Additionally, full pipe flow is required to avoid erroneous data and air entrapment is a cause of erroneous flow data for mag meters.

A Doppler type ultrasonic flow meter requires in excess of ten (10) pipe diameters upstream and five (5) diameters downstream which makes retrofitting WWPSs even more difficult with these types of meters.

The City desires to use telemetry and SCADA data to collect and present flow data, which can avoid the high cost of gravity sewer flow monitoring through subcontractors.

5.2.2 Gravity Flow

Gravity flow monitoring deploys portable meters on a temporary basis (3 to 6 months) due to high maintenance and solids associated with wastewater, and are used on systems that have extensive large diameter piping or for specific investigations on smaller gravity piping. Gravity flow monitoring includes area velocity technology meters located via stainless steel bands inside gravity piping at manhole connections and more recently by Doppler technology located in the manhole above the flow level. The Doppler technology cannot handle surcharged conditions and requires a straight run of pipe through the manhole (one in, one out). Gravity flow meters require confined space entry certification to install and maintain, requiring visits weekly to clean and inspect. Collected gravity flow data transmits via cloud web-based protocol to be analyzed and archived. The City has performed gravity flow monitoring in the past to check the results of gravity system rehabilitation; results were questionable based on the limited rainfall intensity experienced during the limited run. Single locations can cost $5,000 to $10,000 per month to lease not including installation. An alternative to fixed locations is a mobile flow monitoring device that is deployed during and shortly after rainfall events to help pinpoint I/I within a gravity collection system.

5.3 Innovative Flow Monitoring Technologies

5.3.1 Inflow Computation

Inflow computation is a method of calculating the inflow of a WWPS volumetrically. This method of calculating inflows utilizes data collected at the pump stations such as water levels, discharge pressures, and pump runtimes to calculate the amount of inflow to the stations on a daily basis. For example, the practice of a tape measure and a stopwatch is widely used to check the pump output. The inflow is calculated similarly using the rising level in the wet well of the pump station. Level and time measurements should be conducted over numerous pumping and filling cycles to reduce effects of inflow variances.

Inflow is computed on a system-wide basis using programming, or an individual module installed at each pump station, which calculates inflow and then relays the results to the main SCADA system for display and analysis by operators.

Vendors such as BCI Technologies (BCI) can provide a program to compute lift station inflows via computational algorithms. The program can also use rainfall data from National Oceanic and Atmospheric Administration (NOAA) for I/I analysis, by downloading the NOAA database and transferring onto the SCADA server. The Florida Department of Environmental Protection has accepted computational algorithms based on wetwell level changes for flow monitoring. Any vendor such as BCI is required to confirm the accuracy of the calculation results for constant speed pump stations. Additionally, computing inflows for stations with variable frequency drives (VFDs) controlling pump speeds is required. There are vendors such as Specific Energy and Maid Labs Technologies with these capabilities, selection of a vendor could include a pilot test to verify the accuracy of the calculation for constant speed pump stations and VFD stations.

Maid Labs Technologies (MaidLab) has a pump station monitoring system that can calculate WWPS inflows, including for VFD stations, based on field data with a verified accuracy of 97.5%. MaidLab's system includes Mermaid - the monitoring program, and Volucalc RT - the flow-measuring instrument. Please see **Appendix WW5-1** for the cut sheet of Volucalc RT. Volucalc RT installed on control panels utilizing existing control components. Volucalc RT has an algorithm written to compute pump station flows. The algorithm can process real time data, such as level, pump speed, distribution pressure and pump current, to calculate inflow at pump stations where Volucalc RT is installed and transmit with a 4 – 20 mA analog output. Volucalc RT can be connected to the system through Ethernet. MaidLab indicated that a field calibration needs to be performed to verify and optimize the accuracy of calculated results. REI interviewed the utility departments at the City of Lakeland and Martin County who have both used the system since 2013 and both entities indicated good reliability and accuracy of the product.

Section WW5 accepted December 16, 2016.

5.4 Alternative Analysis

As presented in the I/I Control Plan in **Section WW.4**, the CUS Master Plan Team recommends the City install permanent flow monitoring technology at all significant pump stations, perform salinity monitoring spot checks at stations during low rainfall conditions and perform localized gravity flow monitoring at key locations within key pump station basins as needed. Pump station basin flows will provide the granularity to assess basin rehabilitation efforts and limited salinity and gravity flow monitoring will provide information to help the I/I engineering team pinpoint highly deficient areas for rehab and private lateral targeting. This alternatives analysis focuses on the permanent pump station flow monitoring.

Salinity (equivalent to chloride level or conductivity) monitoring can help identify stations that have high salinity groundwater entering the wastewater collection system. According **Section WW.13**, wastewater entering GTL has a total dissolved solids (TDS) of approximately 1,100 mg/L while a typical TDS range for untreated domestic wastewater is 250-850 mg/L (Metcalf and Eddy, 5th Edition, 2013). The City can use either salinity probes or manual sampling and testing methods in pump stations east of the saltwater barrier to obtain salinity data. Stations with a salinity level above a pre-determined value can be identified as high I/I stations due to saltwater entry. The City can also compare the average salinity level at GTL and salinity level during rainfall events to quantitatively understand the impact of inflow on the salinity level.

While installing mag meters to measure pump station flows provides the most accurate data, installing flow meters on all one hundred and eighty-six (186) pump stations was not considered an option based on the high cost per station. Installing the computational algorithm software, such as BCI, and programming to calculate pump station flows based on wet well level data from SCADA is an option. However, further investigation needs to be performed to ensure that available programs can provide flows for VFD stations.

The City currently has six (6) stations with VFD driven pumps, besides the re-pump stations. Installing VFDs and programming to control wastewater pump motor speeds to operate based on maximizing the usage of the wet well volumes (to equalize/reduce peak flows) can reduce energy costs for not only the pump stations but also for the GTL treatment facility. Reductions in flow and reduced motor speeds equate directly to energy savings. For systems with static head, the maximum flow rate is right of the best efficiency point. **Section WW16** recommends thirty-one (31) high energy using pump stations have the pump starters replaced with VFDs. This equates to a total of thirty-seven (37) VFD stations which will need other technology to be employed to calculate flows for these pump stations if the BCI programming is used.

The CUS Master Plan Team identified five (5) alternatives for monitoring WWPS inflows as follows:

1. Use BCI's or a similar vendor's program for all pump stations. This would involve purchasing software and programming it on all the pump stations. Additionally, a pilot test is necessary for the selected vendor to demonstrate the accuracy of calculation results of their program on both fixed speed pump stations and VFD stations.

2. Use BCI's or a similar vendor's program for pump stations with constant speed pumps and install mag meters on the thirty-seven (37) VFD stations. This would involve piping modifications and potentially above ground infrastructure, which would likely result in neighbor complaints.

3. Use BCI's or a similar vendor's program for pump stations with constant speed pumps and install Volucalc RT or similar vendor units at the VFD stations to calculate flow. This would involve adding the instrument either within the existing control cabinet or in a separate panel adjacent to the control cabinet, connecting existing instrument signals to the unit and connecting the unit output to the existing PLC. Pressure transducers would need to be added to the pump discharge piping with the signals going to both the PLC and the Volucalc unit since the Volucalc unit must have the discharge pressure input to calculate flows for the VFD stations. Amperage monitors can also be added to the control system for alarming of low pump output conditions.

4. Install Volucalc RT or similar vendor units at all pump stations. This would involve adding the instrument to thirty-seven (37) VFD stations, either within the existing control cabinet or in a separate panel adjacent to the control cabinet, connecting existing instrument signals to the unit and connecting the unit output to the existing PLC. Pressure transducers would need to be added to the pump discharge piping with the signals going to both the PLC and the Volucalc unit since the Volucalc unit must have the discharge pressure input to calculate flows for the VFD stations. Amperage monitors can also be added to the control system for alarming of low pump output conditions.

5. Continue to install City's flow computation algorithm in the pump stations.

Table WW5-1 below provides a comparison of the estimated costs, advantages and disadvantages for the alternatives.

Table WW5-1. Alternative Summary

No.	Alternative	Estimated Project Cost	Advantages	Disadvantages
1	BCI program for all stations	$75,000[1]	• Minimal cost • No construction at pump stations required	• BCI program's accuracy uncertain • BCI program's ability for VFD stations uncertain
2	BCI program for constant speed pumps+ Mag meters on 37 VFD stations	$ 7,265,000[2]	• Highest accuracy • Proven VFD station accuracy	• Highest cost • BCI program's accuracy uncertain • Requires piping construction
3	BCI program for constant speed pumps+ Volucalc RT on 37 VFD stations	$ 1,782,000[3]	• Minimum construction necessary	• BCI program's accuracy uncertain • RTU upgrades may be necessary
4	Volucalc RT units on all stations	$ 4,056,000[4]	• Proven technology • Proven accuracy	• I/O capacity uncertain • Cost relatively high
5	Continue to install City's flow computation algorithm in the pump stations	$ 0[5]	• Lowest cost • No construction at pump stations required	• Algorithm is not as accurate without BCI analyst software • Losing accuracy not installing Mag meters or Volucalc RT units

[1] The cost of BCI's program is $50,000. A 50% contingency is included due to the uncertainty of this alternative. The cost does not include programming provided by the City. The cost also does not include installing pressure transducers at the VFD stations.

[2] The cost of BCI's program is $50,000 and the estimated cost of re-piping and installation of a mag meter at a pump station is $125,000. The total cost includes contingency of 30% of the construction cost (excluding the program cost) and 20% non-construction costs.

[3] Based on an estimated cost of $30,000 per station including installation of pressure transducers and current monitors. Includes 30% contingency of construction costs and 20% non-construction costs. It is anticipated that the control panels are adequate to install Volucalc RT.

[4] Based on an estimated cost of $30,000 per station for 37 VFD stations including installation of pressure transducers and current monitors and $10,000 per station for the remaining 149 stations. Includes 30% contingency of construction costs and 20% non-construction costs. It is anticipated that the control panels are adequate to install Volucalc RT.

[5] Assuming the City has already purchased the flow computation algorithm license, and would not incur any additional expenses.

5.5 Conclusion and Recommendations

The CUS Master Plan Team recommends the City install permanent flow monitoring technology at all significant pump stations, perform salinity monitoring spot checks at stations during low rainfall conditions and perform localized gravity flow monitoring at key locations within key pump station basins as needed. Pump station basin flows, measured at the pump stations, will provide the granularity to assess basin rehabilitation efforts and limited salinity and gravity flow monitoring will provide information to help the I/I engineering team pinpoint highly deficient areas for rehab and private lateral targeting. Although not a flow measuring method, salinity monitoring helps identify saline groundwater entries into the wastewater system. One available method for gathering wastewater salinity data, as well as flow data, is to install portable temporary monitors within prioritized sewer basins. **Section WW4** recommends limited gravity flow monitoring for prioritized sewer basins to further prioritize I/I mitigation efforts within pump station basins.

As for flow monitoring, Alternative 1 is potentially the most cost efficient and easy-to-implement option. However, the ability of BCI's program to calculate inflow at VFD stations is uncertain. The CUSMP team recommends the City invite BCI to perform a field demonstration to verify the accuracy of their program; and invite MaidLab to verify the accuracy of Volucalc RT's flow data. Alternative 3 is recommended to the City if both BCI's program and MaidLab's Volucalc RT are validated in the field demonstration. See **Section WW9** for Community Investment Plan (CIP) projects with Alternative 3 budgeted. An additional recommendation is for the City to invite BCI to perform a pilot test to verify that their program can accurately calculate inflow at VFD stations.

5.6 Reference

1. U.S. Environmental Protection Agency Science and Ecosystem Support Division, Wastewater Flow Measurement, Athens, Georgia, August 12, 2011.
2. Matthew Cooper, Limitations of Inflow Computation from Pump Station Data – A Monitoring/Modeling Approach
3. Metcalf and Eddy, Inc. 2013. Wastewater Engineering: Treatment and Resource Recovery, 5th Edition (New York: McGraw-Hill).

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Appendix WW5-A

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VOLUCALC™ RT

THE FLOW SOLUTION FOR LIFT STATIONS WITH VARIABLE SPEED OR CONSTANT SPEED PUMPS

MONITOR

FLOW METER

EFFICIENCY BASED CONTROLER

BACKUP CONTROLER

ABNORMAL BEHAVIOR DETECTOR

RTU

LIFT STATION BRAIN

DIN Rail brackets


Front panel door bracket

Watertight enclosure for Volucalc, cellular or WiFi modem, battery backup and connection area

944 André-Liné, Granby, QC, Canada, J2J 1E2
T: 450-375-2144 **Toll-free**: 1-855-875-2144

Maid Labs TECHNOLOGIES

Specifications may change without notice
WWW.MAIDLABS.COM

	 5.7 in/14.5 cm 2.19 in/5.55 cm Bottom	 5.7 in/14.5 cm 2.19 in/5.55 cm Top	 3.94 in/10 cm 2.19 in/5.55 cm Right

Name and Item No.	Volucalc RT MLRT
Product type	Real time volumetric flow meter, Open channel flow meter and derived flow, efficiency based pump controller and auto calibrated variable speed pump flow meter.
Types of recorded and displayed data (always time stamped)	Flow, level, pump capacity, run time, number of starts, abnormal behaviours, time and volume of overflow, annual operational cost in $.
Volumetric flow accuracy (normal operation)	± 1.5 % for most lift station with inlet above pump operating levels. RT allows calculating flow with a partially submerged inlet.
Open channel flow accuracy	Based on level sensor specifications and flow equation used. Available formulas: Manning, California pipe, Rectangular weir with end contractions, Rectangular weir without end contractions, V-notch (or triangular) weir and Trapezoidal (or Cipolletti) weir or use a standard or polynomial flow formula or a lookup table.
MaidMaps functions	Email, SMS, geographic map displays pump operation
Digital inputs	1, 1 Hz
Analog inputs	6 Total: 4x Pump current, 4-20mA, 0-5v, 0-10v, 0-24v and 2x 4-20mA, 0-5v, 0-10v, 0-24v mostly used for level and pressure.
Reading speed of analog input	40 Hz with average every second.
Analog input accuracy	± 0.1 %.

Outputs	6 x digital, activated based on alarm setup or remotely activated with MaidMaps, 1 x 4-20mA output self-powered.
Alarms detected and displayed Action taken when alarms: Relay activation. With MaidMaps: email, SMS, colour changes on geographic map	Level, extreme flow, Hydraulic (high variation in pump capacity), Energy (high variation in electricity consumption), Efficiency (high variation in volume pumped per watt used), Alternation (pumps not alternating normally), ON and OFF times (pumps start or stop for very short period), Operating time (high variation not caused by inflow), Number of starts per day has changed, Level related anomalies, Improbability in results (e.g. water level falls while pumps are not in operation).
Internal temperature sensor accuracy	± 3°C
Memory	2 Gb
Memory	200 Million records
Power supply	12 VDC 1 AMP (included), 12v battery backup (not included)
Integrated Battery Charger	For 12v lead acid battery (MLBATRECH12V)
Communication Interface	USB drive and Ethernet
Display	Backlit graphic 128 x 64
Keyboard	4 soft keys
Dimension inches (cm)	5.7 x 3.9 x 2.14 (14.5) x (9.9) x (5.5)
Weight	0.5 lb/0.22 kg
Accessories	Current sensor, pressure sensor, level sensor, Wi-Fi adaptor, cellular modem, Free MaidMaps geographic web server, MerMaid
Warranty	3 years, parts and labor

Volucalc™ RT

MLRT

The best wastewater pump station monitoring solution for up to 4 pumps.

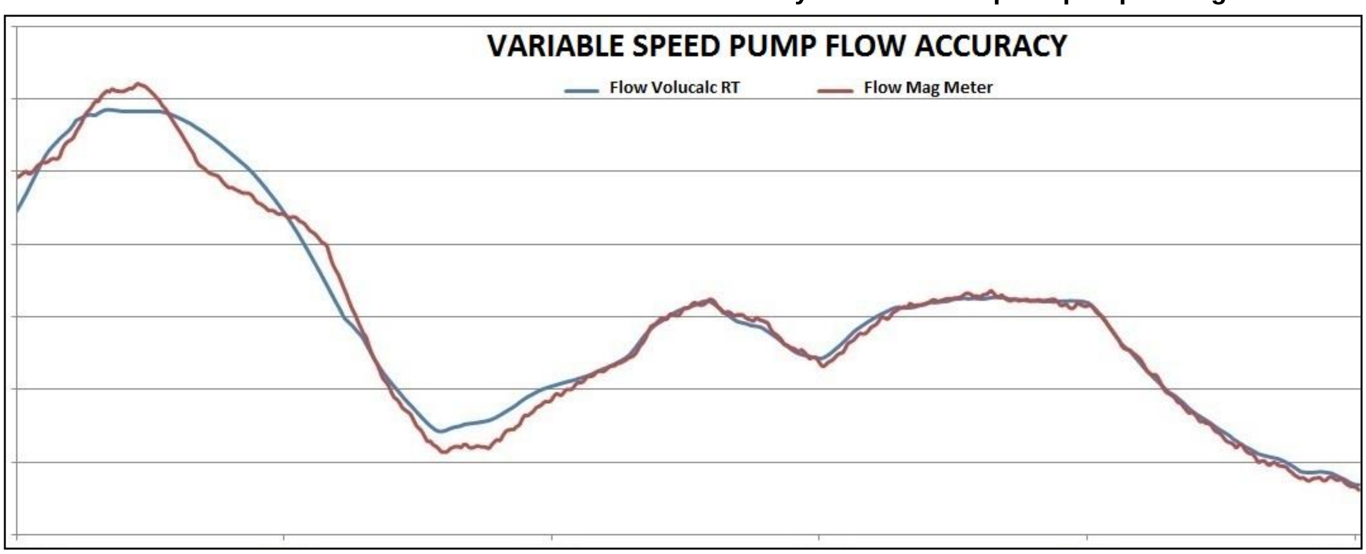
Constant speed pumps

- Uses the most advanced volumetric flow algorithm ever patented to calculate the flow in and out of lift stations with 99% accuracy.
- Calculates the capacity and efficiency (Gallons/Watt) of each pump.
- Uses 4 relay outputs to indicate to the PLC/RTU which pump should be operating next in order to minimize the operational cost of the station while maximizing the pumps' life span.
- Real Time influent flow (analog level sensor required). Real Time flow is calculated every 30 seconds or when the level rises or falls of 3 inches, whatever comes first.
- 4-20mA analog output proportional to flow.
- Detects abnormal pump capacity, efficiency, run time, stop time and sequence of operation and generate alarms on the display and remotely. The free MaidMaps Scada software (or users software) required for remote monitoring.
- Easy installation: connect one current clamp per pump and optional analog level sensor (for real time flow).
- Constant speed pump curves automatically calibrated and used when abnormal level or head conditions occur.
- If no analog level input is available, flow will be calculated at each pump cycle.
- When set as Control Backup and connected to an analog level, if a user set high level is reached without any pump running, the Volucalc will enter control mode in which it closes and opens its pump relays replicating the way the station normally operate.
- Optional Maid Labs MerMaid lift station analysis software compatibility.

Variable speed pumps

- The Volucalc RT integrates up to 4 pump curves with multiple RPM for each to derive pumped flow and calculate inflow rate.
- Uses calibrated pump curves, level and force main pressure to extract the pumps' flow rate and adjust its 4-20mA analog output proportionally.
- In lift stations with 3 pumps or less, Volucalc RT uses the pumps' efficiency to detect abnormal flow rate, like a clogged pump, and generate an alarm indicating that the pump curves cannot be thrusted.
- Pump's RPM comes from VFDs analog outputs.

The following graph compares the accuracy of a properly calibrated Volucalc RT to a Mag Meter in a pump station having variable speed pumps. The accuracy for constant speed pumps is higher!



Common to all stations

- HTML file format reports, which can be opened in a Web browser or exported to Excel. The report to the right was downloaded this way and was not formatted.
- Fits any control panel: small compact flow meter measuring 6 x 4 x 2.2 inches.
- Integrated open channel flow formulas to calculate volume lost in SSO events.
- Abnormal event detection with relay output:
  - Many anomalies are based on compiled history comparison
  - Hydraulic (high variation in pump capacity)
  - Energy (high variation in electrical consumption)
  - Efficiency (high variation in volume pumped per watt usage)
  - Alternation (pumps not alternating normally)
  - ON & OFF times (short pump start or stops)
  - Operating time (high variation not caused by inflow)
  - Level related anomalies
  - Improbability in results (e.g. water level falls while pumps are not in operation)
- Internal battery charger for external battery to keep the level sensor and communication equipment powered during power failure.
- Optional Remote Web monitoring, alarms, data download via our free scada software MaidMaps.
- Communication options: Cellular modem, WiFi Modem, Telephone land line modem, Spread Spectrum Radio, Direct connect to Internet
- TCP/IP MODBUS: Volumes, flow, capacities, efficiencies, starts, run times and all alarms can be reported in real time or totalized since last access.
- Display: Inflow, Outflow, Volume, Run time, Starts, Efficiency (G/watt), Energy consumption, Abnormal conditions, Cost of operation ($/year) and many more.

Monthly report as downloaded to a USB drive

Date	Station						In					
	Energy Efficiency	Efficiency Lost	Wasted GHG	Use of Station	Maximum Level	Rain	Total Volume	Average Inflow	Minimum		Maximum	
									Flow	Hour	Flow	Hour
Unit:	G/Wh	kWh	kg	%	Ft	Inch	G	GPM	GPM	hh:mm:ss	GPM	hh:mm:ss
1	1.53	64.04	N/A	31.14	6.86	0.11	804686	558.9	326.0	0:26:03	1265.8	12:33:03
2	1.56	102.48	N/A	30.63	6.76	0	778256	540.5	263.1	5:13:53	1776.5	0:12:55
3	1.54	88.76	N/A	29.41	6.73	0	744321	516.9	257.9	5:01:57	2340.1	0:15:37
4	1.53	64.52	N/A	37.49	6.99	0.24	936436	350.3	253.8	6:40:11	2329.4	0:15:32
5	1.59	87.42	N/A	37.02	6.86	0.19	[illegible]				[illegible]	0:13:03
[illegible]	1.60	218.22	N/A	33.97			N/A	N/A	N/A	N/A	N/A	
31					N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Totals & Averages	1.5	1534.52	0	28.94	2.13	0.62	13278957	495.6	118.1	1/18/15 3:21	2808.0	1/5/15 0:13

Date	Pump 1						
	Starts	Runtime including combinations	Runtime	Average Current	Volume	Efficiency	Capacity
Unit:		hh:mm:ss	hh:mm:ss	A	G	G/Wh	GPM
1	86	5:51:43	5:49:02	24.37	436184	1.71	1249.6
2	86	5:46:18	5:43:00	23.88	436230	1.78	1271.8
3	82	5:27:58	5:16:33	24.17	401661	1.75	1268.8
4	73	6:50:24	6:27:52	24.7	491112	1.71	1266.1
5	88	6:13:21	6:01:32	[illegible]			[illegible]
[illegible]	85	6:03:04		N/A	N/A	N/A	N/A
31			N/A	N/A	N/A	N/A	N/A
Totals & Averages	1482	94:08:05	93:04:47	24.59	7414164	1.80	1327.8

Date	Pump 2						
	Starts	Runtime including combinations	Runtime	Average Current	Volume	Efficiency	Capacity
Unit:		hh:mm:ss	hh:mm:ss	A	G	G/Wh	GPM
1	86	5:53:53	5:51:12	24.03	442133	1.75	1259.0
2	84	5:42:08	5:38:50	24.09	420459	1.72	1240.9
3	81	5:41:20	5:29:55	23.99	407454	1.72	1235.1
4	73	7:18:18	6:55:46	24.19	511529	1.70	1230.3
5	86	6:56:02	6:44:13	[illegible]			[illegible]
[illegible]	84	6:06:53		N/A	N/A	N/A	N/A
31			N/A	N/A	N/A	N/A	N/A
Totals & Averages	1476	98:59:11	97:55:53	25.16	7517397	1.70	1279.9

Date	Pumps 1 and 2					
	Starts	Runtime	Average Current	Volume	Efficiency	Capacity
Unit:		hh:mm:ss	A	G	G/Wh	GPM
1	1	0:02:41	43.71	0	0	0
2	1	0:03:18	31.80	6190	1.97	1875.9
3	1	0:11:25	32.97	21416	1.90	1875.9
4	4	0:22:32	39.19	41535	1.57	1843.2
5	1	0:11:49	43.22			[illegible]
[illegible]	1	[illegible]		N/A	N/A	N/A
			N/A	N/A	N/A	N/A
Totals & Averages	9	1:03:18	33.74	416020.5	1.90	1816.7

Alarms And Suspicious Events					
Name	From	To	Duration	Threshold	Other Information
Abnormal sequence	1/18/15 3:21	1/18/15 3:46	0:24:39	N / A	Multiple Pump 1 starts in a row

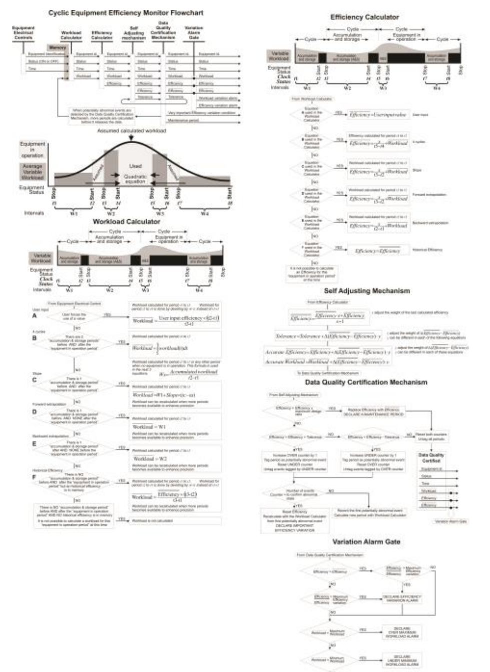
VOLUCALC RT uses the most advanced derived flow and volumetric flow algorithms ever patented.

The algorithm, showed to the right, is used every time a flow calculation is performed for constant speed pumps, with analog level sensor or not.

A calibrated mag meter is the only other technology as accurate, but only when pumps are in operation and you won't get inflow, power consumption, efficiency or any abnormal behavior detection from a mag meter.

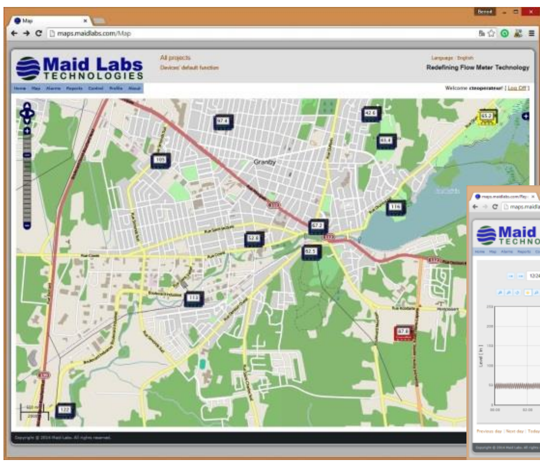
When variable speed pumps are used, the accuracy is as high as the quality of the calibration performed. Pump curves must be readjusted to the reality of the station where the pumps are installed. In duplex and triplex variable speed pumps stations, Volucalc uses the efficiency of a pump to determine when that pump curve cannot be trusted anymore.

Each time a volumetric flow is computed, this algorithm is an element used to calculate the most accurate flow possible for the data available. It is available on request, but it is only one element of the solution.



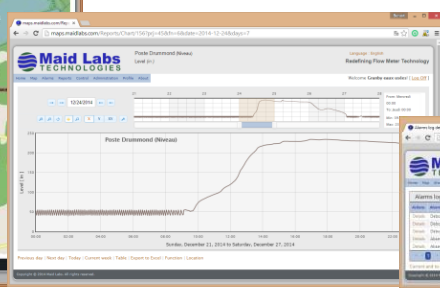
FREE MaidMaps SCADA

You need to know what is going on in real time in your collection system but you don't want to get stuck paying monthly or yearly charges. You want an easy flexible system. The free MaidMaps SCADA software is the solution, on your WEB server or ours.

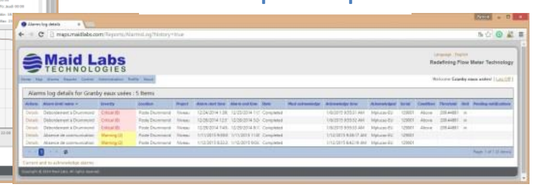


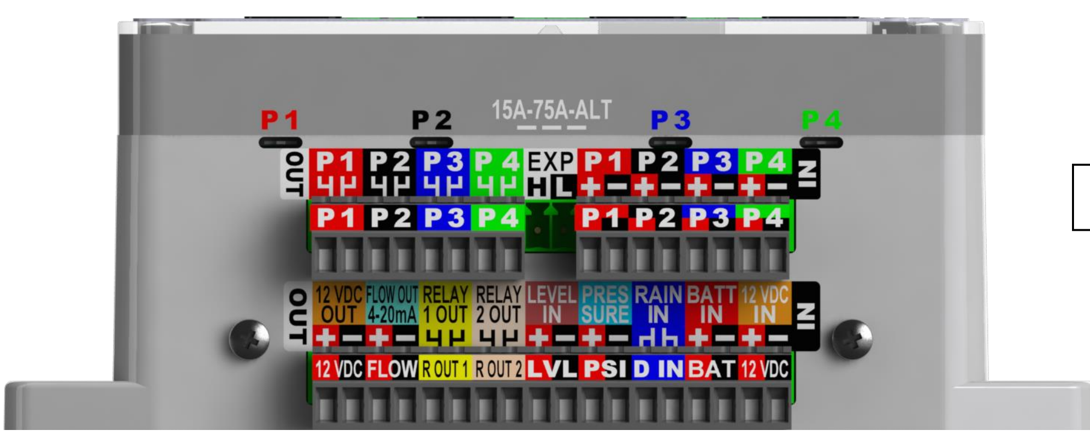
Map with possibility of adding streets

Graphs and Excel Tables



Alarm Setup and Reports





REAL SIZE

944 André-Liné, Granby, QC, Canada, J2J 1E2
T: 450-375-2144 **Toll-free**: 1-855-875-2144

Maid Labs TECHNOLOGIES

Specifications may change without notice
WWW.MAIDLABS.COM

SELECT WHAT YOU NEED

(circle the items that you want us to quote on with the quantity)

Number of pumps	Pumps Constant / Variable	Current sensors required	Specify
1	Constant	1	Pump size (HP) or current per leg
2	Constant	2	Pump size (HP) or current per leg for each pump if not same
3	Constant	3	Pump size (HP) or current per leg for each pump if not same
4	Constant	4	Pump size (HP) or current per leg for each pump if not same
1	Variable	1	Pump size (HP) or current per leg
2	Variable	2	Pump size (HP) or current per leg for each pump if not same
3	Variable	1	Pump size (HP) or current per leg for each pump if not same
4	Variable	0	No input available to record current
1 constant, 1 variable	Mix	2	Pump size (HP) or current per leg for each pump if not same
1 constant, 2 variable	Mix	2	Pump size (HP) or current per leg for each pump if not same. A current sensor will be used for both variable speed pumps at the same time.
1 constant, 3 variable	Mix	1	Pump size (HP) or current per leg for constant speed pumps. No input available to record current for variable speed pumps
2 constant, 1 variable	Mix	3	Pump size (HP) or current per leg for each pump if not same
2 constant, 2 variable	Mix	2	Pump size (HP) or current per leg for constant speed pumps. No input available to record current for variable speed pumps
3 constant, 1 variable	Mix	3	Pump size (HP) or current per leg for constant speed pumps. No input available to record current for variable speed pumps

Current sensors (select size and quantity for each pump station)			
Pump size or better, current of one leg	**Part number**	**Range**	**Description**
For pumps between .5 HP and 40 HP	MLCT75	75 Amps	Mini current sensor 75 Amps
For pumps between 40 HP and 100 HP	MLCT150	150 Amps	Current sensor 150 Amps
For pumps between 100 HP and 250 HP	MLCT300	300 Amps	Current sensor 300 Amps
For pumps between 250 HP and 1000 HP	MLCTP1500	1500 Amps	Current sensor 1500Amps

Level sensors - The existing system can be used if available			
Not required for constant speed pumps, unless Real Time Flow or Backup Controller is wanted. *If longer cable is required, specify.*			
	Part number	**Range**	**Description**
Ultrasonic	MLUS-6M	6 m / 19.7 ft	Ultrasonic level sensor (cable 10 m / 32.8 ft) (deadband 0.6m / 2ft)
Pressure	MLPLR	7.6 m / 25 ft	Level pressure sensor for wastewater lift station (cable 5 m/16 ft)

Communication	Part number	Service	Description
Cellular	MLCELETH	By local provider	Cellular modem with Ethernet port
Wifi	MLWIFIPICO	By local provider	WiFi interface module
Others	Volucalc RT can communicate through most TCP/IP compatible hardware		

Other accessories	Part number	Description
Force main pressure gauge	MLPSVL	100 PS1 Pressure sensor (cable 5 m / 16 ft).
Rain Gauge	MLRG	National Weather Services approved. 0.01" (0.0254mm) per pulse
Water tight enclosure IP67	MLENCPEL1150RT	Watertight lockable enclosure for Volucalc, Modem & Battery
Front panel door bracket	MLSUPPANEL	Brackets to fix Volucalc on panel door
DIN Rail brackets	MLSUPDIN	Brackets to fix Volucalc on Din Rail

WW6 Risk Assessment & Alternative Analysis

This section provides a risk assessment for components within the City's Wastewater Utility that represent a single-point of failure that could result in loss of service for a large portion of the City's collection and/or transmission system. The specific areas of concern are generator installations, singular power supplies, interconnects, and major transmission pipelines including trunk lines within one mile of the respective treatment plant as defined by the scope of services. The risk assessment included developing risk prioritization criteria and applying the criteria to key infrastructure to help prioritize repair, rehabilitation and replacement activities.

6.1 Risk Prioritization Criteria

Risk for utilities asset management purposes is the product of likelihood of failure and consequence of failure. Likelihood of failure involves physical conditions of the asset, such as material, installation date, service condition, and capacity performance indicators. Likelihood of failure information sources include the City's GIS, City staff interviews and limited engineering field visits. Asset condition assessment information is limited and will improve with future field information according to the City's proposed asset management program. **Table WW6-1** presents likelihood of failure criteria and weighting.

Consequence of failure judges the impact on the City if the asset fails. Consequence of failure parameters include size and redundancy. For pipes, large diameter pipelines (both pressurized and gravity) affect more customers during an outage than smaller pipes. The focus of this assessment was on larger pipelines and assets; however, these criteria apply in the future to evaluate all assets. Redundancy judges whether an alternate route, unit or power supply is available. Assets with redundancy will have less consequence of failure due to the alternate asset in place. **Table WW6-1** summarizes consequence of failure criteria and weighting factors**.**

Table WW6-1. Risk Prioritization Criteria – Large-Diameter Pipes

Category	Basis	Weighting	Low Probability	←	→	→	High Probability
			1	2	3	4	5
Likelihood of Failure	Pipe Material[1]	33.3%	PVC or HDPE	--	Unknown or DIP	RCP	PCCP, VCP, CIP
	Installation Date	33.3%	2000 or later	1990 - 2000	1980-1990, Unknown	1970 - 1980	Earlier than 1970
	LOS Require-ments[2,3]	33.3%	Velocity < 5 fps (Meets LOS requirements)	--	Velocity 5-6 fps (Almost meets LOS requirements)	--	Velocity > 6 fps (Fails LOS requirements)
Consequence of Failure	Pipe Diameter	50%	<24"	--	24" – 36"	--	>36"
	Redundancy	50%	Full Redundancy	--	Partial Redundancy	--	No backup/ redundancy

[1]PVC=PolyVinyl Chloride pipe, HDPE=High Density PolyEthylene pipe, DIP=Ductile Iron Pipe, RCP=Reinforced Concrete Pipe, PCCP=Pre-stressed Concrete Cylinder Pipe, VCP=Vitrified Clay Pipe, CIP= Cast Iron Pipe.

[2]Level of service assessed from the 2035 Max Hour forced flow output.

[3]Gravity pipelines assessment does not include velocity.

Section WW6 accepted December 19, 2016.

The City of Fort Lauderdale's wastewater transmission system maintains interconnects with nearby municipalities. Through incoming interconnects, wastewater flows from other municipal service areas including the Town of Davie, the Cities of Oakland Park, Wilton Manors, Tamarac, and Port Everglades into the City's pressurized system and to the George T. Lohmeyer Wastewater Treatment Plant (GTL). The interconnect force mains have sizes ranging between 6 and 16 inches in diameter. Piping materials for the interconnect force mains are generally ductile iron pipe (DIP) and cast iron pipe (CIP). There is a segment of privately owned asbestos cement pipe (ACP) along NE 12th Terrace, from East Commercial Boulevard to the "Oakland Park 1" interconnect. Scoring and weighting of the interconnect force mains for physical condition and capacity performance was similarly developed as explained above. The redundancy scores take into account the number of interconnects that the City has with the user. For example, the Oakland Park interconnects were given a redundancy score of 1 because the City maintains multiple interconnects with this municipality, but the Wilton Manors interconnect was given a redundancy score of 5 because it has significant flow and is only a single interconnect. **Table WW6-2** presents the prioritization criteria.

Table WW6-2. Risk Prioritization Criteria – Interconnects

Category	Basis	Weighting	Low Probability				High Probability
			1	2	3	4	5
Physical Condition[1]	Pipe Material[2]	50%	PVC or HDPE	--	Unknown or DIP	RCP	PCCP, VCP, CIP
	Installation Date	50%	2000 or later	1990-2000	1980-1990, Unknown	1970 - 1980	Earlier than 1970
Capacity Performance[3]	LOS Requirements	50%	Velocity < 5 fps (Meets LOS requirements)	--	Velocity 5-6 fps (Almost meets LOS requirements)	--	Velocity > 6 fps (Fails LOS requirements)
Consequence of Failure	Redundancy	50%	Multiple backups or redundancies	--	One backup or redundancy	--	No backup/ redundancy

[1]Scored based on the characteristics of the pipeline at the interconnect.
[2]PVC=PolyVinyl Chloride pipe, HDPE=High Density PolyEthylene pipe, DIP=Ductile Iron Pipe, RCP=Reinforced Concrete Pipe, PCCP=Pre-stressed Concrete Cylinder Pipe, VCP=Vitrified Clay Pipe, CIP= Cast Iron Pipe.
[2]Capacity performance assessed from the Wastewater Hydraulic Model 2035 Max Hour forced flow output.

The City does not currently have significant outgoing wastewater interconnects for redundancy purposes. Possible redundant outgoing interconnect locations were identified but require coordination and negotiation with the potential receiving party (Broward County).

The risk analysis included the City's existing wastewater transmission emergency generators. Available generator information compiled from the Central Region Wastewater System 2014 Renewal and Replacement Requirement Analysis included a brief description of the in-plant generator, as well as an assessment of the generators for Re-Pump stations A, B and E. **Table WW6-3** presents the likelihood of failure and the consequence of failure ranking criteria for generators. The risk assessment included a determination of critical pump stations that could benefit from permanent generator installations. The generator-need basis is flow to pump station, as determined by the hydraulic model.

Table WW6-3. Risk Prioritization Criteria – Existing Generators

Category	Basis	Weighting (%)	Low Probability 1	2	3	4	High Probability 5
Likelihood of Failure	Condition[1]	50	Excellent	--	Good/Fair	--	Poor
	Useful Life Remaining (Years)[2]	50	>25	20-25	15-20	10-15	<10
Consequence of Failure	Size/ Importance	50	Low Importance		Moderate Importance		High Importance
	Redundancy	50	Multiple backups or redundancy		One backup or redundancy		No backup/ redundancy

[1]Condition was determined from the Central Region Wastewater System 2014 Renewal and Replacement Requirement Analysis.

[2]The useful life estimate of a generator is 25 years, according to Appendix F, Estimated Useful Life Tables from the 2014 Fannie Mae *Instructions for Performing a Multifamily PCA*.

6.2 Risk Assessment and Analysis

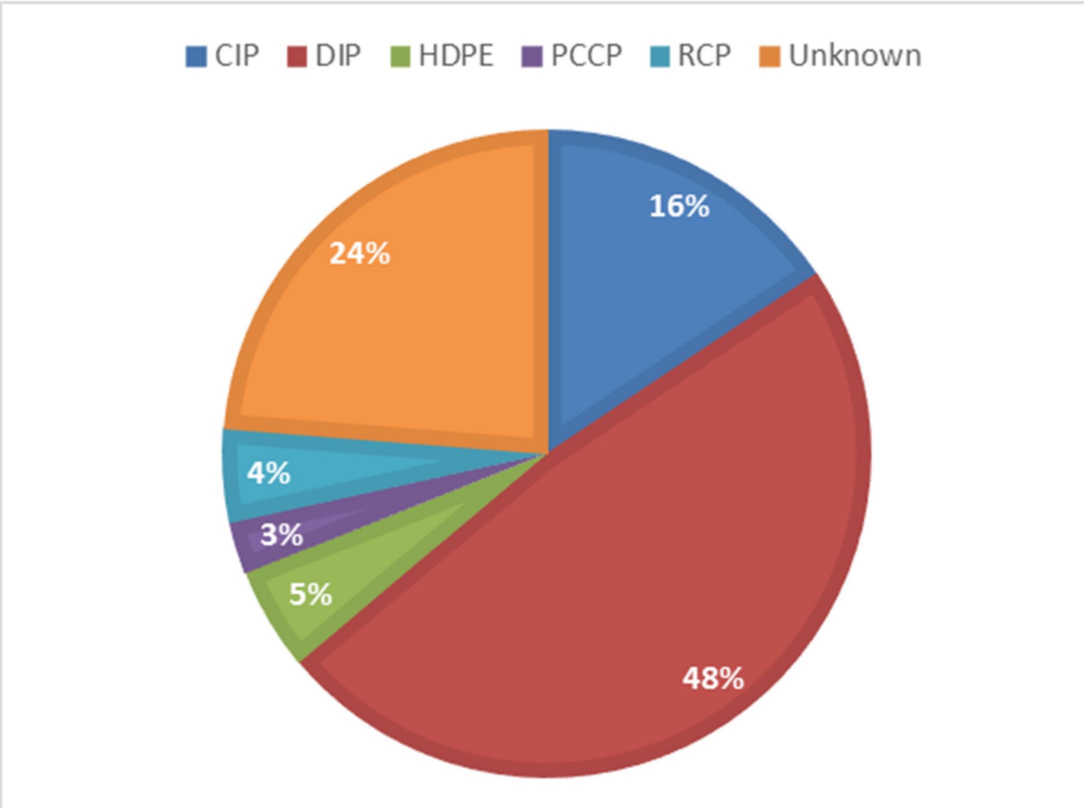
After relevant data was compiled and the risk assessment criteria were identified and applied, a "risk score" was calculated by the large (24" or greater) transmission pipelines, collection trunklines and lift station generators. The risk score categories follow:

- Risk Score 1-2 "Low Risk": The asset is low risk and should be monitored and maintained per typical standards. No other action needs to be taken
- Risk Score 2-3 "Low-Moderate Risk": Maintain asset per usual schedule. No other action required.
- Risk Score 3-4 "Moderate-High Risk": The asset is at risk and requires rehabilitation or replacement within the planning period.
- Risk Score 4-5 "High Risk": The asset is at risk and requires rehabilitation or replacement within the next five years.

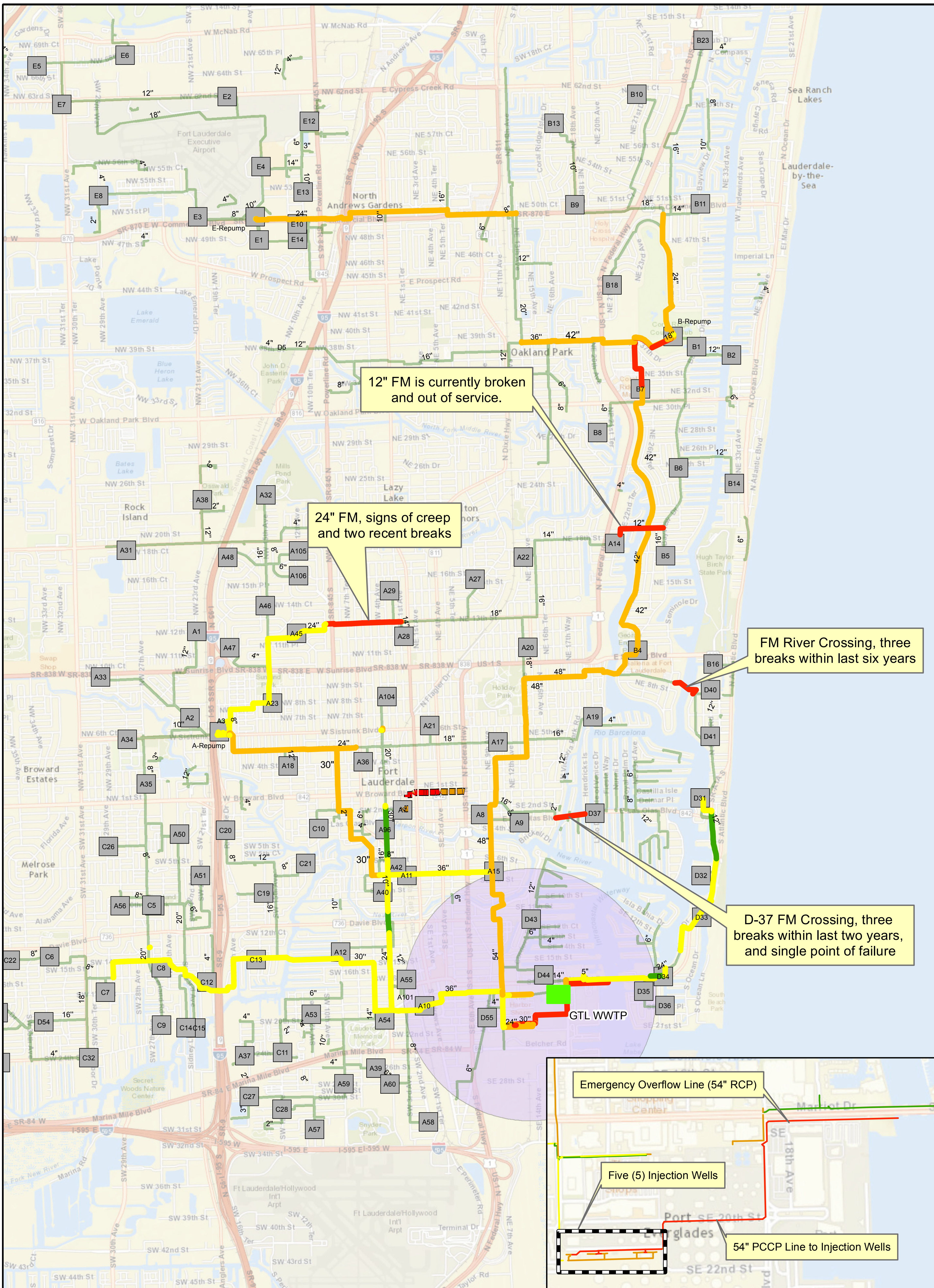
6.3 Risk Assessment Results

The results of the pipeline and interconnect force main rankings are shown in **Figures WW6-2** and **WW6-3,** respectively. Collection and transmission pipelines 24 inches in diameter and greater were ranked. As shown in **Figure WW6-1** below, nearly a quarter of the City's system is pre-stressed concrete cylinder pipe (PCCP), cast iron pipe (CIP), or reinforced concrete pipe (RCP) materials, which are high-risk pipe materials. Furthermore, a large portion of the City's pipelines will reach the end of their 50-year service life within the next ten years. While inspections would identify how much longer the pipe service lives can be extended, this indicates that the City should be budgeting funds to address the most critical of these pipes during the next 5 to 10 years and significant portion over the next 20 years. The soil conditions surrounding the pipe are the determining factors contributing to corrosion. Resistivity is the main determinant for corrosiveness of soil; the lower the resistivity the higher the corrosiveness. Resistivity depends directly on moisture content and salt content in the soil, meaning that a high groundwater table and saltwater intrusion could potentially exacerbate the degradation of metallic (DIP/CIP) and concrete pipe materials. Other potential causes of force main failure include excessive pressures in the pipeline, cycling from pump stations, and transmission of flows containing high concentrations of suspended solids.

Figure WW6-1. Large Diameter Pipeline Material[1]



[1]PVC=PolyVinyl Chloride pipe, HDPE=High Density PolyEthylene pipe, DIP=Ductile Iron Pipe, RCP=Reinforced Concrete Pipe, PCCP=Pre-stressed Concrete Cylinder Pipe, VCP=Vitrified Clay Pipe, CIP= Cast Iron Pipe.



N
W E
S

0 1,500 3,000
Feet

LEGEND

Pressure Main Risk Rank
- Low Risk (1-2)
- Low-Moderate Risk (2-3)
- Moderate-High Risk (3-4)
- High Risk (4-5)

Gravity Pipe Risk Rank
- Low Risk (1-2)
- Low-Moderate Risk (2-3)
- Moderate-High Risk (3-4)
- High Risk (4-5)
- Existing Pressurized Main

- GTL
- 1-Mile Buffer
- Pump Station

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

WASTEWATER COLLECTION AND TRANSMISSION SYSTEM: RISK ASSESSMENT

FIGURE WW6-2

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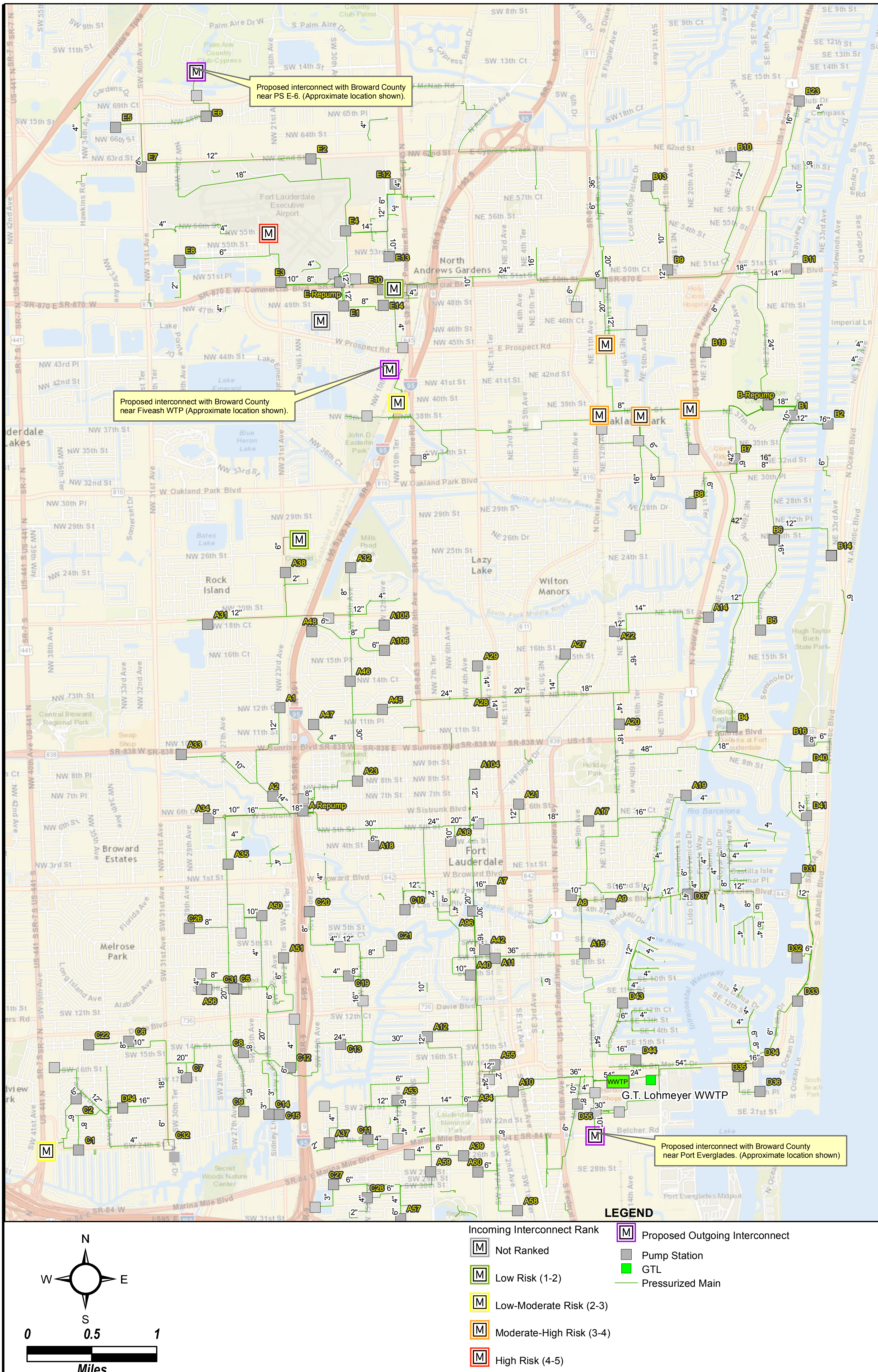

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER INTERCONNECTS RISK ASSESSMENT

FIGURE WW6-3

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Table WW6-4 illustrates the results of the existing generator risk assessment. In the future, City condition inspection results will continue to track and more accurately score the risk of each pump station's generator. The "B" and "E" Re-Pump stations and generator systems were in good condition according to the 2014 Renewal and Replacement Requirement Analysis (R&R Report). "A" Re-Pump station is also in good condition, although not included in the R&R report because it is not a "regional" station. The City replaced generators for the three (3) Re-Pump stations in 2007, all of which are in good condition. Pump Stations D-31 and D-54 are equipped with generators that were built prior to 1972, indicating that they are at the end of their service life. The other City pump stations have a default score of 2.5 and require inspections for more accurate condition assessment. Note that all pumping stations not equipped with an on-site generator, including P.S. D-43 are equipped to use portable, trailered units.

Table WW6-4. Risk Assessment Results – Existing Generators

Generator	Risk Score
Coral Ridge Pump Station ("B" Re-Pump Station)[1]	2.75
Executive Airport Pump Station ("E" Re-Pump Station)[1]	2.75
"A" Re-Pump Station	2.75
P.S. D-31	4.0
P.S. D-37	2.5
P.S. D-40	2.5
P.S. D-54	4.0

[1]The low risk score given to B Re-Pump Station and E Re-Pump Station was due to the "good condition" listing in the 2014 Renewal and Replacement Requirement Analysis, and confirmed by City staff.

6.4 Risk Assessment Summary

A risk analysis was performed to help the City of Fort Lauderdale's wastewater collection and transmission system to prioritize repair and replacement (R&R) efforts on the most critical assets. The CUS Master Plan team drew the following conclusions from the risk assessment:

- Many pressurized pipes within the wastewater transmission system are nearing the end of their service lives.
- There are several lengthy, large diameter (30 to 54-inch) force mains in the wastewater transmission system, critical to providing wastewater service that are high-risk pipe materials.
- The current wastewater transmission system has adequate incoming interconnects to serve the City's neighboring, wholesale wastewater customers.
- The City currently has no active outgoing interconnects; three (3) potential outgoing interconnects were identified for emergency flow out of the City's wastewater transmission system. Implementation of the outgoing interconnects requires coordination with the receiving utility (Broward County) or entity (e.g., Port Everglades) for property easements or emergency outfalls.
- The 54" treated wastewater effluent pipeline is a single point of failure within the wastewater system. Furthermore, the pipeline is PCCP, a material known to cause

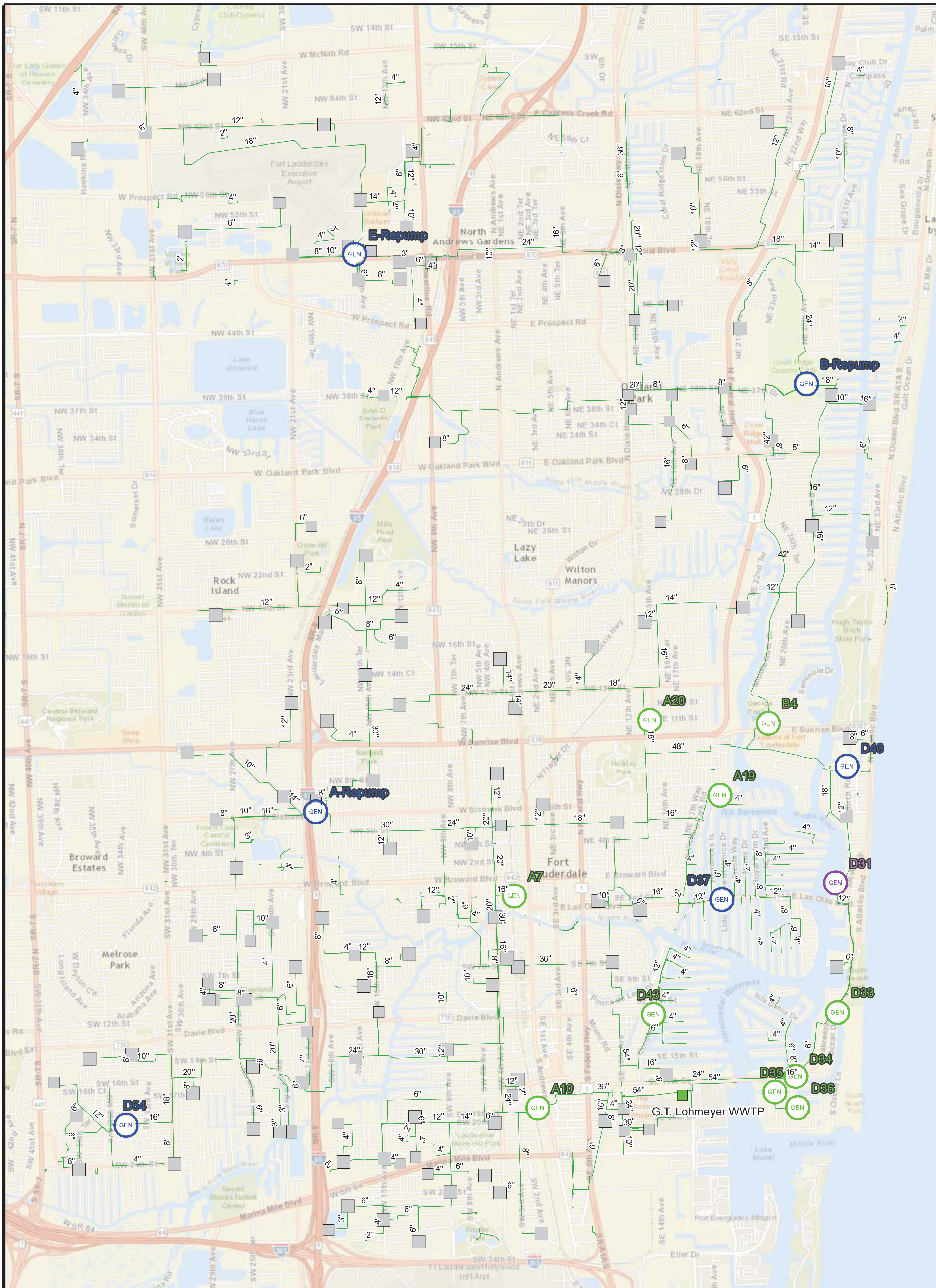
problems for the City and many other utilities. The 54” treated wastewater effluent pipeline has approximately 20 years of useful life remaining; inspection would help verify this service life estimate. Inspection of the 54” costs approximately $150,000 and is included in the capital project. Inspections can cost from $2 to $30 per foot depending on the detail and scope (Pure Technologies).

- Inspection begins with desktop identification of high-risk pipes then progresses to survey level inspection (e.g., Echologics acoustic testing), external non-destructive testing, internal non-destructive testing (tethered or free swimming, e.g. Pure Technologies products) and material testing if needed. Inspection technologies as listed by NASSCO for PCCP include:
    - Electromagnetic
    - Seismic pulse echo
    - Sonar
    - Laser profiling/scanning
    - Acoustic/fiber optic
- Pump stations with known power supply issues and no permanently installed emergency generator system are considered single points of failure.

The CUS Master Plan team recommends the following actions in order to reduce risk to the City’s wastewater transmission and collection system:

- Invest in permanent emergency stand-by diesel generators for several key pump stations identified in this risk analysis as “critical” in order to minimize risk of service based on electric service failure. **Figure WW6-4** depicts the proposed permanent generator additions.
- Replace generators for Pump Stations D31 and D54, because they are approaching the end of their service life and are high-risk equipment.
- Develop a force-main rehabilitation/replacement program in order to replace or rehabilitate pipes before they fail due to expired service lives and high risk pipe materials. The program could include inspection of the largest, most critical PCCP material pipes or simply proceed with complete rehabilitation.
- Continue routine maintenance as recommended in the 2014 Renewal and Replacement Requirement Analysis (“R&R Analysis”).
- Budget for, and implement an air release valve maintenance program for the transmission force mains to minimize risk of internal corrosion, maximize capacity and pipe failure.
- Update the wastewater collection/transmission GIS with the most current available pipeline material, age, service issues and R&R history information to improve the accuracy of the risk analysis and feed the City’s planned asset management system.
- Schedule the 54” treated wastewater effluent pipeline for inspection and rehabilitation, as well as further develop redundancy options. Begin with an external acoustic survey or move directly to an internal non-destructive testing method as discussed above.

Section WW6 accepted December 19, 2016.



LEGEND

- Pump Station (P.S.)
- GEN P.S. with Existing Generator
- GEN P.S. recommended for Permanent Generator
- GEN P.S. with existing Temporary Generator, recommended for Permanent Generator
- GTL
- Pressurized Main

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER GENERATOR RISK ASSESSMENT

FIGURE WW6-4

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6.5 Risk Unit Costs and Community Investment Plan

Construction and capital costs estimates for risk assessment projects include the application of unit costs. Unit pipe costs are dependent on the pipe diameter, route conflicts and method of construction. **Appendix WW6-A** illustrates the estimated unit cost of various pipe diameters in an urban setting. Unit capital costs include construction items (such as furnish and install pipe, valves, fittings, other appurtenances), utility conflict resolution, and overhead and profit. Non-construction costs include land acquisition, legal, administrative, design, permitting, field oversight and contingency. **Appendix WW6-A** also displays conceptual gravity pipe lining unit costs, excluding cleaning and CCTV. The capital cost estimate for a generator with an aboveground fuel tank ranges from approximately $170,000 to $215,000 for each station, dependent upon the size of the generator needed. Note that annual maintenance, labor and service are not in the capital cost estimates but included in the City's operating budget.

Section WW9 presents the risk mitigation Community Investment Plan projects with capital costs. The proposed generators have a preliminary size to be confirmed during the design phase of each generator project. The implementation period for the pipeline projects was determined based on the useful life remaining for the pipeline and an engineering analysis included herein. The final wastewater CIP will display an even and adjusted budget for each 5-year period. The estimated useful service life of the City's pipeline is 50 years consistent with the R&R Analysis; noting that well maintained assets can exceed their useful service lives. **Figure WW6-5** displays the risk mitigation CIP projects.

Section WW6 accepted December 19, 2016.

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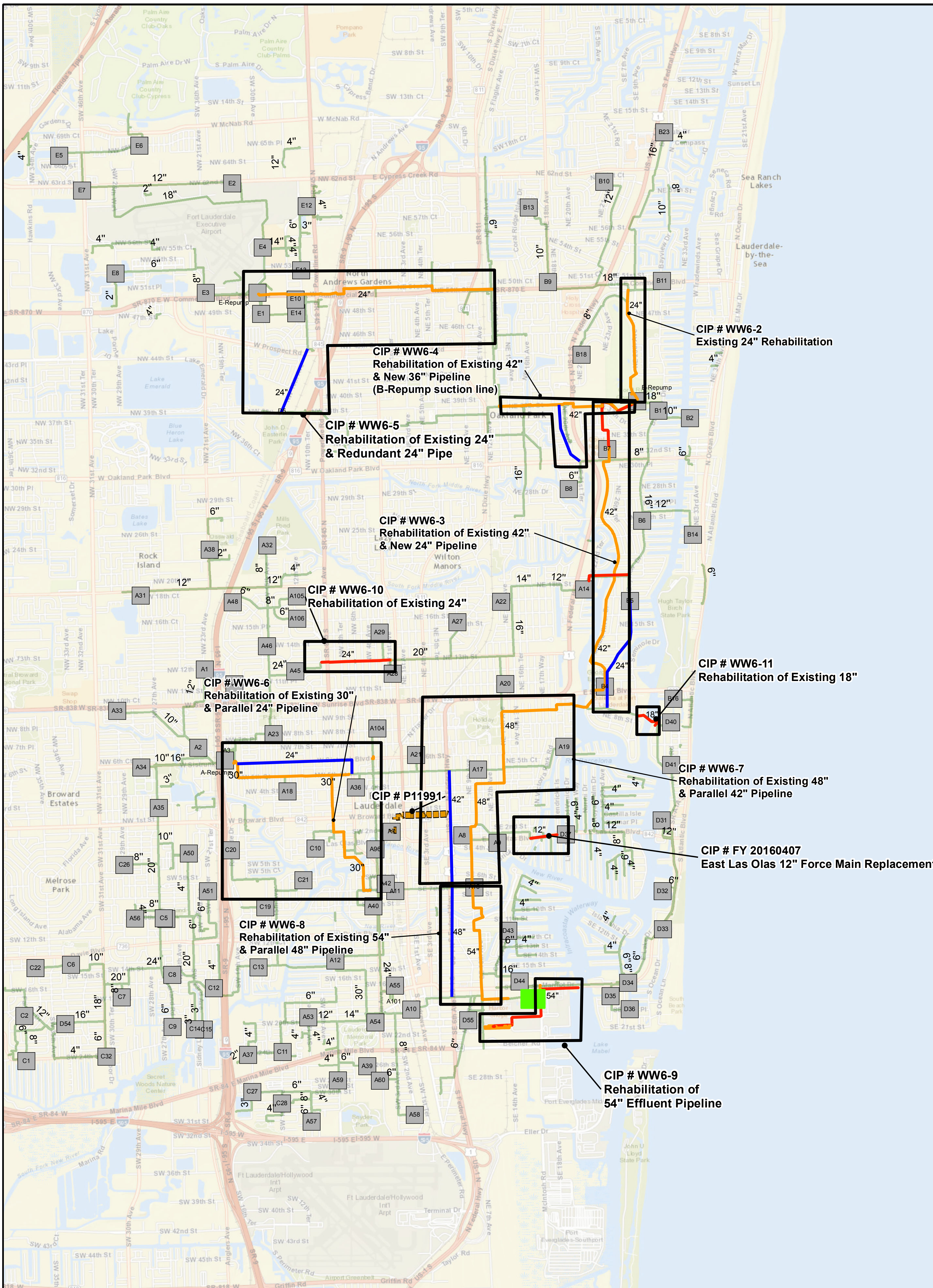

N
W E
S

0 2,500 5,000
Feet

LEGEND

Gravity Pipeline
Moderate-High Risk (Needs Rehabilitation)

Pressurized Pipeline
Proposed Pipeline
Moderate-High Risk (3-4)
High Risk (4-5)

GTL WWTP
Pump Station
Existing Pressurized Main

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

WASTEWATER COLLECTION AND TRANSMISSION SYSTEM: RISK CIP PROJECTS

FIGURE WW6-5

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Appendix WW6-A

Table WW6-A-1. Urban Transmission New Pipe Unit Conceptual Costs[3]

Pipe Diameter (inch)	Unit Construction Cost[1] ($/LF)	Unit Capital Cost[2] ($/LF)
10	$181	$280
12	$187	$290
16	$232	$360
20	$245	$380
24	$277	$430
30	$335	$520
36	$413	$640
42	$503	$780
48	$594	$920
54	$710	$1,100
64	$981	$1,520

[1]Construction cost includes furnish and install all equipment and material, bypassing and contractor mobilization, profit and overhead, and general conditions.
[2]Capital cost includes construction, 10% for program management, 20% for engineering, construction oversight, legal, and 25% contingency.
[3]Capital cost estimates derived from bid prices for similar projects, City of Tampa unit pipe construction contract prices, Toho Water Authority's Cypress Lake Water Transmission Project, and the SJRWMD's Cost Estimating and Economic Criteria for District Water Supply Plan document.

Table WW6-A-2. Gravity Pipe Lining Unit Conceptual Costs[3]

Pipe Diameter (inch)	Unit Construction Cost[1] ($/LF)	Unit Capital Cost[2] ($/LF)
6	$35	$54
8	$40	$62
10	$45	$70
12	$50	$78
16	$60	$93
20	$65	$101
24	$100	$155

[1]Construction cost includes furnish and install all equipment and material, bypassing and contractor mobilization, profit and overhead, and general conditions.
[2]Capital cost includes construction, 10% for program management, 20% for engineering, construction oversight, legal, and 25% contingency.
[3]Capital cost estimates derived from bid prices for similar projects, City of Tampa unit pipe construction contract prices, Toho Water Authority's Cypress Lake Water Transmission Project, and the SJRWMD's Cost Estimating and Economic Criteria for District Water Supply Plan document.

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WW7 Downtown Collection Analysis

7.1 Introduction

The City's wastewater Pump Station A-7 (A-7) collects wastewater from Downtown Fort Lauderdale and pumps it to the City's George T. Lohmeyer Regional Wastewater Treatment Facility (GTL). The area A-7 gravity collection system (A-7 basin) is a gravity pipe network that underlies the heart of Downtown Fort Lauderdale collecting and directing flow to the pump station. Gravity flows currently received by pumping station A-7 are at the station's maximum capacity levels. Any current and future growth will exceed the existing station's capacity. A-7 gravity flows will be increasing in the future with planned redevelopment including new apartments, residential towers, high-rise commercial buildings, and condominiums. Downtown Fort Lauderdale is a Regional Activity Center (RAC), planned to be a regionally significant area with a focus on mixed-use developments to support the City's continued economic growth. **Figure WW7-1** displays the A-7 basin service area that contains approximately 70,000 feet of gravity pipeline and the future planned developments. Pump Station A-7 is located at the northwest service entrance of the Riverwalk Complex at 150 SW 2nd Street. A-7 is a large station, with a large wetwell, and three submersible pumps with variable speed motors. During the rainy season and high tides, they act as constant speed pumps due to elevated flow demands. This section presents a hydraulic evaluation of the Downtown collection system to assess existing and future capacity.

7.2 Existing and Future Conditions

Table WW7-1 presents existing and future projected flow conditions. The A-7 Downtown wastewater collection model (A-7 Downtown Model) includes the City's latest GIS piping data and current flow information estimated from customer water meter data. The water meter data yielded existing wastewater flow estimates and spatial allocation in the existing A-7 Downtown Model to the closest manhole. The future maximum hour flow (MHF) was determined by a combination of the A-7 Downtown Regional Activity Center (RAC) planned developments as future flows and the increase in flow by a peaking factor of 1.15 due to population growth. The 1.15 peaking factor is the ratio from the projected flows for 2035 Total AADF to the 2015 AADF (see **Section WW1**). The A-7 Downtown Model spatially allocated future wastewater flows to the closest manhole to accurately simulate future flows.

Table WW7-1. Model Flow Conditions

Hydraulic Model Scenario	Year	Flow Condition	Hydraulic Model Output (MGD)
Gravity Model: A7 (Downtown)			
Existing MHF*	2015	MHF	4.17
Future MHF*	2035	MHF	5.15

*"Wet" Maximum Hour Flow (MHF): represents wet or absolute wastewater system peak flows during a significant rainfall event. The MHF was calculated by adding the rainfall derived I/I (RDI/I) to the dry MHF.

Section WW7 accepted February 3, 2017.

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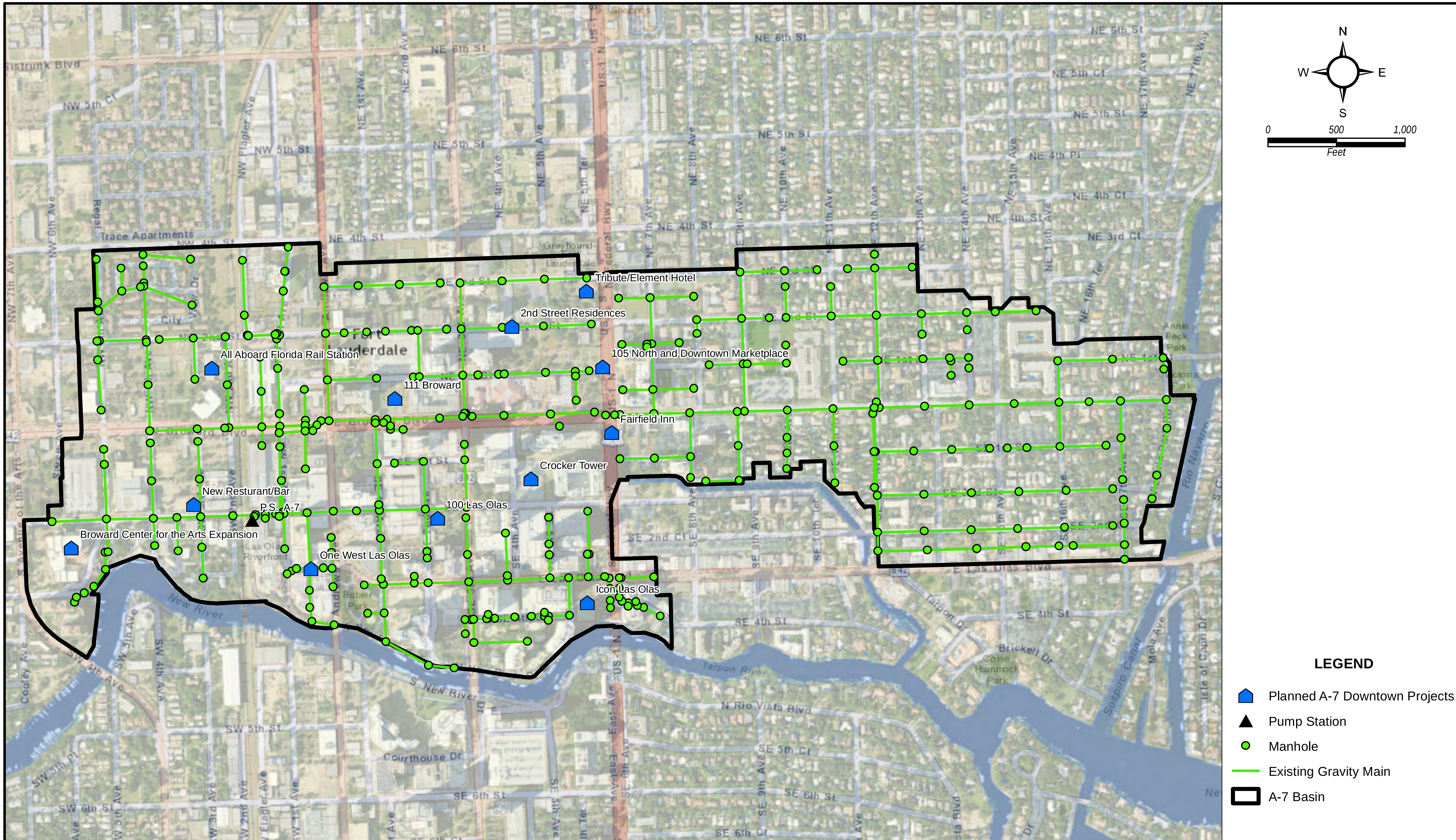


CITY OF FORT LAUDERDALE

COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

WASTEWATER COLLECTION SYSTEM A7 (DOWNTOWN) EXISTING BASIN AND PLANNED PROJECTS

FIGURE WW 7-1

G:\0gis\134001 - FTL Master Plan_MXDs\A-7 Gravity Model\WPHF Existing A-7 Gravity System Service Area V2.mxd

7.2.1 Unit Wastewater Flows by Land Use Type

Anticipated growth in residential, commercial and office development in the A-7 Downtown Regional Activity Center (RAC) area is driving the projected population and wastewater flow increases. **Table WW7-2** presents the unit wastewater flows for the future Downtown Regional Activity Center expansion according to the City's Guidelines for Calculation of Sanitary Sewer Connection Fees. The City of Fort Lauderdale Department of Sustainable Development provided the new developments planned in the Downtown A-7 Basin, which are included in **Figure WW7-2.**

Table WW7-2. Unit Wastewater Flows by Land Use Type

Type of Land Use	Average Day Flow (gallons per day unit)[1]	Unit
Condominium, Apartment	241.5	Each Unit
Single Family House, Duplex, Triplex	300	Each
Merchandising	165	1000 square feet of building area
Hotel (with restaurant and/or meeting rooms)	260.4	Room
Hotel (without restaurant and meeting rooms)	77	Room
Restaurant	749	1000 square feet of building area
Office	191	1000 square feet of building area
Other Commercial	157	1000 square feet of building area

[1] Average day Flow was calculated from the City's Guidelines for the Calculation of Sanitary Sewer Connection Fees.

7.2.2 Wastewater Flow from Planned Developments

The quantity of planned developments multiplied by the appropriate unit demand calculated the additional wastewater flow. The Downtown A-7 Basin has sixteen (16) projects that contribute wastewater flow to the A-7 pump station. The City divides the planned development projects into four (4) categories including completed, in construction, approved for construction, and in review. **Table WW7-3** presents the A-7 planned developments' wastewater flows**. Table WW7-**4 presents the projects that are planned for development in A-7 Basin. The planned developments' estimated flows represent an approximate 24% increase in the A-7 future wet maximum hour flow.

Table WW7-3. Summary A-7 Wastewater Flows from Planned Developments

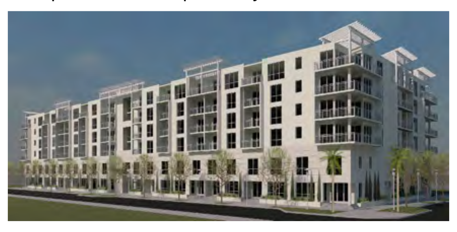
Type of Use	Average Annual Day Flow (MGD)
Completed	.006
In Construction	.018
Approved for Construction	.374
In Review	.247
Total Future Planned Flow	0.646

Section WW7 accepted February 3, 2017.

Table WW7-4. A-7 Wastewater Flows from Planned Developments

Project #	Project Name	Type	Status	Flow (gpd)
5	2nd Street Residences	Residential	Approved	96,117
		Retail	Approved	363
6	Broward Center for the Arts Expansion	Event	Completed	1,884
		Educational	Completed	4,296
9	Fairfield Inn	Hotel	Approved	8,316
15	Crocker Tower	Residential	Review	95,393
		Retail	Review	1,485
16	One West Las Olas	Retail	Construction	301
		Office	Construction	5,575
18	105 North	Retail	Construction	7,579
21	Icon Las Olas	Residential	Approved	65,688
		Retail/Rest.	Approved	41,592
22	111 Broward	Hotel	Approved	17,556
		Retail	Approved	1,537
		Office	Approved	57,277
24	New Restaurant/Bar	Restaurant	Review	7,812
25	All Aboard Florida Rail Station	Commercial	Construction	4,753
27	Tribute/Element Hotel	Hotel	Approved	84,109
		Retail	Approved	1,798
37	100 Las Olas	Hotel	Review	59,371
		Retail	Review	1,441
		Condo	Review	72,684
		Restaurant	Review	4,494
38	Downtown Marketplace	Retail	Review	1,048
		Restaurant	Review	3,579

1. Village Place
700 NE 4th Avenue
6 Story residential, 112 units.
$20 million construction value
Completed   Developer: Graystar/HTG



2. The Manor, Flagler Village
525 NE 5th Terrace
7 Story residential, 382 units.
24,750 sf retail
Completed   Developer: The Spear Group

3. The Edge at Flagler Village
495 N. Federal Highway
7 Story residential, 327 units.
$70 million construction value
Completed   Developer: The Morgan Group

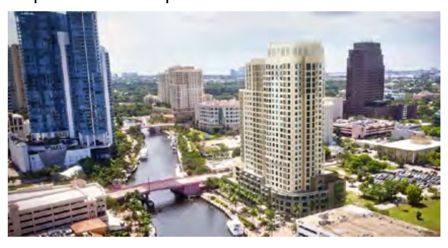
4. One20fourth
120 NE 4th Street
Two buildings, 25 & 14 stories, 386 units.
2,100 sf retail
Approved Plans   Developer: Ellis Diversified

5. 2nd Street Residences
411 NE 2nd Street
30 Story residential, 398 units.
2,200 sf retail
Approved Plans   Developer: Ellis Diversified

6. Broward Center For The Arts Expansion
201 SW 5th Avenue
12,000 sf event pavilion, 27,360 sf
educational wing. $50 million construction value
Destination Restaurant on Riverwalk
Completed

7. Marina Lofts
400 SW 3rd Avenue
Three 25 Story residential towers,
900 units. 19,200 sf retail
$250 million construction value
Approved Plans   Developer: Cymbal Development

8. New River Yacht Club
400 SW 1st Avenue
26 Story residential, 248 units.
4,400 sf retail
$36 million construction value
Completed   Developer: Related



9. Fairfeld Inn
30 S. Federal Highway
8 Story, 108 hotel rooms.
Approved   Developer: LM Hotels, LLC

10. Eighth Avenue Residences
215 SE 8th Avenue
30 Story residential, 262 units.
2,500 sf retail
$62 million construction value
Under Construction   Developer: The Rockefeller Group

11. VU New River
510 SE 5th Street
16 Story residential, 215 units.
2,378 sf retail/restaurant
$68 million construction value
Under Construction   Developer: A L Ventures

12. Broward County Courthouse
100 SE 6th Street
741,000 sf office space
$213 million construction value
LEED Silver Certification
Under Construction

13. The Queue
20 SE 8th Street
7 Story residential, 202 units.
$20 million construction value
Approved Plans   Developer: Hooper-Petrillo

25. All Aboard Florida Rail Station
101 NW 2 Avenue
30,276 sf rail station
$20 million construction value
Under Construction   Developer: FL East Coast Industries, LLC

26. Wisdom Village Crossing
614 N. Andrews Andrews
9 Story residential, 105 units.
$20.26 million construction value
Approved   Developer: Turnstone Dev Corp

27. Tribute/Element Hotel
299 N. Federal Highway
24 Story hotel, 323 rooms.
10,897 sf retail
Approved   Developer: 299 N. Fed Master LLC

28. Fairfield at Flagler Village
673 NE 3rd Avenue
6 Story residential, 292 units.
Approved   Developer: Fairfield

29. Quantum at Flagler Village
701 N. Federal Highway
15 Story residential, 328 units.
9 Story hotel, 137 rooms.
7,572 sf retail
$87.3 million construction value
In review   Developer: F V Land Trust

30. URBN @ Flagler
401 NE 3rd Avenue
33 Story residential, 217 units.
3,200 SF restaurant
In review   Developer: Third Avenue Dev LLC

31. Justice Building Restaurants
524 S. Andrews Avenue
7 Story building
10,030 SF restaurant/retail, 62,250 SF office.
In Review   Developer: Blackhawk Properties

32. Flagler Townhomes
645 NE 4 Avenue
3 Story residential, 5 units.
$1.88 million construction value
In Review   Developer: 645 Art Lofts, LLC

33. 788 East Las Olas
788 E. Las Olas Boulevard
18,142 sf retail, 16,287 sf office.
In Review   Developer: Las Olas Company Inc.

34. Morgan on 3rd Avenue
400 NE 3 Avenue
7 Story residential, 357 units.
4,292 SF retail
$75 million construction value
In Review   Developer: 441 Developers Putnam Realty

35. All Aboard Florida - Parking Facility
155 NW 3 Avenue
7 Story parking facility
1,582 SF retail
In Review   Developer: All Aboard Florida

36. Sistrunk Townhouses
103 NE 6 Street
3 Story residential, 18 units.
$4.5 million construction value
In Review   Developer: FLL Land Holdings LLC

37. 100 Las Olas
100 E. Las Olas Boulevard
46 Story residential and hotel
120 units, 228 hotel rooms.
6,983 sf retail
$200 million construction value
In Review   Developer: KG Las Olas Trustee, LLC

38. Downtown Marketplace
105 N. Federal Highway
1 Story retail and restaurant
6,354 sf retail, 4,778 sf restaurant
$500 thousand construction value
In Review   Developer: Shopping Center Interests, LLC

Legend
- Downtown Development Projects
- Downtown Regional Activity Center
- Northwest Community Redevelopment Agency
- B-Cycle Bicycle Share Station
- Wave Future Streetcar
- All Aboard Florida Future Rail Station
- FEC Railroad-Future Passenger Rail All Aboard Florida

Downtown Development Project Status

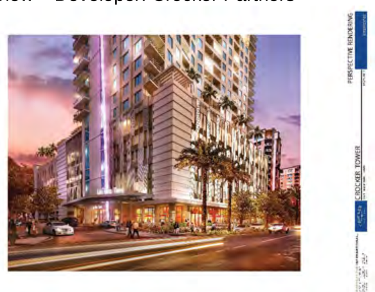
Under Construction	Approved	In Review	Completed
Residential Units - 861 Retail Square Ft. - 55,960 Office Square Ft. - 770,190	Residential Units - 2,810 Retail Square Ft. - 51,100 Office Square Ft. - 299,880 Hotel Rooms - 336	Residential Units - 1,515 Retail Square Ft. - 109,134 Office Square Ft. - 105,675 Hotel Rooms - 688	Residential Units - 1,069 Retail Square Ft. - 29,150

CITY OF FORT LAUDERDALE
Downtown Development Projects

Updated October 2015

14. Pinnacle At Tarpon Rver
224 SE 8th Street
10 Story residential, 112 units.
3,320 sf retail
$30.5 million construction value
Under Construction   Developer: Pinnacle Group

15. Crocker Tower
403 SE 2nd Street
42 Story residential, 395 units.
9,000 sf retail
$120 million construction value
In Review   Developer: Crocker Partners



16. One West Las Olas
1 W. Las Olas Boulevard
7 Story office building
1,827 sf retail, 29,190 sf office
$5 million construction value
Under Construction   Developer: One West LOA, LLC

17. Lofts on 8TH
501 SE 8th Street
14 Story residential, 75 units.
4,057 sf retail
$27 million construction value
In Review   Developer: Lofts on 8th, LLC

18. 105 North
105 N. Federal Highway
3 Story retail
45,935 sf retail
$4.1 million construction value
Under Construction   Developer: HappyLand FL, LLC

19. New River Yacht Club West
401 SW 1 Avenue
36 Story residential, 349 units.
6,388 sf retail
$37 million construction value
Approved   Developer: Related

20. Pineapple House
501 NE 3 Avenue
7 Story residential, 92 multi-family units,
86 social service residential units.
11,897 sf retail
$50 million construction value
Approved   Developer: Phillips Development Company

21. Icon Las Olas
500 E. Las Olas Boulevard
42 Story residential, 272 units.
Under Construction   Developer: Related

22. 111 Broward
121 E. Broward Boulevard
30 Stories, 228 hotel rooms,
9,315 sf retail, 299,880 sf of office.
Approved (Extension Granted)   Dev: Groupe Pacific

23. 500 Federal - North & 400 Federal - South
400 and 500 N. Federal Highway
3 Stories
18,025 sf retail, 9,000 sf restaurant, 27,138 sf office,
5 Story parking garage.
$9.5 million construction value
In Review   Developer: Gaddis Capital Corporation

24. New Restaurant/Bar
301-307 SW 2 Street
10,430 sf restaurant/bar
$3 million construction value
In Review   Developer: 301 Second Corporation

7.3 Gravity Collection Capacity Assessment

7.3.1 Hydraulic Design Criteria

Wastewater collection systems, City standards, industry practice and previous City planning efforts dictate the hydraulic service criteria. Engineering calculations including hydraulic modeling use service criteria to identify capacity-limited areas. **Table WW7-5** presents the service criteria used to evaluate the components of the City's wastewater collection and transmission systems. Manning's pipe roughness coefficients, entered into the hydraulic models, help calculate headloss due to friction along with flow and pipe lengths. The Manning's pipe roughness coefficients were estimated based on material of the respective pipe, as presented in **Table WW7-6**.

Table WW7-5. Hydraulic Design Criteria

System Component	Criteria
Collection (Gravity and Low Pressure)	
Maximum Velocity (Forced MHF)	5 fps
Manning Roughness Factor (n)	.012 - .015 (see Table 7-5 below)
Manholes and Pipes	-Meet minimum slopes -Not surcharging -No overflows

Table WW7-6. Manning's Roughness Coefficient by Material[1]

Material	Manning's "n"
PVC	.012
DIP	.014
CIP	.015
VCP	.015
RCP	.014
UN	.014

[1] Manning's roughness coefficient is related to the roughness of the internal pipe wall and can vary by pipe or lining material; the rougher the internal pipe wall, the higher the Manning's coefficient.

7.3.2 Existing and Future Hydraulic Analysis with No Improvements

The hydraulic model and subsequent analysis of the Downtown A-7 basin identified areas with hydraulic deficiencies or issues relative to the service criteria including pipe surcharging and high velocities. The hydraulic model identified surcharging issues due to the 14" gravity pipe directly east of Pump Station A-7 that collects all the station's wastewater in existing and future scenarios with no improvements. The gravity pipes entering the A-7 pump station are also experiencing capacity issues indicated by velocities greater than 5 fps for existing and future flows without improvements. The model has three outputs from it that are utilized for evaluating a wastewater system, which are below link crown, surcharged, and overflow. The crown of the pipe is the top of the gravity pipe so the below link crown is the wastewater flow is below the top of the pipe. The surcharging output is the wastewater is above the top of the pipe but below the manhole cover. Overflow is any wastewater that spills out to the atmosphere. **Figure WW7-3** illustrates the modeled surcharging issues. The A-7 Downtown model future scenario inputs the 2035 forecast flows including the new planned developments. The future scenarios modeled with no improvements increased the surcharging issues, as presented in **Figure WW7-4**.

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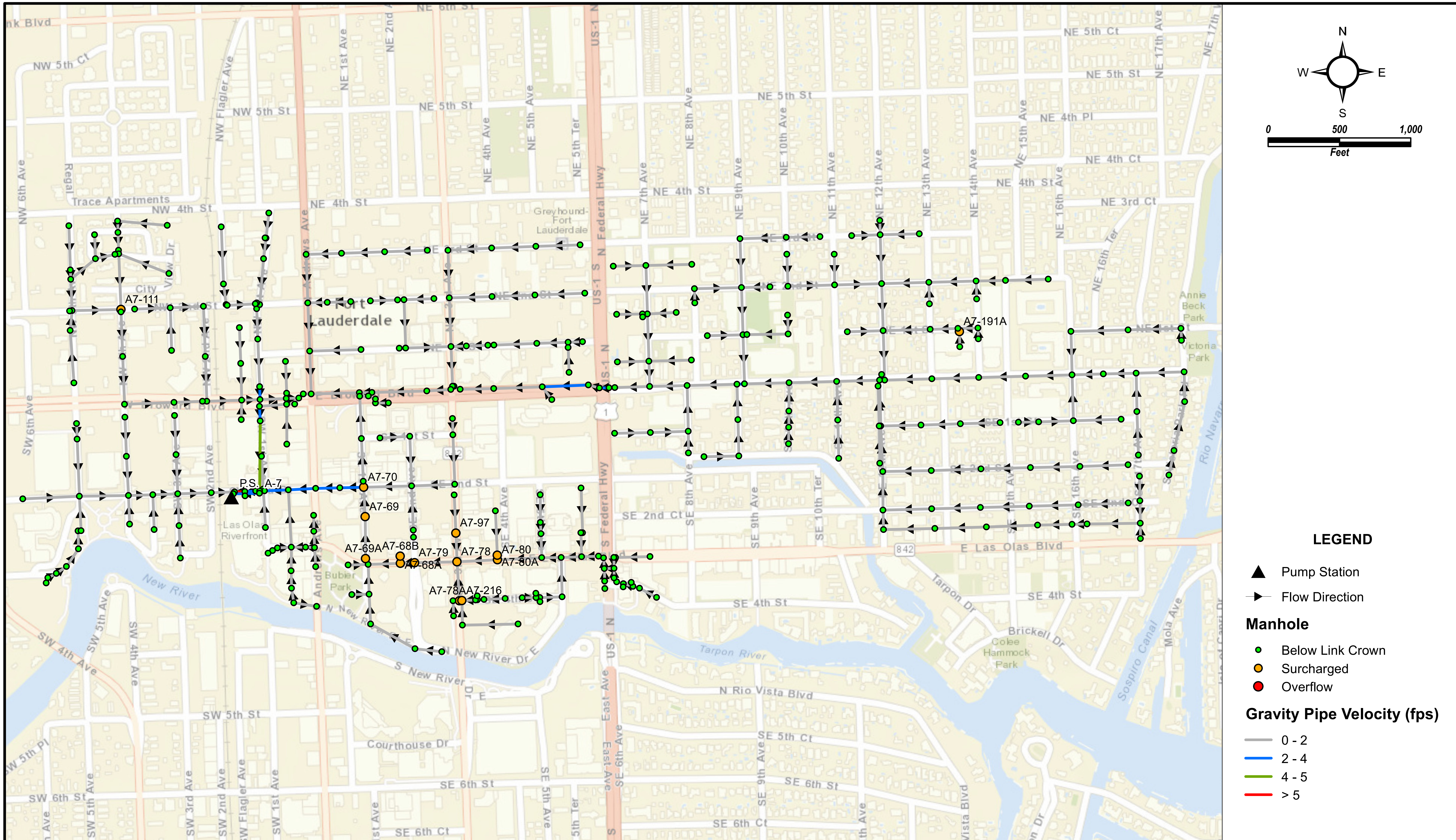

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

WASTEWATER COLLECTION SYSTEM A7 (DOWNTOWN) EXISTING MAX HOUR FLOW OUTPUT

FIGURE WW 7-3

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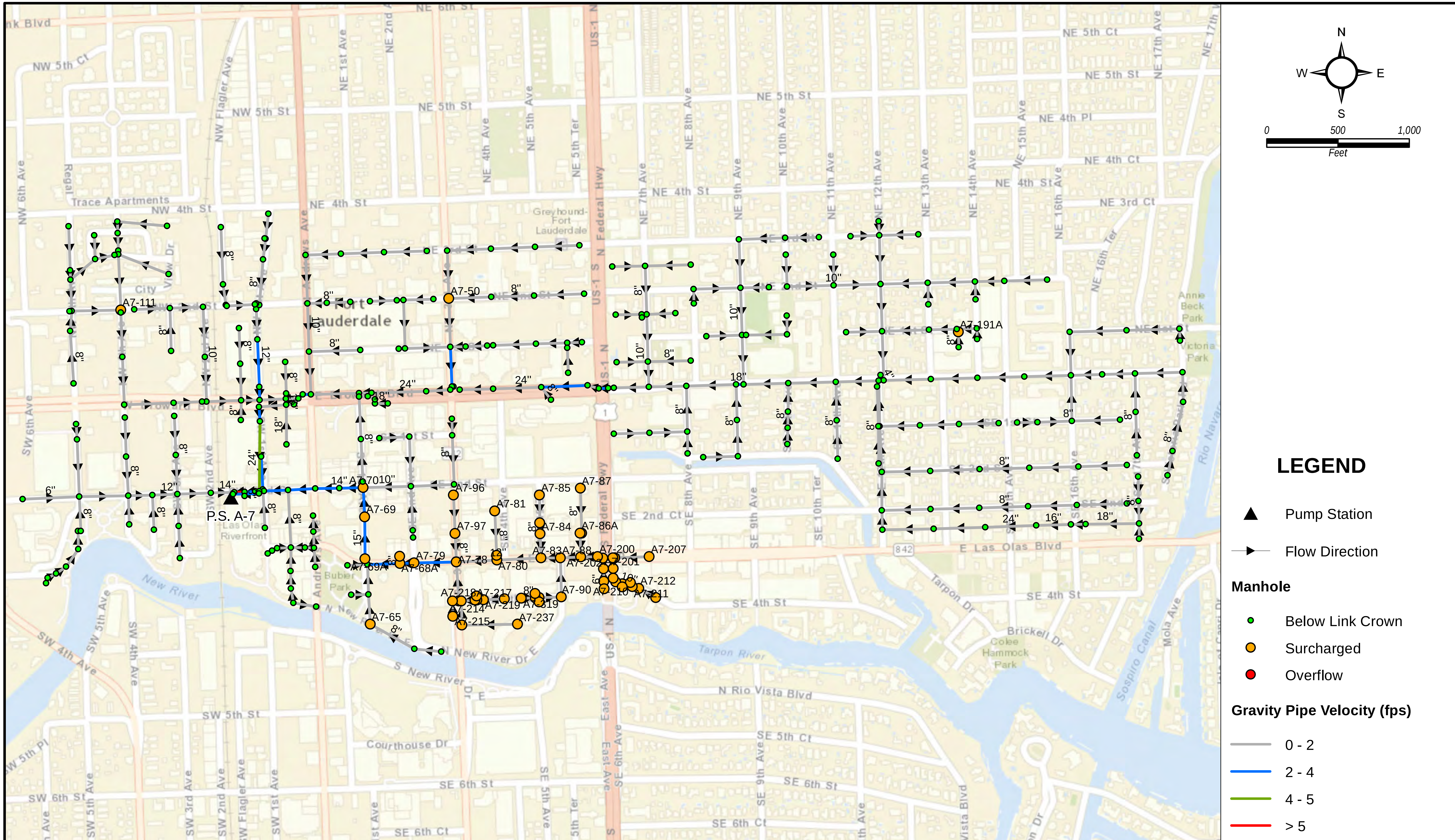


CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER COLLECTION SYSTEM A7 (DOWNTOWN) 2035 MAX HOUR FLOW OUTPUT NO IMPROVEMENTS

FIGURE WW7-4

G:\0gis\134001 - FTL Master Plan_MXDs\A-7 Gravity Model\WPHF Future A-7 Gravity System No Improvements.mxd

7.3.3 Future Hydraulic Analysis with Improvements

The City staff already has a plan to provide relief to the 14” gravity pipe that is collecting the flow from the north section of the A-7 basin. There is a new pump station A-13 planned to be built located at NE Federal Highway and NE 2nd Street. Pump Station A-13 will relieve some of the surcharging issues as well as aid in relieving the Pump Station A-7 from exceeding capacity with the existing and future development. Pump Station A-13 will also reduce the velocities in the 14” pipe.

The new pump station A-13 design capacity will be 1 MGD peak hourly flow. The pump station A-13 will alleviate high flows at Pump Station A-7, which is currently nearing the capacity of its pumps. **Figure WW7-5** presents the primary and secondary design points to display pump dry (normal) and wet (peak) service criteria. The new A-13 design diverts at least 1 MGD of flow to the new duplex, submersible pump station. **Table WW7-6** summarizes the proposed A-13 Pump Station hydraulic conditions from hydraulic model output.

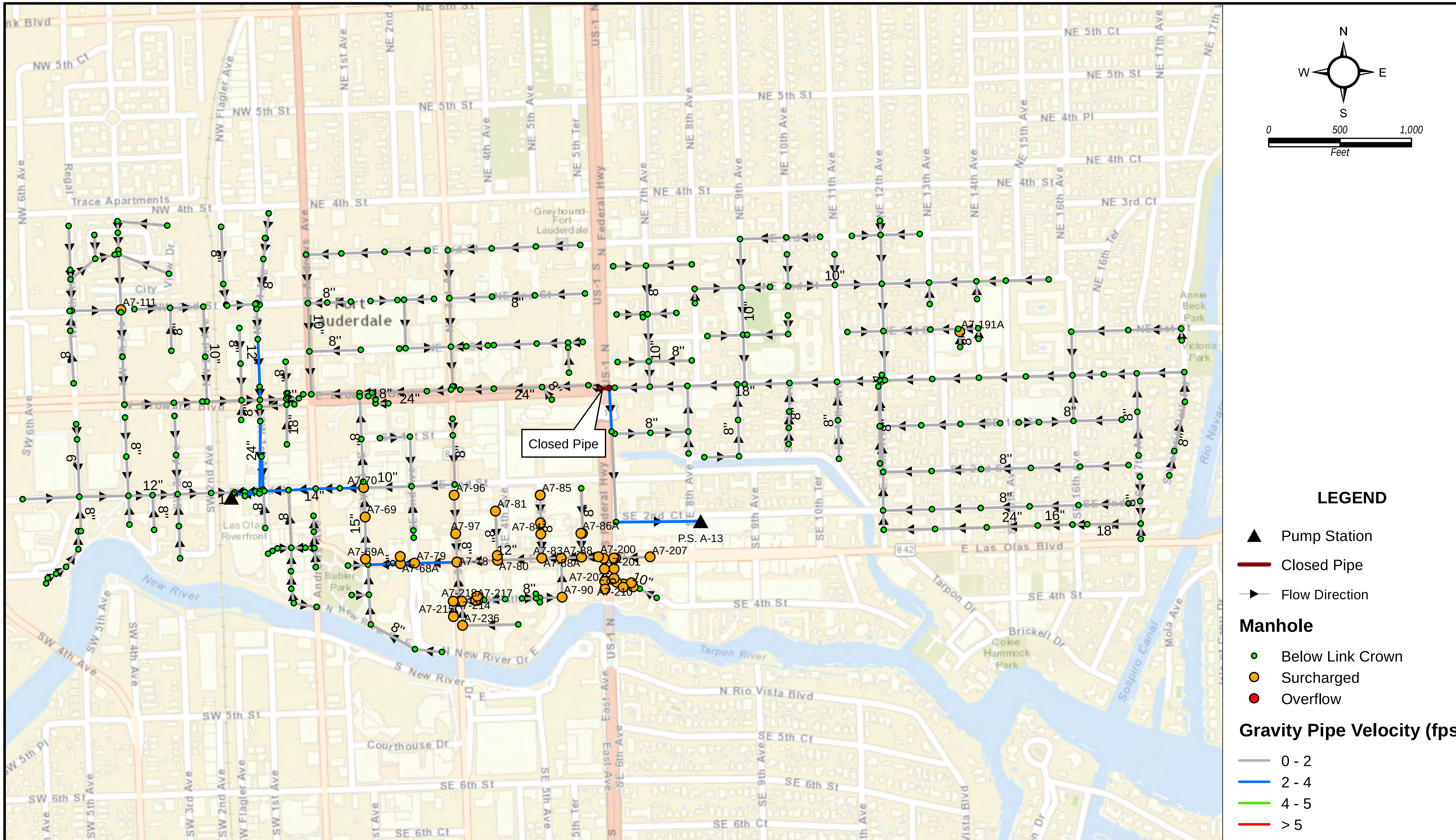
Table WW7-6. Proposed Pump Station A-13 Modeled Hydraulic Conditions

Model Scenario	Pump Station A13 Hydraulic Conditions[1]
Dry Existing Maximum Hourly Flow (MHF)	640 GPM @ 52’ TDH
All Stations N-1 Pumps On	820 GPM @ 98.5’ TDH
Wet Existing Maximum Hourly Flow (MHF)	923 GPM @ 68' TDH

[1] Hydraulic conditions include a minor loss coefficient and should be verified during station design.

According to the hydraulic modeling results, the addition of the new pump station A-13 would relieve some of the surcharging and all of the capacity issues for pump station A-7. **Figure WW7-5** presents the system curves for Dry Peak, wet peak and N-1 Pumps Scenarios. The different scenarios provide different flows through the system, which represents a need for variable frequency drive pumps. Pump Station A-13 does not resolve all of the model-predicted surcharging conditions in the A-7 basin. **Figure WW7-6** illustrates the surcharging issues with Pump Station A-13 constructed and no other improvements. Upsizing pipe and reducing I/I flow would further decrease surcharging. The 2016 to 2020 CIP includes a project for Downtown Sewer Basin Pump Station A-7 to repair sewer system components such as lining of gravity sewers, manholes, and sewer laterals, and was confirmed as a good approach by this Master Plan. Once completed, if A-7 flow is still causing surcharging problems to exist, the next step would be upsizing certain pipes in the A-7 basin to further minimize the surcharging. After the construction of Pump Station A-13, further analysis is recommended because Pump Station A-7 may require future pump hydraulic modifications. Another potential alternative to reduce wastewater flows to the GTL is to encourage the new high-rise buildings to implement a helpful water conservation method such as using gray water for toilet flushing. Requiring new construction to install meters for individual apartments would encourage water conservation and would result in reduced creation of wastewater and provide more revenue. The subsequent section includes methods that potentially encourage high-rise building owners in the Downtown RAC to implement graywater reuse.


Figure WW7-5 A-13 Operating Pump Curve
Total Dynami c Head (ft)
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
1400
Flow (GPM)
Test Pump Curve
Dry Peak (2015 System Curve)
Wet Peak (2015 System Curve)
Model (N-1 Pumps System Curve)
Design Point



CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER COLLECTION SYSTEM A7 (DOWNTOWN) 2035 WITH A-13 IMPROVEMENT MAX HOUR FLOW OUTPUT

FIGURE WW7-6

G:\0gis\134001 - FTL Master Plan_MXDs\A-7 Gravity Model\WPHF Future A-7 Gravity System v2.mxd

7.3.4 Gray Water Reuse in High Rise Buildings

Gray water is defined by the US EPA as "reusable wastewater from residential, commercial and industrial bathroom sinks, bath tub shower drains, and clothes washing equipment drains". In high density commercial areas such as the City's Downtown Regional Activity Center (RAC), reuse of gray water, if implemented, could reduce wastewater flows into the City's system.

Definitions of gray water, as well as the required treatment processes, vary by state. Per Florida building code, the only acceptable use of gray water is for flushing toilets or urinals. In order to do so, the following treatment processes are required:

- Filter System – Gray water must be filtered by an approved method, and have a ball or check valve upstream of the filter.
- Storage – Gray water must be contained in a vented storage container with overflow, and cannot be held for more than three (3) days.
- Disinfectant Injection – The gray water must be disinfected with an approved disinfectant such as chlorine.
- Dye Injection – The system must inject the gray water with green or blue color dye.

A few gray water processes filter water through planted systems. The planted systems use designated plants and their root system to filter certain chemicals depending on the quality of the water, which results in a higher level of treatment than normal gray water. The finished product water can be used for a number of non-potable uses, including:

- Irrigation
- Toilet Flushing
- Other non-potable reuse

The normal gray water filter and filtering through planted systems are two methods the city can consider when talking to the private owners about implementing the reuse methods for water conservation efforts.

In order to reuse gray water and thus reduce the amount of wastewater flows for the City's system, developers and private business owners must implement reuse methods. The required treatment processes listed above represent additional capital and operational costs to the business owner for piping, equipment, etc. Thus, a coordination effort between the City and private entities is required in order to realize this vision. Implementation of gray water reuse by private owners of high-rise buildings could represent a significant benefit to the City's system. In order to encourage private business owners to implement gray water practices, the following techniques have been employed:

- Incentives for reuse – The City could offer a monetary incentive to reduce the capital cost required for a gray water reuse system. This would help business owners afford the initial costs.
- Education of private business owners – Business owners will be encouraged to reuse gray water when they understand that it will reduce the amount of their purchased potable water. The average hotel in Florida consumes almost 22,000 gpd of water[2]; approximately 30% is domestic restroom use (USEPA WaterSense), and half of the 30% (15%) is toilet flushing use.

[2] South Florida Water Management District Water Conservation and Industrial, Commercial, and Institutional Facilities.

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- New Developments – The configuration of current piping construction within a building can have a big effect on the cost of implementing gray water reuse. The municipal code has clear, concise directions regarding the infrastructure of new developments built to handle gray water reuse system.

If implemented, grey water practices could benefit the City by reducing the amount of wastewater treated at the GTL, and could benefit private business owners by reducing the amount of money expended on potable water.

7.4 Downtown Collection Analysis Summary

The CUS Master Plan Team drew the following conclusions from the A-7 Downtown Collection system hydraulic evaluation:

- Fort Lauderdale's Downtown collection system hydraulic model is a pragmatic tool for future capital planning, operational optimization and R&R prioritization purposes.
- The A-7 basin hydraulic evaluation indicated a need for level of service (LOS) improvements to the basin. Table WW7-7 identifies and summarizes level of service criteria and recommended actions including flow diversion and upsizing pipes, pertaining to high velocities, and surcharging issues.
- The new Pump Station A-13 will address the some of the surcharging issues as well as aid in relieving the Pump Station A-7 from exceeding capacity with the existing and future development.
- The planned Pump Station A-13 design and construction is for the near future so the immediate impact of Pump Station A-13 in the existing scenario was not part of the analysis. An analysis of the immediate impacts to the A-7 Downtown Model should be ran to evaluate whether the new Pump Station A-13 relieves any immediate surcharging issues.
- The remaining A-7 basin surcharging issues can be addressed by I/I flow reduction via the upcoming A-7 basin CIP rehabilitation project and upsizing of key gravity mains.
- Gray water can reduce wastewater flow to the City, however, significant costs would be added to the end user, including maintenance and upkeep. The flow reductions are likely to be marginal and not reduce flow to the GTL significantly.
- Requiring new construction to install meters for individual apartments would encourage water conservation and would result in reduced creation of wastewater and possibly provide more revenue.

Table WW7-7. Summary of Collection Level of Service Issues

System Component	Level of Service Criteria	Actions to Comply
Gravity Pipe	PHF Forced Flow Velocity <5 fps	Flow Diversion to Pump Station A-13
Manhole	Surcharging	Flow Diversion to PS A-13, Rehabilitation A-7 Gravity Components and Upsize Pipes

Community Investment Plan (CIP) project identification was a joint effort of the City staff input, engineering analysis, strategic City Initiative compliance, and previous program evaluation.

The CUS Master Plan team confirms and recommends two (2) steps currently planned by the City to help improve the A-7 basin area from surcharging and capacity issues by diverting flow to the proposed Pump Station A-13 and rehabilitation of the A-7 sewer system components including lining of gravity sewer pipes, manholes, and laterals. Upon completion of these two

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projects, the CUS Master Plan team recommends re-evaluating A-7 basin flows, pump station A-7, and investigating the areas identified by the model as surcharging to determine if upsizing certain gravity pipes are required. **Figure WW7-7** illustrates the proposed CIP projects for the A-7 basin. **Figure WW7-8** presents the CIP projects evaluated in the A-7 Downtown Model and the resulting output. The restrictions that Florida has placed on gray water limiting its use to toilet flushing have limited its cost effectiveness as a localized flow reduction strategy.

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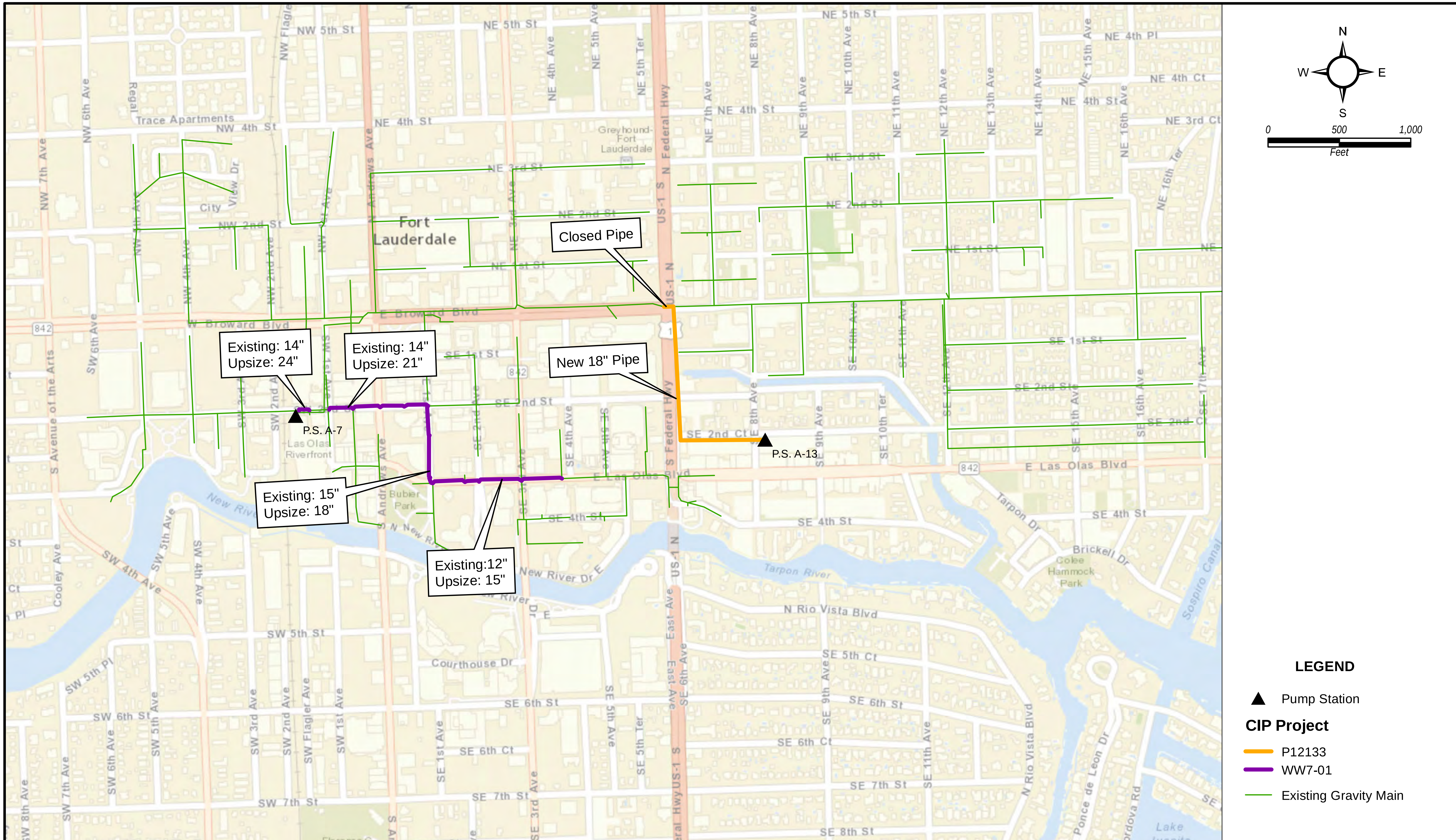
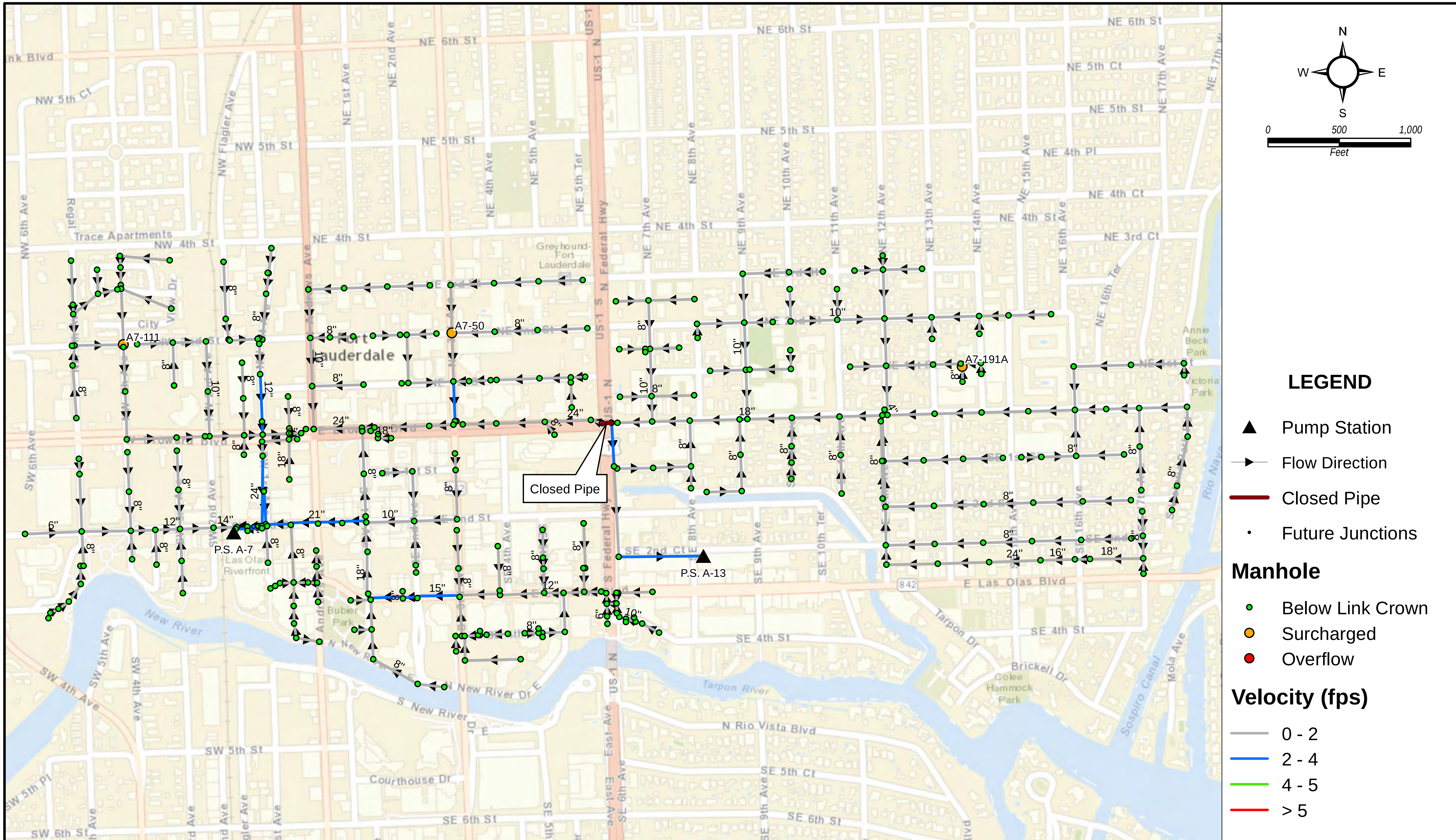


CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER COLLECTION SYSTEM A7 (DOWNTOWN) CAPITAL IMPROVEMENT PROJECTS

FIGURE WW7-7

G:\0gis\134001 - FTL Master Plan_MXDs\A-7 Gravity Model\A-7 Planned CIP Projects.mxd



CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
WASTEWATER COLLECTION SYSTEM A7 (DOWNTOWN) 2035 WITH A-13 AND PIPE IMPROVEMENTS MAX HOUR FLOW OUTPUT

FIGURE WW7-8

G:\0gis\134001 - FTL Master Plan_MXDs\A-7 Gravity Model\WPHF Future with Improvement A-7 Gravity System.mxd

WW8 Wastewater Treatment Capacity

8.1 Background

The George T. Lohmeyer Wastewater Treatment Plant (GTL) is a regional facility that provides wastewater treatment and disposal for the Cities of Ft. Lauderdale, Wilton Manors, Oakland Park and Port Everglades, as well as portions of unincorporated Broward County (the Cities of Tamarac, Dania Beach and the Town of Davie). Eight (8) individual wastewater treatment plants previously served this service area prior to 1986. The creation of the Central Wastewater Region consolidated the service areas of the eight wastewater treatment plants in accordance with the communities' 1978 consensus, as documented in the Broward County Wastewater Management Facility Plan. The Central Wastewater Region agreements designated the City of Ft. Lauderdale (City) as the lead agent to provide wastewater collection and treatment services to the Region in accordance with P.L. 92-500 (the Clean Water Act). Participating municipalities own and operate their individual wastewater collection systems consisting of gravity sewers, lift stations, and forcemains. The City owns and operates the regional system, including GTL, Re-Pump Stations “A”, “B” and “E”, and forcemains connecting the re-pump stations to GTL.

The “Agreements with Large Users of the Central Regional Wastewater System”, signed in 1982 and implemented in 1986 when GTL began full operation, formalized this Central Wastewater Region. The Agreements' first 20-year contract ended in Fiscal Year 2001-02 and was amended in 2001 to cover the next 20 years terminating on December 31, 2021.

GTL is located on a 9.58-acre site near S.E. 17th Street and Eisenhower Boulevard in the City of Ft. Lauderdale, as shown in **Figure WW8-1**. GTL provides secondary treatment followed by effluent disposal via deep injection wells (IW). The five (5) IWs are located approximately one-quarter mile south of the site. GTL's Florida Department of Environmental Protection (FDEP) Wastewater Treatment permit dated September 7, 2011 (FDEP Permit Number: FLA041378-012-DW1P) and expiring September 6, 2016, defines the permitted capacity as 56.6 MGD maximum 3-month average daily flow (M3MADF). The major liquid treatment processes include screening, grit removal, pure oxygen generation, activated sludge treatment, clarification, and chlorination, as shown in the process flow diagram in **Figure WW8-2**.

The City performs an analysis annually as required by FDEP Rule 62-600.405(5) to confirm the treatment capacity of GTL. The most recent Capacity Analysis Report (2015) concluded that GTL had sufficient capacity to accommodate expected flow increases through the year 2024.

High-purity oxygen is used for the activated sludge process at GTL. This provides a design solids retention time (SRT) of approximately 1.5 days, as opposed to conventional activated sludge processes that have SRTs of 5-15 days. Shorter SRTs result in smaller tank volumes, allowing GTL to meet BOD removal requirements on a smaller footprint than other biological treatment methods. For these reasons, the high-purity oxygen biological system is still the proper treatment method for GTL.

However, there are concerns that the cryogenic oxygen system needs to be replaced since the facility is aging and there are a limited number of facilities still operating. The system's level of complexity also requires a higher level of training for operations staff. Replacing the facility with Vacuum Pressure Swing Adsorption (VPSA) is discussed in more detail in **Section WW16**, however, possible noise or vibration issues would need to be addressed during design.

Section WW8 accepted December 16, 2016.

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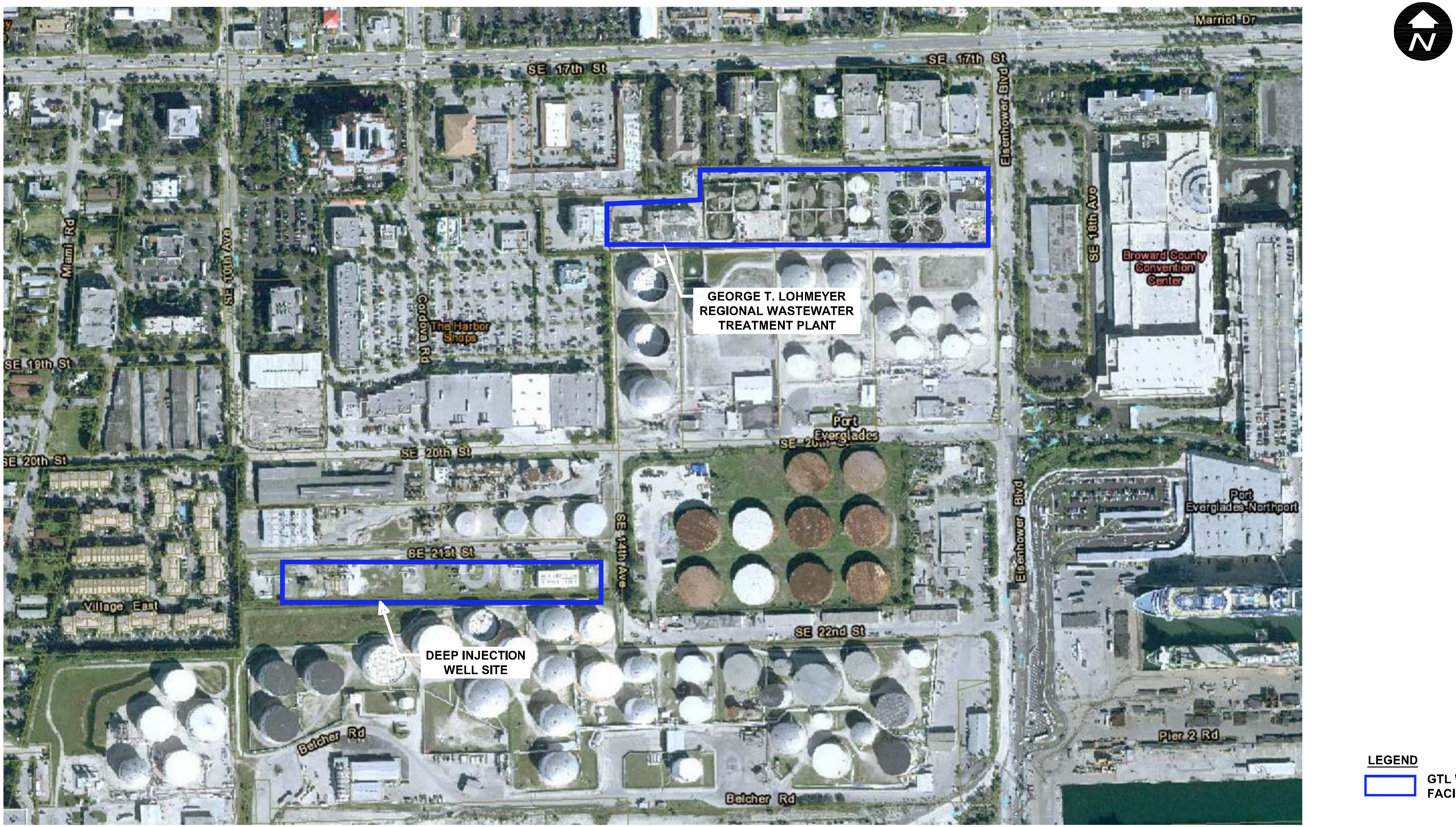
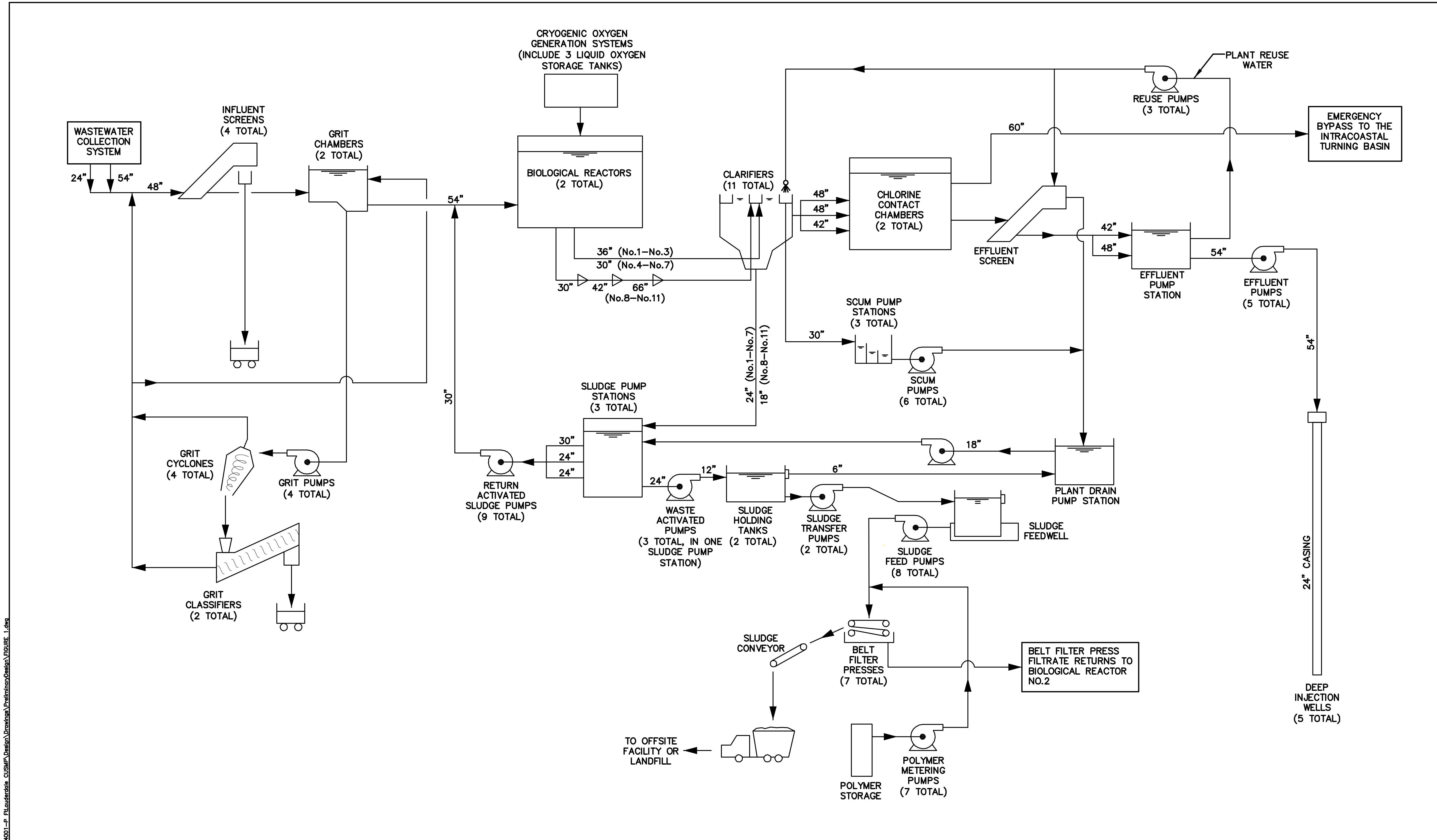


LEGEND

GTL WWTP FACILITIES

CITY OF FT. LAUDERDALE
GEORGE T. LOHMEYER WASTEWATER TREATMENT PLANT
EXISTING FACILITY PLAN

FIGURE WW8-1



CITY OF FORT LAUDERDALE
GEORGE T. LOHMEYER WASTEWATER TREATMENT PLANT
PROCESS FLOW DIAGRAM

FIGURE WW8–2

The ongoing I/I issues at GTL result in a diluted or reduced BOD loading to the biological treatment system, which results in reduced oxygen requirements. However, I/I should be reduced to minimize peak flow events that can overload the clarifiers and impact the treatment process. I/I reduces capacity and increases O&M costs.

In general, GTL treatment equipment needs upgrading, as described in **Section WW10**. The facility is now 30 years old, so process equipment and associated structures need to be evaluated in detail while following the R&R schedule outlined in **Section WW10**.

The purpose of this section is to update and document current GTL capacity status versus the City's level of service standards through the 20-year planning horizon to year 2035. This section identifies and addresses required capacity-related GTL improvements to facilitate timely budgeting, planning, design, and construction to meet the City of Ft. Lauderdale's level of service criteria. This section presents an evaluation of each major treatment process' capacity, and discusses required additions and improvements to GTL to meet 20-year wastewater flow and loading projections.

8.2 Existing and Future Flows and Loadings

GTL's current annual average daily flow (AADF) is 39.9 MGD and M3MADF is 50.7 MGD (based on projections from **Section WW1**), resulting in an associated peaking factor of 1.27. In addition to AADF and M3MADF flows, other calculated flows are used to design and evaluate process capacities for GTL's facility unit processes. By establishing historical peaking factors that relate these various calculated flows to GTL's AADF, it is possible to compare the individual process capacities to the most critical flow value: the permitted GTL capacity, which is given in terms of M3MADF.

The calculated flows used in the process analysis are defined in the bullets below, with the resulting peaking factors (from Section WW1) summarized in **Table WW8-1** for the planning horizon.

- Average Annual Daily Flow (AADF) – The average total wastewater flow to GTL for the calendar year.
- Three-Month Average Daily Flow (3MADF) – The total volume of wastewater flow during a period of three consecutive months, divided by the number of days in that three-month period. 3MADF is a rolling monthly average of the current month and the two preceding months and represents seasonal flow to GTL.
- Maximum Three-Month Average Daily Flow (M3MADF) - The highest 3MADF that occurs during a calendar year.
- Maximum Month Average Daily Flow (MMADF) – The average daily flow during the calendar month with the highest volume of wastewater flow that occurs during a calendar year.
- Maximum Daily Flow (MDF) – The highest wastewater flow in a single 24-hour day during a calendar year.
- Maximum Hourly Flow (MHF) – The highest wastewater flow in a one-hour period during a calendar year.

Section WW8 accepted December 16, 2016.

Table WW8-1. Summary of GTL Peaking Factors (versus AADF) and Projected Flows

Parameter	Peaking Factors	2015	2020	2025	2030	2035
Flow (mgd)						
AADF	--	39.9	41.0	43.1	44.7	45.6
M3MADF	1.27	50.7	52.1	54.7	56.8	57.9
MMADF	1.33	53.1	54.5	57.3	59.5	60.6
MDF	1.95	77.8	80.0	84.0	87.2	88.9
MHF	2.2	87.8	90.2	94.8	98.3	100.3

Note: The 2015 AADF of 39.9 MGD is based on a projection as per **Section WW1**.

8.2.1 Historical Loadings

Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) loading rates (based on flows and concentrations) under average day, maximum month, and maximum day conditions are needed to assess GTL biological treatment capacity over the next 20 years. Flows over the next 20-years are shown in **Table WW8-1** above. Historical wastewater BOD and TSS concentration and loading data for GTL from 2008 through 2014 are summarized in **Table WW8-2** and **Table WW8-3**, respectively, noted as follows:

- Annual Average Day Loadings (AADL) were based on average of monthly loading data provided by the City.
- Maximum Month Average Daily Loadings (MMADL) were based on the MMADL as provided by the City.
- Maximum Daily Loadings (MDL) were found by identifying the 98th percentile of maximum daily loadings for each year and multiplying daily plant influent by daily BOD concentration reported in City's Monthly Operating Report (MOR).

Table WW8-2. Historical GTL Influent Biological Oxygen Demand Loading

Year	BOD						
	Annual Average concentration (mg/L)	AADL (lbs/day)	MMADL (lbs/day)	MDL[1] (lbs/day)	MMADL Peaking Factor	MDL Peaking Factor	Adjusted Peaking Factor
2014	101	32,441	37,245	52,153	1.15	1.61	1.38
2013	80	25,937	30,269	38,049	1.17	1.47	1.32
2012	91	30,510	36,299	51,256	1.19	1.68	1.43
2011	100	30,700	34,118	46,265	1.11	1.51	1.31
2010	96	29,414	35,422	44,984	1.20	1.53	1.37
2009	98	29,912	34,421	43,883	1.15	1.47	1.31
2008	91	26,889	33,618	39,751	1.25	1.48	1.36
Average	**94**	**29,401**	**34,485**	**45,192**	**1.17**	**1.53**	**1.35**

[1] The MDL calculation used the 98th percentile of maximum daily loadings of every year

Table WW8-3. Historical GTL Influent Total Suspended Solids Loading

Year	TSS					
	Annual Average concentration (mg/L)	AADL (lbs/day)	MMADL (lbs/day)	MDL[1] (lbs/day)	MMADL Peaking Factor	MDL Peaking Factor
2014	118	37,830	43,286	74,924	1.14	1.98
2013	114	37,130	42,497	62,178	1.14	1.67
2012	104	34,575	48,405	68,150	1.40	1.97
2011	127	38,722	50,699	80,113	1.31	2.07
2010	114	35,360	41,151	72,317	1.16	2.05
2009	106	32,150	40,987	58,545	1.27	1.82
2008	98	29,162	34,555	50,058	1.18	1.72
Average	**112**	**34,990**	**43,083**	**66,612**	**1.23**	**1.90**

[1] The MDL calculation used the 98th percentile of maximum daily loadings of every year

The annual average BOD concentration for the 7-year period from 2008 to 2014 is 94 mg/L, which is well below typical municipal wastewater strength, **likely due to a continuous I/I flow contribution.** The BOD concentration for typical untreated domestic wastewater ranges from 110-400 mg/L, with an average concentration of 220 mg/L (Metcalf and Eddy, 5th Edition, 2013). The annual average BOD concentration reported in the previous master plan, which used data from the years 2000 to 2005, was 89 mg/L. The average daily BOD loading (AADL) from 2008 to 2014 is 29,401 lb/day, while the maximum-month average-day (MMADL) and maximum-day (MDL) BOD loading peak factors over the 7-year evaluation period are 1.17 and 1.53, respectively.

Influent TSS concentrations and loading rates generally showed similar peaking factors to influent BOD. The average influent TSS concentration at GTL from 2008 to 2014 is 112 mg/L. The MMADL and MDL influent TSS peak loading factors are 1.23 and 1.90, respectively.

Based on the Total Kjeldahl Nitrogen (TKN) concentrations reported by City staff, an average concentration of 20 mg/L was used to calculate the loading forecast. Influent TKN concentrations and loading rates generally relate to influent BOD patterns. Therefore, MMADL and MDL BOD peak loading factors of 1.17 and 1.53 were used to project TKN loadings, consistent with the City's previous master plan.

8.2.2 Loadings Forecasts

Future BOD, TSS and TKN loadings were calculated using the projected AADF for the planning horizon and the historical average influent concentrations to develop projected average day loadings. These average loadings were converted to associate MMADL and MDL values by using the wastewater constituent loading peaking factors as summarized in **Table WW8-4**.

Table WW8-4. Average Wastewater Constituent Concentration and Peaking Factors

Parameter	Average Concentration (mg/L)	Maximum Month Peaking Factor	Maximum Day Peaking Factor
BOD	94	1.17	1.53
TSS	112	1.23	1.90
TKN	20	1.17	1.53

Table WW8-5 shows the resulting AADLs for GTL up until the year 2035, based on the AADF projections developed in Section WW1.

Table WW8-5. Forecast System-wide Average Annual Day Loadings (AADL)

Year	AADF (MGD)	BOD (lbs/day)	TSS (lbs/day)	TKN (lbs/day)
2015	39.9	31,280	37,270	6,655
2020	41.0	32,142	38,297	6,839
2025	43.1	33,789	40,259	7,189
2030	44.7	35,043	41,753	7,456
2035	45.6	35,749	42,594	7,606

Projected flows and peaking factors for flows and loadings were then used to calculate key influent loadings over the planning horizon, as summarized in **Table WW8-6**. These constituent loading values were used to evaluate the effective capacity of GTL treatment processes and effluent disposal systems.

Table WW8-6. Design Flows and Wastewater Constituent Concentrations

Parameter	Peaking Factors	2015	2020	2025	2030	2035
Flow (mgd)						
AADF	--	39.9	41.0	43.1	44.7	45.6
M3MADF	1.27	50.7	52.1	54.7	56.8	57.9
MMADF	1.33	53.1	54.5	57.3	59.5	60.6
MDF	1.95	77.8	80.0	84.0	87.2	88.9
MHF	2.2	87.8	90.2	94.8	98.3	100.3
BOD Loading (lbs/day)						
AADL	--	31,280	32,142	33,789	35,043	35,749
MMADL	1.17	36,598	37,607	39,533	41,000	41,826
MDL	1.53	47,976	49,298	51,823	53,747	54,829
TSS Loading (lbs/day)						
AADL	--	37,270	38,297	40,259	41,753	42,594
MMADL	1.23	45,842	47,106	49,518	51,357	52,391
MDL	1.90	70,695	72,644	76,365	79,200	80,794
TKN Loading (lbs/day)						
AADL	--	6,655	6,839	7,189	7,456	7,606
MMADL	1.17	7,787	8,001	8,411	8,723	8,899
MDL	1.53	10,183	10,463	10,999	11,408	11,637

Note: As described in detail in **Section WW8.4**, reducing I/I will potentially avoid the need for treatment plant expansion in the year 2035.

8.3 Wastewater Treatment/Disposal Level of Service Criteria

Table WW8-7 summarizes the design or level of service criteria for GTL process components. The level of service criteria for the capacity evaluation provides the design loads, loading factors and key design criteria used to determine the effective capacity of each process.

Table WW8-7. GTL Design (Level of Service) Criteria

Process	Criteria
Screening	
Influent Screens Capacity	38 mgd, each
Influent Screens Reliability Criteria	Meet MHF with one unit out of service, includes bar rack[3]
Grit Removal	
Grit Tank Loading Rate	40,000 gpd/sf @ MHF
Grit Tank Reliability Criteria	Two minimum, with bypass provisions[1]
Biological Treatment System	
Oxygen Transfer Efficiency	90%
Actual Oxygen Utilization Rate	1.1 lb O_2/lb BOD,
Solids Retention Time (SRT)	1.5 days (maximum)[5] @ MMADF
Return Activated Sludge (RAS) Rate	Sufficient to remove thickened solids from clarifiers and maintain target MLSS in biological reactors
Reliability Criteria, Mechanical Aerators	Multiple units required[3]
Reliability Criteria, Bioreactors	Minimum of two basins of equal volume[3]
Reliability Criteria, Oxygen Compressors	Maintain MHF oxygen delivery with largest unit out of service[3]
Reliability Criteria, Clarifiers	Capacity for 75 percent of MHF with largest unit out of service[3]
Clarifier Hydraulic Loading Rate	1,200 gpd/sf @MHF[1]
Clarifier Solids Loading Rate	35 lbs/day/sf @ MHF & Design RAS Rate[1]
Mechanical Aerators	
AORT	5.5 lbs oxygen/hp-hr[1]
Biosolids Storage	
Biosolids Detention Time	Two days detention time @ MMADF
Biosolids Storage Reliability Criteria	Volume provides time necessary for R&R, Maintain continuous operation, [3]
Belt Filter Press Biosolids Dewatering	
Biosolids Dewatering Loading Rate	900 lbs/hr dry solids @ MMADL[2]
Biosolids Dewatering Operating Time	24 hours/day, 5 days/week[5]
Biosolids Dewatering Reliability Criteria	Capacity for maximum month sludge production operating 5 days/week, 16 hours/day, with largest unit out of service
Effluent Disinfection	
Deep Well Injection	Disinfection not required
Alternate Disposal (Surface Water Outfall)	15 min. contact time and 0.5 mg/L residual
Effluent Pumping	Pump MHF with largest unit out of service[3]
Deep Well Injection	10 feet per second velocity @ MHF[4]

[1] *Recommended Standards for Wastewater Facilities 2014 Edition (Ten States Standards)*
[2] Manufacturer's recommendation
[3] Design Criteria from Mechanical, Electric, and Fluid System and Component Reliability. EPA, 1973
[4] FDEP-approved discharge velocity rate
[5] Historic operation at GTL

8.4 Wastewater Treatment Capacity Evaluation

Treatment capacity is evaluated by comparing future wastewater flow and loading projections for GTL to the flow and loading capacities of each major process calculated using the associated level of service design criteria. This flow and loading comparison identifies expansion needs relative to future flows and process capacities.

Noting that the projected year 2035 M3MADF is 57.9 MGD, which is slightly higher than the current permitted capacity for GTL, individual components were checked for capacity versus the projected flow. **Section WW4** indicates that approximately half of the City's daily influent is I/I. It is imperative that the City significantly reduce I/I flow during this planning period to avoid the substantial cost of the potential need of plant expansion. The development of flow projections in **Section WW1** of this report included estimates of flow reduction to GTL as a result of future I/I mitigation, and accounted for these efforts in the overall projections of flow through 2035. As such, the use of these resulting projections in this section inherently accounts for future I/I reduction in the assessment of the individual wastewater process components.

8.4.1 Preliminary Treatment

8.4.1.1 Influent Channels and Screens

Wastewater contains large solids and grit that can interfere with the treatment processes. To protect process equipment from these materials requires screening and grit removal. The influent screens at GTL remove 6 millimeter (mm) debris and larger. There are four (4) existing Huber Rakemax screens, each with a maximum capacity of 38 MGD. EPA requires Class I Reliability for the influent screens, which includes providing capacity to meet MHF with one unit out of service.

The current firm capacity of the influent screening process at GTL with one screen out of service is 114 MGD MHF (38 MGD x 3), which is greater than the projected design of 100.3 MGD MHF. Thus, the influent screening process has sufficient capacity to meet future flow conditions.

The 114 MGD influent screen capacity is equivalent to a 65.8 MGD M3MADF (114 MGD x (M3MADF PF 1.27)/ (MHF PF 2.2)), which is sufficient to treat the projected 2035 GTL flow of 57.9 MGD M3MADF.

8.4.1.2 Grit Removal

After the influent flow passes though the influent screen, it enters a large grit tank for gravity settling. The influent grit tank slows the flow velocity to allow heavy solids such as sand and gravel to settle to the bottom of the basin, thus removing these solids from the treatment process.

GTL uses two 40-foot square grit tanks (total area = 3,200 sf) fitted with Dorr-Oliver Detritor grit removal equipment. Regulations do not mandate this process, but grit removal is advisable, especially in Florida, with the large amount of sand that enters gravity systems. Using the manufacturer's recommended loading rate of 40,000 gpd/sf at MHF, both chambers operating together can achieve a capacity of 128 MGD (40,000 gpd/sf x 3,200 sf), which is greater than the projected flow of 100.3 MGD MHF. Thus, the grit removal process has sufficient capacity to meet future flow conditions.

The 128 MGD grit-removal capacity is equivalent to a 73.9 MGD M3MADF (128 MGD x (M3MADF PF 1.27)/ (MHF PF 2.2)), which is sufficient to treat the projected 2035 GTL flow of 57.9 MGD M3MADF.

8.4.2 Secondary Treatment

GTL secondary treatment system is comprised of several process components, including the oxygen generation and supply system, biological reactors with surface aerators, return activated sludge pumping and secondary clarification.

8.4.2.1 Pure Oxygen System

A cryogenic oxygen facility generates the oxygen supply for biological treatment of wastewater. The system includes gaseous oxygen generating compressors, back-up storage of liquid oxygen, and delivery of the oxygen (gaseous) to the biological reactors. Using three existing oxygen generating compressors, GTL facility has a rated capacity of 55 tons per day (tpd) of gaseous oxygen (at 98% purity or greater). However, GTL only uses two compressors at a time. GTL can also generate 2.5 tpd of liquid oxygen, while generating 45 tpd of gaseous oxygen. Additionally, GTL can store up to 194 tons of liquid oxygen on site to meet peak oxygen demands.

Oxygen supplied to the system has the capacity to treat 79.3 MGD M3MADF of wastewater flow. The capacity was calculated using the values and equations summarized below:

- At an effective oxygen transfer efficiency (from head space into water) of 90 percent and an oxygen purity of 98 percent, 0.9 (oxygen transfer efficiency) x 0.98 (percent purity) x 55 tons O_2/day = 49 tons O_2/day (97,020 lb O_2/day), is available to organisms on a sustained basis.
- To treat maximum-day BOD loadings, allowances are included for non-BOD oxygen losses equal to a total oxygen demand of 8.5 tons O_2/day (see Section WW16 for further information). 8.5 tons O_2/day = 17,000 lb O_2/day.
- The oxygen remaining for the treatment of BOD at M3MADF is 97,020 lb O_2/day - 17,000 lb O_2/day = 80,020 lb O_2/day.
- At an oxygen utilization rate of 1.1 lb O_2/day/lb BOD, the oxygen generating system has the capacity to treat 72,746 lb/day of BOD at M3MADF (80,020 lb O_2/day / 1.1 lb O_2/day/lb BOD).
- The 72,746 lb/day of BOD that can be treated is equivalent to a wastewater flow of 79.3 MGD M3MADF ((72,746 lb/day of BOD) / (94 mg/L average day BOD concentration x 1.17 MMADL BOD Factor x 8.34 lb/mg/L)). Please note the MMADL BOD factor of 1.17 was used as a conservative estimate of the M3MADL BOD factor in this calculation.

The wastewater flow of 79.3 MGD on an M3MADF is greater than the projected design M3MADF of 57.9 MGD. Thus, the oxygen system has sufficient capacity to meet future flow conditions.

8.4.2.2 Biological Reactors

GTL uses two biological reactors, each with two (2) flow trains with three stages per train. Each stage has dimensions of 50 ft by 50 ft by 15 ft side water depth. Each reactor has a volume of 225,000 ft^3 (1 reactor x 2 trains x 3 stages x 50 ft x 50 ft x 15 ft) with a combined volume of 3.4 MG (2 reactors x 225,000 ft^3 x 7.48 gallon/ft^3).

Each of the stages uses mechanical aeration to transfer oxygen from the reactor head space to the wastewater. Both reactors in conjunction with the mechanical aerators satisfy the EPA Class 1 reliability criteria (which addresses the need for redundancy).

Biological solids are maintained in each of the biological reactors according to the control parameter solids retention time (SRT), and removed from the effluent by the secondary clarifiers. A higher SRT value requires higher concentrations of mixed liquor suspended solids (MLSS) to be maintained in the biological reactors, which is separated from the effluent by the secondary clarifiers and then, using sludge pumps, re-pumped at a controlled rate back to the biological reactors. A lower SRT requires lower MLSS concentrations and reduces the solids loading to the clarifiers and amount repumped to the biological reactors. The relationship between SRT and MLSS in the biological reactors, for a given plant capacity, is given in **Table WW8-8.**

Table WW8-8. Bioreactor MLSS

Bioreactor MLSS at Increasing Flows for the GTL WWTP			
M3MADF (mgd)	SRT = 1 day	SRT =1.5 days	SRT = 2.0 days
50	1,215	1,822	2,430
55	1,336	2,004	2,673
57.9	1,407	2,110	2,813

The MLSS concentration in the biological reactors and corresponding SRT is dependent on the maximum solids loading rate that the clarifiers can effectively thicken and handle. The clarifier capacity under these conditions is confirmed later in Section WW8.4.2.4. Based on the discussion in that section, the maximum MLSS that can be treated by the secondary clarifiers is 2,813 mg/L at MHF.

Assuming the highest maintained MLSS is 2,813 mg/L, a typical pure oxygen system food-to-microorganism (F/M) ratio can be used to determine the maximum allowable BOD loading to the biological process. Multiple industry references suggest a maximum F/M ratio of 1.0 for pure oxygen systems. The resulting capacity of the biological system was calculated as follows:

- At an F/M ratio of 1.0, the allowable BOD loading is equal to the pounds of volatile solids in the reactors, or the mixed liquor volatile suspended solids (MLVSS).
- GTL data indicated a typical volatile fraction of solids of 0.84 in sludge removed from the facility.
- The MLVSS inventory was calculated as (2,813 mg/L x 0.84 x 3.4MG x 8.34 lb/(mg/L x MG), or 67,002 lb MLVSS.
- A corresponding BOD loading of 67,002 lb/day would occur at a M3MADF of (67,002 lb/day / (94 mg/L x 1.17 MMADL BOD Factor x 8.34 lb/(mg/L x MG)), or 73.0 MGD M3MADF.

The wastewater flow of 73.0 MGD on an M3MADF is greater than the projected design M3MADF of 57.9 MGD. Thus, the biological reactors have sufficient capacity to meet future flow conditions.

8.4.2.3 Aerators

The biological reactors at GTL utilize a total of twelve (12) mechanical aerators to provide oxygen (supplied by a cryogenic pure oxygen system described in the preceding section) in support of the system's biological processes. The aerators have a combined power of 1,100 hp. The actual oxygen transfer rate (AOTR) of the mechanical aerators in an oxygen environment is approximately 5.5 lb oxygen/hp-hr, equivalent to an oxygen supply capacity of 128,700 lb/day to the clarifiers when operating at normal wastewater temperatures and with the largest aerator out of service ((1,100hp - 125hp) x 5.5 lb oxygen/hp-hr x 24 hr/day). The oxygen transfer capacity of 128,700 is greater than the oxygen supply capacity of 78,000 lb/day. Thus, the oxygen transfer system is adequate.

The biological process consumes approximately 1.1 pounds of O_2 per pound of BOD removed. This oxygen transfer therefore allows for the treatment of a MHF of 156 MGD (100.3 MGD MHF x 128,700 lb/day / (1.1 lb O2/day/lb BOD x 75,150 (MHF PF 2.2 x 34,159) lb/day at MHF)), which is less than the projected design MHF of 100.3 MGD. Thus, the aerators do not provide sufficient capacity to meet future flow conditions with the largest aerator out of service.

To confirm the design criteria of 5.5 lb oxygen, a second aeration transfer reference was utilized. For pure oxygen system, brake horsepower requirement for dissolution and mixing typically run from 0.08 to 0.14 hp per 1,000 gallons. This equates to 7.0 MG (975 hp / 0.14 hp per 1,000 gallons), which is higher than the available biological reactor volume of 3.4 MG. Thus, there is sufficient aeration in the biological reactors.

The 111.4 MGD aerator capacity (975 HP x 5.5 lb oxygen/hp-hr x 24 hours x 1.1 lb O2/day/lb BOD x 8.34 lb/ mg/L x 1.34 (PF) x 94 mg BOD/L) is equivalent to an M3MADF of 64.3 MGD (111.4 MGD x (M3MADF PF 1.27)/ (MHF PF 2.2)), which is sufficient to treat the projected 2035 GTL capacity of 57.9 MGD M3MADF.

8.4.2.4 Secondary Clarifiers

The secondary clarifiers provide a quiescent zone for the settling of the MLSS from the aeration process units. The clarification process typically performs two (2) basic functions. The first function of the clarifier is to separate the MLSS from the treated liquid or effluent. The second purpose is to collect and thicken the settled solids prior to return to the process. The clarified effluent, referred to as secondary effluent, flows to the next unit process basin and the settled solids return to the beginning of the treatment process, or are thickened, dewatered and stabilized for disposal.

Since large quantities of solids pass through the clarifier and on to the next unit process if the design rates are exceeded, the clarifier should be designed for peak loading conditions. There are two (2) major design criteria for the clarification process as follows:

1. Surface Loading Rate or Overflow Rate
2. Solids Loading Rate

Secondary clarifiers are designed based on MHF, and the design criteria listed above. It is important to note that average conditions for the surface and solids loading rates are also used to verify clarifier sizing. Therefore, standard references for clarifier design generally publish loading rates for the two (2) criteria identified above.

Table WW8-9 summarizes published clarifier design criteria.

Table WW8-9. Secondary Clarifier Industry Standard Design Criteria Summary

Criteria	Standard	Reference
Surface Overflow Rate at Average Daily Flow (gpd/sf)	400 to 800	Metcalf & Eddy, 1991
	800	MOP 8, 1998
	400 to 800	EPA Design Manual
Surface Overflow Rate at MHF (gpd/sf)	1,000 to1,200	Metcalf & Eddy, 1991
	1,200	10 States Standards
	800 to 1,000	EPA Design Manual
Solids Loading Rate at Average Daily Flow (lb/d/sf)	19.2 to 28.8	Metcalf & Eddy, 1991
	20 to 30	MOP 8, 1998
Solids Loading Rate at MHF (lb/d/sf)	48	Metcalf & Eddy, 1991
	50 to 80	MOP 8, 1998
	50	10 States Standards
Depth (feet)	12 to 20	Metcalf & Eddy, 1991
	10 to 15	MOP 8, 1998
	12	10 States Standards
	12 to 15	EPA Design Manual

The original criteria used for the design of the secondary clarifiers at GTL are listed below:

GTL's Design Surface Overflow Rate @ MHF conditions = 1,200 gpd/sf

GTL's Design Solids Loading Rate @ MHF conditions = 35 lb/d/sf

For the purposes of this evaluation, the following AADF criteria were also utilized to verify clarifier design:

GTL's Surface Overflow Rate @ AADF conditions = 600 gpd/sf

GTL's Solids Loading Rate @ AADF conditions = 20 lb/d/sf

GTL has seven (7) square clarifiers each with a surface area of 9,025 sf (95 ft x95 ft), and four (4) circular clarifiers each with a surface area of 5,026 sf (80 ft diameter). These clarifiers provide a total surface area of 83,300 sf. Based on a hydraulic loading criterion of 1,200 gpd/sf at MHF, clarification maximum capacity for all eleven units is 99.9 MGD MHF (83,300 sf x 1,200 gpd/sf). This capacity is equivalent to 58.0 MGD M3MADF (99.9 MGD x (M3MADF PF 1.27)/ (MHF PF 2.2)).

To meet Class I reliability standards, the facility must be able to treat 75 percent of AADF (45.6 MGD x 0.75 = 34.2 MGD) and MHF (100.3 x 0.75 = 75.2) with the largest unit (the square clarifier) out of service. With one of the seven square clarifiers out of service, the actual firm capacity is equivalent to 44.6 MGD AADF ((83,300 sf – 9,025 sf) x 600 gpd/sf), and 89.1 MGD MHF ((83,300 sf – 9,025 sf) x 1,200 gpd/sf). Thus, the clarifiers have sufficient capacity to meet EPA Class I Reliability Criteria on an AADF and MHF basis.

The next step to evaluate clarification capacity is to compare the solids loading rates (SLR) to design flow conditions, including RAS flow (design 35 percent of wastewater flow). Assuming the design MLSS concentration of 2,110 mg/L (1.5 days SRT at design capacity), an average SLR of 13.0 lb/d/sf ((2,110 mg/L x 45.6 MGD x 1.35 RAS flow x 8.34 lb/ mg/L) / 83,300 sf) and a peak SLR of 28.6 lb/day/sf ((2,110 mg/L x 100.3 MGD x 1.35 RAS flow x 8.34 lb/ mg/L) / 83,300 sf) were calculated. As both the calculated AADF SLR and MHF SLR meet required values

(20.0 lb/day/sf average SLR and 35.0 lb/d/sf peak SLR), there is sufficient clarification capacity to meet industry standards for secondary clarification at GTL.

8.4.2.5 Return Sludge Pumps

GTL utilizes return sludge pumps to return solids from the clarifiers back to the biological reactors, to maintain the MLSS concentration in the system. GTL has a total of nine (9) return sludge pumps which provide a total capacity of 55.9 MGD. To maintain the sludge removal from the clarifiers, assuming 8,000 mg/L RAS solids concentration (0.8% solids), total RAS flow must be approximately 35 percent of GTL AADF (45.6 MGD x 0.35 = 16.0). Thus, the pumps are adequate to maintain the required return flows.

8.4.2.6 Waste Sludge Pumps

Excess from the settled sludge, or waste activated sludge (WAS), is pumped to the sludge handling process. The three (3) WAS pumps each have 1,200 GPM capacity. However, due to pipe configurations and hydraulic head limitations, the pumps have a maximum output of 1600 GPM, or 2.3 MGD. On average, GTL is returning 0.8 MGD WAS. With an AADF of 39.9 MGD, the WAS rate is 2%. Assuming the same WAS rate, the future WAS of the projected 2035 M3MADF flow (57.9 MGD) is 1.16 MGD (57.9 MGD X 2%), which is less than current WAS pump capacity (2.3 MGD). Thus, the pumps are sufficient to maintain future WAS flows.

8.4.3 Effluent Disposal

GTL uses a total of five (5) effluent pumps with variable frequency drives to send treated effluent to an IW system for effluent disposal. The effluent pumping system has three (3) 1,750-hp pumps each with a capacity of 32 MGD, and two (2) 1,250-hp pumps each with a capacity of 22 MGD.

These effluent disposal pumps provide a total capacity of 140 MGD ((32 MGD x 3) + (22 MGD x 2)), and a firm capacity with the largest pump out of service of 108 MGD ((32 MGD x 2) + (22 MGD x 2)). As the 108 MGD pump capacity is greater than the projected design MHF of 100.3 MGD, the effluent disposal system has sufficient capacity to meet future flow conditions.

The 108 MGD effluent disposal system would be sufficient to provide service for an equivalent GTL flow of 62.3 MGD M3MADF (108 MGD x (M3MADF PF 1.27)/ (MHF PF 2.2)), which is sufficient to treat the projected 2035 GTL capacity of 57.9 MGD M3MADF.

8.4.3.1 Deep Injection Well System and Disposal Capacity

GTL utilizes a Class I municipal IW system, located approximately 2,000 feet from the plant, for disposal of treated effluent. A 54-inch diameter force main connects GTL effluent pump station to the IW system, which consists of five (5) Class I municipal deep wells, three (3) on-site dual-zone monitoring wells, and one (1) regional dual-zone monitoring well. The City originally constructed injection well IW-5 as a test well to evaluate the feasibility of deep well injection at the site in 1981. The City constructed injection wells IW-1, IW-2, and IW-3 in 1982 and 1983, and placed the injection well system into service in 1984. The City constructed injection well IW-4 in 1997, and placed it into service in 1998 to meet increased disposal demands.

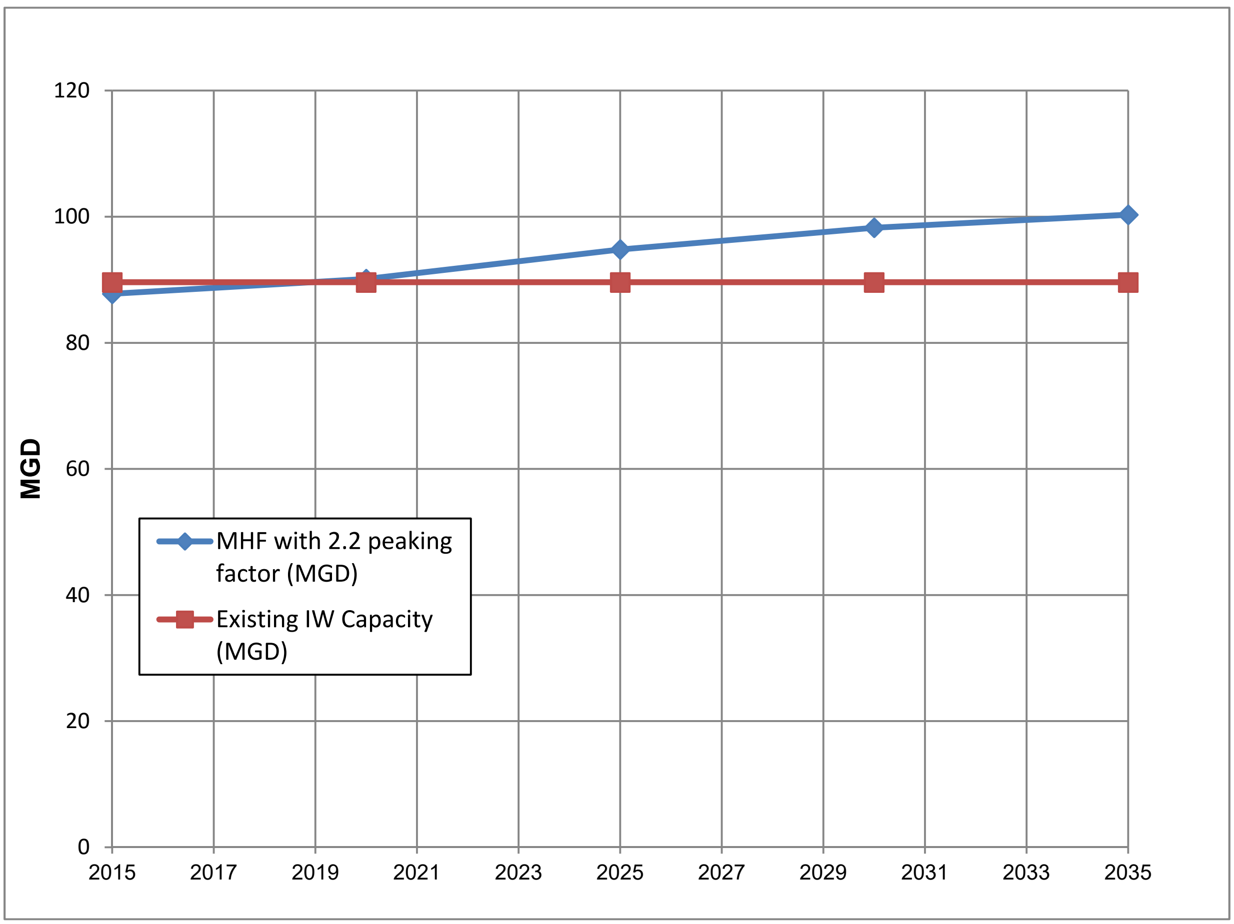
8.4.3.1.1 Disposal Capacity Evaluation

During normal operations (injection velocity of 10 feet per second), each of the five (5) IWs has a permitted MHF injection capacity of 18.7 MGD. The IW system capacity provides a total disposal capacity of 93.5 MGD MHF (18.7 MGD x 5), which is less than the projected design MHF of 100.3 MGD. Thus, the IW system has insufficient capacity to meet future flow conditions.

During emergency conditions or planned testing of the wells, such as mechanical integrity testing (injection velocity of 12 feet per second), firm disposal capacity must be provided (largest IW out of service), and the IWs have a permitted MHF injection capacity of 22.4 MGD. Operating under emergency conditions, this provides a total disposal capacity of 112 MGD MHF (22.4 MGD x 5), and firm capacity with the largest pump out of service of 89.6 MGD MHF.

The 89.6 MGD MHF IW system capacity (limiting capacity based on emergency operation condition) is equivalent to a 51.7 MGD M3MADF (89.6 MGD x (AADF PF 1.27)/ (MHF PF 2.2)), which is insufficient to treat the 2035 GTL capacity of 57.9 MGD M3MADF. The reduction of I/I can eliminate the need of a new deep injection well, which can save the City the labor and cost associated with such a project. Funding source(s) need to be identified for I&I removal on a fast track basis to regain capacity lost to I&I.

Figure WW8-3. Current Deep Injection Well (IW) System Disposal Capacity and Projected GTL Effluent MHF.



According to the projections, the effluent flow could exceed the normal operating MHF IW capacity beginning in 2019 under emergency conditions or during integrity testing. Therefore, the City will need one (1) additional IW to meet MHFs, unless influent flows to GTL are reduced. The velocity during maximum hourly flow should never exceed 12 feet per second when one or more wells are taken out of service during planned testing, maintenance or emergency conditions. Due to the high I/I flows creating a high maximum hourly flow to GTL, the CUSMP team recommends to perform MIT during the dry season to stay within the 12 feet per second velocity limitation. The opportunity to reduce influent resides in reducing I/I flow, which is estimated to be over 55% of the average plant influent. It will be necessary to construct a new dual-zone monitoring well associated with a new IW. It is important to note that wastewater disposed of via a new Class I IW would require tertiary treatment to meet the requirements of Rule 62-528, FAC (Rule). Existing injection wells IW-1 through IW-5 are exempt from this Rule since the wells were constructed prior to implementation of the Rule, but would lose their exemption if a new IW-6 is constructed.

It typically takes approximately 18 to 24 months to place a Class I IW and associated dual-zone monitoring well into service once the permittee submits a construction permit application to FDEP for processing. Unless I/I can be significantly reduced, the CUS Master Plan Team recommends that the process of IW design and permit application preparation begin in January 2017 to ensure the additional disposal capacity is in place by the beginning of 2019. The current permit processing fee for a Class I injection well construction permit is $12,500. The CUSMP Team recommends the City consider investing in reducing I/I aggressively rather than spending money on the additional injection well and all the associated electrical and other construction costs. The construction permit would also allow the construction of the new dual-zone monitoring well.

Effluent disposed of via the new IW would be required to be treated to high level disinfection standards unless the new IW were also utilized for disposal of a non-hazardous industrial waste stream. The City currently disposes of only municipal wastewater effluent treated to secondary standards. If the City used a new IW for disposal of industrial wastewater and treated effluent, FDEP would require the City to treat the effluent to secondary standards, which is the level of treatment currently provided by GTL. The FDEP would then classify the new well as a Class I Industrial injection well and would require an injection liner inside the final casing of the well. The addition of a new IW would not affect the current level of treatment requirements of effluent disposed via the existing IWs. Therefore, given the costs and lack of available space to construct plant facilities associated with treating effluent to high level disinfection standards, it is recommended that the new IW be permitted for disposal of both secondary treated effluent and a non-hazardous industrial waste stream to allow the Class I Industrial well classification. The source of this non-hazardous industrial waste stream has not yet been identified; however, landfill leachate has been used as industrial waste in such application. There is uncertainty of cost in this alternative, such as the cost of the pipelines required to convey such non-hazardous industrial flows. The CUSMP Team recommends the City to further investigate and identify such potential non-hazardous industrial waste contributors, as the need for an additional injection well is inevitable unless the City can significantly reduce I/I flow. However, the location for an additional well would be difficult because of the well spacing limitations on the existing site. Land availability near the GTL for an additional injection well is also limited. A separate pipeline from GTL to the new IW would be required to convey the municipal wastewater/industrial wastewater. The current construction capital costs to add a Class I Industrial injection well and dual-zone monitor well to the existing IW system is approximately 4.75 to 5.25 million dollars. An additional IW alternative would be much less expensive than modifying GTL to meet tertiary standards.

8.4.3.1.2 IW Replacement and Rehabilitation

Once constructed, municipalities have typically not replaced the subsurface portion of Class I injection wells in South Florida. Surface equipment such as wellhead piping, bolts, restraining rods, valves, flowmeters, and transducers may need replacement due to exposure to the elements. The wellheads and surface piping, valves and fittings should be properly prepared and painted to protect them from corrosion every five (5) years in conjunction with the Mechanical Integrity Testing (MIT). Typically, the injection pressure of an injection well will gradually increase over time due to partial plugging of the injection zone and buildup of material on the inside of the final casing.

Material buildup on the inside of the final casing of the IWs can be greatly reduced by brushing the casing wall with a non-aggressive casing brush. This method has been effective at reducing injection pressures which will save on electrical costs to pump effluent down the injection wells. The inside wall of the final casing of each IW should be brushed followed by back-flowing the well in association with MIT of the wells which is required every five (5) years. The estimated cost of brushing the inside wall of the final casing is approximately $5,000 per well when done in association with the performance of the MIT. The estimated cost of brushing the inside wall of the final casing is approximately $20,000 per well when not done in association with the MIT. Infrastructure required for the IWs to be back-flowed is in place to readily allow back-flowing of the IWs. The inside of the final casing of each of the IWs was most recently brushed in 2014 in association with the most recently performed MIT of the wells and proved to be highly effective. Rehabilitation of the injection wells, in the form of acidization, should take place approximately every ten (10) years to lower injection pressures further. Each of the injection wells underwent acidization in 2015 at a cost of approximately $70,000 per well. The well capacity improvements from the 2015 acidization were not nearly as affective as brushing the inside the final casing of each well. However, the acidization does serve to reduce material that can build-up in the fractures and cavities of the injection zone. Therefore, the next acidization of the IWs should take place in 2025.

The dual-zone monitoring wells constructed with a steel final casing are subject to a high failure rate due to exposure to high-salinity groundwater. Most of the dual-zone monitor wells in South Florida that were originally constructed with a steel final casing have been either rehabilitated to replace the steel final casing with Fiberglass Reinforced Pipe (FRP) casing or have been plugged and replaced. The City constructed Monitor wells MW-1 and MW-2 with steel final casings. Monitor wells MW-3 and the regional dual-zone monitor well (RMW-1) were constructed with a FRP final casing and should not require replacement prior to 2035. It is likely that MW-2 will need to be replaced prior to 2035 because MW-1 was replaced in 1995 due to a casing failure; however, it is not possible to predict when such replacement will be needed. The current replacement cost of a dual-zone monitor well is approximately $1,250,000.

8.4.3.2 Biosolids Handling

Biosolids at GTL are pumped into two (2) sludge storage tanks located at the facility. Sludge from the clarifiers is thickened in the storage tanks and dewatered using belt filter presses. After dewatering, the biosolids in cake form are hauled offsite for further processing or hauled to the Central Disposal Landfill in Pompano Beach, Florida. The primary infrastructure components related to biosolids handling capacity at GTL are the sludge storage tanks, and the belt filter presses.

8.4.3.3 *Sludge Storage*

Sludge is stored in two (2) existing onsite tanks, which the City originally built as anaerobic digesters. The City equipped the two (2) 60 ft diameter tanks with mixing and aeration devices to provide each a storage capacity of 450,000 gallons (0.45 MG). Additionally, the City equipped both tanks with decanting capability, which thicken the sludge to up to 2 percent solids. At 2 percent solids (20,000 mg/L), the sludge storage tanks can store a total of 150,120 lb dry solids (0.45 MG x 8.34 lb/ gal x 20,000 mg/L x 2 tanks). The max month solids production rate is 41,356 lb/day (94 mg/L BOD x 8.34 lb/ mg/L x 45.6 MGD x 0.87 lb TSS created/lb BOD x MMADF PF 1.33). The capacity of the sludge storage tanks with 2 percent solids provide 3.63 days (150,120 lb / 41,365 lb/day) of storage.

This sludge storage is equivalent of 95.8 MGD ((150,200 lb/ 2 days) / (8.34 lb/ mg/L x 94 mg/L BOD)), which is greater than the projected design M3MADF of 57.9 MGD (anticipated BOD = 94 mg/L). Thus, the sludge storage has sufficient capacity.

Table WW8-10 summarizes the available sludge storage times at concentrations of 1, 1.5 and 2 percent solids at a biological process SRT of 1.5 days. At a solids concentration of 1 percent, the sludge storage time is less than the desired 2 days of storage. In order to meet the City's goal of two days minimum storage without construction of additional storage volume, the decanting system should be operated to maintain a minimum 1.4 percent solids concentration in the tanks.

Table WW8-10. Sludge Storage Detention Time at Increasing Flows and Average Solids Concentration

Sludge Storage Detention Time at SRT = 1.5 days (days)			
M3MADF (MGD)	1% solids	1.5% solids	2% solids
50	2.10	3.15	4.20
55	1.91	2.87	3.82
57.9	1.81	2.72	3.63

8.4.3.4 *Dewatering Belt Filter Presses*

The City performs biosolids dewatering using seven (7) belt filter presses (BFP), each with an effective width of 2 meters and a loading capacity of 900 lb/hr of dry solids. The belt presses are designed to handle the maximum month biosolids production while operating at 24 hours per day, 5 days per week, with one unit out of service. Based on these criteria, the belt filter presses can dewater 129,600 lb/day (900 lb/hr x 24 hours/day x 6 BFP) for 5 days per week, which is equivalent to an average day waste sludge production capacity of 92,571 lb/day (900 lb/hr x 24 hours/day x (5/7) operating days x 6 BFP). Under design conditions, this solids loading to the belt presses would equate to a total plant flow of approximately 135.7 MGD (92,571 lb/day / (94 mg/L BOD x 0.87 lb TSS/lb BOD x 8.34 lb/ mg/L). The available solids processing rate of 92,571 lb/day is greater than the projected M3MADF design biosolids production rate of 52,500 lb/day.

Based on these calculations, the belt presses have sufficient capacity to meet the projected 2035 flows on both a flow and solids loading basis.

8.5 Capacity Summary and Recommendations

Based on the capacity analysis, GTL treatment processes have sufficient capacity to treat wastewater for the projected 2035 flow of 57.9 MGD M3MADF. However, overall capacity will be limited by the facility's effluent disposal system, specifically the injection well capacity, which will not meet emergency condition capacity requirements beginning in the year 2021. Additionally, projected flows will begin to exceed GTL's current permitted capacity of 56.6 MGD in the year 2032. As mentioned in **Section WW4**, reducing I/I flow can temporarily eliminate the needs for an additional injection well and GTL expansion due to capacity issue.

The CUSP Team recommends the following:

- Accelerate the investigation and implementation of methods to reduce I/I flows, to positively impact all capacity-related limitations.
- Initiate design, permitting, and construction of a sixth IW in January 2017, to expand effluent disposal capacity by the year 2019.
- Investigate methods for avoiding tertiary treatment requirements associated with the addition of the sixth IW, including potential for categorizing the new well as a non-hazardous industrial waste stream. Section WW-14 (Wastewater Reuse) for example presented a potential method and capital cost for same.
- Perform MIT on injection wells during dry season to avoid exceeding the maximum velocity of 12 feet per second when taking an injection well out of service.
- Operate sludge storage tanks such that a minimum of 1.4 percent solids is maintained to ensure City's goal of minimum two days of sludge storage is met.
- Pursue a permit capacity increase (required by 2032 under current conditions) after IW-6 construction up to the 57.9 MGD M3MADF projected 2035 flow.

A summary of the individual process capacities is provided in **Table WW8-11**.

Table 8-11. GTL WWTP Process Capacity Summary (57.9 MGD M3MADF Forecast for 2035)

Process	Capacity M3MADF (MGD)	Adequate Capacity (Y/N)
Influent Channels and Screens	65.8	Y
Grit Removal	73.9	Y
Biological Treatment - Pure Oxygen System - Biological Reactors - Aerators	 76.4 67.0 64.3	 Y Y Y
Secondary Clarifiers	58.0	Y
Effluent Disposal	62.3	Y
Deep Injection Well System Disposal	51.7	**N**
Sludge Storage	95.8	Y
Dewatering Belt Filter Presses	135.7	Y

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WW9 Wastewater Community Investment Plan (CIP)

9.1 Introduction

The Wastewater Community Investment Plan (CIP) and CUSMP recommended projects provides a short term (five-year), mid-term (ten to fifteen-year) and long-term (twenty-year) capital improvements necessary for the City's wastewater system to provide reliable and quality service. The Wastewater CIP and the CUSMP recommended projects include categories for treatment plants, collection system, pump stations, and force mains. Funding methods for the improvements are proposed based on existing and potential funding resources.

The CIP was compiled to accomplish the following goals in alignment with the City's strategic utility vision:

Sector of Infrastructure	Goals established in 2014
Wastewater Treatment	• Investigate feasibility of anaerobic digestion for the purpose of methane capture • Convert biosolids to marketable agricultural land application use • Use reclaimed water as a barrier between potable water and salt intrusion, and expand deep well capacity
Wastewater Collection and Transmission	• Increase I/I monitoring and identify projects that will minimize reduce I/I. • Raise lift station walls, and protect against flooding so that the sewer system is not the first failure to occur during a storm event
Infrastructure Renewal	• Prioritize transmission system projects to prevent main breaks and customer outages.
Energy and Water Conservation	• Reduce energy consumption 20% by the year 2020. • Increase the use of grey water irrigation, especially in commercial and multi-family buildings. • Analysis of the efficiency of pumps in both process and service capacities

Section WW9 accepted February 20, 2017.

This section includes a schedule of improvements necessary to ensure reliable and/or improved wastewater system service for the next 20 years (FY 2015 to FY 2035). The CUSMP Team analyzed the City's existing Council Approved 2016 CIP and incorporated several updated recommendations, policies, and procedural projects after evaluating the entire wastewater utility system.

The City's CIP funds separately (the Central Regional/Wastewater Fund) the regional treatment plant and regional transmission system due to its unique charter. The George T. Lohmeyer Wastewater Treatment Plant (GTL) is a regional facility that provides wastewater treatment and disposal for the Cities of Ft. Lauderdale, Wilton Manors, Oakland Park and Port Everglades, as well as portions of unincorporated Broward County (the Cities of Tamarac, Dania Beach and the Town of Davie). The creation of the Central Wastewater Region consolidated the service areas of the previous eight wastewater treatment plants in accordance with the communities' 1978 consensus, as documented in the Broward County Wastewater Management Facility Plan. The Central Wastewater Region agreements designated the City of Ft. Lauderdale (City) as the lead agent to provide wastewater collection and treatment services to the Region in accordance with P.L. 92-500 (the Clean Water Act). Participating municipalities own and operate their individual wastewater collection systems consisting of gravity sewers, lift stations, and forcemains. The City owns and operates the regional system, including GTL, Re-Pump Stations "A", "B" and "E", and forcemains connecting these re-pump stations to GTL. The "Agreements with Large Users of the Central Regional Wastewater System", signed in 1982 and implemented in 1986 when GTL began full operation, formalized this Central Wastewater Region. The Agreements' first 20-year contract ended in Fiscal Year 2001-02 and was amended in 2001 to cover the next 20 years terminating on December 31, 2021.

The City's wastewater collection and transmission is solely the responsibility of the City and is funded through the Water and Sewer Master Plan Fund.

9.2 Regional Wastewater Treatment Plant and Transmission

The GTL Plant is a well-designed and operated facility that adequately serves the City and its regional partners. The GTL Plant has some aging components that are in need of replacement. The Central Region completes an annual repair and replacement (R&R) report that identifies and budgets GTL Plant and the regional transmission system R&R needs. The CUSMP utilized this report in addition to site visits that identified additional 5 year and future regional R&R projects. One of the major R&R needs is the oxygen generation system which is also an excellent opportunity to move toward a more efficient technology. The GTL has adequate capacity to meet the City's 20 year projected needs but is hampered by large influxes of inflow and infiltration (I/I). The I/I increases salinity, making beneficial reuse more costly and hampers operations by diluting the wastewater and taxing the GTL's hydraulics. One capacity recommendation as a result of the I/I peak flows is a new redundant deep well. The top needs of the GTL and Central Regional system are summarized below:

1. GTL SCADA improvements
2. Reduce Inflow and Infiltration
3. Upgrade/replace GTL Cryogenic System and change from pneumatic to electric controls
4. GTL electrical upgrades with sub-metering at all MCC onsite and dedicated feed with internal looping with backfeed
5. Reduce biosolids hauling/disposal cost
6. Grit Removal (to mitigate sand issues and improve settling)
7. More efficient oxygen transfer

8. Substations master tie-in
9. Clarifier spray bars and bottom sweeps
10. Reactor 2 drain piping manifold at SPS-2: interconnection of piping to direct flow to any of the three pumps, currently only pump No. 1; replacement of VFDs

9.3 Collection and Transmission System

The City's collection and transmission system has robust capacity in part due to a $700M program implemented over the last 13 years (Waterworks 2011). The system is aged and many pipes are outdated and in need of rehabilitation as evidenced by the significant number of force main breaks experienced. The City's I/I has actually increased over the last ten years in spite of the significant Waterworks investments. While the City has been spending approximately $3M per year to rehabilitate the gravity collection systems, engineering field work and prioritization is recommended to translate the capital investment into tangible I/I flow reductions. The CUSMP wastewater collection and transmission system CIP is focused on rehabilitating key wastewater transmission mains that are outdated pipe materials and near service life end, reinstating key waterway transmission crossings, focused capacity related projects like splitting the A-7 sewer basin, performing engineering field work to minimize I/I and target rehab projects, pump station rehabilitation, hardening and beautification, and rehabilitating the gravity collection system to minimize R&R. Much of the service lateral piping is outdated and likely a significant I/I contributor: the CUSMP recommends funding R&R and addressing private laterals through ordinances and communication with elected officials and citizens. The major priority areas are as follows:

1. Inflow and Infiltration mitigation including City and private service laterals
2. Additional forcemain capacity in key areas and waterway crossings
3. PCCP and other outdated pipe material rehab/replacement
4. Reinstate key waterway forcemain crossings
5. Pump station rehabilitation, flood sealing and beautification

9.4 Energy Conservation

Recommended energy conservation methods include replacing the cryogenic oxygen generation system with a more efficient technology, variable speed drives on pump stations and anaerobic digestion of biosolids to reducing hauling energy and costs and generate energy in the future. The oxygen generation improvement itself should achieve the City's 20% energy reduction goal at the GTL. Several other small process suggestions were considered as well to reduce the GTL's carbon footprint.

9.5 City of Fort Lauderdale 20-Year Wastewater System CIP

Table WW9-1 summarizes the City's Community Investment Plan (CIP) for the various wastewater components and fund groupings. **Table WW9-2** and **Table WW9-3** present the City's 5-year CIP for Funds 451 (Regional Wastewater) and 454 (Water & Sewer Master Plan), respectively. **Table WW9-4** and **Table WW9-5** present the additional CUSMP-recommended for the 20-year planning horizon also for Funds 451 (Regional Wastewater) and 454 (Water & Sewer Master Plan), respectively. The CIP tables are organized by the City's CIP fund and are sorted by the primary CUSMP task and the project number.

Section WW9 accepted February 20, 2017.

Table WW9-1. Projected CIP Summary and CUSMP Recommended Projects Comparison

Category		FY 2017-2021	FY 2022-2026	FY 2027-2031	FY 2032-2036
Central Regional WW Fund (451)					
WW Treatment Regional	Planned CIP	$52,039,556	$0	$0	$0
	Unfunded CIP	$9,167,600	--	--	--
	CUSMP Additional	$26,072,693	$43,076,200	$41,056,600	$27,013,000
WW Pump Stations Regional	Planned CIP	$1,568,501	$0	$0	$0
	Unfunded CIP	$1,000,000	--	--	--
	CUSMP Additional	$936,192	$3,191,200	$3,690,400	$1,245,200
WW Force Main Regional	Planned CIP	$217,537	$0	$0	$0
	Unfunded CIP	$8,367,600	--	--	--
	CUSMP Additional	$28,046,000	$7,947,000	$31,369,000	$0
Utility Wide Regional	Planned CIP	$6,687,269	$0	$0	$0
	Unfunded CIP	$1,961,421	--	--	--
	CUSMP Additional	$20,646,959	$10,888,072	$5,988,073	$2,682,510
Subtotal Planned CIP:		*$60,512,863*	*$0*	*$0*	*$0*
Subtotal Unfunded CIP:		*$20,496,621*	*--*	*--*	*--*
Subtotal CUSMP Additional:		*$75,701,844*	*$65,102,472*	*$82,104,073*	*$30,940,710*
Fund 451 TOTAL:		**$156,711,328**	**$65,102,472**	**$82,104,073**	**$30,940,710**
Water and Sewer Master Plan Fund (454)					
WW Collection	Planned CIP	$42,949,306	$0	$0	$0
	Unfunded CIP	$50,406,104	--	--	--
	CUSMP Additional	$5,509,000	$64,716,500	$68,075,500	$108,750,000
WW Pump Stations City	Planned CIP	$9,503,253	$0	$0	$0
	Unfunded CIP	$0	--	--	--
	CUSMP Additional	$20,825,250	$23,146,750	$15,762,500	$22,660,000
WW Force Mains	Planned CIP	$3,095,350	$0	$0	$0
	Unfunded CIP	$0	--	--	--
	CUSMP Additional	$31,851,000	$4,072,000	$220,000	$0
WA Total	Planned CIP	$89,517,619	$0	$0	$0
	Unfunded CIP	$20,695,662	--	--	--
	CUSMP Additional	$136,713,476	$159,347,270	$148,725,212	$81,198,646
Utility Wide City	Planned CIP	$3,121,472	$0	$0	$0
	Unfunded CIP	$22,997,500	--	--	--
	CUSMP Additional	$26,238,890	$18,247,229	$12,207,925	$10,402,925
Subtotal Planned CIP:		*$148,187,000*	*$0*	*$0*	*$0*
Subtotal Unfunded CIP:		*$94,099,266*	*--*	*--*	*--*
Subtotal CUSMP Additional:		*$221,137,616*	*$269,529,750*	*$244,991,137*	*$223,011,571*
Fund 454 TOTAL:		***$463,423,882***	***$269,529,750***	***$244,991,137***	***$223,011,571***

Notes:
- City Planned CIP totals include Unspent Balance as of 9/29/16
- Please Refer to this link for the existing Fort Lauderdale 2017 to 2021 Community Investment Plan. http://www.fortlauderdale.gov/departments/city-manager-s-office/budget-cip-and-grants-division/community-investment-plans

9.6 Funding

Internal and external funding sources are essential to the successful execution of the CIP projects that require funding and financing. Currently, rates and impact fees for services internally generate the main revenue source fueling the wastewater fund. The Large Users Agreement plays an important role in budgeting wastewater improvement projects for the Central Regional assets. The Central Regional agreement requires a calculated amount of funds that transfer from the overall wastewater fund to a replacement and improvement reserve account specifically for planned Central Regional projects. Funds also transfer from the operating fund for the execution of planned sewer master plan projects.

The Central Regional/Wastewater Fund (Fund 451) and Water/Sewer Master Plan Fund (Fund 454) are the two main accounts the City uses to fund wastewater projects. The rates and fees the City charges for water/wastewater services replenish the Fund 451 and Fund 454 account.

The City's current wastewater system, while functional, requires immediate attention particularly with respect to reducing I/I and preparing for sea level rise. Most of the City's collection system pipes are over 50 years old and reaching service life end. Based on the analysis in Table WW9-1 above, the City has a five year funding gap of $151M for wastewater. The City is transferring over $20 million a year collected from residents' water and sewer bills and using the money to cover other City expenses. This is the first source of funding to add to help cover the funding gap. The City should also pursue federal funding for the planned, energy conserving oxygen generation system to help offset the customers costs.

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Table WW9-2. City of Fort Lauderdale
Wastewater Community Investment Plan - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	WW06	P11710	GTL EMERGENCY GENERATOR CONNECTION	This project is to install a connection for an Emergency Generator and to upgrade the existing 4160 Volt switchgear at GT Lohmeyer Wastewater Treatment Plant (GTL WWTP). Project will include any required building repairs for providing proper space conditioning for new/upgraded equipment.	For operation of the plant the 4160 Volt switchgear and a source of power is required at all times. The installed generator does not have any redundancy and has failed. This will allow for more reliable operation of the plant electrical system.	3,918,047	-	-	-	-	-	3,918,047	-	-	-	-
451	WW08	FY 20150293	GEORGE T. LOHMEYER (GTL) MECHANICAL INTEGRITY TEST	The Mechanical Integrity test (MIT) includes casing pressure testing, geophysical logging, video surveying, temperature logging, and radioactive tracer surveying of the 3,000 feet deep injection well at the George T. Lohmeyer Water Treatment Plant.	The MIT must be conducted every five years, and completed by the date that is listed in the underground injection control (UIC) permit. The next MIT date will be in October 2019.		-	-	617,889	-	-	617,889	-	-	-	-
451	WW08	P12106	GTL DRAINAGE SYSTEM	This project constructs improvements necessary to restore the drainage system for the George T Lohmeyer (GTL) Wastewater Treatment plant. The plant's drainage system is not currently connected to a discharge outfall. To avoid flooding adjacent private property storm water is pumped into the plant's treatment process during moderate to heavy rain events.	This project is necessary to prevent flooding of private property adjacent to the wastewater treatment plant. The property owners subjected to the flooding have provided numerous complaints.	520,421	-	-	-	-	-	520,421	-	-	-	-
451	WW08	P12107	SLUDGE WEIGHING SCALES	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.	147,376	-	-	-	-	-	147,376	-	-	-	-
451	WW08	P12174	UNDERGROUND INJECTION CONTROL (UIC) PERMITS	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.	105,775	-	-	-	-	-	105,775	-	-	-	-
451	WW10	FY 20150283	GTL EFFLUENT PUMPS REPLACEMENT	This project is for the replacement of the George T. Lohmeyer Water Treatment Plant's effluent pumps. The project's replacement schedules are: - Two pumps in 2017; and - Three pumps in 2018.	The effluent pumps providing deep well injection has a useful life of 15 years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. These five pumps were installed in 2003. All impellers have been replaced, but the rotating assemblies and volutes will need repair or replacement.		-	300,000	1,455,258	-	-	1,755,258	-	-	-	-
451	WW10	FY 20150285	PRE-TREATMENT CHANNEL STOP GATES	This project is for pre- treatment channel stop gates at the George T. Lohmeyer Water Treatment Plant.	The gates have a useful life of 20 years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. These gates were installed in 1984. These gates control and isolate raw wastewater flows within the pre- treatment building, and are essential in containing flows and preventing overflows.		-	534,476	-	-	-	534,476	-	-	-	-
451	WW10	FY 20150286	REACTOR BASIN CONCRETE/CORROSION REPAIR	This project is for reactor basin concrete corrosion repair at the George T. Lohmeyer Water Treatment Plant.	The concrete repairs were previously done in 2003, and has a useful life of 15 years according to the 2013 Central Regional Wastewater System Renewal and Replacement Requirement Analysis.		-	669,879	-	-	-	669,879	-	-	-	-
451	WW10	FY 20150288	GEORGE T. LOHMEYER (GTL) SLUDGE SCREW CONVEYOR	This project is for the replacement of biosolids screw conveyors at the George T. Lohmeyer Water Treatment Plant.	The conveyors were installed new in 1999 and 2005, and have a useful life of 15 years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. The wear liners have been replaced in a portion of the conveyors to prolong the useful life.		-	812,404	-	-	-	812,404	-	-	-	-
451	WW10	FY 20150289	GEORGE T. LOHMEYER CHLORINE SYSTEM	This project is for the replacement of the chlorine feed system at the George T. Lohmeyer Wastewater Treatment Plant. The work is for the disinfection of effluent and maintaining the deep wells.	The chlorine system was installed new in 2006, and has a useful life of ten years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. This system must be maintained to assure the safe application of disinfectant to the effluent.		-	982,947	-	-	-	982,947	-	-	-	-
451	WW10	FY 20150291	REGIONAL B RE-PUMP VARIABLE FREQUENCY DRIVE (VFD)	This project is for the replacement of the Variable Frequency Drive (VFD) at B-repump.	The VFD has a useful life of ten years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. This drive was installed in 2009.		-	-	570,108	-	-	570,108	-	-	-	-
451	WW10	FY 20150292	GEORGE T. LOHMEYER (GTL) CHLORINE SCRUBBER	This project will fund the chlorine scrubber replacement at the George T. Lohmeyer Water Treatment Plant.	The scrubber has a useful life of ten years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. This drive was installed in 2006. The scrubber is an integral part of the facility's Risk Management Plan, and must be maintained according to this plan.		-	-	370,570	-	-	370,570	-	-	-	-

Table WW9-2. City of Fort Lauderdale
Wastewater Community Investment Plan - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	WW10	FY 20150294	ODOR CONTROL DEWATERING BUILDING	This project is for the George T. Lohmeyer Water Treatment Plant odor control system Dewatering building study and upgrade.	The dewatering process odor control system has a useful life of 20 years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. This system was constructed and installed in 1999. The system needs to be studied and upgraded to alleviate odor concerns from the facilities neighbors.		-	-	285,054	-	-	285,054	-	-	-	-
451	WW10	FY 20160422	CLARIFIER EFFLUENT PROCESS PIPING	This project is for the replacement of Prestressed Concrete Cylinder Pipes (PCCP) for the clarifier effluent system at the George T. Lohmeyer Wastewater Treatment Plant	The PCCP pipe at GTL was installed in the early 1980s. This pipe has failed in other locations causing reportable spills. The pipe has experienced numerous of failures across the United States due to poor quality control during the manufacturing process.					1,236,270	-	1,236,270	-	-	-	
451	WW10	FY 20160455	G.T. LOHMEYER WWTP BELT PRESS SLUDGE FEED PUMPS	The eight belt press sludge pumps move approximately 1% sludge slurry form the two sludge holding tanks to the belt filter presses for the dewatering operation.	The pumps were installed new in 2007 with a useful life of five years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. These pumps have been maintained with rotor replacements beyond their useful life. At the replacement date, the electrical control panels and hardware would need to be included.			85,516	142,527	-		228,043	-	-	-	
451	WW10	FY 20170513	REPLACEMENT OF THE FREIGHT ELEVATOR AT THE GTL WWTP	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.		-		-	-	-	-	-	-	-	800,000
451	WW10	FY 20170517	G.T. LOHMEYER (GTL) GRIT PUMPS REPLACEMENT	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.		-		-	-	57,011	57,011	-	-	-	-
451	WW10	FY 20170518	G.T. LOHMEYER (GTL) SLUDGE TRANSFER PUMPS	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.		-		-	-	38,447	38,447	-	-	-	-
451	WW10	FY 20170519	G.T. LOHMEYER (GTL) PT SEAL WATER SYSTEM	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.		-		-	-	34,327	34,327	-	-	-	-
451	WW10	FY 20170520	GEORGE T. LOHMEYER SLUDGE HOLDING TANK DECANTING V	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.		-		-	-	273,652	273,652	-	-	-	-
451	WW10	FY 20170521	G.T. LOHMEYER INJECTION WELL BACKFLUSH PUMP	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.		-		-	-	71,263	71,263	-	-	-	-
451	WW10	FY 20170525	UNDERGROUND INJECTION CONTROL (UIC) PERMITS	This project is for Renewal of Florida Department of Environmental Protection UIC Permit for operation of five Class I injection wells.	The UIC permit for George T. Lohmeyer must be renewed every five years. Renewal application must be submitted 60 days prior to expiration date of January 22, 2017.		-		-	-	109,848	109,848	-	-	-	
451	WW10	P00401	REGIONAL RENEWAL & REPLACEMENT	The City is the owner and operator of the Broward County Central Wastewater System . The regional system consists of wastewater transmission lines, re-pump stations and the wastewater treatment facility. This project accounts for the costs associated with these facilities. Annually the Region prepares a Central Region Wastewater Renewal and Replacement Analysis that is a 20-year financial plan for the systems renewal and replacements. This project identifies those funding requirements. Annually we evaluate the regional components and validate their condition against the expected life span previously analyzed. The information on the component(s) is(are) then updated based on when it should be replaced including its anticipated cost. This information is entered into a 20 year rotating replacement database to ensure sufficient funds are collected.	Provides for current and future needs, as noted in the Wastewater Master Plan and annual Central Region Renewal and Replacement Report.	577,085	235,515	649,918	2,213,506	5,425,636	5,375,214	14,476,874	-	-	-	
451	WW10	P11340	GEORGE T. LOHMEYER (GTL) STRUCTURE IMPROVEMENTS	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification. This project was completed in July of 2013.		-	-	-	-	-	-	-	-	-	-
451	WW10	P11683	GTL BUILDING PARAPET AND ENVELOPE REPAIR	CIP 2017-2021 for Description	CIP 2017-2021 for Justification. This project was completed in August of 2013		-	-	-	-	-	-	-	-	-	-
451	WW10	P11689	GTL DEWATERING SLUDGE FEED MIXERS REPLACEMENT	CIP 2017-2021 for Description	CIP 2017-2021 for Justification. This project was completed in January of 2015.		-	-	-	-	-	-	-	-	-	-
451	WW10	P11731	48 IN WASTEWATER PIPE EMERGENCY REPLACEMENT	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	217,537	-	-	-	-	-	217,537	-	-	-	8,367,600

Table WW9-2. City of Fort Lauderdale
Wastewater Community Investment Plan - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	WW10	P11773	GTL PLANT REHABILITATION OF PCCP PIPE	Design & Construction of the rehabilitation or replacement of PCCP process pipe within the GT Lohmeyer Wastewater Treatment Plant (GTL WWTP). Work will include planning design & construction as follows:1) identification of pipes to be replaced 2) analysis and determination of rehabilitation-vs-replacement 3) develop short & long term action plan for replacement schedule 4) identification of bypass piping requirements opinion of probable construction cost and rehabilitation schedule.	O&M staff indicated that existing PCCP process pipes within GTL WWTP have deteriorated (leaking) and must be replaced. O&M staff have requested assistance from Engineering staff to coordinate project management for the planning design and construction of such PCCP process pipes.	7,127,622	-	-	-	-	-	7,127,622	-	-	-	8,367,600
451	WW10	P11781	CRYOGENIC PLANT	This project is to upgrade all equipment and controls to the latest technology in order to automate the Cryogenic Plant and increase reliability at George T. Lohmeyer (GTL) Wastewater Treatment Plant (WWTP). The project will include any required control room upgrades for proper space conditioning. The work includes engineering evaluation, and upgrades to several components of the Cryogenic plant, including upgrade of the control systems, valve replacements, cold box rehabilitation, replacement of the motor control counter, upgrades to back up systems, and maintenance of the air compressors.	A reliable source of liquid oxygen is required to operate the wastewater plant. This project will increase reliability of the Cryogenic plant, providing a more efficient supply of liquid oxygen and allow more monitoring of the plant. Extensive repairs are required to maintain the plant in reliable working condition. The original equipment is 30 years old. The necessary repairs are expected to exten the life for another 15 years of good working condition.	5,138,117	-					5,138,117	-	-	-	
451	WW10	P11854	REGIONAL WASTEWATER METER REPLACEMENT	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.	99,961	-	-	-	-	-	99,961	-	-	-	-
451	WW10	P11876	GRIT CHAMBER REHAB: PRELIM DESIGN	Design recommendation for the rehabilitation of all concrete and equipment located within the grit chambers permitting assistance during bid process construction cost estimate for all items services during construction and final certification. City will provide construction observation services.	City identified in the planned annual renewal R&R Report that the reinforced concrete walls for both grit chambers and associated concrete channels are scheduled for replacement at this time.P11876 was completed in January of 2016.	682,885	-	-	-	-	-	682,885	-	-	-	-
451	WW10	P12169	GEORGE T. LOHMEYER (GTL) ODOR CONTROL SYSTEM	This project is for the George T. Lohmeyer Odor Control System upgrade and rehabilitation.	The pre- treatment process Odor Control System has a useful life of 20 years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. The existing system was constructed and installed in 1984. The system needs to be studied and upgraded to alleviate odor concerns from the facility's neighbors.	175,332	-	-	-	-	-	175,332	-	-	-	-
451	WW10	P12170	GEORGE T. LOHMEYER CONCRETE RESTORATION	This project is to assess rthe concrete surfaces and structures at the George T. Lohmeyer Wastewater Treatment Plant for failures. The work will create the bid specs for concrete repairs, oversee the bid process, and provide construction inspection services.	There are many areas of the George T. Lohmeyer Water Treatment Plant showing concrete failures that are safety hazards due to falling concrete in work areas. The structural integrity of the building may also be compromised. The rehabilitation of the rebar and concrete is necessary to mitigate these safety hazards.	291,021	-					291,021	-	-	-	
451	WW10	P12171	BUTLER BUILDING UPGRADE AT GTL WELLFIELD	The Butler building is used for the Beach crew office, staging area, and the storage of the George T. Lohmeyer WWTP equipment and maintenance items. The building is deteriorated and is exposed to the environment in places. The building needs to be assessed for upgrades or replacement to bring into compliance with the Miami/Dade specifications.	The building houses equipment, materials and personnel. It has significantly deteriorated, allowing the elements to enter and affect all stored materials and operations.	288,058	-					288,058	-	-	-	
451	WW10	P12173	FLORIDA DEPARTMENT ENVIRONMENTAL PROTECTION PERMITS	This project is for the renewal of Florida Department of Environmental Protection George T. Lohmeyer (GTL) Operating Permit.	The operating permit for GTL must be renewed every five years. Renewal application must be submitted 180 days prior to expiration date of September 7, 2016.	162,032	-	-	-	-	-	162,032	-	-	-	-
451	WW10	P12175	GEORGE T. LOHMEYER (GTL) BELT PRESSES	This project is for replacement of biosolids dewatering equipment at the George T. Lohmeyer Waste Water Treatment Plant which currently consists of seven belt filter presses.	The belt presses were installed in 1999, and has a useful life of 18 years according to the 2014 Central Regional Wastewater System Renewal and Replacement Requirement Analysis. They have been maintained over the last 18 years, and have reached the end of their useful life. Other newer technologies for dewatering biosolids will also be considered.		855,162	855,162	-	-	-	1,710,324	-	-	-	-

Table WW9-2. City of Fort Lauderdale
Wastewater Community Investment Plan - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	WW10	P12251	CLARIFIER PIPE REPLACEMENT	This project will replace suspect prestressed concrete cylinder pipe for clarifier battery 1 and 2 influent and clarifier battery 3 distribution piping.	The piping was installed around 1979-1984 time frame. The piping was manufactured by Interpace, and has demonstrated to have suspect quality control issues during production. A section of a similar pipe within the facility has previously failed.		1,236,270	1,236,270	1,236,270	1,236,270	1,236,270	6,181,350	-	-	-	-
451	WW10	P12252	GEORGE T. LOHMEYER (GTL) INTERIOR PAINTING	This project will provide a protective coating application of all interior surfaces at the George T. Lohmeyer Water Treatment Plant.	The interior coatings have a useful life of ten years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. These surfaces were coated in 2007.		475,091	475,091	475,091	-	-	1,425,273	-	-	-	-
451	WW10	P12253	REGIONAL RE-PUMP CABLE CONDUCTIVITY AND WIRING	This project will fund the preliminary design recommendations for the rehabilitation. It will also provide funds for permitting, assistance during the bid process, construction cost estimate for all items, services during construction, and the final certification. The City will provide construction observation services.	It was determined in the planned annual Renewal and Replacement Report, that the repumps are scheduled for replacement at this time.		467,896	-	-	-	-	467,896	-	-	-	-
451	WW10	P12254	CRYOGENIC COMPRESSOR (MACS)-Note this project will not be necessary if City implements VPSA oxygen generation technology as recommended by the CUSMP	This project will fund the preliminary design recommendations for the replacement of the cryogenics compressor (MACS) at the GTL WWTP. It will also provide funds for permitting assistance during the bid process construction cost estimates for all items, services during construction, and the final certification. the City will provide construction observation services.	The scheduled replacement of the cryogenic compressor was indented in the annual Renewal and Replacement report.		356,317	356,317	356,317	-	-	1,068,951	-	-	-	-
451	WW10	P12255	GEORGE T. LOHMEYER (GTL) EXTERIOR PAINTING	This project is for a protective coating application on all exterior surfaces at the George T. Lohmeyer Water Treatment Plant.	The exterior coatings have a useful life of five years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. These surfaces were coated in 2010. This is done to protect all concrete and metal surfaces from corrosion and deterioration. It is also improving the appearance of this facility for our neighbors.		271,380	-	-	-	271,380	542,760	-	-	-	-
451	WW10	P12257	REGIONAL RE-PUMP ELECTRONIC MAINTENANCE	This project will provide the Electronic Operations and Maintenance manual for B and E repumps. It will also provide funds for permitting, assistance during the bid process, construction cost estimate for all items, services during construction, and the final certification. The City will provide construction observation services.	The manual is used to supply information to regulatory agencies when requested. It is also a very important tool for maintaining the operation and maintenance information concerning the repump stations during personnel changes in the department.		233,948	-	-	-	-	233,948	-	-	-	-
451	WW10	P12258	REGIONAL RE-PUMP HOISTING EQUIPMENT FOR B&E	This project will replace hoisting equipment at B and E repumps. It will also provide funds for permitting, assistance during the bid process, construction cost estimate for all items, services during construction, and the final certification. The City will provide construction observation services.	The hoisting equipment has a useful life of 15 years according to the 2013 Central Region Wastewater System Renewal and Replacement Requirement Analysis. This equipment was installed in 1982.		196,588	-	-	-	-	196,588	-	-	-	-
451	WW13	P12190-451	STORMWATER ASSET MANAGEMENT SYSTEM	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.		-	-	-	-	-	-	-	-	-	100,000
Totals						**19,451,269**	**4,328,167**	**6,957,980**	**7,722,590**	**7,898,176**	**7,467,412**	**53,825,594**	**-**	**-**	**-**	**17,635,200**

Table WW9-3. City of Fort Lauderdale
Wastewater Community Investment Plan - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WW03	P12203	441 NW 7TH AVENUE SEWER EXTENSION	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	328,711	-	-	-	-	-	328,711	-	-	-	
454	WW04	FY 20150202	RIVER OAKS SEWER BASIN A-12 LATERALS	The rehabilitation of sewer laterals identified in Sewer Basin A-12 by using the cured-in-place	Inflow and Infiltration reduction in Sewer Basin A-12 and maintain compliance with DEP standards.		-	558,103	799,350	450,000	-	1,807,453	-	-	-	1,498,243
454	WW04	FY 20150204	DURRS SEWER BASIN A-23 LATERALS	This project is for the rehabilitation of selected sewer laterals in Sewer Basin A-23. Rehabilitation is done by using the cured-in-place pipe method for lateral pipes. The work will include pre- and post TV survey, flow monitoring, flow bypass, and rehabilitation of the sewer laterals.	This project will lead to inflow and infiltration (I&I) reduction in Sewer Basin A-23, in compliance with Department of Environmental Protection standards for I&I. This sanitary sewer basin was identified as having excessive inflow and infiltration flows which contributes additional sewage to George T. Lohmeyer Wastewater Treatment Plant.		-	989,389	989,389	-	-	1,978,778	-	-	-	1,407,012
454	WW04	FY 20150211	TARPON RIVER BASIN A-11 REHABILITATION	The project includes the rehabilitation of mainline sewers, point repairs, minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers, manholes and sewer laterals for Basin A-11 . Work also includes pre- and post television survey, flow monitoring, traffic control and site restoration.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL.		-	-	1,000,000	750,000	-	1,750,000	-	-	-	1,250,000
454	WW04	FY 20150212	VICTORIA PARK BASIN A-17 PUMP STATION REHABILITATION	The project includes the rehabilitation of mainline sewers, point repairs, minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers, manholes and sewer laterals in Victoria Park for Basin A-17 . Work also includes pre- and post television survey, flow monitoring, traffic control and site restoration.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL.		-	-	-	-	-	-	-	-	-	3,000,000
454	WW04	FY 20150213	HARBOR BEACH BASIN D34 REHABILITATION	The project includes the rehabilitation of mainline sewers, point repairs, minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals. Work also includes pre- and post television survey, flow monitoring, traffic control and site restoration at the Harbor Beach Basin D-34.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL		-	-	725,000	1,250,000	-	1,975,000	-	-	-	250,000
454	WW04	FY 20150214	LAS OLAS ISLES BASIN D37 REHABILITATION	The project includes the rehabilitation of mainline sewers, point repairs, minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals. Work also includes pre- and post television survey, flow monitoring, traffic control and site restoration for North and South Las Olas Isles.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL.		-	1,500,000	1,000,000	500,000	-	3,000,000	-	-	-	1,000,000
454	WW04	FY 20150215	DOLPHIN ISLES BASIN B14 REHABILITATION	The project includes the rehabilitation of mainline sewers, point repairs, minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals. Work also includes pre- and post television survey, flow monitoring, traffic control and site restoration for Dolphin Isles (B14.1 & B14.2).	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL.		-	-	-	-	-	-	-	-	-	2,000,000
454	WW04	FY 20150216	CORAL RIDGE BASIN B4 REHABILITATION	The project includes the rehabilitation of mainline sewers, point repairs, minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals. Work also includes pre- and post television survey, flow monitoring, traffic control and site restoration at Coral Ridge.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL.		-	-	-	-	-	-	-	-	-	3,000,000

Table WW9-3. City of Fort Lauderdale
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Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WW04	FY 20150217	IMPERIAL POINT BASIN B10 REHABILITATION	The project includes the rehabilitation of mainline sewers, point repairs, minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals. Work also includes pre- and post television survey, flow monitoring, traffic control and site restoration for Imperial Point Basin B10.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL.		-	1,009,860	1,000,000	1,000,000	-	3,009,860	-	-	-	2,000,000
454	WW04	FY 20150218	CORAL RIDGE COUNTRY CLUB ESTATES BASIN B11 REHAB	The project includes the rehabilitation of mainline sewers, point repairs, minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for Basin B-11. Work also includes pre- and post television survey, flow monitoring, traffic control and site restoration. Note: The City's FY 2016 CIP shows $3.5M in "unfunded" for FY 20150218.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL.		-	-	-	-	-	-	-	-	-	3,500,000
454	WW04	FY 20150222	A-27 SEWER SYSTEM REHAB MIDDLE RIVER TERR	Project includes the rehabilitation of mainline sewers manholes and service laterals at Sewer Basin A-27 in Middle River Terrace. Work includes pre- and post television survey, flow monitoring, traffic control and site restoration.	To meet the water & sewer infrastructure improvement goals. This sanitary sewer basin was identified as having excessive infiltration and inflow.		-	-	725,000	1,250,000	-	1,975,000	-	-	-	250,000
454	WW04	FY20130220	DILLARD PARK SEWER BASIN A-1 REHAB	The project includes the rehabilitation of mainline sewers point repairs minor road restoration and landscaping the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals throughout Basin A-1. Work also includes pre- and post television survey flow monitoring traffic control and site restoration.	This is a 2007 master plan recommendation. Thissanitary sewer basin was identified as havingexcessive inflow and infiltration flows contributingadditional sewage to GT Lohmeyer Waste WaterTreatment Plant.		-	-	-	-	-	-	-	-	-	2,000,000
454	WW04	P11163	SOUTH MIDDLE RIVER TERRACE SEWER BASIN A-29	This project is for the rehabilitation of selected mainline sewers and laterals in Sewer Basin A-29. Rehab using the cured-in-place method. This work includes pre- and post TV survey, flow monitoring, flow bypass, traffic control, site restoration, and all other related operations.	Inflow and Infiltration reduction in Sewer Basin A-29; Compliance with DEP standards for I/I. This project has been approved by the Commission and is based on the 2000 Water/Wastewater Master Plan.		-	2,148,577	-	-	-	2,148,577	-	-	-	2,400,000
454	WW04	P11563	VICTORIA PARK SEWER BASIN A-19 REHAB	Project includes the rehabilitation of mainline sewers manholes and service laterals. Work includes pre- and post television survey flow monitoring traffic control and site restoration.	To meet the water & sewer infrastructure improvement goals.	1,620,911	-	-	-	-	-	1,620,911	-	-	-	3,201,201
454	WW04	P11565	CORAL RIDGE CLUB ESTATES: SEWER BASIN B-1 REHAB	The project includes the rehabilitation of mainline sewers point repairs minor road restoration and landscaping using trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for Basin B-1. Work also includes pre- and post television survey flow monitoring traffic control and site restoration.	To meet the water & sewer infrastructureimprovement goals per the 2007 WW MasterPlan.	1,136	-	-	-	-	4,526,088	4,527,224	-	-	-	4,526,088
454	WW04	P11566	RIO VISTA SEWER BASIN REHAB PUMP STATION D-43	This project includes the rehabilitation of mainline sewers in the Rio Vista neighborhood associated with pump station D-43. Work includes pre- and post television survey flow monitoring traffic control and site restoration.	To meet the water & sewer infrastructure improvement goals.	789,272	-	-	-	-	2,680,687	3,469,959	-	-	-	2,680,687
454	WW04	P11664	BASIN B-6 SANITARY SEWER SYSTEM REHAB	The project includes the rehabilitation of mainline sewers point repairs minor road restoration and landscaping the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals in Sewer Basin B-6. Work also includes pre- and post television survey flow monitoring traffic control and site restoration.	Rehabilitation of sanitary sewer collection mains and laterals is required to reduce inflow and infiltration which can adversely impact system capacity to transmit and treat wastewater. This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage.	1,304	-	-	-	-	-	1,304	-	-	-	3,040,508

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Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WW04	P11864	BERMUDA RIVIERA SEWER BASIN B-2 REHAB	This project is for the relining of sanitary sewer collection mains and laterals. It includes the rehabilitation of mainline sewers point repairs minor road restoration and landscaping the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals. Work also includes pre- and post television survey flow monitoring traffic control and site restoration.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GT Lohmeyer Wastewater Treatment Plant. Rehabilitation of sanitary sewer collection mains and laterals is required to reduce inflow and infiltration which can adversely impact system capacity to transmit and treat wastewater. Construction date will be adjusted to coincide with the Florida Department Of Transportation's planned road modifications at this location. It is nearing the end of design.	1,156	-	-	-	-	1,120,757	1,121,913	-	-	-	1,120,757
454	WW04	P11865	CORAL RIDGE ISLES SEWER BASIN B-13 REHAB	The project includes the rehabilitation of the sanitary sewer collection system throughout Basin B-13. This includes but not limited to point repairs minor road restoration and landscaping the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals. Work also includes pre- and post television survey flow monitoring traffic control and site restoration.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GTL. Rehabilitation of sanitary sewer collection mains and laterals is required to reduce inflow and infiltration which can adversely impact system capacity to transmit and treat wastewater.	1,735	-	-	-	-	-	1,735	-	-	-	2,214,262
454	WW04	P11991	DOWNTOWN SEWER BASIN PUMP STATION A-7 REHABILITATION	The project includes the rehabilitation of manholes lateral service connections main lines point repairs minor road restoration and landscaping the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for pump station A-7. Work also includes pre- and post rehabilitation close circuit television survey flow monitoring traffic control and site restoration.	This sewer basin area was earmarked as part of the2007 Wastewater Master Plan to be rehabilitated.This sanitary sewer basin was identified as havingexcessive inflow and infiltration contribution to theGT Lohmeyer Wastewater Treatment Plant.	1,156,197	3,790,184	-	-	-	-	4,946,381	-	-	-	5,177,297
454	WW04	P12001	SEWER BASIN D-40 REHAB	The project includes the rehabilitation of mainline sewers point repairs minor road restoration and landscaping the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for Basin D-40. Work also includes pre- and post television survey flow monitoring traffic control and site restoration. Note: The City's FY 2016 CIP shows $614,596 in existing funding for P12001.	This is a 2007 master plan recommendation. Thissanitary sewer basin was identified as havingexcessive inflow and infiltration flows contributing additional sewage to GT Lohmeyer Wastewater Treatment Plant. The work is complete and may enter a testing phase.	92,601	-	-	-	-	-	92,601	-	-	-	-
454	WW04	P12049	FLAGLER HEIGHTS SEWER BASIN A-21 LATERALS	The rehabilitation of sewer laterals identified in Sewer Basin A-21 by using the cured-in-place pipe method for lateral pipes. The work will include pre- and post TV survey flow monitoring flow bypass satisfactory rehabilitation of the sewer laterals in Sewer Basin A-21.	Inflow and Infiltration reduction in Sewer Basin A-21; Compliance with DEP standards for I/I.	931,144	-	-	-	-	370,448	1,301,592	-	-	-	370,448
454	WW04	P12055	BASIN A-18 SANITARY SEWER COLLECTION SYSTEM	The project includes the rehabilitation of mainline sewers point repairs minor road restoration and landscaping the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for Basin A-18. Work also includes pre- and post television survey flow monitoring traffic control and site restoration.	This is a 2007 master plan recommendation. This sanitary sewer basin was identified as having excessive inflow and infiltration flows contributing additional sewage to GT Lohmeyer Wastewater Treatment Plant. Design is almost complete.	1,984,750	-	-	-		4,327,601	6,312,351	-	-	-	4,327,601
454	WW04	P12109	SW 8TH STREET (SW 3RD AVE AND SW 4TH AVE) SANITARY SEWER IMPROVEMENTS	This project is to install 340 linear feet of new gravity sanitary sewer and 330 linear feet of new water mains on SW 8th Street from SW 3rd Avenue to SW 4th Avenue.	The work will involve installing a new sanitary sewer on SW 8th Street per the 2008 Water Master Plan.	486,151	36,000	-	-	-	-	522,151	-	-	-	-
454	WW04	P12110	SW 9 STREET RIVERSIDE SANITARY SEWER	This project is to install 300 linear feet of new gravity sanitary sewer and 300 linear feet of water mains on SW Street from Riverside Drive to I-95.	The work will involve installing a new sanitary sewer on SW 9th Street per the 2008 Water Master Plan	534,147	-	-	-	-	-	534,147	-	-	-	

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454	WW07	P12133	NEW PUMP STATION A-13 REDIRECTION E OF F	The project is for a new pump station A-13 to be constructed by the intersection of North Federal Highway and East Broward Boulevard.	See CDM Smith Technical Memorandum on Sewer Collection Basin A-7 Flow Diversion and Pump Station A-8 Improvement Analysis.	2,065,461	276,470	-	-	-	-	2,341,931	-	-	-	-
454	WW10	FY 20160407	EAST LAS OLAS 12 FORCE MAIN REPLACEMENT	This project is to replace approximately 300 linear feet of 12 inch sewer force main from the Isle of Capri to 1721 E. Las Olas Blvd.	The force main installed in 1958 has failed twice in 2015 with significant environmental impact to the Rio Navarro canal. These failures are due to internal pipe corrosion. The Broward County Domestic		-	-	-	-	-	-	-	-	-	-
454	WW10	FY 20160429	SOUTH MIDDLE RIVER FORCE MAIN RIVER CROSSING	This project is to restore/replace approximately 450 linear feet of the existing 12" CIP force main that is currently out of service due to a pipe failure. It is important to note that this is a subaqueous river crossing.	The original construction date is 1967. The force main was taken out of service due to a failure of the pipe. This is the only force main river crossing in the north part of the City that could allow the flow to be diverted to the east . This diversion would happen in the event of a force main failure to the west. The restoration of the force main river crossing would restore the system redundancy. The design should consider increasing the size from 12" to 16."		-	550,000	-	-	-	550,000	-	-	-	-
454	UW6	P12178	UTILITIES STORAGE BUILDING (STEEL PREFAB)	This project is to construct a prefabricated steel building such as a "Butler" building to store equipment and materials for use in utilities projects. The pipe yard/depot at the Public Works compound is at its maximum capacity. There are no available covered storage spaces to keep components out of the weather.	Pipe components such as valves and repair clamps have rubberized parts that need to be stored in locations out of the elements to prevent decomposition and premature failure. The electrical components and panels have the same requirements. The materials used for sidewalk repairs and construction materials should also be stored in a dry space. As City crews undertake additional responsibilities, storage spaces becomes critical for the components' quality.	250,000	-	-	-	-	-	250,000	-	-	-	97,500
454	WW10	FY 20160430	BAYSHORE DRIVE FORCE MAIN INTRACOASTAL CROSS	This project is to replace approximately 4,420 linear feet of the existing 18" ductile iron pipe (DIP) for the force main that has suffered multiple failures over the last ten years. The force main is currently in service. It is necessary to note that this is a subaqueous crossing of the Intracoastal Waterway.	The original construction date was 1982. The force main has had at least three significant failures over the last ten years. This force main transports sewage from the east of Sunrise Boulevard area to the beach where it goes to the wastewater plant. This is a significant transmission main that must remain viable.		-	900,000	-	-	-	900,000	-	-	-	-
454	WW10	P11567	PUMP ST REHABS A12,B10, B22, D37 & D45	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	57,116	-	-	-	-	-	57,116	-	-	-	-
454	WW10	P11766	PUMP STATION D-37 REHABILITATION	Replacement of existing D-37 pump station (wet pit-dry pit arrangement) with a triplex submersible pump station constructed on site.	The D-37 pump station is part of a group of pump stations (Phase III Pump Station Rehab) designated for rehabilitation or replacement under the Waterworks 2011 Capital Improvement Program. This project was completed in August 2016.	316,015	-	-	-	-	-	316,015	-	-	-	-
454	WW10	P11879	PUMP STATION B-10 REHABILITATION	This project is for the replacement of station pumps valves suction and discharge piping re-route of discharge force main new sump pumps ladders grates and hatches; new HVAC electrical and control system. The work also includes repairs to the wet-well and structural repairs to	Station B-10 is part of a group of pump stations identified under the (now completed) Water Works 2011 program for rehabilitation or replacement. This group was identified as Phase III Pump Station Rehab.	884,570	556,436	-	-	-	-	1,441,006	-	-	-	-
454	WW10	P11880	PUMP STATION A-12 REHABILITATION	Replacement of station pumps valves suction and discharge piping re-route of discharge force main new sump pumps ladders grates and hatches; new HVAC electrical and control system. The work also includes repairs to the wet well and structural repairs to the station.	Station A-12 is part of a group of pump stations identified under the (now completed) Water Works 2011 program for rehabilitation or replacement. This group was identified as Phase III Pump Station Rehabilitation.	694,207	365,750	-	-	-	-	1,059,957	-	-	-	-
454	WW10	P11881	PUMP STATION D-45 REPLACEMENT	Replacement of existing Shone ejector pump station with a new prefabricated duplex	Station D-45 is part of a group of pump stations identified under the Wastewater Master Plan for	495,517	20,718	-	-	-	-	516,235	-	-	-	-
454	WW10	P11882	PUMP STATION B-22 REPLACEMENT	Replacement of existing wet pit - dry pit station with a new duplex submersible station on site adjacent to the existing and abandonment of the old station.	Station B-22 is part of a group of pump stations identified under the Wastewater Master Plan for rehabilitation or replacement. This group was identified as Phase III Pump Station Rehabilitation.	423,189	-	-	-	-	317,765	740,954	-	-	-	-
454	WW10	P11889	DEMOLITION ABANDONMENT OF PUMP STATIONS	Preliminary evaluation and inspection of existing conditions design permitting and preparation of construction contract documents for the demolition and abandonment of pump stations A-44 A-97 and C-31. The work includes demolition of station mechanical and electrical equipment demolition of the concrete structures abandon/remove utility connections such as water electric and force main site restoration work and connection of the properties.	Pump Station A-97 is no longer required and not in service as the property it served (Sunny reach Acres Townhomes in Riverside Park n/hood) is now connected directly to the city sanitary system. Therefore this station can be demolished. As sanitary sewer is now available on streets adjacent to pump stations A-44 (Progresso n/hood) and C-31 (Riverland Annex n/hood) the properties served by these stations will be connected directly to the city sewer. These two stations will no longer be required.	166,290	43,471	-	-	-	-	209,761	-	-	-	-

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454	WW07	P12133	NEW PUMP STATION A-13 REDIRECTION E OF F	The project is for a new pump station A-13 to be constructed by the intersection of North Federal Highway and East Broward Boulevard.	See CDM Smith Technical Memorandum on Sewer Collection Basin A-7 Flow Diversion and Pump Station A-8 Improvement Analysis.	2,065,461	276,470	-	-	-	-	2,341,931	-	-	-	-
454	WW10	FY 20160407	EAST LAS OLAS 12 FORCE MAIN REPLACEMENT	This project is to replace approximately 300 linear feet of 12 inch sewer force main from the Isle of Capri to 1721 E. Las Olas Blvd.	The force main installed in 1958 has failed twice in 2015 with significant environmental impact to the Rio Navarro canal. These failures are due to internal pipe corrosion. The Broward County Domestic		-	-	-	-	-	-	-	-	-	-
454	WW10	FY 20160429	SOUTH MIDDLE RIVER FORCE MAIN RIVER CROSSING	This project is to restore/replace approximately 450 linear feet of the existing 12" CIP force main that is currently out of service due to a pipe failure. It is important to note that this is a subaqueous river crossing.	The original construction date is 1967. The force main was taken out of service due to a failure of the pipe. This is the only force main river crossing in the north part of the City that could allow the flow to be diverted to the east . This diversion would happen in the event of a force main failure to the west. The restoration of the force main river crossing would restore the system redundancy. The design should consider increasing the size from 12" to 16."		-	550,000	-	-	-	550,000	-	-	-	-
454	UW6	P12178	UTILITIES STORAGE BUILDING (STEEL PREFAB)	This project is to construct a prefabricated steel building such as a "Butler" building to store equipment and materials for use in utilities projects. The pipe yard/depot at the Public Works compound is at its maximum capacity. There are no available covered storage spaces to keep components out of the weather.	Pipe components such as valves and repair clamps have rubberized parts that need to be stored in locations out of the elements to prevent decomposition and premature failure. The electrical components and panels have the same requirements. The materials used for sidewalk repairs and construction materials should also be stored in a dry space. As City crews undertake additional responsibilities, storage spaces becomes critical for the components' quality.	250,000	-	-	-	-	-	250,000	-	-	-	97,500
454	WW10	FY 20160430	BAYSHORE DRIVE FORCE MAIN INTRACOASTAL CROSS	This project is to replace approximately 4,420 linear feet of the existing 18" ductile iron pipe (DIP) for the force main that has suffered multiple failures over the last ten years. The force main is currently in service. It is necessary to note that this is a subaqueous crossing of the Intracoastal Waterway.	The original construction date was 1982. The force main has had at least three significant failures over the last ten years. This force main transports sewage from the east of Sunrise Boulevard area to the beach where it goes to the wastewater plant. This is a significant transmission main that must remain viable.		-	900,000	-	-	-	900,000	-	-	-	-
454	WW10	P11567	PUMP ST REHABS A12,B10, B22, D37 & D45	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	57,116	-	-	-	-	-	57,116	-	-	-	-
454	WW10	P11766	PUMP STATION D-37 REHABILITATION	Replacement of existing D-37 pump station (wet pit-dry pit arrangement) with a triplex submersible pump station constructed on site.	The D-37 pump station is part of a group of pump stations (Phase III Pump Station Rehab) designated for rehabilitation or replacement under the Waterworks 2011 Capital Improvement Program. This project was completed in August 2016.	316,015	-	-	-	-	-	316,015	-	-	-	-
454	WW10	P11879	PUMP STATION B-10 REHABILITATION	This project is for the replacement of station pumps valves suction and discharge piping re-route of discharge force main new sump pumps ladders grates and hatches; new HVAC electrical and control system. The work also includes repairs to the wet-well and structural repairs to	Station B-10 is part of a group of pump stations identified under the (now completed) Water Works 2011 program for rehabilitation or replacement. This group was identified as Phase III Pump Station Rehab.	884,570	556,436	-	-	-	-	1,441,006	-	-	-	-
454	WW10	P11880	PUMP STATION A-12 REHABILITATION	Replacement of station pumps valves suction and discharge piping re-route of discharge force main new sump pumps ladders grates and hatches; new HVAC electrical and control system. The work also includes repairs to the wet well and structural repairs to the station.	Station A-12 is part of a group of pump stations identified under the (now completed) Water Works 2011 program for rehabilitation or replacement. This group was identified as Phase III Pump Station Rehabilitation.	694,207	365,750	-	-	-	-	1,059,957	-	-	-	-
454	WW10	P11881	PUMP STATION D-45 REPLACEMENT	Replacement of existing Shone ejector pump station with a new prefabricated duplex	Station D-45 is part of a group of pump stations identified under the Wastewater Master Plan for	495,517	20,718	-	-	-	-	516,235	-	-	-	-
454	WW10	P11882	PUMP STATION B-22 REPLACEMENT	Replacement of existing wet pit - dry pit station with a new duplex submersible station on site adjacent to the existing and abandonment of the old station.	Station B-22 is part of a group of pump stations identified under the Wastewater Master Plan for rehabilitation or replacement. This group was identified as Phase III Pump Station Rehabilitation.	423,189	-	-	-	-	317,765	740,954	-	-	-	-
454	WW10	P11889	DEMOLITION ABANDONMENT OF PUMP STATIONS	Preliminary evaluation and inspection of existing conditions design permitting and preparation of construction contract documents for the demolition and abandonment of pump stations A-44 A-97 and C-31. The work includes demolition of station mechanical and electrical equipment demolition of the concrete structures abandon/remove utility connections such as water electric and force main site restoration work and connection of the properties.	Pump Station A-97 is no longer required and not in service as the property it served (Sunny reach Acres Townhomes in Riverside Park n/hood) is now connected directly to the city sanitary system. Therefore this station can be demolished. As sanitary sewer is now available on streets adjacent to pump stations A-44 (Progresso n/hood) and C-31 (Riverland Annex n/hood) the properties served by these stations will be connected directly to the city sewer. These two stations will no longer be required.	166,290	43,471	-	-	-	-	209,761	-	-	-	-

Table WW9-3. City of Fort Lauderdale
Wastewater Community Investment Plan - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WW10	P11893	VIBRATION & NOISE ASMT/REMEDY PUMP B-14	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	2,110	-	-	-	-	148,000	150,110	-	-	-	-
454	WW10	P11905	UTILITIES RESTORATION	The work includes repairing gravity sewer mains as well as other sanitary sewer repairs and construction limited storm sewer repairs and construction and pressure pipe repair and construction as needed at various locations throughout the City.	This contract will be used for projects that are beyond the capacity of the City crews.	228,461	-	192,000	192,000	192,000	-	804,461	-	-	-	192,000
454	WW10	P12075	10 IN SEWER MN TARPON RIV AT ANDREWS AV	CIP 2017-2021 for Description	CIP 2017-2021 for Justification. This project was completed in Novemvber of 2016.	47,908	-	-	-	-	-	47,908	-	-	-	-
454	WW10	P12124	CENTRAL BEACH ALLIANCE PUMP STATION (STATION D-41) REPLACEMENT	CIP 2017-2021 for Description	CIP 2017-2021 for Justification.	1,587,121	470,257	-	-	-	-	2,057,378	-	-	-	-
454	WW10	P12177	EAST LAS OLAS 12" FORCE MAIN REPLACEMENT	This project is to replace approximately 1900 linear feet of 12 inch force main from SE 17th	The force main installed in 1958 has failed twice in 2015 with significant environmental impact to the	1,091,837	224,802	-	-	-	-	1,316,639	-	-	-	
454	WW10	P12202	LIFT STATION D-11 FLOW ANALYSIS & REDESIGN	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.	487,790	-	-	-	-	-	487,790	-	-	-	-
454	WW13	P12190-454	STORMWATER ASSET MANAGEMENT SYSTEM	CIP 2017-2021 for Description.	CIP 2017-2021 for Justification.		125,000	-	-	-	-	125,000	-	-	-	-
Totals						**16,726,807**	**5,909,088**	**7,847,929**	**6,430,739**	**5,392,000**	**13,491,346**	**55,797,909**	**-**	**-**	**-**	**50,503,604**

Table WW9-4. City of Fort Lauderdale
Wastewater Additional CUSMP Projects - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	WW03	WW3-19	FORCE MAIN (GTL TRUNK LINE PARALLEL) IMPROVEMENTS	Install approximately 5,100 LF of 42" force main, along US 1 from SE 18th Street to SE 7th Street. Replace existing 36" DIP force main with approximately 1500 LF 48" force main on SE 18th Street, from US 1 to SE 10th Ave. Replace 54" DIP force main with 60" force main along SE 10th Ave, from SE 16th Court to SE 18th Court.	This is a 2016 CUS Master Plan recommendation. Upsizing the pipeline will reduce the high velocities in the pipeline leading to the GTL, minimize hydraulic surge, provide additional capacity and will allow the pipe to be replaced with a more reliable and lower-risk material.		-	-	-	-	-	-	7,947,000	-	-	
451	WW06	WW6-03	42" FORCE MAIN REHABILITATION AND NEW PIPELINE	This project includes replacement of approximately 17,500 feet of deteriorated DIP force main along Middle River Dr. from W Oakland Park Ave. to E Sunrise Blvd., including installation of approximately 4,500 feet of new 24" force main, inspection of existing pipe, and performance of all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system and provide redundancy. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	15,585,000	-	
451	WW06	WW6-04	42" FORCE MAIN REHABILITATION AND NEW PIPELINE	This project includes rehabilitation of approximately 8,000 feet of deteriorated DIP force main along NE 38th St., from N Dixie Hwy to Coral Ridge Country Club, including installation of approximately 3,000 feet of new 24" force main along NE 19th Ave., from NE 38th St to NE 32nd St, inspection of existing pipe, and performance of all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system and provide redundancy. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	7,530,000	-	7,530,000	-	-	-	
451	WW06	WW6-05	24" FORCE MAIN REHABILITATION AND NEW PIPELINE	This project includes rehabilitation of approximately 11,800 feet of deteriorated DIP force main along W Commercial Blvd, including installation of approximately 3,000 feet of new 24" force main, inspection of existing pipe, and performance of all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system and provide redundancy. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	5,074,000	-	-	5,074,000	-	-	-	
451	WW06	WW6-07	48" FORCE MAIN REHABILITATION AND PARALLEL PIPELINE	This project includes rehabilitation of approximately 13,400 feet of deteriorated DIP force main along SE 10th Ave., from E Sunrise Blvd. to P.S. A-15, including installation of approximately 5,400 feet of new parallel 36" force main, inspection of existing pipe, and performance of all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system and provide redundancy. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	-	15,784,000	-	
451	WW06	WW6-08	54" FORCE MAIN REHABILITATION AND PARALLEL PIPELINE	This project includes rehabilitation of approximately 6,000 feet of the deteriorated trunk line (material is unknown; assumed CIP) along US 1, from into the GTL plant, including inspection of existing pipe, installation of approximately 5,100 feet of new parallel 48" force main, and performance of all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system and provide redundancy. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	300,000	11,292,000	-	11,592,000	-	-	-	
451	WW06	WW6-09	EFFLUENT MAIN REHABILITATION	This project includes rehabilitation of the 54" inch PCCP pipeline leading from GTL to the injection wells, including inspection of existing pipe, and performance of all related work.	This is a 2016 CUS Master Plan recommendation. The 54" pipeline from GTL WWTP to the injection wells is a single point of failure for the wastewater system, and rehabilitation will lower the risk. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	3,850,000	-	-	3,850,000	-	-	-	
451	WW08	WW8-1	ADDITION OF DEEP INJECTION WELL	The projected peak flow at the GTL WWTP is predicted to exceed disposal capacity. In order to accommodate projected flow, a 6th Class I IW and associated dual-zone monitor well will need to be constructed.	This is a 2016 CUS Master Plan recommendation. According to the Maximum Hourly Flow (MHF) projections, the IW system will exceed the normal operating MHF disposal capacity in 2023. Therefore, one (1) additional IW will be needed to meet MHF.		-	-	-	5,262,500	-	5,262,500	-	-	-	-
451	WW08	WW8-2	GTL - SURFACE EQUIPMENT REPLACEMENT	Surface equipment such as wellhead piping, valves, flowmeter, and transducer will need replacement.	This is a 2016 CUS Master Plan recommendation. Due to exposure to the elements surface equipment tends to deteriorate rapidly over time. It is necessary to maintain the equipment to ensure proper treatment of wastewater at GTL.		-	-	-	-	-	-	1,100,000	-	-	-
451	WW08	WW8-3	INJECTION WELL REHABILITATION (ACIDIZATION) 5 WELL	Renewal of operating permit for existing five wells required every five (5) years.	This is a 2016 CUS Master Plan recommendation. The IW system is operated in accordance with conditions set forth in Florida Department of Environmental Protection (FDEP) Operating Permit No. 0054569-444-UO and Rule 62-528, Florida Administrative Code (FAC). The IW operating permit needs to be secured every five years.		-	-	-	-	-	-	350,000	-	-	-

Table WW9-4. City of Fort Lauderdale
Wastewater Additional CUSMP Projects - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	WW08	WW8-4	INJECTION WELL REHABILITATION (ACIDIZATION) SINGLE WELL	Renewal of operating permit for new 6th well required every five (5) years.	This is a 2016 CUS Master Plan recommendation. The IW system is operated in accordance with conditions set forth in Florida Department of Environmental Protection (FDEP) Operating Permit No. 0054569-444-UO and Rule 62-528, Florida Administrative Code (FAC). The IW operating permit needs to be secured every five years.		-	-	-	-	-	-	-	70,000	-	-
451	WW08	WW8-5	OPERATING PERMIT (0054569-444-UO) RENEWAL 5 WELL	An IW operating permit has a duration of five (5) years per Rule 62-528.440(3), FAC. Renewal of operating permit for existing wells.	This is a 2016 CUS Master Plan recommendation. The IW system is operated in accordance with conditions set forth in Florida Department of Environmental Protection (FDEP) Operating Permit No. 0054569-444-UO and Rule 62-528, Florida Administrative Code (FAC). The IW operating permit needs to be secured every five years.		-	50,000	-	-		50,000	-	50,000	50,000	-
451	WW08	WW8-6	OPERATING PERMIT (0054569-444-UO) RENEWAL SINGLE WELL	An IW operating permit has a duration of five (5) years per Rule 62-528.440(3), FAC. Renewal of operating permit for new 6th well.	This is a 2016 CUS Master Plan recommendation. The IW system is operated in accordance with conditions set forth in Florida Department of Environmental Protection (FDEP) Operating Permit No. 0054569-444-UO and Rule 62-528, Florida Administrative Code (FAC). The IW operating permit needs to be secured every five years.		-	-	-	10,000	-	10,000	10,000	10,000	10,000	-
451	WW08	WW8-7	FDEP SUBMITTAL WITH MIT RESULTS 5 WELL	Rule 62-528.425(1)(d), FAC, requires the Class I IWs undergo Mechanical Integrity Testing (MIT) a minimum of once every five (5) years. MIT testing and submittal to FDEP for existing five wells.	This is a 2016 CUS Master Plan recommendation. The IW system is operated in accordance with conditions set forth in Florida Department of Environmental Protection (FDEP) Operating Permit No. 0054569-444-UO and Rule 62-528, Florida Administrative Code (FAC). The IW operating permit needs to be secured every five years.		-	150,000	-	150,000	-	300,000	150,000	150,000	150,000	-
451	WW08	WW8-8	FDEP SUBMITTAL WITH MIT RESULTS SINGLE WELL	Rule 62-528.425(1)(d), FAC, requires the Class I IWs undergo Mechanical Integrity Testing (MIT) a minimum of once every five (5) years. MIT testing and submittal to FDEP for additional 6th well.	This is a 2016 CUS Master Plan recommendation. MIT includes performance of a video survey, casing pressure test, high-resolution temperature logging and a radioactive tracer survey. An evaluation of the previous five (5) years of monitoring and operating data is also required to be submitted to the FDEP with the MIT results.		-	-	-	-	-	-	60,000	30,000	30,000	-
451	WW08	WW8-9	DUAL-ZONE MONITOR WELL REPLACEMENT	Old monitor wells constructed with steel casing have historically failed and need replacement.	This is a 2016 CUS Master Plan recommendation. Rule 62-528.425(1), FAC, requires monitoring of groundwater within 150 ft. of an injection well.		-	-	-	-	-	-	-	2,500,000	-	-
451	WW10	WW10-7	GTL WWTP R&R	General R&R services for the City's GTL Wastewater Plant not specifically called out in other CIP projects. (Reference R&R Report provided in the Master Plan for a list of projects to be included).	This is a 2016 CUS Master Plan recommendation. This project is for R&R for the City's regional wastewater treatment plant, GTL.			2,294,112	6,089,660	789,421	-	9,173,193	23,915,200	29,266,600	26,743,000	
451	WW10	WW10-8	REGIONAL B AND E REPUMP STATIONS FUTURE R&R	General Pump station R&R for Regional B and E Repump Stations not specifically called out in other CIP projects.	This is a 2016 CUS Master Plan recommendation. The City has identified pump stations due to be rehabilitated to ensure capacity to deliver peak flows.		-	210,800	126,692	584,400	14,300	936,192	3,191,200	3,690,400	1,245,200	
451	WW13	WW13-2	GTL structural evaluation and building upgrade	The project includes performing a structural evaluation to identify building/treatment structure components that are susceptible to wind gust hazard. The project also includes construction to replace windows, doors, etc. to harden the identified areas.	GTL was built in 1980s and the wind pressure requirement was 120 mph. While the Florida Building Code has been updated multiple times during the years and the wind pressure requirement is currently 180 mph. GTL staff' safety, City's assets and equipment are threatened by potential wind gust caused by extreme weather events. As climate is changing, performing an engineering evaluation and upgrading the buildings to meet current code is necessary for the purpose of protecting people, the infrastructure, and equipment during extreme weather events.		-	-	90,000	-	-	90,000	1,000,000	-	-	
451	WW15	WW15-1	Biosolids Processing Siting Study	Study to provide siting specifics for anaerobic digester and solar drying alternatives. Included is the determination and cost for the availability of waste heat from the FPL power plant for thermal drying.	City is paying over $2M per year to contract haul biosolids. Volume reduction is needed to reduce the long term cost and exposure to rising energy/transportation costs.				100,000			100,000	-	-	-	
451	WW15	WW15-2	Biosolids Processing Facility Design and Construction	Design and construct selected biosolids processing facility.	City is paying over $2M per year to contract haul biosolids. Volume reduction is needed to reduce the long term cost and exposure to rising energy/transportation costs.						1,000,000	1,000,000	15,097,000	-	-	

Table WW9-4. City of Fort Lauderdale
Wastewater Additional CUSMP Projects - Fund 451

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
451	WW15	WW15-3	BIOSOLIDS DEWATERING PERFORMANCE ENHANCEMENTS	Pilot test, design and construct compressed air biosolids dewatering conditioning process and equipment.	City is paying over $2M per year to contract haul biosolids. Volume reduction is needed to reduce the long term cost and exposure to rising energy/transportation costs.					1,500,000	1,500,000	3,000,000	-	-	-	
451	WW15	WW15-4	BIOSOLIDS NUTRIENT RECOVERY AND HARVESTING	Plan, pilot test, design and construct struvite recovery process.	City is paying over $2M per year to contract haul biosolids. Volume reduction is needed to reduct the long term cost and exposure to rising energy/transportation costs. Recovery and reuse of nutrients will benefit the environment and help achieve long term goals.							-	-	3,500,000	-	
451	WW16	WW16-03	GTL OXYGEN GENERATION SYSTEM REPLACEMENT	Replace the existing cryogenic oxygen generation system with a 30 tpd multiple-bed VPSA system.	Energy Savings		-	808,000	808,000	2,693,000	1,077,000	5,386,000	-	-	-	
451	WW16	WW16-04	GTL MOTOR REPLACEMENTS	Replace (7) remaining standard efficiency surface aerator motors with high efficiency motors.	Energy Savings		-	84,000	-	-	-	84,000	-	-	-	
451	WW16	WW16-05	GTL BIOLOGICAL TREATMENT PROCESS IMPROVEMENTS	Perform demonstration testing of chemicals to reduce nitrification.	Energy Savings		-	25,000	-	-	-	25,000	-	-	-	
451	WW16	WW16-06	GTL CLARIFIER MECHANISM REPLACEMENTS	Replace existing clarifier mechanisms with spiral blade mechanisms on clarifiers 1 through 7.	Energy Savings		-	-	667,000	-	-	667,000	889,000	-	-	
451	WW16	WW16-07	GTL CLARIFIER PIPING MODIFICATIONS	Provide piping and controls to convert Clarifier Nos. 8, 9, 10, and 11 to equalization tanks for the effluent pumps during periods of low/medium flows.	Energy Savings		-	-	-	390,000	-	390,000	-	-	-	
451	WW16	WW16-08	GTL EFFLUENT PUMP PIPING MODIFICATIONS	Remove effluent pump check valves and program existing motor actuated isolation valves.	Energy Savings		-	135,000	-	-	-	135,000	-	-	-	
451	WW16	WW16-09	GTL SITE LIGHTING LED CONVERSION	Replace site lighting with LED fixtures.	Energy Savings		-	88,000	88,000	88,000	88,000	352,000	-	450,000	-	
451	WW16	WW16-10	GTL HEAT PUMP INVESTIGATIONS	Perform demonstration testing of heat pump heat sinks.	Energy Savings		-	15,000	-	-	-	15,000	-	-	-	
451	WW16	WW16-11	GTL BUILDING ENVELOPE ENERGY AUDIT	Perform Energy Audit on Buildings	Energy Savings		-	3,000	-	-	-	3,000	-	-	-	
451	WW16	WW16-12	GTL RAS/WAS SYSTEM MODIFICATIONS	Install facilities to screen WAS flows and portion of RAS flows.	Energy Savings		-	-	-	-	-	-	475,000	-	-	
451	WW16	WW16-13	BRUSH INSIDE WALL OF CASING SINGLE WELL	For additional sixth well, brush the inside wall of the casing with a non-aggressive wire brush to reduce material build-up on the casing. Perform in association with MIT.	This is a 2016 CUS Master Plan recommendation. Build-up of material on the inside water in the well final casing increases operating pressures. Brushing the inside wall of the casing reduces material build-up and decreases operating pressure. Perform in association with MIT.		-	-	-	-	-	-	5,000	5,000	5,000	
451	WW16	WW16-14	BRUSH INSIDE WALL OF CASING FIVE WELLS	For existing five wells, brush the inside wall of the casing with a non-aggressive wire brush to reduce material build-up on the casing. Perform in association with MIT.	This is a 2016 CUS Master Plan recommendation. Build-up of material on the inside water in the well final casing increases operating pressures. Brushing the inside wall of the casing reduces material build-up and decreases operating pressure. Perform in association with MIT.		-	-	-	-	-	-	25,000	25,000	25,000	
451	WW16	WW16-15	SOLAR POWER GENERATION AND BIOGAS CLEANING/CONVERSION UNIT	Energy Savings	Energy Savings		-	-	-	-	-	-	-	5,000,000	-	WW
451	WW17	WW17-1	Retrofit high-efficiency plumbing fixtures	Replace existing low-efficiency plumbing fixtures with high-efficiency ones, including faucets, urinals, toilets, and shower heads throughout the GTL plant.	Water conservation is a City strategic initiative. Retrofitting high-efficiency plumbing fixtures can help reduce the City's water consumption at GTL plant.		-	-	30,000	-	-	30,000	-	-	-	
Totals						**-**	**-**	**3,862,912**	**17,223,352**	**30,289,321**	**3,679,300**	**55,054,885**	**54,214,400**	**76,116,000**	**28,258,200**	**-**

Table WW9-5. City of Fort Lauderdale
Wastewater Additional CUSMP Projects - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WW03	WW3-01	PUMP STATION D-31 UPGRADE	Replacement of existing D-31 pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Identified as undersized due to the future developments in the area; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	650,000	-	650,000	-	-	-	
454	WW03	WW3-02	PUMP STATION B-16 UPGRADE	Replacement of B-16 pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary. Extend the existing 6" force main conveying its flow into the gravity sewer of PS D-41 to manifold into the discharge 18" force main leaving PS D-40.	This is a 2016 CUS Master Plan recommendation. Identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event. Avoid repumping PS B-16 and increase capacity of PS D-41		-	-	250,000	-	-	250,000	-	162,500	-	
454	WW03	WW3-03	PUMP STATION B-1 UPGRADE	Replacement of B-1 pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	-	-	250,000	-	-	
454	WW03	WW3-04	PUMP STATION A-33 UPGRADE	Replacement of A-33 pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	280,000	-	280,000	-	-	-	
454	WW03	WW3-05	PUMP STATION A-35 UPGRADE	Replacement of A-35 pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	-	-	280,000	-	-	
454	WW03	WW3-06	PUMP STATION A-28 UPGRADE	Replacement of A-28 pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	-	-	650,000	-	-	
454	WW03	WW3-07	FORCE MAIN CROSSING REINSTATEMENT (FROM PUMP STATION A-14)	Reinstate the pipeline crossing directly after pump station A-14 to assist with high velocities in the force mains downstream of A-14. Pipe section is 2,100 LF from the corner of NE 22nd Ave and NE 19th across Bal Harbour and connects to the existing main at Middle River Dr.	This is a 2016 CUS Master Plan recommendation. Reopening the crossing will help to reduce pressures and velocities in the transmission system near Pump Station A-14. This main will increase system capacity, reduce energy cost and provide redundancy in case of emergencies.		-	609,000	-	-	-	609,000	-	-	-	
454	WW03	WW3-08	FORCE MAIN (MIDDLE RIVER DRIVE) IMPROVEMENTS	Improvements to divert flows from the force main running along Middle River Dr. Valves at pump stations A-14 and B-1 are to be closed diverting flow to an existing 18" main running down Bayview Dr. from pump station B-1 to Oakland Park Blvd, which changes to 16" from Oakland Park Blvd to pump station B-5. Add approximately 1 mile of new 24" main from B-5 running south along Bayview Dr. to connect to the existing NE 9th St. force main.	This is a 2016 CUS Master Plan recommendation. This main will alleviate excessive velocities and pressures thereby conserving energy. The proposed main will increase system capacity and provide redundancy in the transmission system.		-	-	-	-	-	-	-	220,000	-	
454	WW03	WW3-09	PUMP STATION D-34 UPGRADE	Replace pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	-	-	650,000	-	-	
454	WW03	WW3-10	FORCE MAIN (US1) UPSIZE	Install approximately 5,500 LF of new 24" force main parallel to the 48" force main down US 1, from NE 5th St to SE 7th Street. (Construction May not be feasible along US-1)	This is a 2016 CUS Master Plan recommendation. This main will alleviate excessive velocities and pressures thereby conserving energy and reducing the risk of hydraulic surge. The proposed main will increase system capacity in the transmission system.		-	4,290,000	-	-	-	4,290,000	-	-	-	
454	WW03	WW3-11	FORCE MAIN (SUCTION SIDE TO B REPUMP) UPSIZE	Replace both 30" existing pipes with approximately 200 LF of new 48" pipe on suction side of B-Repump located in the Coral Ridge Country Club.	This is a 2016 CUS Master Plan recommendation. This is a 2016 CUS Master Plan recommendation. Increasing the pipe diameters to suction side of B-Repump will increase facility capacity, minimize hydraulic surge risk and reduce energy cost.		-	-	-	-	-	-	250,000	-	-	
454	WW03	WW3-12	FORCE MAIN (NW 22ND ROAD) UPSIZE	Upsize approximately 1,900 LF of force main along NW 22nd Rd from NW 8th St to I-95. Existing 12" mains will be replaced with 16" force main and existing 14" mains will be increased to 20" mains.	This is a 2016 CUS Master Plan recommendation. This main will alleviate excessive velocities and pressures thereby conserving energy and reducing the risk of hydraulic surge. The proposed main will increase system capacity in the transmission system.		-	-	-	-	-	-	722,000	-	-	

Table WW9-5. City of Fort Lauderdale
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Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WW03	WW3-14	HYDRAULIC MODEL CALIBRATION	This project includes development of a calibration protocol for the newly constructed hydraulic model, collection of field data, compilation and incorporation of field data into the hydraulic model, and comparison of field data with hydraulic model outputs.	This is a 2016 CUS Master Plan recommendation. In order to provide the most beneficial use for the hydraulic model, the model should be calibrated with field data to resolve discrepancies between the model output and conditions seen in the field, as well as to verify the accuracy of the model.		-	-	250,000	-	-	250,000	-	-	-	
454	WW03	WW3-15	PUMP STATION E-8 UPGRADE	Replace pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	450,000	450,000	-	-	-	
454	WW03	WW3-15	FORCE MAIN (FROM PUMP STATION A-54 TO A-10) UPSIZE	Install approximately 1900 LF of 30" force main parallel to the existing 30" force main running from pump station A-54 to pump station A-10 starting at SW4th Ave. Running east along SW19th St to S Andrews Ave.	This is a 2016 CUS Master Plan recommendation. This main will alleviate excessive velocities and pressures thereby conserving energy and reducing the risk of hydraulic surge. The proposed main will increase system capacity in the transmission system.		-	-	-	-	988,000	988,000	-	-	-	
454	WW03	WW3-16	FORCE MAIN (NEAR PUMP STATION D-34) UPSIZE	Upsize approximately 100 LF of force main running from the discharge side of pump station D-34 to SE 17th St from two smaller 4" and 8" mains to a single 12" main.	This is a 2016 CUS Master Plan recommendation. This main will alleviate excessive velocities and pressures thereby conserving energy and reducing the risk of hydraulic surge. The proposed main will increase system capacity in the transmission system.		-	-	-	-	100,000	100,000	-	-	-	
454	WW03	WW3-17	FORCE MAIN (SUCTION SIDE TO E REPUMP) UPSIZE	Upsize approximately 60 LF of 6" suction main of E-Repump to a 20" force main.	This is a 2016 CUS Master Plan recommendation. This main will alleviate excessive velocities and pressures thereby conserving energy and reducing the risk of hydraulic surge. The proposed main will increase system capacity in the transmission system.		-	-	-	-	-	-	100,000	-	-	
454	WW03	WW3-18	A-REPUMP DISCHARGE LINE IMPROVEMENTS	Upsize approximately 12,650 LF of existing 30" force main starting at A-Repump near I-95 and NW 6th street and ending near the intersection of SW 6th Ave and SW 7th St. to a 42" force main.	This is a 2016 CUS Master Plan recommendation. This main will alleviate excessive velocities and pressures thereby conserving energy and reducing the risk of hydraulic surge. The proposed main will increase system capacity in the transmission system.		-	-	-	-	9,867,000	9,867,000	-	-	-	
454	WW03	WW3-20	PUMP STATION B-8 UPGRADE	Replace pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	-	-	450,000	-	-	
454	WW03	WW3-21	PUMP STATION A-39 UPGRADE	Replacement of the A-39 impeller or pumps with lower capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as oversized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	-	-	280,000	-	-	
454	WW03	WW3-22	PUMP STATION B-14 UPGRADE	Replacement of B-14 pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	450,000	450,000	-	-	-	
454	WW03	WW3-23	PUMP STATIONS C-1 AND C-2 REPLACEMENT	Replacement of C-1 and C-2 stations. Upgrade C-1 pumps with higher capacity models. Replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified C-1 as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event. Stations C-1 and C-2 are Priority 1 R&R targets.		-	-	-	1,300,000	-	1,300,000	-	-	-	
454	WW03	WW3-24	PUMP STATION E-4 UPGRADE	Replacement of E-4 pumps with higher capacity models.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	120,000	-	120,000	-	-	-	
454	WW03	WW3-25	PUMP STATION D-41 REPLACEMENT/D-40 DIVERSION	Replace P.S. D-41 with a new pump station that connects to the adjacent force main and no longer flows to D-40, and close pipes to prevent flow from B-16 into D-40. This will provide capacity relief for P.S. D-40. (Design of D-41 has began and is nearing permitting stage as of May 2016)	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	450,000	-	-	-	450,000	-	-	-	
454	WW03	WW3-26	PUMP STATION D-37 DIVERSION	Divert flow from PS D-37 (near Las Olas Blvd.) by re-routing D-38 to the east with a short gravity main and force main extension. PS D-37 has had historical issues with overflows and increasing the force main size would disrupt City roads.	This is a 2016 CUS Master Plan recommendation. Diverting PS D38 flow to the new beach force main can create capacity relief for PS D37 and is less intrusive to construct. It would reduce SSOs and FDEP violations.		-	900,000	-	-	-	900,000	-	-	-	

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454	WW03	WW3-27	FORCE MAIN (B-1 DISCHARGE) IMPROVEMENTS	Tie in the 10" and 18" force main cross over on Bayview Dr (approximately 350 LF) to NE 37th Ct. in order to reduce velocity. A valve closure may be required to implement.	This is a 2016 CUS Master Plan recommendation. Improvements in this area will divert flow away from the GTL force main, reducing the flow and velocity as well as reducing B-1 discharge main velocities.		-	-	-	150,000	-	150,000	-	-	-	
454	WW03	WW3-29	PUMP STATION A-16 UPGRADE	Replacement of A-16 pumps with higher capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as undersized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	450,000	450,000	-	-	-	
454	WW03	WW3-30	FORCE MAIN (FROM PUMP STATIONS D-35 TO D-36) UPSIZE	Upsize the existing 8" and 10" force mains to approximately 2,000 LF of new 12" force main, along Harbour Inlet Dr, from A1A to Barbara Dr, and along Barbara Dr, from Harbour Inlet Drive to the Stranahan River.	This is a 2016 CUS Master Plan recommendation. This main will alleviate excessive velocities and pressures thereby conserving energy and reducing the risk of hydraulic surge. The proposed main will increase system capacity in the transmission system.		-	-	-	-	580,000	580,000	-	-	-	
454	WW03	WW3-31	PUMP STATION A-37 UPGRADE	Replacement of the A-37 impeller or pumps with lower capacity models. Rehabilitate/replace station piping, valves and appurtenances and wet well as necessary.	This is a 2016 CUS Master Plan recommendation. Hydraulic analysis identified as oversized; rehabilitate to ensure capacity to deliver peak flows during a rainfall event.		-	-	-	-	-	-	450,000	-	-	
454	WW04	WW4-01	SEWER BASIN A7 FIELD TESTING AND INFLOW REMOVAL	Smoke test and repair inflow defects including manhole lid liners and cleanout plugs. Pre/post-rehab flow test, salinity test and calculate/compare N-RDI/I to update I/I priority targets.	Locate and correct inflow issues and direct limited I/I mitigation budget to most needed infrastructure. Energy conservation, sea level rise readiness and minimizing capital capacity needs at pump stations and the GTL.		-	-	656,000	-	-	656,000	-	-	-	
454	WW04	WW4-02	SEWER BASIN A18 and A21 FIELD TESTING AND INFLOW REMOVAL	Smoke test and repair inflow defects including manhole lid liners and cleanout plugs. Pre/post-rehab flow test, salinity test and calculate/compare N-RDI/I to update I/I priority targets.	Locate and correct inflow issues and direct limited I/I mitigation budget to most needed infrastructure. Energy conservation, sea level rise readiness and minimizing capital capacity needs at pump stations and the GTL.		-		-	757,000	-	757,000	-	-	-	
454	WW04	WW4-03	SEWER BASIN A23, C2 and D40 FIELD TESTING AND INFLOW REMOVAL	Smoke test and repair inflow defects including manhole lid liners and cleanout plugs. Pre/post-rehab flow test, salinity test and calculate/compare N-RDI/I to update I/I priority targets.	Locate and correct inflow issues and direct limited I/I mitigation budget to most needed infrastructure. Energy conservation, sea level rise readiness and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	753,000	753,000	-	-	-	
454	WW04	WW4-04	SEWER BASIN A12 and A27 FIELD TESTING AND INFLOW REMOVAL	Smoke test and repair inflow defects including manhole lid liners and cleanout plugs. Pre/post-rehab flow test, salinity test and calculate/compare N-RDI/I to update I/I priority targets.	Locate and correct inflow issues and direct limited I/I mitigation budget to most needed infrastructure. Energy conservation, sea level rise readiness and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	897,000	-	-	
454	WW04	WW4-05	SEWER BASIN A19, A22 and B4 FIELD TESTING AND INFLOW REMOVAL	Smoke test and repair inflow defects including manhole lid liners and cleanout plugs. Pre/post-rehab flow test, salinity test and calculate/compare N-RDI/I to update I/I priority targets.	Locate and correct inflow issues and direct limited I/I mitigation budget to most needed infrastructure. Energy conservation, sea level rise readiness and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	1,104,000	-	-	
454	WW04	WW4-06	SEWER BASIN A29, B10, B14, C1, A31, B11, E3 and D43 FIELD TESTING AND INFLOW REMOVAL	Smoke test and repair inflow defects including manhole lid liners and cleanout plugs. Pre/post-rehab flow test, salinity test and calculate/compare N-RDI/I to update I/I priority targets.	Locate and correct inflow issues and direct limited I/I mitigation budget to most needed infrastructure. Energy conservation, sea level rise readiness and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	3,522,000	-	-	
454	WW04	WW4-07	SEWER BASIN E6, A11, B23, B8, B13, B1, B2 and B6 FIELD TESTING AND INFLOW REMOVAL	Smoke test and repair inflow defects including manhole lid liners and cleanout plugs. Pre/post-rehab flow test, salinity test and calculate/compare N-RDI/I to update I/I priority targets.	Locate and correct inflow issues and direct limited I/I mitigation budget to most needed infrastructure. Energy conservation, sea level rise readiness and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	2,331,000	-	-	
454	WW04	WW4-08	RECURRING FUTURE FIELD TESTING AND INFLOW REMOVAL	Smoke test and repair inflow defects including manhole lid liners and cleanout plugs. Pre/post-rehab flow test, salinity test and calculate/compare N-RDI/I to update I/I priority targets.	Locate and correct inflow issues and direct limited I/I mitigation budget to most needed infrastructure. Energy conservation, sea level rise readiness and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	800,000	4,000,000	4,000,000	
454	WW04	WW4-09	UPGRADE A21 and A23 SEWER BASINS REHAB PROJECTS TO 80%	Upgrade the 30% project to 80% rehabilitation of mainline sewers point repairs minor road restoration and landscaping the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	15,000,000	-	-	
454	WW04	WW4-10	UPGRADE A27 and B4 SEWER BASINS REHAB PROJECTS TO 80%	Upgrade the 30% project to 80% rehabilitation of mainline sewers point repairs minor road restoration and landscaping. Also, the use of trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	-	10,000,000	-	

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454	WW04	WW4-11	CITY LATERAL CREW EQUIPMENT AND SUPPLIES	Equipment and Materials for a City staffed lateral lining crew. Start with the next 50% of laterals in Sewer Basins rehabbed by the City over the last 10 years and the 30% Rehab jobs ongoing and planned.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	1,500,000	500,000	500,000	2,500,000	-	-	-	
454	WW04	WW4-12	RECURRING FUTURE CITY LATERAL CREW EQUIPMENT AND SUPPLIES	Equipment and Materials for a City staffed lateral lining crew. Start with the next 50% of laterals in Sewer Basins rehabbed by the City over the last 10 years and the 30% Rehab jobs ongoing and planned.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	6,000,000	6,000,000	6,000,000	
454	WW04	WW4-15	SEWER BASIN C2 REHAB	The project includes the 80% rehabilitation of manholes, lateral service connections, main line point repairs minor road restoration and landscaping using trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for pump station C-2. Work also includes pre- and post rehabilitation close circuit television survey flow monitoring traffic control and site restoration.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	4,773,000	-	-	
454	WW04	WW4-16	SEWER BASIN A22 REHAB	The project includes the 80% rehabilitation of manholes, lateral service connections, main line point repairs minor road restoration and landscaping using trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for pump station A-22. Work also includes pre- and post rehabilitation close circuit television survey flow monitoring traffic control and site restoration.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	9,214,000	-	-	
454	WW04	WW4-17	SEWER BASIN C1 REHAB	The project includes the 80% rehabilitation of manholes, lateral service connections, main line point repairs minor road restoration and landscaping using trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for pump station C-1. Work also includes pre- and post rehabilitation close circuit television survey flow monitoring traffic control and site restoration.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	4,325,500	4,325,500	-	
454	WW04	WW4-18	SEWER BASIN A31, B23, B8, E3 and E6 REHAB	The project includes the 80% rehabilitation of manholes, lateral service connections, main line point repairs minor road restoration and landscaping using trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for pump stations A31, B23, B8, E3 and E6.. Work also includes pre- and post rehabilitation close circuit television survey flow monitoring traffic control and site restoration.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	-	20,000,000	-	
454	WW04	WW4-19	RECURRING FUTURE SEWER BASIN REHAB	The project includes the 80% rehabilitation of manholes, lateral service connections, main line point repairs minor road restoration and landscaping using trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for pump stations A31, B23, B8, E3 and E6.. Work also includes pre- and post rehabilitation close circuit television survey flow monitoring traffic control and site restoration.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	-	-	40,000,000	
454	WW04	WW4-20	RECURRING PRIVATE LATERAL REHABILITATION	The rehabilitation of private sewer laterals by using the cured-in-place pipe method for lateral pipes. The work will include pre- and post TV survey flow, monitoring flow bypass satisfactory, and rehabilitation of the private sewer laterals.	Repair private service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	8,000,000	15,000,000	50,000,000	

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454	WW04	WW4-21	RECURRING FUTURE CONTRACTOR PERFORMED SEWER BASIN REHABILITATION	The project includes the 80% rehabilitation of manholes, lateral service connections, main line point repairs minor road restoration and landscaping using trenchless technologies to repair sewer system components such as lining of gravity sewers manholes and sewer laterals for pump station C-2. Work also includes pre- and post rehabilitation close circuit television survey flow monitoring traffic control and site restoration.	Repair mains, manholes and service laterals to minimize I/I and mitigate sea level rise and King Tide events. City will maximize lateral rehab cost efficiency by self performing. Energy conservation and minimizing capital capacity needs at pump stations and the GTL.		-	-	-	-	-	-	8,750,000	8,750,000	8,750,000	
454	WW05	WW5-1	PUMP STATION COMPUTATIONAL FLOW MEASUREMENT ANALYSIS AND TEST	Invite BCI, MaidLab and other comparable vendors to perform a field demonstration of their pump station flow monitoring system (program for BCI and Volucalc RT for MaidLab). Vendors need to verify the accuracy of their flow computation system on both constant speed and VFD pump stations. Project includes selecting stations for demonstration, installing clamp-on meters, collecting calculation result from BCI program, performing engineering analysis to evaluate data, etc.	This is a 2016 CUS Master Plan recommendation. The City is seeking a solution that can monitor pump station flow including VFD stations. BCI needs to demonstrate that their program can calculate accurate inflow for VFD stations. Once successfully verified, BCI's program can be the most cost-efficient solution to monitoring I/I at City's 186 pump stations.		-	40,000	-	-	-	40,000	-	-	-	
454	WW05	WW5-2	PUMP STATION FLOW MONITORING SYSTEM	This project includes purchasing software and hardware for a pump station monitoring program for constant speed pumps and installing instruments that will monitor VFD stations inflow.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to identify and monitor I/I issues in order to reduce the wastewater flow to GTL WWTP. This is part of the "Climate Resilience" strategic initiative. Also the selected software products can also monitor pump station power consumption to help optimize operation to reduce power consumption, in order meet City's goal. City says only software purchase needed, no capital costs were therefore included.		-	-	-	-	-	-	-	-	-	
454	WW06	WW6-02	24" FORCE MAIN REHABILITATION	This project includes rehabilitation of approximately 5,500 feet of deteriorated DIP force main along NE 25th Ave. from E Commercial Blvd. to W Oakland Park Ave., including inspection of existing pipe and performance of all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	-	-	3,000,000	-	-	
454	WW06	WW6-06	30" FORCE MAIN REHABILITATION AND NEW PIPELINE	This project includes rehabilitation of approximately 12,000 feet of deteriorated CIP force main along NW 5th St. and along Nw 9th Ave., from A-Repump to SW 7th St., including installation of approximately 6,000 feet of new 24" force main along W Sistrunk Blvd. from NW 19th Ave. to NW 7th Ave., inspection of existing pipe, and performance of all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	11,769,000	-	11,769,000	-	-	-	
454	WW06	WW6-10	24" FORCE MAIN REHABILITATION	This project includes rehabilitation of approximately 3,300 feet of 24" CIP pipeline along NW 13th St., from SR 845 S to SR 811 , including inspection, and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	1,914,000	1,914,000	-	-	-	
454	WW06	WW6-11	18" FORCE MAIN REHABILITATION	This project includes rehabilitation of approximately 1,000 feet of 18" DIP pipeline across the river from NE 9th St. to N Birch Road, including inspection, and all related work.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to prevent failure of a portion of the transmission system. This project is part of the "Infrastructure Renewal" Strategic Initiative.		-	-	-	-	434,000	434,000	-	-	-	
454	WW06	WW6-12	SEWER BASIN A-7 PERMANENT GENERATOR	This project includes one new permanent emergency standby 200 kW diesel generator for P.S. A-7, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	215,000	-	-	-	215,000	-	-	-	
454	WW06	WW6-13	SEWER BASIN A-10 PERMANENT GENERATOR	This project includes one new permanent emergency standby 40 kW diesel generator for P.S. A-10, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	170,000	-	-	-	170,000	-	-	-	
454	WW06	WW6-14	SEWER BASIN A-19 PERMANENT GENERATOR	This project includes one new permanent emergency standby 100 kW diesel generator for P.S. A-19, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	200,000	-	-	-	200,000	-	-	-	

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Wastewater Additional CUSMP Projects - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WW06	WW6-15	SEWER BASIN A-20 PERMANENT GENERATOR	This project includes one new permanent emergency standby 100 kW diesel generator for P.S. A-20, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	200,000	-	-	-	200,000	-	-	-	
454	WW06	WW6-16	SEWER BASIN B-4 PERMANENT GENERATOR	This project includes one new permanent emergency standby 40 kW diesel generator for P.S. B-4, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	-	185,000	-	-	185,000	-	-	-	
454	WW06	WW6-17	SEWER BASIN D-33 PERMANENT GENERATOR	This project includes one new permanent emergency standby 40 kW diesel generator for P.S. D-33, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	-	185,000	-	-	185,000	-	-	-	
454	WW06	WW6-18	SEWER BASIN D-31 PERMANENT GENERATOR	This project includes one new permanent emergency standby 100 kW diesel generator for P.S. D-31, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	-	215,000	-	-	215,000	-	-	-	
454	WW06	WW6-19	SEWER BASIN D-34 PERMANENT GENERATOR	This project includes one new permanent emergency standby 40 kW diesel generator for P.S. D-34, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	-	170,000	-	-	170,000	-	-	-	
454	WW06	WW6-20	SEWER BASIN D-35 PERMANENT GENERATOR	This project includes one new permanent emergency standby 100 kW diesel generator for P.S. D-35, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	-	-	215,000	-	215,000	-	-	-	
454	WW06	WW6-21	SEWER BASIN D-36 PERMANENT GENERATOR	This project includes one new permanent emergency standby 100 kW diesel generator for P.S. D-36, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	-	-	170,000	-	170,000	-	-	-	
454	WW06	WW6-22	SEWER BASIN D-43 PERMANENT GENERATOR	This project includes one new permanent 100 kW emergency standby diesel generator for P.S. D-43, above-ground fuel storage tank, and automatic transfer switch (ATS).	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	-	-	215,000	-	215,000	-	-	-	
454	WW06	WW6-23	SEWER BASIN D-54 PERMANENT GENERATOR	This project includes replacement of existing generator with one new permanent 150 kW emergency standby diesel generator for P.S. D-54, above-ground fuel storage tank and automatic transfer switch.	This is a 2016 CUS Master Plan recommendation. The purpose of this project is to provide a redundant power supply for the transmission system. This is part of the "Climate Resilience" strategic initiative.		-	-	-	185,000	-	185,000	-	-	-	
454	WW07	WW7-1	GRAVITY PIPE IMPROVEMENTS TO THE DOWNTOWN COLLECTION SYSTEM	• Upsize 920 feet of the existing 12" gravity pipe to a 15" gravity pipe along E Las Olas Blvd from SE 1st Ave to SE 4th Ave. • Upsize 750 feet of the existing 14" gravity pipe to 21" gravity pipe right by the pump station and along SE 2nd St. from SW 1st Ave to SE 1st Ave. • Upsize 84 feet of the existing 14" gravity pipe to 24" gravity pipe right by the pump station A-7 along SW 2nd St. • Upsize 560 feet of the existing 15" gravity pipe to 18" gravity pipe right along SE 1st Ave. from East Las Olas to SE 2nd St.	This is a 2016 CUS Master Plan recommendation. The upsized gravity pipe will alleviate surcharging issues in the area as predicted by hydraulic modeling.		-	-	843,000	-	-	843,000	-	-	-	
454	WW10	WW10-1	A PUMP STATIONS R&R	General Pump station R&R for A pump Stations not specifically called out in other CIP projects.	This is a 2016 CUS Master Plan recommendation. The City has identified pump stations due to be rehabilitated to ensure capacity to deliver peak flows.		-	739,000	714,000	958,000	1,489,000	3,900,000	7,170,000	4,910,000	9,630,000	
454	WW10	WW10-2	B PUMP STATIONS R&R	General Pump station R&R for B pump Stations not specifically called out in other CIP projects.	This is a 2016 CUS Master Plan recommendation. The City has identified pump stations due to be rehabilitated to ensure capacity to deliver peak flows.		-	-	890,000	492,500	772,500	2,155,000	3,410,000	1,440,000	2,810,000	
454	WW10	WW10-3	C PUMP STATIONS R&R	General Pump station R&R for C pump Stations not specifically called out in other CIP projects.	This is a 2016 CUS Master Plan recommendation. The City has identified pump stations due to be rehabilitated to ensure capacity to deliver peak flows.		-	-	-	1,300,000	-	1,300,000	1,680,000	100,000	4,350,000	
454	WW10	WW10-4	D PUMP STATIONS R&R	General Pump station R&R for D pump Stations not specifically called out in other CIP projects.	This is a 2016 CUS Master Plan recommendation. The City has identified pump stations due to be rehabilitated to ensure capacity to deliver peak flows.		-	-	285,000	1,300,000	1,396,000	2,981,000	5,640,000	6,520,000	5,060,000	
454	WW10	WW10-5	E PUMP STATIONS R&R	General Pump station R&R for E pump Stations not specifically called out in other CIP projects.	This is a 2016 CUS Master Plan recommendation. The City has identified pump stations due to be		-	-	1,052,500	604,000	247,500	1,904,000	1,340,000	2,170,000	530,000	

Table WW9-5. City of Fort Lauderdale
Wastewater Additional CUSMP Projects - Fund 454

Fund	Primary Task	PROJECT #	PROJECT TITLE	PROJECT DESCRIPTION	JUSTIFICATION	Unspent Balance as of 9/29/16	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017-FY 2021 CIP Total	FY 2022-FY 2026 CIP Total	FY 2027-FY 2031 CIP Total	FY 2032-FY 2036 CIP Total	UN-FUNDED
454	WW13	WW13-1	PUMP STATION FLOOD MITIGATION AND BEAUTIFICATION	The project includes adding floodwalls to identified pump stations and possibility beautify the station throughout the floodwalls to meet aesthetical requirements.	As a result of engineering analysis, 37 pump stations are identified as being susceptible to flooding due to predicted high tide, storm surge events, and sea level rise. Mitigating the flooding risk can prevent further loss of the infrastructure during extreme weather events. It also can help reduce inflow of flood water into the pump stations through the wet well covers.		-		115,000	115,000	115,000	345,000	460,000	460,000	280,000	
454	WW16	WW16-01	COLLECTION SYSTEM VFD INSTALLATION AND PROGRAMMING	Install VFD's on (24) remote wastewater pump stations and provide programming on (28) stations with VFD driven pumps to maximize usage of wet well volumes.	Energy Savings		-	-	436,750	436,750	436,750	1,310,250	436,750	-	-	
454	WW16	WW16-02	COLLECTION SYSTEM SYNCHRONIZATION	Install system wide programming to synchronize the operation of all remote pump stations.	Energy Savings		-	-	165,000	-	-	165,000	-	-	-	
Totals						**-**	**-**	**7,813,000**	**7,912,250**	**21,517,250**	**20,942,750**	**58,185,250**	**91,935,250**	**84,058,000**	**131,410,000**	**-**

WW10 Wastewater R&R Improvements

The City of Fort Lauderdale wastewater system consists of the George T. Lohmeyer Wastewater Treatment Plant (GTL), 5 deep injection wells, 186 pump stations, 3 repump stations, approximately 135 miles of forcemain and 368 miles of gravity sewer. The overall service area includes approximately 180,000 people. The wastewater system is divided into two categories, the Central Region Wastewater System and the City Wastewater Collection and Transmission System. Funding for the Central Region Wastewater system includes the GTL, 5 injection wells, 2 repump stations and 23.5 miles of forcemain that connect the other Central Regional Cities to the GTL. The remaining wastewater infrastructure directly connects to City of Fort Lauderdale customers and is considered the City Wastewater Collection and Transmission System. Renewal and Replacement (R&R) responsibilities for the Central Region Wastewater System are executed in accordance with the Large User Agreement between the region's large users which include the cities of Fort Lauderdale, Oakland Park and Wilton Manors, Port Everglades Authority, and portions of Tamarac and Town of Davie. The City Wastewater Collection and Transmission System R&R responsibilities are undertaken solely by the City of Fort Lauderdale.

In accordance with the Large User Agreement of the Central Regional Wastewater System, an R&R analysis is required annually. The Large User R&R identifies areas of improvements within the regional wastewater system and estimates the useful life of major equipment so that future replacement can be scheduled, and the required funding can be reserved. The City's Distribution and Collection Section tracks R&R needs for the City's Wastewater Collection and Transmission System. R&R assessments and studies for the GTL electrical power distribution system (**Section UW3**) are also incorporated into the R&R schedule herein. This CUS Master Plan reviewed ongoing R&R efforts, toured facilities and interviewed staff to complete and summarize R&R needs through fiscal year 2035 for the GTL, the Central Regional Transmission System, the City Wastewater Collection and Transmission System, and the overall wastewater electrical system.

10.1 G.T Lohmeyer Wastewater Treatment Plant

The City of Fort Lauderdale owns and operates GTL. The plant's current domestic wastewater operating permit was issued by the Florida Department of Environmental Protection (FDEP) on September 7th, 2011 and expires September 6th, 2016. The City is currently in the process of renewing the GTL operating permit. The operating permit allows the plant to treat a capacity of 56.6 million gallon per day (MGD) maximum three month average daily flow (MTMADF).

GTL anticipated equipment repair and replacement, as well as facility improvements, are scheduled in the Central Region Wastewater System 2015 R&R Analysis (2015 R&R Analysis). The most recent R&R was completed in June 2015 and includes updated tables summarizing the plant's needs and equipment condition. An updated 2016 R&R Analysis was completed and approved in mid- 2016. The 2015 R&R analysis addressed all major processes at GTL including:

- Pretreatment
- Biological Treatment
- Clarification
- Chlorination
- Effluent Screening
- Effluent Disposal
- Biosolids Management

REI met with City staff to review the tables and confirm the validity of the information presented in the 2015 R&R Analysis. City staff provided information regarding critical changes in equipment

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condition and equipment repairs or replacements following the June 2015 R&R reporting period. An updated condition summary of major equipment at GTL that changed since the 2015 R&R Analysis is presented below in **Table WW10-1**.

Table WW10-1. GTL Equipment Condition Update

Equipment	Year Replaced/ Rebuilt	Comment	Condition
Grit Chamber No. 1	2015	Concrete rehabilitation completed and the collector driver replaced.	Excellent
Grit Chamber No. 2	2015	Concrete rehabilitation completed and the collector driver replaced.	Excellent
Biological Reactor Train A Stage 2	2015	Mixer motor replaced.	Excellent
RAS Pump No. 1	2015	Impeller replaced.	Good
Sludge Pump Station No. 1	2015	Impeller replaced.	Good
Sludge Pump Station No. 2	2015	Impeller replaced.	Good
Sludge Pump Station No. 3	2015	Impeller replaced.	Good
Sludge Transfer Pump No. 3	2015	Pump replaced.	Excellent
Sludge Grinder No. 2	2015	Grinder refurbished.	Good
Sludge Feed Pumps No. 1 thru No.9	2015	Completed.	Excellent
Polymer Pump No. 1-7	2015	Pumps and controllers replaced.	Excellent

Information provided based on discussions with City staff.

The CUS Master Plan Team updated the R&R table based on site visits, information provided by City staff and recommendations of various sections within the CUSMP. **Table WW10-2** illustrates the anticipated R&R needs of the GTL Wastewater Treatment Plant based upon the 2015 R&R Analysis and CUS Master Plan updates. The total R&R expenditure for the GTL increased by approximately $10 million when compared to the 2015 R&R Analysis, primarily due to the additional CUS Master Plan-identified electrical needs. **Section UW3** provides details of the electrical system evaluation and identified needs.

Table WW10-2. GTL 2016 Renewal and Replacement Requirement Analysis

Item	Quantity	Useful Life[1] (Yrs)	Year Purchased/ Rehabbed	Remaining Useful Life (Yrs)	Condition (Excellent, Good, Fair, Poor)	Cost Per Unit [3]	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
G.T. Lohmeyer WWTP															
Influent Screening	4	10	2012 (4)	6	Excellent	$321,945					$1,287,781	$1,287,781			$1,287,781
Screenings Screw Conveyor	1	15	2012	11	Excellent	$131,482								$131,482	
PT Bridge Crane Hoisting Equipment	2	15	2010	9	Good	$162,828							$325,656		
Grit Chamber Drives	2	15	2015	14	Excellent	$111,500								$111,500	$111,500
Grit Chamber Covers	2	15	2015	14	Good	$114,022								$228,043	
Grit Chamber Concrete Repair & Coating	2	20	2015	14	Good	$800,000									$800,000
Grit Chamber Roof Deck Resealing	1	15	2012	11	Good	$64,389								$64,389	
Grit Pumps	4	7	2007 (4)	2	Good	$14,253					$57,011	$57,011		$57,011	$57,011
Cyclones	4	10	2002 (4)		Poor	$5,701							$22,804		$22,804
Grit Hydrogritter	2	15	2011 (2)	10	Good	$142,527							$285,054		
PT Building Façade Repair	1	20	2012	16	Good	$695,402									$695,402
PT Channel Concrete Corrosion Repair	7	20	2008 (4), 2009 (2), 2011 (1)	12	Fair	$339,225								$2,374,574	
PT Channel Stop Gates	15	20	2013 (15)	17	Excellent	$35,632		$534,476				$534,476			$534,476
PT Effluent Weir Gates	2	20	2008 (2)	12	Good	$71,263							$142,527		
PT Seal Water System	1	10	2014	8	Excellent	$34,327					$34,327	$34,327		$34,327	
Influent Slide Gates to Reactors	4	20	2006 (2), 2007 (2)	10	Fair	$35,632							$71,263	$71,263	
Influent Flow Meters, PT(2), R2 (1)	3	10	2007 (1), 2011 (1), 2012 (1)	6	Good	$21,970					$21,970	$21,970	$21,970	$43,940	$21,970
Lightning Aerators	12	15	2011 (3), 2012 (3), 2013 (6)	12	Good	$142,527								$1,710,324	
Reactor Basin Concrete Corrosion Repair	-	15	2003	15	Poor	$669,879		$666,879				$666,879			$669,879
Cryogenic Oxygen Compressors	3	15	1998 (1), 2000 (1), 2004 (1)	3	Poor	$356,317		$356,317	$356,317			$712,634		$712,634	$356,317
Cryogenic Oxygen Plant Cold Box	1	30	1983		Poor	$1,287,781									
Cryogenic Oxygen/Misc. Control System	-	30	1983		Poor	$3,863,344									$114,022
Cryogenic Oxygen Storage Tanks	3	20	1983 (1), 2010 (2)	14	Good	$712,636							$712,636	$1,425,272	
Cryogenic System Cooling Towers	2	20	1995 (1), 1996		Poor	$114,022									$114,022
Cryogenic Oxygen Building Seamless Flooring Replacement	1	20	2012	16	Good	$71,263									
Clarifiers 1-7 (Square)	7	30	2001 (1), 2002 (5),	16	Good/Excellent	$520,226								$520,226	$3,121,357
Clarifiers 8-11 (Circular)	4	30	2003 (1), 2004 (1), 2014 (2), 2015 (2)	22	Fair/Good	$397,648								$795,296	$795,296
Clarifier Underflow Valves	11	15	1983 (3), 2005 (4), 2013, 2007 (4)	7	Good/Excellent	$7,982				$31,926		$31,926	$31,926	$23,945	$31,926
Clarifier Battery Algae Resistant Resurfacing	3	10	2010 (1), 2012 (1), 2013 (1)	7	Good	$151,647							$454,941		$454,941
Sludge Pumps - Station 1	3	15	2007 (3), 2012, 2015	6	Good	$42,757							$128,270		
SPS-1 Seal Water System	1	10	2009	3	Fair	$34,327		$34,327				$34,327		$34,327	
Sludge Pumps - Station 2	3	15	2007 (3), 2011, 2013, 2014	6	Good	$42,757							$128,270		
SPS-2 Seal Water System	1	10	2009	3	Fair	$34,327		$34,327				$34,327		$34,327	
Sludge Pumps - Station 3	6	15	2008(6)	7	Good	$71,263							$427,581		
SPS-3 Seal Water System	1	10	2008	3	Fair	$34,327		$34,327				$34,327		$34,327	
VFDs for SPS 1, 2, 3 + N.P.W. + SFPs	18	20	2007 (14),	11	Good/Fair	$71,263								$1,282,743	
SPS 3 Monorail Hoisting Equipment	1	15	1984		Poor	$54,923								$54,923	
Sludge Transfer Pumps 3 & 4, Pumps	2	5	2003 (1), 2005(1), 2015	4	Excellent	$50,000		$38,447			$38,447	$76,894	$76,894	$76,894	$76,894
Sludge Transfer Pumps 3 & 4, Motors	2	10	2008 (2), 2015	9	Excellent	$21,970		$43,940				$43,940		$43,940	
Sludge Grinders	2	10	2007 (1), 2008(1), 2011, 2015	5	Good	$13,682		$13,682				$13,682		$27,364	
Sludge Holding Tank Recirculation Pumps	2	10	2000 (2), 2013		Poor/Excellent	$68,413				$136,826		$136,826		$136,826	
Sludge Holding Tank Mixer/Blowers	2	15	2012 (2)	11	Excellent	$38,954								$77,907	

Table WW10-2. GTL 2016 Renewal and Replacement Requirement Analysis (Continued)

Item	Quantity	Useful Life[1] (Yrs)	Year Purchased/ Rehabbed	Remaining Useful Life (Yrs)	Condition (Excellent, Good, Fair, Poor)	Cost Per Unit [3]	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
Sludge Holding Tank Decanting Valves	12	15	2006 (12)	5	Fair	$22,804					$273,652	$273,652			$273,652
Belt Press Sludge Feed Pumps	8	5	2007 (3), 2008 (5), 2012	1	Poor	$28,505		$85,516	$142,527		$85,516	$313,559	$228,043	$228,043	$228,043
Sludge Feed Pump Wetwell Mixers	3	10	2012 (3)	6	Good	$33,528							$100,584		$100,584
Belt Presses	7	18	1999 (7)	1	Fair	$427,581		$855,162				$855,162			$2,993,067
Dewatering Monorail Hoisting Equipment	1	15	2007	6	Fair	$54,923							$54,923		
Sludge Screw Conveyor	8	15	1999 (6), 2005 (2), 2012	4	Poor/Good	$135,401		$812,404		$270,801		$1,083,205		$812,404	$270,801
Sludge Distribution Screw Conveyor	2	15	2005 (2)	4	Poor	$135,401				$270,801		$270,801			$270,801
Sludge Truck Weighing Scales	2	5	2005 (2)		Poor	$121,148				$242,296		$242,296	$242,296	$242,296	$242,296
Truck Bay Concrete Beam Repair	1	50	2010	44	Good	$712,636									
Polymer Pumps	7	10	1999 (9), 2015	9	Excellent	$15,000							$105,000		$105,000
Traveling Water Screens	3	15	1996 (1), 1997 (1), 1999 (1)		Fair	$35,632		$35,632				$35,632		$71,264	$35,632
Effluent Pumps	5	15	2003 (5), 2009, 2014	2	Fair/ Good	$356,317		$1,068,952				$1,068,952			$1,781,587
Effluent Pump VFD Upgrade	5	15	2003, 2008, 2010, 2014	7	Good	$60,000				$300,000		$300,000		$1,500,000	
Effluent Flowmeters	5	10	1984 (4), 1998		Poor	$6,784		$6,784				$6,784	$27,138	$6,784	$27,138
Effluent Pump VFD A/C Units	2	15	2011 (2)	15	Good	$54,276							$108,552		
Effluent Building Seal Water System	1	10	2011, 2013	5	Good/Excellent	$34,327					$34,327	$34,327		$34,327	
Effluent Pump Station Monorail Hoisting Equipment	1	15	1984		Poor	$54,923								$54,923	
Injection Well Backflush Pump	1	15	1984		Poor	$71,263					$71,263	$71,263			$71,263
Deep Injection Wells (*assumes work will be done as CIP)	5	50	1984 (4), 1998 (1)	18	Good	$7,126,363									
Deep Injection Wells Acid Rehabilitation	5	30	1984 (4), 1998 (1), 2015	29	Good	$350,000							$350,000		
Brush Inside Wall of Well Casings	5	5	1984 (4), 1998 (1), 2015	4	Good	$25,000		$25,000		$25,000		$50,000	$25,000	$25,000	$25,000
Paint Well Piping-Platforms-Electrical Building	1	5	2010		Poor	$28,505				$28,505		$28,505	$28,505	$28,505	$28,505
NPW Pumps	3	15	2008 (3), 2010, 2015	7	Good	$28,505							$85,516		
NPW Monorail Hoisting Equipment	1	15	1984		Poor	$54,923								$54,923	
NPW Hydrostrainers	2	15	2011 (2)	10	Excellent	$88,198							$176,397		
Odor Control System - Dewater Bldg.	1	20	1999	3	Fair/Poor	$285,054			$285,054			$285,054			
Odor Control System - Holding Tank	1	20	2007	11	Fair	$1,125,966								$1,125,966	
Odor Control System - Headworks	1	20	1984		Fair/ Poor	$1,852,854									$1,852,854
Emergency Chlorine Scrubber	1	10	2006, 2013	7	Good	$370,570			$370,570			$370,570	$370,570		$370,570
Chlorine Building Monorail Hoisting Equipment	1	15	2000		Fair/Poor	$54,923								$54,923	
Chlorine System	1	10	2006		Fair/Good	$997,692		$997,692				$997,692	$997,692		$997,692
Reactors & Clarifier Battery 3 Influent Process Piping	--	50	1979/1984	18	Fair/Poor	$13,000,000		$2,000,000	$2,000,000	$2,000,000		$6,000,000			
Clarifier Battery 1,2 Influent & Clarifier Battery Distribution	--	50	1979/1984	18	Fair/Poor	$3,708,810		$1,236,270	$1,236,270			$2,472,540			
Clarifier Effluent Process Piping	--	50	1979/1984	18	Fair/Poor	$3,708,810				$1,236,270	$2,472,540	$3,708,810			
Effluent Pump and Deep Injection Well Piping	--	50	1989	23	Fair/Poor	$3,708,810							$3,708,810		
Dewatering & RAS Process Piping	--	50	1979/1984	18	Fair/Poor	$3,708,810							$2,472,540	$1,236,270	
Miscellaneous Pumps, Motors, Actuators, etc.	1	-	--	--	--	$114,022		$114,022	$114,022	$114,022	$114,022	$456,088	$570,110	$570,110	$570,110
Public Address System	--	30	2012	26	Good	$712,636									
Computer System Hardware	1	5 + 20	2001, 2007, 2014	--	Good	$3,563,181			$3,565,181			3565181	$178,159	$178,159	$178,159
Plant Wide Instrumentation Replacement	--	10	1983		Poor	$1,814,744			$1,814,744			$1,814,744		$1,814,744	
Preventative Maintenance on Electrical Components	--	-	--	--	--	$69,798		$69,798	$69,798	$69,798	$69,798	$279,192	$348,990	$348,990	$348,990
Electrical Testing and Maintenance (Arcflash)	--	5	--		Poor	$203,535					$203,535	$203,535	$203,535	$203,535	$203,535
Emergency Generator	1	30	2008	22	Good	$997,692									
Automatic Transfer Switch	1	20	2009	13	Good	$474,915								$1,287,781	
4160V Switchgear (Service Pts. 1 - 3)	3	20	1979 (1), 2005	9	Fair	$1,287,781							$2,575,563		$1,287,781
Unit Substations(4)	12	20	--	--	--	$643,891		$1,287,782	$1,287,782	$1,287,782		$3,863,346	$643,891		
Motor Control Centers (MCC)	14	20	1978, 1984		Poor	$250,000								$500,000	
Security System	--	10	2004, 2014	9	Good	$1,282,744							$1,282,744		$1,282,744
Electronic Operation and Maintenance Manual Update	--	5	2009		--	$110,289				$110,289		$110,289	$110,289	$110,289	$110,289
Wastewater Master Plan	--	5	2007, 2016	5	--					$427,581		$427,581	$427,581	$427,581	$427,581
FDEP Deep Injection Well - UIC Permit	1	5	2012	1	--	$109,848					$59,848	$59,848	$109,848	$109,848	$109,848
FDEP Deep Injection Well Mechanical Integrity Test	5	5	2009, 2015	4	--	$123,578		$150,000		$150,000		$300,000	$300,000	$300,000	$300,000

Table WW10-2. GTL 2016 Renewal and Replacement Requirement Analysis (Continued)

Item	Quantity	Useful Life[(1)] (Yrs)	Year Purchased/ Rehabbed	Remaining Useful Life (Yrs)	Condition (Excellent, Good, Fair, Poor)	Cost Per Unit [(3)]	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
FDEP Deep Injection Well Mechanical Integrity Test	5	5	2009, 2015	4	--	$123,578		$150,000		$150,000		$300,000	$300,000	$300,000	$300,000
FDEP Operating Permit	1	5	2011		--	$164,771					$164,771	$164,771	$164,771	$164,771	$164,771
WWTP Interior Painting - Plant Wide	-	10	2007	1	Fair	$1,425,273		$475,091	$475,091			$950,182	$475,091	$1,221,562	$475,091
WWTP Exterior Painting - Plant Wide	-	5	2010, 2003(2), 2007		Fair/Poor	$271,380					$271,380	$271,380	$271,380		$271,380
Roofing Replacement - Plant Wide	11	20	2008(1), 2010(1), 2011(1)	15	Good	$128,274							$256,549	$1,154,468	
Plant Drainage	1	50	--	--	--	$500,000									
Electrical/ I&C/ SCADA Evaluation	1	5	--	--	--	$385,700				$385,700		$385,700	$385,700	$385,700	$385,700
Asphalt Overlay - Plant Wide	-	30	1983		Fair	$106,897			$106,897			$106,897	$106,897	$106,897	$106,897
Building Upgrades - Plant Wide	11	20	2010	14	Good	$516,979								$4,652,807	$1,033,957
Doors, Louvers, Window Replacements - Plant Wide	-	20	2011	15	Good	$2,067,914								$146,000	$146,000
Butler Building Rehab at Deep Injection Wells	-	20	2015	19	Good	$292,000									
Effluent Pumps Medium Voltage Solid State Starters[(2)]	3	15	--			$150,000		$450,000				$450,000			
Plant Electrical Documents Update[(2)]	1	--	--	--	--	$80,000		$80,000				$80,000			
Grounding and Surge Protective System Study[(2)]	1	10	2005		Fair	$75,000		$75,000				$75,000			
Plant Lighting Protection System Implementation.[(2)]	1	15	--	--	--	$400,000		$200,000	$100,000	$100,000		$400,000			
SPS No.1 and Clarifiers 1,2 and 3 Control and Power Wire[(2)]	1	25	--	--	--	$2,000,000		$800,000	$600,000	$600,000		$2,000,000			
SPS No.2 and Clarifiers 4,5, 6 and 7 Controls and Power Wire[(2)]	1	25	--	--	--	$2,800,000					$1,000,000	$1,000,000	$1,800,000		
Sludge Holding Tanks Controls and Power Wire[(6)]	1	25	--	--	--	$800,000							$800,000		
Chlorine Building Controls and Power Wire[(2)]	1	25	--	--	--	$800,000				$800,000		$800,000			
Scum Pump, Drainage, Lift Station, Electrical and Control[(2)]	1	25	--	--	--	$300,000		$100,000	$100,000	$100,000		$300,000			
Medium Voltage Feeders Replacement[(2)]	1	25	--	--	--	$900,000					$300,000	$300,000	$600,000		
480V Variable Frequency Drives Replacement[(2)]	10	10	2008	2	Fair	$35,000					$400,000	$400,000			$400,000
5KV Fused Disconnect Switch to Feeder 2F5[(2)]	1	25	--	--	--	$350,000					$350,000	$350,000			
480V Generator Connection Switchboard to SPS No.3[(2)]	1	25	--	--	--	$250,000							$250,000		
480V Generator Connection Switchboard to Effluent PS[(2)]	1	25	--	--	--	$300,000							$300,000		
Total Annual R&R Expenditures (Original)								**$12,681,800**	**$12,624,300**	**$8,687,600**	**$4,786,100**	**$38,779,800**	**$26,596,500**	**$29,266,700**	**$26,742,900**

(1) Useful Life based on experience with previous and existing equipment at GTL WWTP, or similar equipment other WWTPs.

(2) Items previously not included in the Central Region Wastewater System 2015 R&R Analysis table.

(3) All unit costs based on Central Region Wastewater System 2015 R&R Analysis except (2).

10.2 Central Regional Transmission System

The City of Fort Lauderdale maintains and operates the Central Regional Transmission System which transmits wastewater flows from the Large User collection and transmission systems to the GTL. The Regional Transmission System consists of two (2) re-pump stations, Large User billing meters, and approximately 23.5 miles of force main. In this section the estimated expenditure and schedule for major equipment and facilities within the Regional Transmission System is discussed.

10.2.1 Regional Repump Stations

B Repump Station is located in the center of Coral Ridge Country Club, in the City of Fort Lauderdale. The B Repump Station consists of four (4) variable-speed pumps and other ancillary equipment. B Repump station receives flows from the E Repump Station and the northeast portion of the wastewater service area. E Repump Station is located in the vicinity of the Executive Airport in the City of Fort Lauderdale. The E Repump station consists of three (3) variable speed pumps and receives flows from the northwest portion of the wastewater service area. Operational control of the stations are based upon maintaining a preset suction pressure. Both stations are also equipped with emergency generators which were installed in 2007. B Re-pump Station and E Repump Station were listed as “good condition” in the 2015 R&R Analysis, and confirmed by City staff. The R&R needs of the Regional Repump Stations are shown in **Table WW10-3.** The table lists the equipment condition, useful life, and present and future cost for refurbishment and replacement. There were no significant changes in expenditure or schedule from the 2015 R&R Analysis.

Section WW10 accepted January 11, 2017.

Table WW10-3. Regional Repump Station 2016 Renewal and Replacement Requirement Analysis

Renewal and Replacement Description	Quantity	Useful Life (Years)	Calendar Yr. Purchased/ Rehabbed	Remaining Useful Life (Years)	Condition (Excellent, Good, Fair, Poor)	Cost Per Unit (2015$)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
Repump Stations															
Coral Ridge Repump Station (B)															
Pumps 1, 2, 3 & 4	4	15	2009 (4)	8	Good	$256,549							$1,026,196		
Motors	4	20	2009 (4)	13	Good	$13,569								$54,276	
Variable Frequency Drives	4	10	2009 (4)	3	Excellent	$142,527				$570,108		$570,108		$570,108	
Motor Control Center (MCC)	1	20	2009	13	Good	$406,203								$406,203	
Switchgear	1	20	2009	13	Good	$407,070								$407,070	
SCADA & Controls	1	7	2011	2	Good	$133,685			$133,685			$133,685	$133,685		$133,685
Generator	1	30	2009	23	Good	$427,581									
Flowmeters	3	10	2012 (3)	6	Good	$2,714							$8,142		$8,142
Valve Actuators	2	20	2009 (2)	13	Good	$14,251								$28,502	
Piping, Valves and Bypass	1	20	2009	13	Good	$427,581								$427,581	
HVAC, Paint, Security and Roofing	1	15	2009	8	Good	$171,034							$171,034		
Hoisting Equipment	1	15	1982		Poor	$98,294		$98,294				$98,294			$98,294
Building, Doors, Louvers, Windows	1	15	2009	8	Good	$94,983							$94,983		
Electronic O&M Manual	1	10	2012	6	Good	$133,685							$133,685		$133,685
Electrical Cables and Loop Wiring	1	10	2012	6	Good	$267,370							$267,370		$267,370
Executive Airport Repump Station (E)															
Pumps 1, 2 & 3	3	15	2008 (3)	7	Good	$213,790							$641,370		
Motors	3	20	2008 (3)	12	Good	$13,569								$40,707	
Variable Frequency Drives	3	10	2008 (3)	2	Excellent	$135,690			$407,070			$407,070		$407,070	
Motor Control Center (MCC)	1	20	2008	12	Good	$406,203								$406,203	
Switchgear	1	20	2008	12	Good	$407,070								$407,070	
SCADA & Controls	1	7	2011	2	Good	$133,685			$133,685			$133,685	$133,685		$133,685
Generator	1	30	2008	22	Good	$427,581									
Flowmeters	3	10	2008	2	Good	$2,714			$8,142			$8,142		$8,142	
Valve Actuators	2	20	2008 (2)	12	Good	$14,251								$28,502	
Piping, Valves and Bypass	1	20	2008	12	Good	$427,581								$427,581	
HVAC, Paint, Security and Roofing	1	15	2008	7	Good	$114,022							$114,022		
Hoisting Equipment	1	15	1982		Poor	$98,294		$98,294				$98,294			$98,294
Building, Doors, Louvers, Windows	1	15	2008	7	Good	$94,983							$94,983		
Electronic O&M Manual	1	10	2011	5	Good	$100,263							$100,263		$100,263
Electrical Cables and Loop Wiring	1	10	2011	5	Good	$200,526							$200,526		$200,526
Regional Metering Stations															
Meters	-	10	2014	--	Excellent	$14,251		$14,251	$14,251	$14,251	$14,251	$57,004	$71,255	$71,255	$71,255
Total Annual R&R Expenditures								**$210,800**	**$696,800**	**$584,400**	**$14,300**	**$1,506,300**	**$3,191,200**	**$3,690,300**	**$1,245,200**

10.2.2 Regional Forcemains

The regional forcemain system consists of approximately 23.5 miles of forcemain ranging from 6 inches to 54 inches in diameter. The regional forcemain system includes the primary trunk line that connects the Large Users to the GTL. The trunk line transmits flow from the E Repump Station and the City of Tamarac in the north. Similarly the regional system conveys east-side flows from B Repump Station, City of Oakland Park, City of Wilton Manors, and the southeast beach area. The regional system also transmits west-side flows from the Riverland road area and the Town of Davie and a short run connects Port Everglades to the GTL from the south.

A significant portion of the regional forcemains were installed between 1977 and 1981; consequently, many of the forcemains are approaching or surpassing the midpoint of their useful life expectancy. There are also sections of the forcemain system installed between 1950 and 1977 that are approaching or have exceeded the end of their useful life expectancy. The installation dates of the wastewater transmission system forcemains (regional and non-regional) are illustrated in **Figure WW10-1**. The regional forcemains include several lengthy, large diameter (30 to 54 inch) pipelines, critical to the transmission system that were fabricated from high risk pipe materials, such as cast iron pipe (CIP) and pre-stressed concrete cylinder pipe (PCCP). The regional forcemain system was analyzed as part of the risk prioritization for Large-Diameter Pipes in **Section WW6**. Based on parameters such as pipe material, installation date, level of service requirements and redundancy, the mains were ranked and prioritized for repair and replacement as needed. **Table WW10-4** shows the criteria used to evaluate the large pipe risk prioritization.

Table WW10-4. Risk Prioritization Criteria – Large-Diameter Pipes

Category	Basis	Weighting	Low Probability				High Probability
			1	2	3	4	5
Likelihood of Failure	Pipe Material	33.3%	PVC or HDPE	--	Unknown or DIP	RCP	PCCP, CIP
	Installation Date	33.3%	2000 or later	1990 - 2000	1980-1990, Unknown	1970 - 1980	Earlier than 1970
	LOS Require-ments[1,2]	33.3%	Velocity < 5 fps (Meets LOS reqmt.)	--	Velocity 5-6 fps (Almost meets LOS reqmt.)	--	Velocity > 6 fps (Fails LOS reqmt.)
Consequence of Failure	Pipe Diameter	50%	<24"	--	24" – 36"	--	>36"
	Redundancy	50%	Full Redundancy	--	Partial Redundancy	--	No backup/ redundancy

The results of the risk prioritization were used to develop and schedule specific projects to address the R&R needs for the regional forcemains. **Table WW10-5** identifies the R&R needs of the Central Region forcemains prioritizing specific forcemain sections with high likelihood or consequence of failure rankings. The 2015 Regional System R&R Analysis budgeted approximately $2.6 million annually for fiscal years 2026 through 2055. The risk prioritization analysis herein, concluded that forcemain R&R should occur sooner (as early as fiscal year 2018) as indicated in Table WW10-5.

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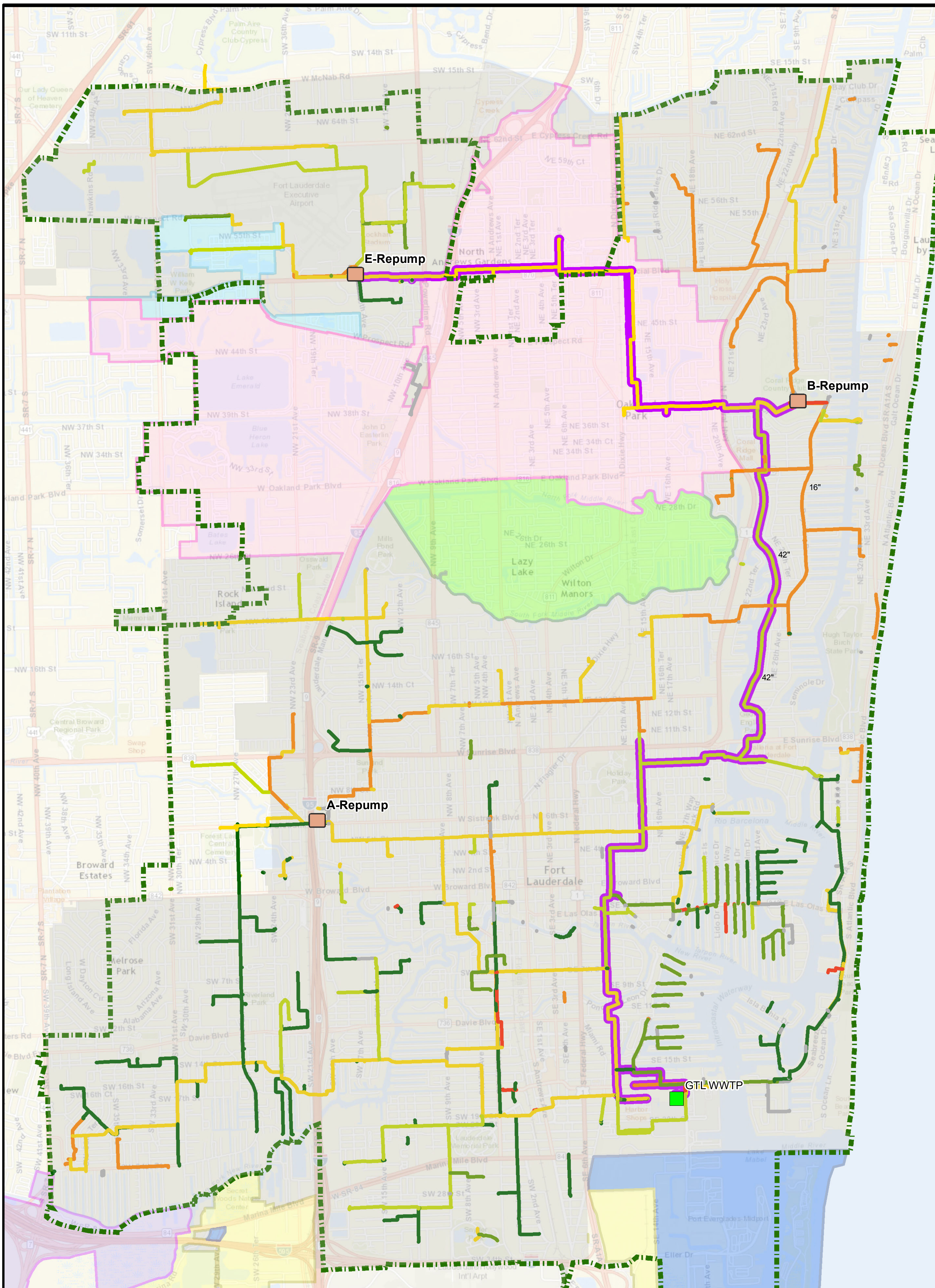

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CITY OF FT. LAUDERDALE
Pump Station
WW Service Area
Regional FM

Wholesale Customers
DANIA BEACH
DAVIE
PORT EVERGLADES
OAKLAND PARK
TAMARAC
WILTON MANORS

Wastewater Force Main Installation Date
Unknown
1950-1959
1960-1969
1970-1979
1980-1989
1990-1999
2000 and Later

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
Wastewater Transmission System: Force Main Installation Date

FIGURE WW10-1

G:\0gis\134001 - FTL Master Plan_MXDs\Wastewater R&R\Pressure_Date_Install.mxd

Table WW10-5. Regional Forcemain 2016 Renewal and Replacement Requirement Analysis

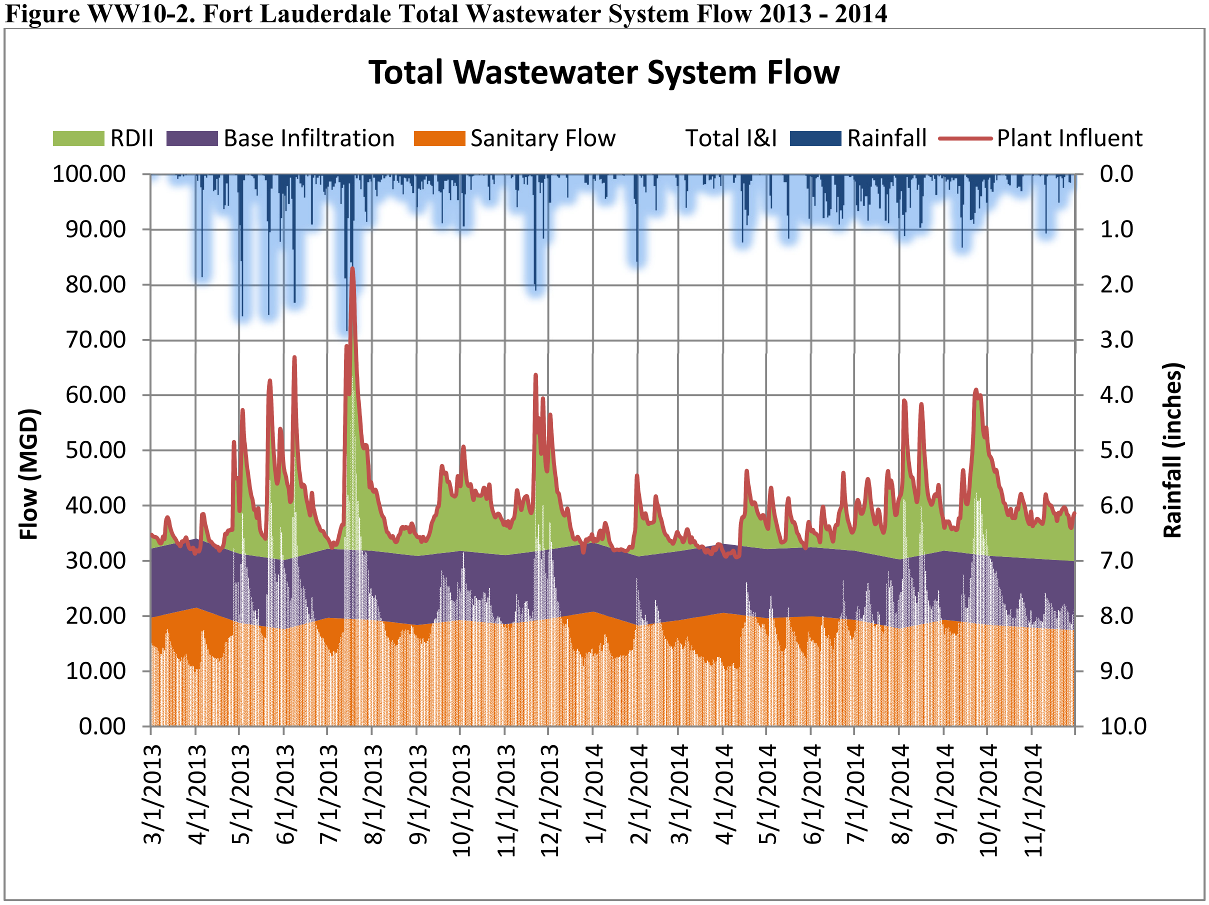
Renewal and Replacement Description	City/Reiss Project No.	Diameter	Quantity (length ft.)	Calendar Yr. Installed/ Rehabed	Risk Score[1]	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
42" Force Main (Middle River Dr) Rehabilitation and New Pipeline	WW6-3	42"/ 24"	17,500/ 4,500	1980	4								$15,585,000	
42"Force Main (NE 38th St.) Rehabilitation and New Pipeline	WW6-4	42"/24"	8,000/ 3,000	1980	4				$7,530,000		$7,530,000			
24" Force Main (Commercial Blvd.) Rehabilitation and New Pipeline	WW6-5	24"	11,800/ 3,000	1979	3			$5,074,000			$5,074,000			
48" Force Main (SE 10th Ave.) Rehabilitation and New Pipeline	WW6-7	48"/36"	13,400/ 5,400	1980	3								$15,784,000	
54" Force Main (GTL Influent) Rehabilitation and New Pipeline	WW6-8	48"/54"	5,100/ 6,000	1977	4			$300,000	$11,292,000		$11,592,000			
Effluent Main Rehabilitation	WW6-9	54"	3,500	1982	4			$3,850,000			$3,850,000			
Force Main (GTL TRUNK LINE PARALLEL) IMPROVEMENTS	WW3-19	48"/60"	6,600/ 1,500	1977, 1980	4							$7,947,000		
Total Annual R&R Expenditures								**$9,224,000**	**$18,822,000**		**$28,046,000**	**$7,947,000**	**$31,369,000**	

[1] Risk scores are 1 to 5 with 5 being the highest risk; scores of 3 and above were targeted for R&R over the 20 year planning horizon.

10.3 Collection R&R Needs

The City's gravity collection system was constructed primarily of vitrified clay piping prior to the 1990's and some were laid on wooden pipe supports or "bridges". Over time the wooden supports have rotted away and along with soil settling have propagated cracks in the inflexible, brittle clay pipes. The City has also targeted removal of Orangeburg gravity pipe and backyard gravity pipes from its system due to service life and access issues. The installation dates of the collection system gravity pipelines are illustrated in **Figure WW10-3**. Along with service lateral and brick manhole deterioration and a high groundwater table, these issues have contributed to a high amount of infiltration and inflow (I/I). The I/I contribution to the collection and transmission system is a significant portion (more than 50%) of the annual total system flow. **Figure WW10-2** shows the constituents of wastewater system flow from 2013 – 2014 compared to daily rainfall in the City.

Figure WW10-2. Fort Lauderdale Total Wastewater System Flow 2013 - 2014



(Data Source: National Weather Service (NWS))

Overall, the system's influent is closely correlated with rainfall events. The peak flow during wet weather conditions regularly exceeds 80 MGD. The City is addressing I/I with an annual repair and replacement (R&R) budget to rehabilitate gravity pipes, service laterals, and manholes to help maintain an acceptable level of service. However, further efforts are needed to reduce I/I flow to acceptable levels.

R&R needs were identified through a combination of Distribution and Collection staff knowledge, I/I analysis, and risk assessment. Collection system R&R projects include gravity pipe lining, manhole rehabilitation, manhole lid liners, service lateral rehabilitation and RDI/I monitoring and identification efforts. R&R efforts were prioritized to minimize risk and reduce RDI/I contributions to optimize hydraulic conditions in the collection system. Gravity Collection System Renewal and Replacement Schedule is presented in **Table WW10-6**. More detailed I/I study and risk analysis can be found in **Section WW4**.

Section WW10 accepted January 11, 2017.

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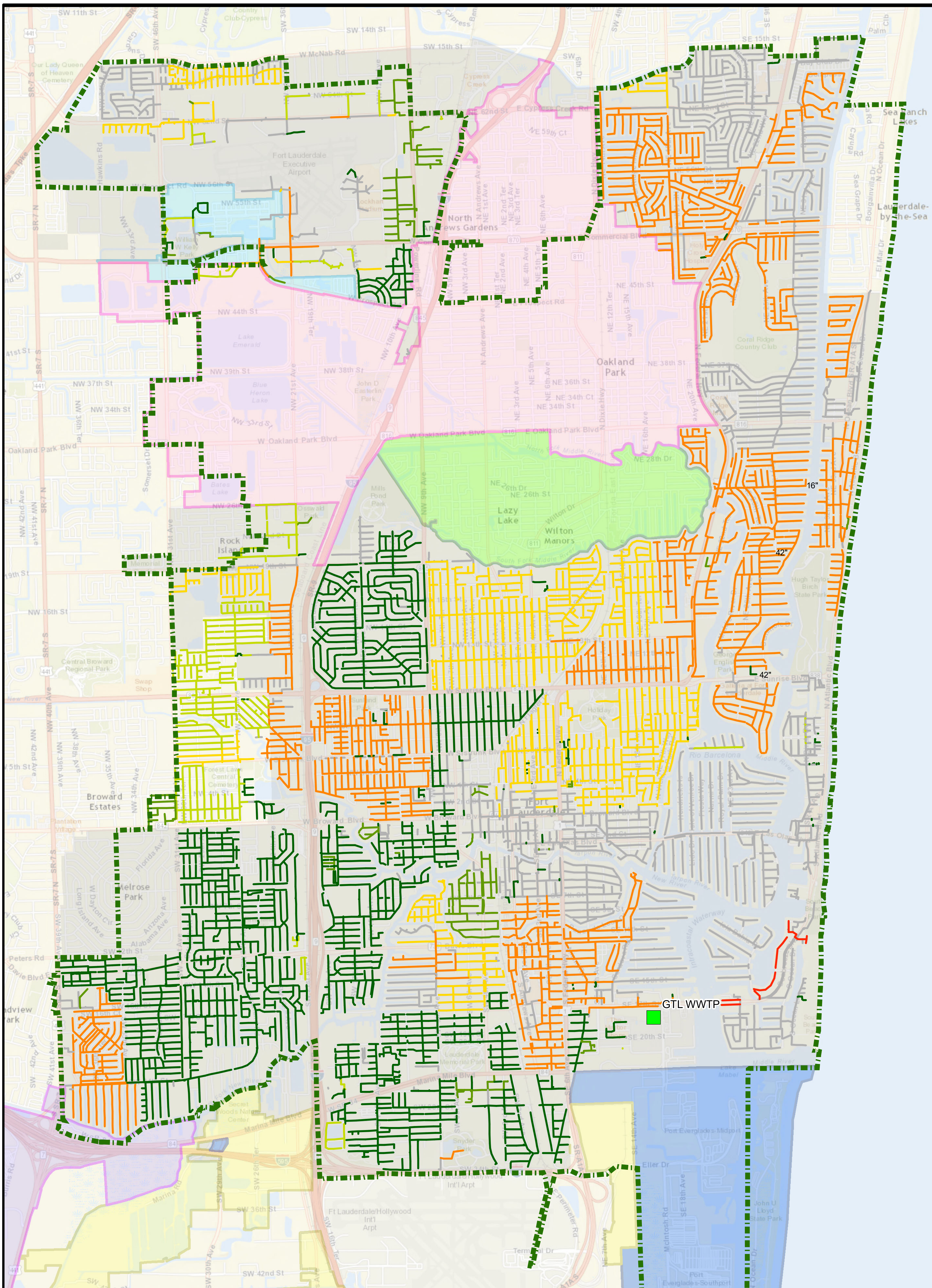

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LEGEND

Wholesale Customers
- DANIA BEACH
- DAVIE
- PORT EVERGLADES
- OAKLAND PARK
- TAMARAC
- WILTON MANORS

- GTL
- WW Service Area
- CITY OF FT. LAUDERDALE

Gravity Main Installation Date
- Unknown
- 1950-1959
- 1960-1969
- 1970-1979
- 1980-1989
- 1990-1999
- 2000 or later

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

Wastewater Collection System: Gravity Pipeline Installation Date

FIGURE WW10-3

G:\0gis\134001 - FTL Master Plan_MXDs\Wastewater R&R\Gravity_Date_Install.mxd

Table WW10-6. Gravity Collection System 2016 Renewal and Replacement Requirement Analysis

Renewal and Replacement Description	Project #	Calendar Yr. Install/ Rehab	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
Wastewater Collection R&R Projects - City Funded	Varies	Varies	$6,540,040	$3,842,000	$8,159,765	$7,592,000	$8,142,000	$34,275,805			
Wastewater Collection R&R Projects - City Unfunded	Varies	Varies			$13,952,950	$13,952,950	$13,952,950	$41,858,849			
Wastewater Collection R&R Projects - CUSMP	Varies	Varies			$7,999,000	$6,257,000	$6,253,000	$20,509,000	$42,966,500	$54,325,500	$10,000,000
Recurring Private Lateral Rehabilitation	WW4-20	Varies							$8,000,000	$15,000,000	$50,000,000
Recurring Future Contractor Performed Sewer Basin Rehabilitation	WW4-21	Varies							$8,750,000	$8,750,000	$8,750,000
Total Annual Collection/Transmission R&R Expenditures			**$6,540,040**	**$3,842,000**	**$30,111,715**	**$27,801,950**	**$28,347,950**	**$96,643,654**	**$59,716,500**	**$78,075,500**	**$68,750,000**

10.4 Transmission R&R Needs

The City wastewater transmission projects consist of the forcemain and pump station projects that are not a part of the regional transmission system.

10.4.1 City Transmission System Pump Station R&R

The City owns and operates 186 pump stations and 3 repump stations across its service area. Recently the City developed the Wastewater Pumping Station Evaluation & Rehabilitation Priorities 2015 report (Priorities Report). The Priorities Report included general information regarding pump station R&R needs. Although the report is in draft form, Reiss reviewed the report with D&C Staff and developed a pump station R&R schedule and budget. The Priorities Report set priority codes for each pump station in the transmission system to schedule R&R needs. **Table WW10-7** lists estimated costs based on the information provided in the Priorities Report.

Table WW10-7. Pump Station R&R Cost Estimation[1]

R&R Need	Estimated Cost	Frequency (Years)
Mechanical Upgrade	$215,000 Duplex Station $270,000 Triplex Station	10
Electrical Upgrades	$40,000 Duplex Station $50,000 Triplex Station	20
Emergency Generator	$10,000 Maintenance	1
Structural Repairs	$20,000	20
I&I Issue	Unit costs included in gravity rehabilitation	50
Pump Station Demolition and Replacement	$1,100,000 Duplex $1,400,000 Triplex	As needed
Work Performed by Staff	15% subtracted for City self-performed work	-

[1] Engineering and construction services fees not included.

The City Priorities Report includes ten year R&R needs. To address the R&R cost for beyond ten years, fiscal year 2025 through 2035, the above cost estimation table was used in conjunction with notes provided within the City Priorities Report. The anticipated Wastewater Pump Station Renewal and Replacement Schedule is shown in **Table WW10-8** for each pump station group.

A specific area of concern at the pump stations was emergency backup power supply including permanent generators, portable generator installations and dual power supplies. The City wastewater transmission system currently has five (5) pump station generators (not including B and E Repump stations generators). Pump stations A Repump, D-37 and D-40 have permanent generators and D-31 and D-54 have portable onsite generators. Based on the generator risk assessment of **Section WW6** and discussions with Distribution & Collection staff, generators at pump stations D-31 and D-54 are recommended for replacement. Pump station D-43 has hook-up provisions for a generator but no onsite generator, therefore a new generator is recommended for pump station D-43. New generators are also recommended for other pump stations throughout the transmission system. These projects are addressed in **Section WW6** of the CUSMP and will be recommended as CIP projects.

Section WW10 accepted January 11, 2017.

Table WW10-8. Wastewater Pump Station 2016 Renewal and Replacement Requirement Analysis

PUMP STATION GROUPING	Number of Stations	Priority 1 Stations	Priority 2 Stations	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
Wastewater Pump Station R&R Projects - City-Planned	--	--	--	$ 895,971	$ 1,153,520	$ 317,765	-	-	$ 2,367,256	-	-	-
Wastewater Pump Station R&R Projects - City-Unfunded	--	--	--	-	-	-	-	-	-	-	-	-
Other A Pump Stations R&R	66	A-7, A-12, A-21, A-23	A-8, A-11, A-41	$ -	$ 739,000	$ 714,000	$ 958,000	$ 1,489,000	$ 3,900,000	$ 7,170,000	$ 4,910,000	$ 9,630,000
Other B Pump Stations R&R	22	B-10, B-11, B-22	B-4, B-7, B-12, B-14, B-16	-	-	$ 890,000	$ 492,500	$ 772,500	$ 2,155,000	$ 3,410,000	$ 1,440,000	$ 2,810,000
Other C Pump Stations R&R	26	C-1, C-2	--	-	-	-	$ 1,300,000	-	$ 1,300,000	$ 1,680,000	$ 100,000	$ 4,350,000
Other D Pump Stations R&R	57	D-31, D-37, D-41, D-45	D-7, D-8, D-9, D-10, D-13, D-14, D-18, D-19, D-20, D-21, D-22, D-23, D-24, D-40	-	-	$ 285,000	$ 1,300,000	$ 1,396,000	$ 2,981,000	$ 5,640,000	$ 6,520,000	$ 5,060,000
Other E Pump Stations R&R	15	E-6, E-7		-	-	$ 1,052,500	$ 604,000	$ 247,500	$ 1,904,000	$ 1,340,000	$ 2,170,000	$ 530,000
Total Annual R&R Expenditures	**186**			**$ 895,971**	**$ 1,892,520**	**$ 3,259,265**	**$ 4,654,500**	**$ 3,905,000**	**$ 14,607,256**	**$ 19,240,000**	**$ 15,140,000**	**$ 22,380,000**

10.4.2 Wastewater Transmission Forcemain R&R

The transmission forcemains requiring R&R were identified by their material, age and criticality. The approximate age of the City wastewater transmission system is shown along with the regional wastewater transmission system in **Figure WW10-1**. These forcemains were prioritized in **Section WW6** using the same criteria shown in **Table WW10-4**. The pre-stressed concrete cylinder pipe (PCCP), cast iron and older force main pipe materials are prone to deterioration and have been responsible for numerous maintenance issues and failures. Trunk lines and interconnects susceptible to single-point failure that could result in loss of service for a large portion of the City's system were also identified. The resulting Wastewater Transmission Renewal and Replacement Schedule is shown in **Table WW10-9.**

10.5 Recommendations and Conclusions

Table WW10-10 below shows the suggested annual wastwater system R&R expenditures associated with the recommended projects included in this report section. **Section WW9** also presents the Wastewater R&R Improvements costs as part of the Community Investment Plan (CIP).

Table WW10-10. Suggested Annual Wastwater System R&R Expenditures

Wastewater System	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
Central Regional Wastewater System	$77,000,136	$35,053,400	$64,326,000	$27,988,100
City Wastewater Transmission and Collection System	$84,199,689	$92,928,500	$86,635,500	$134,330,000
Total Wastwater System R&R Expenditures	$161,199,825	$127,981,900	$150,961,500	$162,318,100

The CUS Master Plan team recommends the following actions to ensure a successful R&R program for the overall wastewater transmission and collection system:

- In general the R&R items described in the various tables should be addressed in a timely manner.
- Projects currently listed in the City CIP have also been identified as necessary in the R&R tables herein. The City should verify cost for projects ready for construction to ensure appropriate funds are available.
- With over 180 pump stations having various components with various useful life values, the Wastewater Pumping Station Evaluation & Rehabilitation Priorities 2015 Report should be completed and updated annually so that the transmission system can be accurately maintained.
- Distribution & Collection staff indicated that there are currently no routine maintenance programs for important components of the transmission system, including air release valves, generators, etc. A regularly scheduled maintenance program should be implemented for these components to help preserve the anticipated useful life.

Table WW10-9. Wastewater Transmission Forcemain 2016 Renewal and Replacement Requirement Analysis

Renewal and Replacement Description	City/Reiss Project No.	Diameter (Inch)	Quantity (length ft.)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2017 - FY 2021	FY 2022 - FY 2026	FY 2027 - FY 2031	FY 2032 - FY 2036
Force Main R&R Projects - City Planned	Varies	Varies	Varies	$224,802	$1,450,000							
24" FORCE MAIN REHABILITATION (NE 25th Ave.)	WW6-02	24	5,500							$3,000,000		
30" FORCE MAIN REHABILITATION AND NEW PIPELINE (W Commercial blvd.)	WW6-06	30 /24	12,000/ 6,000				$11,769,000		$11,769,000			
24" FORCE MAIN REHABILITATION (NE 13th St.)	WW6-10	24	3,300					$1,914,000	$1,914,000			
18" FORCE MAIN REHABILITATION (NE 9th St.)	WW6-11	18	1,000					$434,000	$434,000			
FORCE MAIN (MIDDLE RIVER DRIVE) IMPROVEMENTS	WW3-08	24	300								$220,000	
FORCE MAIN (FROM PUMP STATIONS D-35 TO D-36) UPSIZE	WW3-30	12	2,000					$580,000	$580,000			
FORCE MAIN (SUCTION SIDE TO B REPUMP) UPSIZE	WW3-11	48	200							$250,000		
FORCE MAIN (OAKLAND PARK) UPSIZE	WW3-17	20	2,000							$700,000		
FORCE MAIN (NW 22ND ROAD) UPSIZE	WW3-12	16 /20	1,900							$722,000		
FORCE MAIN (FROM PUMP STATION A-54 TO A-10) UPSIZE	WW3-15	30	1,900					$988,000	$988,000			
FORCE MAIN (NEAR PUMP STATION D-34) UPSIZE	WW3-16	12	100					$100,000	$100,000			
FORCE MAIN (SUCTION SIDE TO E REPUMP) UPSIZE	WW3-17	6	20							$100,000		
A-REPUMP DISCHARGE LINE IMPROVEMENTS	WW3-18	42	12,650					$9,867,000	$9,867,000			
FORCE MAIN CROSSING REINSTATEMENT (FROM PUMP STATION A-14)	WW3-7		2,100		$609,000				$609,000			
FORCE MAIN (B-1 REPUMP DISCHARGE) IMPROVEMENTS	WW3-27	10	350				$150,000		$150,000			
PUMP STATION D-37 DIVERSION	WW3-26	--	--		$900,000				$900,000			
LARGE DIAMETER FORCE MAIN INSPECTIONS/TESTING	--	Varies	--			$200,000			$200,000	$200,000	$200,000	$200,000
OTHER SMALL/INTERMEDIATE DIAMETER FORCE MAIN R&R	--	Varies	--					$1,500,000	$1,500,000	$4,000,000	$3,000,000	$3,000,000
Total Annual R&R Expenditures				$224,802	**$2,959,000**	**$200,000**	**$11,919,000**	**$15,383,000**	**$29,011,000**	**$8,972,000**	**$3,420,000**	**$3,200,000**

WW11 Wastewater Regulatory Impacts

The City's wastewater system is required to meet the United States Environmental Protection Agency regulations (EPA), Florida Department of Environmental Protection (FDEP) regulations and Broward County Environmental Protection and Growth Management Department (EPGMD) for wastewater collection, transmission, treatment and disposal. FDEP regulations have incorporated the EPA regulations for treated wastewater and wastewater facilities. EPGMD regulations are administered and enforced in accordance with the Broward County Code of Ordinances. In addition to meeting the requirements of Federal, State, and Local regulatory agencies, the City also has International Standard Organization (ISO) 9001 and 14001 certifications. ISO challenges organizations to establish their own objectives and targets to effectively and reliably manage environmental obligations. ISO 9001 quality management standards require organizations or local governments to ensure that their products and services consistently meet customer's requirements, and that quality is continually improved. ISO 9001 has a branch of standards for local governments which is ISO 18091 which provides guidelines for the application of the ISO 9001 standards. ISO 14001 environmental management standards require organizations to identify, understand, and comply with applicable environmental laws and regulations based on the Plan-Check-Do-Review-Improve cycle. ISO requirements are beneficial for organizations to help promote regulatory compliance.

The existing and proposed FDEP and EPGMD rules and impacts to the City's wastewater system are discussed in this section of the report. The purpose of this section is to identify regulatory changes on wastewater collection, transmission, treatment, and disposal systems.

11.1 Existing Regulatory Status

The George T. Lohmeyer Wastewater Treatment Plant (GTL) has a permitted capacity of 56.6 million gallons per day (MGD) maximum three month average daily flow (M3MADF) through FDEP Domestic Wastewater Facility Permit No. FLA041378-012-DW1P. Secondary treated effluent generated at the plant is disposed of via five (5) Class I Deep Injection Wells (IWs) which operate in accordance with FDEP Operating Permit No. 0054569-444-UO and Rule 62-528, Florida Administrative Code (F.A.C.). The GTL has a National Pollutant Discharge and Elimination System (NPDES) stormwater discharge permit under the facility identification number FLR05H034-002. Unclassified biosolids are produced from the plant solids handling process and are disposed of in accordance with FDEP Permit No. FLA041378 and Section 403.087, Florida Statutes. GTL also operates under EPGMD License No. WWTP-0700-15 for the mentioned facilities. GTL's two (2) dual stage and one (1) three stage scrubbers have a Broward County air permit No. AO-00197-15 expiring 9/1/2017. The primary rules that impact permitting and planning of GTL and the associated collection and transmission system are described in **Table WW11-1**.

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Table WW11-1. Primary Wastewater Regulations

Regulation	Description
Chapter 62-528, Underground Injection Control, F.A.C.	Establishes criteria for the construction and operation of injection wells in such a way that the injected fluid remains in the injection zone, and that unapproved interchange of water between aquifers is prevented.
Chapter 62-600, Domestic Wastewater Facilities, F.A.C.	Provides minimum standards for the design and operational criteria of domestic wastewater facilities. Establishes minimum treatment requirements for domestic wastewater facilities.
Chapter 62-604, Collection Systems and Transmission Facilities, F.A.C.	Establishes design, construction, and operation requirements for wastewater collection and transmission systems.
Chapter 62-620, Wastewater Facility and Activities Permitting, F.A.C.	Establishes the procedures to obtain a permit to construct, operate or modify domestic and industrial wastewater facilities. Includes requirements for establishing permit limitations and conditions. Contains requirements for monitoring and reporting after the permit is issued.
Chapter 62-640, Biosolids, F.A.C.	Regulates the beneficial use of biosolids in Florida, including the distribution and marketing of biosolids and the land application of biosolids.
Chapter 27, Pollution Control, Broward County Code of Ordinance	Establishes terms, conditions, requirements, limitations and restrictions for environmental protection within the limits of Broward County, FL.
Chapter 34, Water and Sewer, Broward County Code of Ordinance	Regulates the water and sewer distribution, collection and transmission systems and establishes wastewater discharge standards within the limits of Broward County, FL.

The following primary wastewater regulations rule impacts are noted:

- **Chapter 62-528, Underground Injection Control, F.A.C.**
    - The City's IWs are regulated by Chapter 62-528, F.A.C. Regulations require the operating permit to be renewed at least once every five years. The renewal permit application must be submitted no later than 60 days prior to the permit expiration date. Normal practice has been to submit the renewal permit application 6 months prior to the renewal date to allow the regulators time to review and ask for additional information. The City's current Class I operating permit has an expiration date of January 22, 2017 and therefore a renewal application should be submitted by July 22, 2016. The FDEP permit processing fee (required to be submitted with the permit application) is currently $10,000 per injection well; therefore, the permit processing fee to renew the injection well system operating permit will be $50,000 (plus an additional $10,000 if a sixth IW has been added to the system). The estimated consulting fees associated with renewing the injection well system operating permit are approximately $50,000. The permit processing time is typically 6 months. As long as the permittee submits the permit application at least 60 days prior to the expiration date of the current permit, the permittee can continue to operate the injection well system after the current permit expires.

- **Table WW11-2** below provides approximate operating permit application due dates through 2035 and was prepared with the assumption that the permit renewal application is submitted 6 months prior to the permit expiration date and the permitting period is six (6) months.

Table WW11-2. Permit Renewal Application Due Dates

Permit Expiration Date	Renewal Application Due Date	Renewed Permit Issue Date
January 22, 2017	July 22, 2016	January 22, 2017
January 21, 2022	July 21, 2021	January 21, 2022
January 20, 2027	July 20, 2026	January 20, 2027
January 19, 2032	July 19, 2031	January 19, 2032

- There have been no changes to Chapter 62-528, F.A.C. since the previous permit renewal that would impact the City's current operating, monitoring, and reporting requirements for the injection wells.
- In addition to the operating permit renewal requirement, the current regulations also include monitoring of the injection fluid and well integrity in accordance with Chapter 62-528.425, F.A.C. and reporting in accordance with Rule 62-528.430, F.A.C. Rule 62-528(1)(d), F.A.C., requires the Class I IWs undergo mechanical integrity testing (MIT) a minimum of once every five (5) years. The MIT includes performance of a video survey, casing pressure test, high-resolution temperature logging, and a radioactive tracer survey. Mechanical cleaning of well casings during the MIT is not a requirement of the FAC rule but the City has elected to clean their injection wells at the time of the MIT. FDEP requires the City to submit an evaluation of the previous five (5) years of monitoring and operating data with the MIT results. The date on which the casing pressure test is completed sets the due date for the next MIT of the well. FDEP requires that a MIT plan for the injection well system that includes the testing procedures be submitted no later than six (6) months prior to the MIT due date. The testing typically takes place approximately two (2) months prior to the MIT due date to allow time for equipment failures that could delay completion of testing, which in turn could lead to FDEP fines for overdue testing. There are no FDEP processing fees associated with MIT of an injection well; however, well testing contractor fees have averaged approximately $30,000 per injection well over the last several years and the estimated consulting fee associated with MIT of the injection well system is approximately $125,000. The cost of mechanical cleaning is approximately $25,000 per injection well. Additional costs will be associated with the time required by City staff to manage and track the project. The 2015 effort required $17,280 in City engineering administration fees over a three (3) month design period and a three (3) month testing period. It should be noted that well testing contractor fees have been highly variable over the last five (5) to ten (10) years, ranging from a low of approximately $20,000 per well to as high as $60,000 per well. **Table WW11-3** below lists the most recent pressure testing dates for the injection wells, the date by which subsequent MIT plans must be submitted to the FDEP, and the estimated date

when the subsequent casing pressure tests must be completed through 2035.

Table WW11-3. MIT Due Dates

Action	IW-1	IW-2	IW-3	IW-4	IW-5	IW-6*
Most Recent Pressure Test	September 10, 2014	August 27, 2014	August 15, 2014	October 29, 2014	September 19, 2014	Not Applicable
MIT Plan Due Date	February 15, 2019	February 15, 2019	February 15, 2019	February 15, 2019	February 15, 2019	Not Applicable
Pressure Test Due Date	September 9, 2019	August 26, 2019	August 14, 2019	October 28, 2019	September 18, 2019	Not Applicable
MIT Plan Due Date	February 14, 2024	February 14, 2024	February 14, 2024	February 14, 2024	February 14, 2024	Not Applicable
Pressure Test Due Date	September 8, 2024	August 25, 2024	August 13, 2024	October 27, 2024	September 17, 2024	January 1, 2023
MIT Plan Due Date	February 12, 2029	February 12, 2029	February 12, 2029	February 12, 2029	February 12, 2029	June 30, 2027
Pressure Test Due Date	September 7, 2029	August 24, 2029	August 12, 2029	October 26, 2029	September 16, 2029	December 31, 2027
MIT Plan Due Date	February 11, 2034	February 11, 2034	February 11, 2034	February 11, 2034	February 11, 2034	June 30, 2032
Pressure Test Due Date	September 6, 2034	August 23, 2034	August 11, 2034	October 25, 2034	September 15, 2034	December 30, 2032

*Assuming a sixth injection well is constructed and its first pressure test is completed on January 1, 2023.

- **Chapter 62-600, Domestic Wastewater Facilities, F.A.C.**
  - Wastewater permit was issued by the FDEP in September of 2011. Revisions to Chapter 62-600, F.A.C. were made since the last Domestic Wastewater Permit renewal:
    - In October 2013, Rule 62.600.520 was introduced discontinuing discharge to ocean outfalls. The City does not utilize ocean outfalls, therefore, this revision has no impact on the City.
    - Recent revisions to Chapter 62-600 F.A.C. did not contain relevant changes to treatment requirements and do not significantly impact the GTL's operations.
- **Chapter 62-604, Collection Systems and Transmission Facilities, F.A.C.**
  - There have been no recent changes to the Chapter 62-604, F.A.C. which regulates the Collection Systems and Transmission Facilities.
  - Chapter 62-604.500, F.A.C. states that all equipment required for the collection/transmission of domestic wastewater shall be maintained so as to function as intended. Therefore, the City must continue to repair, replace, and upgrade its collection/distribution facilities to ensure they are functioning per the permitted design. I/I flows are a direct indicator that repairs are needed within a collection system. The City's collection/transmission system must undergo significant repairs to reduce I/I flows to remain in compliance with Chapter 62-604.500.

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- **Chapter 62-620, Wastewater Facility and Activities Permitting, F.A.C.**
    - In June of 2015, Rule 62-620, F.A.C. under section 316(b) of the Clean Water Act was revised. The revision was intended to implement the requirements for cooling water intake structures that withdraw cooling water from waters of the United States to utilize the best technology available (BTA) for minimizing adverse environmental impacts. The City does not have a cooling water intake system that withdraws from waters of the United States, therefore this revision did not have an impact the City.
    - Chapter 62-620 F.A.C establishes the procedures to obtain a permit to construct, operate, or modify domestic and industrial wastewater facilities. The City should continue to update and report as required to meet requirements for monitoring and reporting for issued permits.
- **Chapter 62-640, Biosolids, F.A.C.**
    - The City produces unclassified biosolids year round from the secondary treatment process at GTL and contract with a private company that hauls, processes and reuses/disposes the biosolids offsite. The contractor is responsible for classification and proper reuse/disposal. Currently, the City is in compliance with both the Federal Part 503 Rule and the State Chapter 62-640, F.A.C.
    - On August 29, 2010 amendments to the Chapter 62-640 State Rule took effect. The amendments affected the common practices used in land applying Class B biosolids by introducing additional requirements for permitting, monitoring, reporting, and site restrictions.
    - The amendment also prohibited the use of Class A and Class B biosolids for land application in Lake Okeechobee, Caloosahatchee River, and St. Lucie River watersheds as defined in Section 373.4595(2).
    - The City has various options for disposing of the biosolids produced at GTL through the Sludge Disposal Agreement with Biosolids Distribution Services, LLC. Currently biosolids can be disposed of at a Residuals Management Facility (RMF) which generates a Class AA material for use in land application or disposed of at a waste to energy biofuel production facility.
    - The City has the option of landfilling the GTL biosolids in the event the primary disposal option is interrupted.
    - While the 2010 Chapter 62-640, F.A.C. amendments have minimal impact on the City’s current biosolids disposal option, the amendments, as well as several Counties’ independent restrictions, have significantly reduced the amount of land available for application of Class A and Class B biosolids.
    - There have been no changes in State or local regulations on Class AA biosolids, therefore, the City’s agreement with RMF to produce Class AA material can continue without impact. Nevertheless, the City does have a mechanism in place to utilize the landfill if the RMF were to stop accepting the City’s biosolids.

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- **Chapter 27, Pollution Control, Broward County Code of Ordinance**
    - The City's current license to operate a wastewater treatment facility in Broward County, FL was issued for the GTL on July 1st, 2015. This license is issued under the provisions of Chapter 27 of the Broward County Code of Ordinances which includes standards and regulations for the construction, modification and operation of domestic wastewater facilities. In accordance with Chapter 27, licenses shall be renewed sixty (60) days prior to expiration. The City's license expires June 30th, 2016 therefore renewal should occur prior to May 1st, 2016. The license renewal fee is $2,500.
    - There have been no significant changes to the provisions of Chapter 27 in over 13 years, therefore the general and special conditions of the City for a License to operate a Wastewater Treatment Facility is not expected to change in the upcoming license period, nor in the near future.
- **Chapter 34, Water and Sewer, Broward County Code of Ordinance**
    - Chapter 34 includes the sanitary sewer and septic tank ordinance which sets the connection requirements for the sanitary sewer collection and transmission system. This Chapter also sets forth uniform wastewater discharge requirements for users of the Wastewater Facility of Broward County which enables the county to comply with applicable federal and state laws as required by the Clean Water Act.
    - Similar to the provisions of Chapter 27, there have been no significant changes to the Chapter 34 in over 13 years nor are there any proposed revisions. Consequently there are no anticipated impacts to the City's current operations.

11.2 Proposed Wastewater Regulations

Proposed wastewater regulations relevant to the City include two impending amendments to the FDEP wastewater regulations as well as an EPA rule that will likely stay in a proposed state for the foreseeable future. The proposed wastewater regulations that could impact the City's wastewater treatment and collection system are provided below:

- Chapter 62-600, F.A.C. amendments to update, clarify, and eliminate redundancy in requirements applicable to domestic wastewater facilities,
- Chapter 62-624, F.A.C. revisions regarding Municipal Separate Storm Sewer Systems (MS4), and
- EPA's proposed Sanitary Sewer Overflow Rule.

The FDEP in September 2015 provided notice proposing to amend Chapter 62-600, F.A.C., to update, clarify, and eliminate redundancy in requirements applicable to domestic wastewater facilities. The proposed rules will simplify and clarify requirements, correct rule references, and will be consistent with recently adopted rules and statutory requirements. The proposed amendment will also repeal requirements that are obsolete, duplicative of other rules or statutory requirements, or have been superseded by other rules or statutory requirements. Some requirements from Chapter 62-601, F.A.C., Domestic Wastewater Treatment Plant Monitoring, will be incorporated into Chapter 62-600, F.A.C. Furthermore Chapter 62-601, F.A.C., is proposed for repeal simultaneously with the adoption of the proposed amendments to Chapter 62-600, F.A.C. The proposed amendments are not anticipated to affect the GTL that currently has Class I reliability.

FDEP published a Notice of Rule Development in April 2013 to revise Chapter 62-624, F.A.C., Municipal Separate Storm Sewer Systems (MS4). The City's wastewater plant currently does not operate under a MS4 permit, but may pursue one in the near future for restoring the wastewater plant stormwater system connection to a surface water outfall. The proposed April 2013 revisions will update the Multi-Sector Generic Permit for industrial stormwater to be consistent with EPA's 2008 general permit requirements, which are primarily associated with an Annual Report requirement and certain requirements for facilities that discharge to impaired water bodies with adopted total maximum daily loads (TMDLs). The proposed rule revisions could increase permitting and monitoring requirements should the City proceed with the stormwater outfall plan for the GTL.

The EPA's proposed Sanitary Sewer Overflow Rule was proposed to enforce the 1972 Clean Water Act and eliminate wastewater overflows into the environment. The rule has remained in a proposed state for over 10 years and is considered a guideline for utilities to follow unless excessive overflows dictate administrative orders. The rule is summarized as follows:

- EPA Sanitary Sewer Overflow Rule
    - Insufficient system capacity is the cause of sanitary sewer overflows (SSOs). To combat the increasing incidence of SSOs in the U.S., the U.S. EPA has proposed an SSO rule focused on the capacity, management, operation, and maintenance (CMOM) of sanitary sewer collection systems. To comply with the EPA's proposed SSO rule, which requires the elimination of all overflow events, the development of a CMOM program will be required to address pipe blockages, inflow and infiltration, pipe breaks, and power failures that typically cause SSOs.
    - The Clean Water Act (CWA) of 1972 prohibits spills to waters of the United States. The proposed SSO rule enforces the same, but requires additional reporting of spills no matter where they occur, including sewer backups into buildings.
        - Reporting requirements include notification of significant spills (> 1000 gallons) to waterways of the U.S. within 24 hours, monthly reporting of all spills to waters of the U.S., and annual reporting of all spills and building backups. After adoption of the proposed SSO rule, National Pollutant Discharge Elimination System (NPDES) permit holders and owners of satellite sewer collection systems will be required to implement CMOM programs that:
            - Properly manage, operate, and maintain the sewer collection system.

- Provide adequate collection system capacity.
- Respond promptly and effectively to stop or mitigate SSO events.
- Notify affected parties of an SSO event.
- Make available the CMOM Program Plan and ongoing audits to the general public.

- CMOM Program Requirements will satisfy the regulatory requirements of the proposed SSO rule, and wastewater handling facilities are required to develop a CMOM program that includes:

    - A CMOM Program Summary. Identifies program goals, staff responsibilities and legal authority, collection system documentation, engineering standards, maintenance activities, tracking procedures for reviewing program implementation and effectiveness, and notification requirements.
    - A System Evaluation and Capacity Assurance Plan (SECAP). Outlines required engineering activities and includes a capital improvement program (CIP) that will bring the sewer collection system into compliance.
    - An Overflow Response Plan. Establishes operating procedures for detecting an overflow event, responding, and communicating during the event.
    - Ongoing CMOM Program Audits. Evaluate program implementation and effectiveness, and correct deficiencies in the CMOM program. Audits are required to be made available to the public.

11.3 Conclusion and Recommendations

The CUS Master Plan Team drew the following conclusions from the evaluation:

- It is not anticipated that future wastewater regulatory changes will impact the City's wastewater treatment system significantly.

- To minimize its significant inflow and infiltration (I/I), the City underwent extensive capacity and maintenance rehabilitation to its pump station and force main system as part of a 10 year program (Waterworks 2011) and maintains its wastewater collection system on a regular basis. Although these efforts comprise much of EPA's SSO guidance, including CMOM, the City has a significant amount of work left to reduce I/I to a feasible level.

- The EPA's SSO guidance, including CMOM, recommend that utilities perform maintenance including:

    - Pump Station Preventive Maintenance
        - Electrical Maintenance
        - Mechanical Maintenance
        - Physical Maintenance

    - Force Main Preventive Maintenance
        - Air Release Valves
        - Valve Exercise Program

- Gravity Line Preventive Maintenance
  - Routine Hydraulic Cleaning
  - Routine Mechanical Cleaning
  - Root Control Program
  - Manhole Preventive Maintenance
- Maintenance of Way
  - Maintenance of Rights-of-Way and Easements
  - Monitoring of Street Paving
  - Line Location for Third Parties
- Un-Scheduled Maintenance
  - Response to Complaints

The CUS Master Plan Team provides the following recommendations for wastewater regulatory compliance:

- Increase historical funding to reduce I/I in the wastewater collection system to approximately $6 million per year over the next 20 year CIP period to rehabilitate the collection system. (as scheduled in Section WW4)
- Derive and implement requirements for consecutive water systems to reduce their wastewater return flows.
- Adequately staff, equip and fund wastewater collection maintenance as recommended by the EPA including gravity pipe cleaning and root control and pump station, force main and air release valve maintenance.
- Pass ordinances to address inadequate sewer service laterals including inspection and repair upon property transactions.
- Budget for, and add manpower and equipment to perform service lateral inspections and lining in-house.
- Budget the permitting fees related to the injection well (IW) system for renewal and MIT cleanings (projects budgeted in **Section WW8**).
- Annually monitor notice of amendments by FDEP related to wastewater and the following primary wastewater regulations:
  - Chapter 62-528, Underground Injection Control, F.A.C.
  - Chapter 62-600, Domestic Wastewater Facilities, F.A.C.
  - Chapter 62-604, Collection Systems and Transmission Facilities, F.A.C.
  - Chapter 62-620, Water Facility Permitting, F.A.C.
  - Chapter 62-640, Domestic Wastewater Residuals, F.A.C.

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WW12 Wastewater Funding

The City of Fort Lauderdale (City) has expanding communities that require its wastewater system to expand while remaining functional and ensuring the protection of public and environmental health, in addition to enabling communities to grow and attract business. The City's proposed Fiscal Year (FY) 2016 – FY 2020 Community Investment Plan (CIP) includes various projects related to the expansion, rehabilitation and upgrade of its wastewater facilities and collection system. For the purpose of this evaluation, wastewater funding shall include both the Sewer Master Plan fund as well as Central Regional/Wastewater Fund.

Internal and external funding sources are essential to the successful execution of the CIP projects that require funding and financing. Currently, rates and impact fees for services internally generate the main revenue source fueling the wastewater fund. The Large Users Agreement plays an important role in budgeting wastewater improvement projects within the City's central region. The agreement requires a calculated amount of funds that transfer from the overall wastewater fund to a replacement and improvement reserve account specifically for planned wastewater projects. Funds also transfer from the operating fund for the execution of planned sewer master plan projects.

12.1 Estimated Funding Needs

The Wastewater Fund (Fund 451) and Water/Sewer Master Plan Fund (Fund 454) are the two main accounts the City uses to fund wastewater projects. The rates and fees the City charges for water/wastewater services replenish the Fund 451 and Fund 454 account. **Table WW12-1** presents the possible funding sources available to the City for CIP projects.

12.1.1 Central Regional Wastewater System Fund (451)

In 1978, under the Broward County Wastewater Facility Plan, the City was chosen to lead the Central Regional Wastewater System Fund, which provides treatment services to the "Central Region". The Central Region includes Fort Lauderdale, Oakland Park, Wilton Manors, Port Everglades, portions of the City of Tamarac and the Town of Davie. Fund 451 is used to support and/or improve the operations of the Central Regional Wastewater System, which include facilities such as the George T. Lohmeyer Wastewater Treatment Plant and various re-pump stations throughout the area.

12.1.2 Water and Sewer Master Plan Fund (454)

The Water and Sewer Master Plan Funds are established from residual funds transferred from the Water and Sewer operating fund. Fund 454 is used to fund improvements to the City's water and sewer system. The City utilizes projected rate increases that will augment the available revenue of Fund 454 by approximately 5% each year to help with inflation and allow the City to replenish the money within the fund.

12.1.3 Community Investment Plan Funding Needs

The anticipated revenues, along with the projected rate increases, will not allow the City to complete the 2016 to 2024 unfunded CIP projects. According to the City's existing 2016-2020 CIP, there are over forty (40) wastewater projects that currently do not have adequate funding. These unfunded projects have an estimated project cost of $42 million dollars. In addition, the CUS Master Plan Team has proposed new wastewater projects to be completed within the next five years, which will cost approximately $94 million dollars. Consequently, prioritization of projects should be a continuous process to ensure that the projects with the highest priority

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receive funding when available. **Section WW9** presents the wastewater CIP Projects for 2016-2020.

12.2 Funding Methods

There are several regional, federal and state funding programs, which vary by program goals, eligibility requirements, system type (water, wastewater, stormwater, etc.), funding amount, project location, and application process. Unfortunately, not many of these programs are viable for the City's wastewater CIP projects unless they can be linked to other programs through total water management approaches such as implementation or expanded use of reclaimed water as a source of irrigation water in lieu of potable water or as a direct or indirect source of potable supply. The three main areas of external funding investigated were loans, bonds and grants. The South Florida Water Management District (SFWMD) identified potential sources of funding for the district in its 2015 South Florida Environmental Report. The funding sources that will be discussed herein are not a complete list of all available funding, but represent the funding that would potentially suit the CIP projects based on the CUS Master Plan Team's research. The City could pursue the following programs, which provide wastewater project funding when funds are available:

- Clean Water State Revolving Fund Loan Program (CWSRF)
- Cooperative Funding Program
- Florida Renewable Energy Technologies Grants
- Guaranteed Energy Performance Savings Contracting Act
- US Department of Energy Funding Programs
- American Recovery and Reinvestment Act of 2009
- Revenue Bonds
- Federal Funding

12.2.1 Clean Water State Revolving Loan Fund

Section 403.1835, F.S. authorized Florida's water pollution control revolving loan program. This statute establishes the Wastewater Treatment and Stormwater Management Revolving Loan Trust Fund, which meets federal requirements for a State Revolving Fund (SRF). The statute authorizes the department to fund the planning, design, construction, and implementation of wastewater management systems and stormwater management systems. The act also authorizes financial assistance for a wide range of services, equipment, and construction associated with nonpoint source pollution control. The advantage of the SRF loan is that it has flexible terms with low interest rates that are well below market rates. The SRF program can be combined with other funding sources to assist in providing the best financing for an individual project. The first step in obtaining a pre-construction or construction loan is to submit a Request for Inclusion application to the Florida Department of Environmental Protection FDEP to establish a project ranking on the priority list as outlined in Rule 62-503.600 F.A.C. and to determine the financing rate on the loan. FDEP's program meetings review requests on a quarterly basis. The next application deadline for project inclusion will be on November 15th, 2015. The subsequent deadline will occur on February 15th, 2016.

Steps involved in obtaining a pre-construction or construction loan include:

1. Request for inclusion – The project sponsor submits an application to the Florida Department of Environmental Protection FDEP to establish a project ranking on the priority list as outlined in Rule 62-503.600 F.A.C. and to determine the financing rate on the loan.

Section WW12 accepted December 19, 2016.

2. Documentation for priority listing. – The sponsor shall meet the priority list hearing for the upcoming fiscal year. Documentation shall be submitted 30 days prior to that hearing. See Rule 62-503.700 for documentation required.

3. List project on the priority list – Determination shall be made when documentation is reviewed and the Department recommends the project.

4. Loan application with supporting planning documents – A loan application shall be completed on Form 62-503.900(3) and shall be submitted to the Department with the project being listed on the project priority-funding list.

5. Loan agreement – After the completed loan application is submitted, and the sponsor has provided reasonable assurance that it has the financial capability to complete the project and repay the loan; the project sponsor shall enter into a negotiated written agreement as drafted by the Department.

6. Disbursements – Shall be for allowable costs and shall be made under the terms of the loan agreement.

12.2.2 Cooperative Funding Program

The Cooperative Funding Program (CFP) is designed to assist local governments, water providers and water users within the South Florida Water Management District to construct and or implement stormwater projects, alternative water supply projects and water conservation projects. The CFP is a cost-sharing program that requires local governments to match funds typically up to 75% of the project cost. The district governing board each fiscal year decides the cost share based on available funds and the proposed project priority. Applicants applying for cooperative funding must demonstrate that the project is in support of the District's Strategic Plan and Regional Water Supply Plans. The application deadline for the 2016 fiscal year has passed and SFWMD staff is uncertain if the program will continue in the 2017 fiscal year based on recent and proposed legislation. The CFP status will need monitoring for updates. In Fiscal Year 2015, Amendment 1, also known as the Florida Land and Water Conservation Amendment, was passed by voter referendum as a potential funding mechanism. The legislative details for administering and distributing the funds is still a work in progress. Amendment 1 will provide approximately 10 billion dollars in funding for eligible projects over the next twenty years. The framework to access the Amendment 1 funds may require the use of existing programs like the CFP. Though the original purpose of Amendment 1 was to make land purchases for conservation, the current language of the amendment should allow for water conservation funding, as well as provide for utilities infrastructure funding in the near future.

12.2.3 Florida Renewable Energy Technologies Grants

The Florida Renewable Energy Technologies & Energy Efficiency Act (Senate Bill 888) originally established the Renewable Energy Technologies Grants Program in 2006. The program provides renewable energy matching grants for demonstration, commercialization, research and development projects involving emerging and proven renewable energy technologies. The grant program was designed to stimulate capital investment in the state and enhance the utilization of renewable energy technologies within Florida. The 2008 Florida Legislature expanded the program to include energy efficient technologies as well as renewable energy resources, including hydrogen, biomass (which includes municipal solid waste), solar energy, geothermal energy, wind energy, ocean energy, waste heat and hydroelectric power. To date, the state has issued 27 grants for over $42 million; however, this program has not received funding by the legislature for the past 2 years, due to the economy and the lack of funds available in the state. The proposed renewable resources for Florida include biomass, and the definition of biomass includes a power source that is comprised of combustible residue or gases from forest products manufacturing waste or co-products from agricultural and orchard crops, waste or co-products from livestock and poultry operations, waste or byproducts from food processing, urban wood waste, municipal solid waste, Municipal liquid waste treatment operations and landfill gas. A renewable fuel for production of electric power could be produced from wastewater treatment plant processes, through the combustion of dried biosolids or biogas byproducts of the anaerobic digestion process. Waste heat formed from converting fuel to electricity, can also be used to heat digesters or to help dry biosolids in wastewater facilities. The Florida Department of Environmental Protection (FDEP) has administered this program since its inception; however, the 2011 Florida Legislature decided that in the future, renewable energy funding opportunities would be administered by the Department of Agriculture and Consumer Services (DOACS) as authorized by Senate Bill 2106. SB 2106 transfers the duties of the Florida Energy and Climate Commission, with respect to planning and developing the state's energy policy, and its duties under the Florida Energy and Climate Protection Act, to the DOACS.

12.2.4 Guaranteed Energy, Water, and Wastewater Performance Savings Contracting Act

The Guaranteed Energy, Water, and Wastewater Performance Savings Contracting Act was authorized in Florida by Section 489.145 F.S. Under this program, water and wastewater facilities gain access to funds for projects that promote energy efficiency and energy conservation. A key benefit of the Guaranteed Energy Savings Contract is that utilities can execute energy saving projects when other forms of capital cost funding or grants are not readily available for use by state or municipal water and wastewater facilities. The Department of Management Services administers the contracts by utilizing ten prequalified contractors referred to as energy service companies (ESCO). Through coordination with the facility owner, the selected ESCO conducts an investment grade audit to identify the energy saving improvements, designs and constructs the project and arranges the financing. The energy cost savings generated from the improvements funds the project debt service over the contract period. The owner continues to pay current energy costs already funded by existing rates so no new debt or rate increases are required. It should be noted that FPL is currently listed as one of Florida's ESCOs.

12.2.5 US Department of Energy Funding Programs

The US Department of Energy (DOE) has been aggressively promoting emerging renewable energy programs in the past several years. In 2014, twenty-two (22) projects received loan guarantees valued at approximately $600 million. The bulk of the DOE's current funding goals for the projects this year are related to municipal solid wastes, agricultural residues, and biomass feedstocks specifically grown for energy. The primary focus of these loan guarantees was to reduce investor risk associated with first time commercial scale renewable energy projects.

12.2.6 Revenue Bonds

Revenue bonds are bonds that are secured by a pledge of future rate revenues of the utility. The City's Water Works 2011 program was primarily funded by using bonds. Currently, the City has debt payments totaling approximately $30 million dollars annually. Refinancing to a lower interest rate and/or paying off the debt ahead of schedule will benefit the City by putting capital dollars into City infrastructure instead of banks' revenue. Further debt is not recommended, but if the City wishes to issue revenue bonds to finance additional Community Investment Program

(CIP) projects, a series of reports to support the bonding process are required. Several of these will include:

- Rate sufficiency tests to support payback of bond funds
- Historical operating results of the utility system
- Revenue forecasts and development of a detailed rate revenue model
- Capital expenditure funding analysis which will include identification of all sources of funds and all capital needs
- Rate comparisons of existing rates and illustration of overall competitiveness with local governments and private utilities
- Disclosure certificate associated with bond issuance that attests to reasonableness of projections in bond feasibility report

12.2.7 Other Federal Funding Sources

Congress has the ability to appropriate federal funds directly to projects of national significance. Reliance on direct federal funding can be risky and is not recommended. Obtaining direct federal funding typically requires congressional lobbying and knowledge of the channels to access those funding opportunities to compete for limited financial resources. Federal agencies also coordinate with state agencies to provide grant funding to local governments to help the federal agency achieve their objectives. Potential grant funding sources include the Environmental Protection Agency (e.g. STAG, WRDA, and Brownfields), Department of Housing and Urban Development, Department of Transportation, U.S. Army Corps of Engineers, FEMA, and Department of Agriculture. Available funding for these agencies has drastically reduced over recent years and will need monitoring for future updates.

Table WW12-1. Wastewater Funding Summary

Fund	Capital Projects	Eligibility	Action Items	Deadline
Clean Water State Revolving Fund Loan (Base rate: 0.7%, 20-year term, 3 month application cycles)	• Wastewater • Stormwater	• Construct municipal wastewater facilities • Energy efficiency • Build decentralized wastewater treatment systems • Create green infrastructure projects	• Review and compare SRF terms vs. revenue bonds • Identify projects and apply if applicable	• 11/2015 • 2/2016
SFWMD Cooperative Funding	• Stormwater • Potable water	• Areas discharging to an impaired water body • Areas with total maximum daily load allocations • Areas identified in a Best Management Action Plan • Areas identified within a Surface Water Improvement and Management Plan.	• Identify applicable cooperative stormwater projects	• Ongoing based on funding projects becoming available
US Department of Energy and Renewable Energy Technologies Grant	• Wastewater renewable and energy efficiency projects	• Development projects relating to renewable energy technologies.	• Identify applicable projects that demonstrate renewable energy (VPSA Oxygen Plant and Anaerobic Digesters)	• Application must be received 15 business days prior to the application deadline for the prime funder. Ongoing based on funding projects becoming available
Revenue Bonds	• Unfunded projects for revenue generating utilities	• Revenue bonds may be issued to construct or expand upon various revenue-generating utilities, including -Water and Sewer System Projects -Wastewater Plant Projects	• Review CIP deliverable and required projects versus revenue funding to identify bond amount	• Ongoing based on funding projects becoming available

12.3 Conclusions and Recommendations

As depicted in **Table WW12-2**, the anticipated revenues with the projected rate increase would be sufficient to complete the 2016 to 2024 unfunded CIP projects, however, significant portions of the revenue are dedicated to debt service and other City capital and operating funds. Internal and external funding sources are essential to the successful execution of the CIP projects. Regional, federal and state funding programs may provide an alternate funding source for the unfunded projects.

- The Wastewater Fund (Fund 451) and Water/Sewer Master Plan Fund (Fund 454) are the two main accounts the City uses to fund wastewater projects.
- According to the City's proposed CIP for fiscal years 2016-2020, it is estimated there are numerous unfunded wastewater and utility wide projects totaling over 52 million dollars of deficit based on projected water/wastewater revenues.
- The City should prioritize projects to ensure projects with the highest priority receive funding as it becomes available. For example, forestall neighborhood gravity pipe lining projects (including 42 million dollars unfunded) for higher priority projects including force main replacements associated with pipe failures identified in the CUSMP Additional Projects.
- The City should identify projects by eligibility requirements, program goals, and system type to link funding sources available to projects (i.e. wastewater, energy efficiency, alternative source, reuse, etc.). Each project could meet more than one eligibility requirement.
- The City should review on an annual basis program funding goals to determine project eligibility for alternative funding sources from regional, federal and state funding programs.
- The City should closely monitor legislative actions related to state administration of Amendment 1 funds and be prepared to respond to program submission requirements for those projects that are likely to receive the highest priority for those funds.
- The City should apply for grant eligible projects.
- The City should consider refinancing their current debt payments of $30 million dollars annually to a lower interest rate or paying the debt off ahead of schedule.

Section WW12 accepted December 19, 2016.

Table WW12-2. Wastewater CIP Summary[1,2,3]

Category		Unspent 2016	2017	2018	2019	2020	2021	FY 2017-2021	FY 2022-2026	FY 2027-2031	FY 2032-2036
City Projected Sewer Rate Revenue[1]		--	$50,500,000	$53,053,224	$55,735,694	$58,554,524	$61,516,081	$279,359,523	$357,541,976	Not Projected	Not Projected
Central Regional WW Fund (451)											
WW Regional	Planned CIP	$19,451,269	$4,328,167	$6,957,980	$7,722,590	$7,898,176	$7,467,412	$53,825,594	$0	$0	$0
	Unfunded CIP	--	--	--	--	--	$18,535,200	$18,535,200	--	--	--
	CUSMP Additional	$0	$0	$3,862,912	$17,223,352	$30,289,321	$3,679,300	$55,054,885	$54,214,400	$76,116,000	$28,258,200
Utility Wide Regional	Planned CIP	$2,154,899	$3,517,370	$915,000	$0	$0	$203,535	$6,790,804	$0	$0	$0
	Unfunded CIP	$0	$0	$0	$0	$0	$1,961,421	$1,961,421	$0	$0	$0
	CUSMP Additional	0	$0	$3,660,321	$3,575,042	$5,292,043	$8,119,553	$20,646,959	$10,888,072	$5,988,073	$2,682,510
Subtotal Planned CIP:		$21,606,168	$7,845,537	$7,872,980	$7,722,590	$7,898,176	$7,670,947	*$60,616,398*	*$0*	*$0*	*$0*
Subtotal Unfunded CIP:		--	--	--	--	--	$20,496,621	*$20,496,621*	--	--	--
Subtotal CUSMP Additional:			$0	$7,523,233	$20,798,394	$35,581,364	$11,798,853	*$75,701,844*	*$65,102,472*	*$82,104,073*	*$30,940,710*
Fund 451 WW/UW TOTAL:		$21,606,168	$7,845,537	$15,396,213	$28,520,984	$43,479,540	$39,966,421	**$156,814,863**	**$65,102,472**	**$82,104,073**	**$30,940,710**
Water and Sewer Master Plan Fund (454)											
WW City Total	Planned CIP	$16,476,807	$5,909,088	$7,847,929	$6,430,739	$5,392,000	$13,491,346	$55,547,909	$0	$0	$0
	Unfunded CIP	--	--	--	--	--	$50,406,104	$50,406,104	$91,935,250	$84,058,000	$131,410,000
	CUSMP Additional	$0	$0	$7,813,000	$7,912,250	$21,517,250	$20,942,750	$58,185,250	$91,935,250	$84,058,000	$131,410,000
Utility Wide City	Planned CIP	$2,500,722	$120,750	$200,000	$100,000	$200,000	$0	$3,121,472	$0	$0	$0
	Unfunded CIP	--	--	--	--	--	$22,997,500	$22,997,500	--	--	--
	CUSMP Additional	$0	$0	$4,076,500	$3,165,300	$7,876,500	$11,120,590	$26,238,890	$18,247,229	$12,207,925	$10,402,925
Subtotal Planned CIP:		$18,977,529	$6,029,838	$8,047,929	$6,530,739	$5,592,000	$13,491,346	*$58,669,381*	*$0*	*$0*	*$0*
Subtotal Unfunded CIP:		--	--	--	--	--	$73,403,604	*$73,403,604*	--	--	--
Subtotal CUSMP Additional:		$0	$0	$11,889,500	$11,077,550	$29,393,750	$32,063,340	*$84,424,140*	*$110,182,479*	*$96,265,925*	*$141,812,925*
Fund 454 WW/UW TOTAL:		$18,977,529	$6,029,838	$19,937,429	$17,608,289	$34,985,750	$118,958,290	***$216,497,125***	***$110,182,479***	***$96,265,925***	***$141,812,925***

Notes:

1. Revenue Source: Sewer Rate Revenue Projections in the Burton & Associates City of Fort Lauderdale - FY 2015 Water/Sewer Fund Analysis
2. Note that significant portions of the Sewer Rate Revenue are dedicated to debt service and other City capital and operating funds and unavailable to Funds 451 and 454.
3. Section WW9 Wastewater CIP includes further CIP project details.

WW13 Climate Change Strategies

13.1 Introduction

Climate change impacts including sea-level rise, intensified tropical weather events and precipitation extremes are exacerbating coastal communities' issues with wastewater collection and treatment systems. Aging wastewater collection infrastructure is already causing service failures, road and other utilities damage, inflow and infiltration and significant capital budgets to repair and replace. Climate change impacts are threatening wastewater infrastructure, portending an increase in the amount of sewage that overwhelms collection systems and treatment facilities, potentially causing destructive overflows (Bovarnick, et al., 2014).

Southeast Florida is considered one of the most vulnerable areas to climate change and sea level rise in the United States due to its expansive shoreline, low elevation, highly permeable aquifers, high groundwater table, and the proximity of dense population centers and economic developments to the coastline (Koch-Rose et al., 2011). Located on the coastline of southeast Florida, the City of Fort Lauderdale (City) shares these vulnerabilities, as well as being subject to meteorological events such as flooding from extreme high tides, prolonged heavy rains, and storm surge events from hurricanes and tropical storms (Edwards et al., 2014). **Table WW13-1** summarizes the elevation analysis of Fort Lauderdale. Because of vulnerabilities associated with a large population residing in low-lying coastal areas, it is imperative for the City's Utility Department to develop adaptation strategies for predicted climate change impacts.

This section highlights climate change issues relevant to the City's wastewater system, including extreme weather events, stormwater management, impending sea level rise, and other related concerns. The comprehensive utility strategic master plan (CUSMP) team identified improvements to equip the City's wastewater system to withstand the inevitable climate change, as well as helping protect the community in the years to come.

13.2 Risks and Impacts

13.2.1 Increasing Temperature

Figure WW13-1 shows the temperature trend of the City of Fort Lauderdale provided by National Climatic Data Center (NCDC) of National Oceanic and Atmospheric Administration (NOAA). The data indicate an overall warming trend over the past 100+ years of approximately 0.25^{o}F per decade.

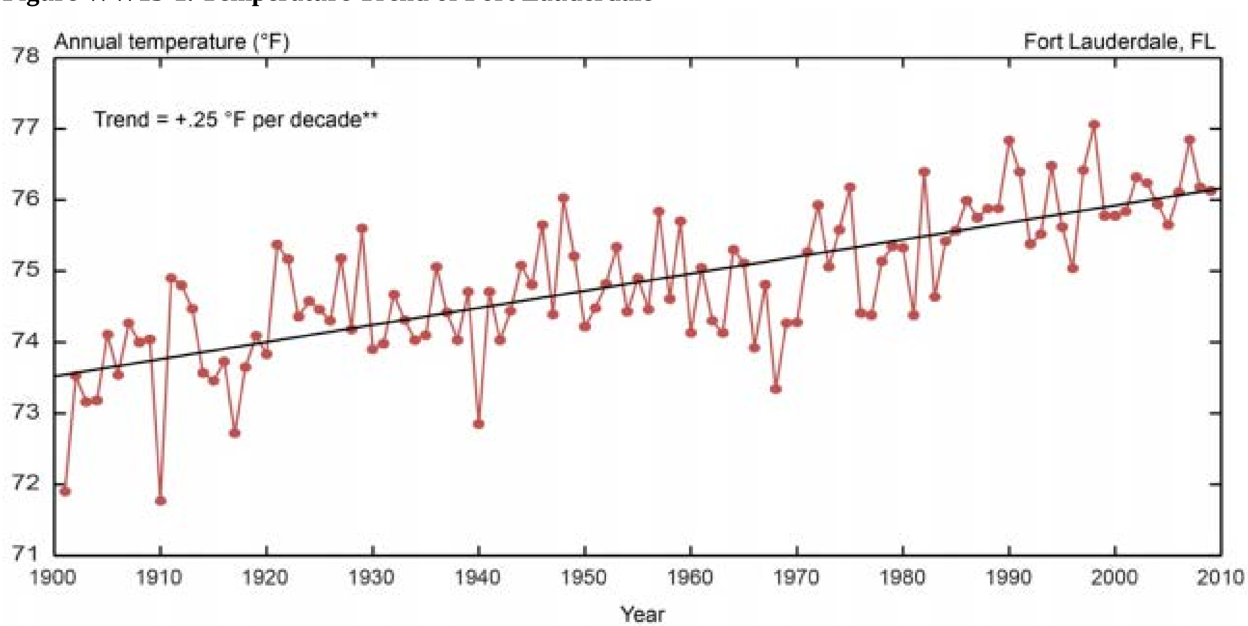
Table WW13-1. Summary of Elevation Analysis (Source: www.climatecentral.org)

Fort Lauderdale	Elevation Above Local Mean High Tide									
	1ft	2ft	3ft	4ft	5ft	6ft	7ft	8ft	9ft	10ft
Population below elevation	11,348	16,137	40,350	72,148	94,445	112,384	128,302	147,676	156,437	159,565
Percent population below elevation	7%	10%	24%	44%	57%	68%	78%	89%	95%	96%

Section WW13 accepted July 16, 2016.

Fort Lauderdale	Elevation Above Local Mean High Tide									
	1ft	2ft	3ft	4ft	5ft	6ft	7ft	8ft	9ft	10ft
Housing units below elevation	8,596	12,589	27,753	44,666	55,731	63,956	71,480	81,019	85,842	88,232
Percent housing units below elevation	9%	14%	30%	48%	60%	69%	77%	87%	92%	95%
Total land below elevation (acres)	1,280	1,831	5,064	8,925	11,376	13,346	15,382	18,766	20,195	20,527
Percent total land below elevation	6%	9%	24%	42%	54%	63%	73%	89%	96%	98%
Acres of land surface below elevation	1,263	1,769	4,867	8,567	10,990	12,952	14,938	18,300	19,695	20,027
Percent of acres of land below elevation	6%	9%	24%	42%	54%	63%	73%	89%	96%	97%

Figure WW13-1. Temperature Trend of Fort Lauderdale



Source: National Climatic Data Center (NCDC) of National Oceanic and Atmospheric Administration (NOAA)

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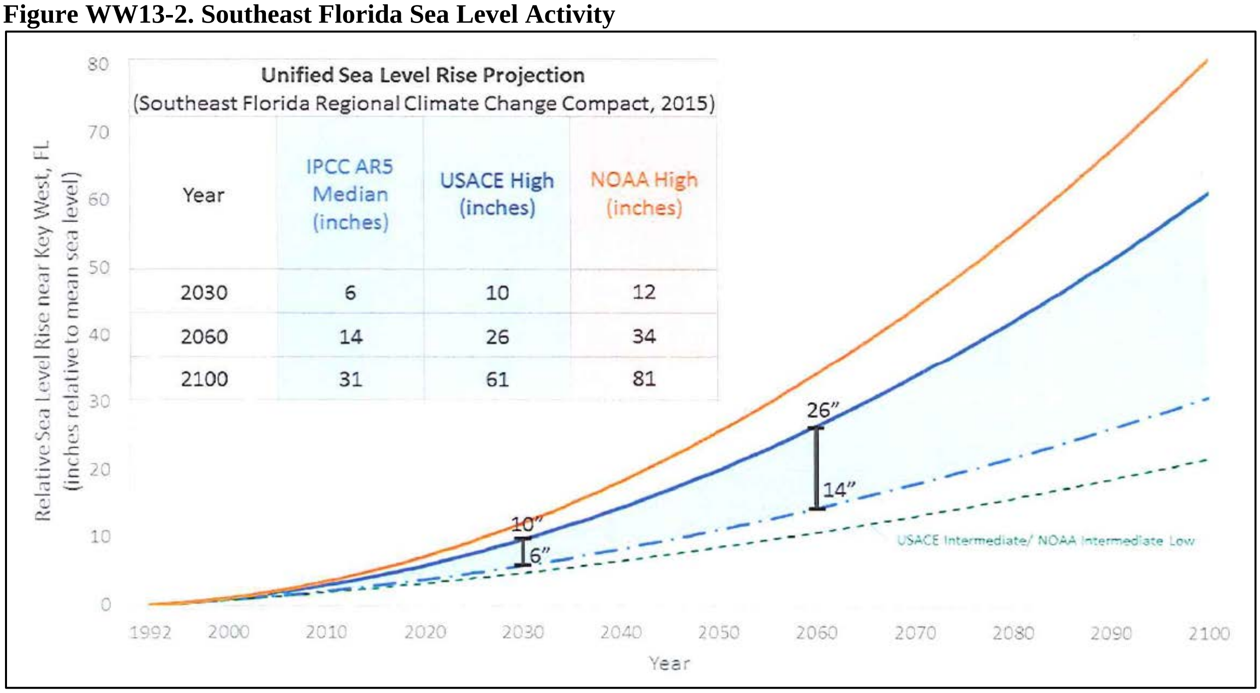
Higher air temperature causes lower oxygen solubility in water, which may lead to slightly higher oxygen demand at wastewater treatment plants. Optimum temperatures for bacterial activity in a biological treatment process are in the range of 77 to 95 ºF. Aerobic digestion and nitrification stop when the temperature rises to 122 ºF. The extrapolated temperature rise over the next 20 years will not adversely affect the City's George T. Lohmeyer Wastewater Treatment Plant (GTL) treatment process. In areas where wastewater treatment plant effluent makes up the majority of flow in streams and rivers, higher temperature effluent from wastewater treatment may have detrimental effects on aquatic life fisheries; however, the GTL discharges to deep injection wells and not to surface water. The effect of higher temperatures on the injection zone has not been studied and is not known.

13.2.2 Sea Level Rise

During the first half of the previous century, the global rate of sea level rise averaged approximately 1.6 mm (0.06 inches) per year. The rate of rise increased to an average of 1.7 mm (0.07 inches) per year during the second half of the last century, followed by a more significant increase to 3.3 mm (0.13 inches) per year measured during the last decade. Local tide data reinforces this trend of rising sea level, which documents an increase in regional sea level of about 9 inches during the last 100 years. While there continues to be uncertainty about the overall extent of sea level rise that might be realized in the coming century, the Third National Climate Assessment (NCA) report presents a probable range of 1 to 4 ft. by 2100.

In southeast Florida, partner counties in the Southeast Florida Regional Climate Change Compact, inclusive of Broward, Palm Beach, Miami-Dade and Monroe Counties, have collectively agreed to use modified guidance developed by the U.S. Army Corps of Engineers and a planning scenario of 9 to 24 inches additional sea level rise by 2060, consistent with projections presented in the 2014 NCA. **Figure WW13-2** shows the observed and predicted sea level activity.

Figure WW13-2. Southeast Florida Sea Level Activity



Year	IPCC AR5 Median (inches)	USACE High (inches)	NOAA High (inches)
2030	6	10	12
2060	14	26	34
2100	31	61	81

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Sea level rise produces varied challenges with respect to wastewater facilities and infrastructure. Impacts include increased infiltration of groundwater due to groundwater level rise and elevated chloride concentrations into wastewater collection systems. These impacts can impair normal operations and maintenance, as well as opportunities for beneficial use of reclaimed water as an alternative water supply. The increased groundwater infiltration can cause higher costs of pumping, treatment, and disposal, as well as wear and tear of the system.

Figure WW13-3 presents the inundation zones under four sea level rise scenarios, involving increases ranging from 1 to 4 ft. Sea level rise estimates presented in **Figure WW13-2** indicate that a 1 ft. rise from the 2015 sea level may occur by about 2032, according to the maximum sea level rise projection. Consequently, for purposes of the time period applicable to the Master Plan, assuming a 1 ft. sea level rise appears appropriate for evaluating potential impacts to wastewater infrastructure. Maximum sea level rise projections, based on the “NOAA High” curve shown in **Figure WW13-2** above, for 2 ft., 3 ft., and 4 ft. sea level rise occur in 2048, 2061, and 2073, respectively, according to estimates presented in **Figure WW13-2**.

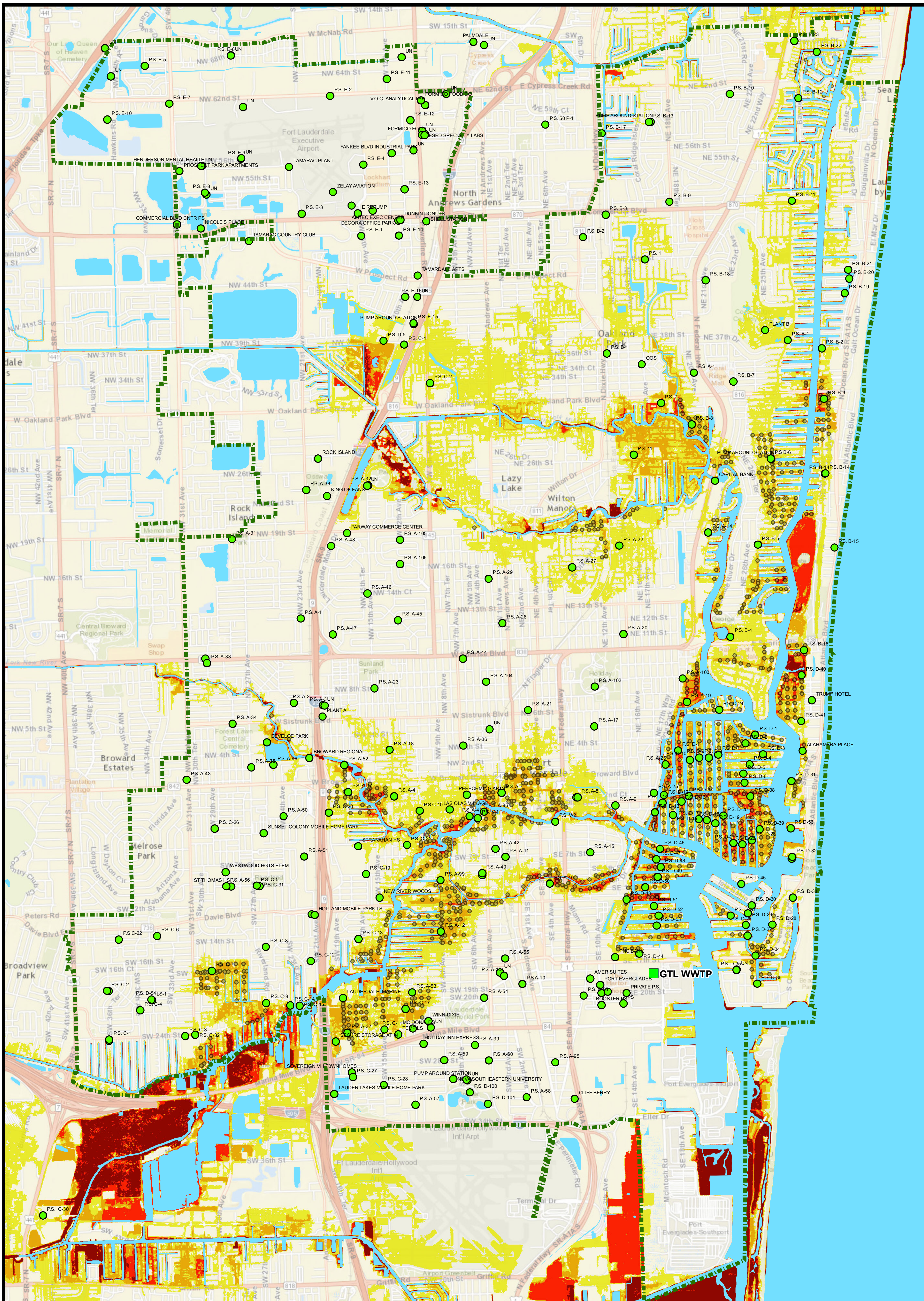
Information presented in **Figure WW13-3** indicates that the GTL plant is not directly affected by a 4 ft. sea level rise, which is not projected to occur until the latter portion of the 21st century. However, with a 4 ft. sea level rise, the impact of a hurricane surge could have the potential to adversely affect the plant. Sea level increases less than the 4 ft. maximum, however, cause elevated groundwater tables resulting in increased infiltration and inflow (I/I). A comprehensive I/I Control Plan is presented in **Section WW4** to address I/I issues. Additionally, higher groundwater tables reduce the capacity to store rainfall and result in more runoff during rainfall events. The City is also undergoing similar stormwater planning initiatives.

The CUS Master Plan Team used geographic information system (GIS) wastewater system component data to analyze the City’s current pump stations and manholes with respect to the predicted sea level rise scenarios to identify high-risk facilities. The findings are presented below in **Table WW13-2**.

Table WW13-2. Inundated Manholes and Pump Stations due to Sea Level Rise

Year	Sea Level Rise Scenario[2]	Number of Facilities in Inundation Zone[1]	
		Pump Stations	Manholes
2030	1ft	1 (D-20)	5[3]
2045	2ft	15	220
2075	3ft	35	931

[1] This table focuses on areas permanently inundated by SLR. Impacts of temporary flooding caused by tides or extreme weather events are discussed in **Section 13.2.4**.
[2] Sea level rise scenarios are based on the USACE High curve shown in Figure WW13-2.
[3]The five manholes are B3-90-5, D1-44-206A, D1-44-206B, D1-44-206C, and D2-35-4 according to “Notes” from the City’s GIS shapefile.



N
W E
S

0 1,500 3,000
Feet

***The green circles representing pump stations in the map are greatly enlarged to be visible. The pump station actual sizes are much smaller and are mostly outside the 1 ft. SLR area (except for D-20) according to GIS.**

Legend

- WW Service Area
- Pump Stations*
- Current Water Body
- Manholes affected by 1-3 feet SLR
- 1 ft. SLR Inundation Area
- 2 ft. SLR Inundation Area
- 3 ft. SLR Inundation Area
- 4 ft. SLR Inundation Area
- GTL

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITIES STRATEGIC MASTER PLAN
SEA LEVEL RISE INUNDATION MAP (1 - 4 FEET)

FIGURE WW13-3

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13.2.3 Saltwater Intrusion

Sea level rise increases the salinity of both surface water and groundwater due to inundation of low lying coastal areas and saltwater intrusion into coastal aquifers. Sea level rise and declining water tables promote significant saltwater intrusion, although excessive groundwater pumping within coastal wellfields may also contribute to intrusion problems. **Figure WW13-4** shows the landward limit of the saltwater interface in the City as provided by South Florida Information Access, United States Geological Survey (SOFIA, USGS).

Salinity is the saltiness or dissolved salt content of a body of water. Total dissolved solids (TDS) is a parameter commonly used to quantify salinity. Typically, the TDS range for untreated domestic wastewater matches the potable water supply. In coastal regions, the TDS of collected wastewater can be elevated due to I/I. The City's finished water (treated drinking water) TDS ranges from 150 - 200 mg/L. According to information provided by City staff, the GTL influent TDS averages approximately 1,100 mg/L, which is higher than that of the City's finished water. The increased wastewater influent salinity supports the conclusion in **Section WW4** (I/I Prioritization Update) that, on average, at least 50% of GTL's influent is I/I.

The higher salinity groundwater enters the collection system as I/I through compromised gravity pipes, service laterals and manholes. The saltwater can cause severe and premature corrosion of equipment at the GTL plant, as well as substantially increasing flow to the plant and using valuable system capacity needed during critical peak flow periods. Saltwater intrusion can also reduce the potential availability and beneficial uses of reclaimed wastewater due to high chloride concentration, which cannot be used for land application without reverse osmosis treatment. Additionally, saltwater intrusion decreases the ability of microorganisms to process nitrogen, which reduces the effectiveness of the wastewater treatment process. The I/I Control Plan, presented in detail in **Section WW4**, identifies strategies and projects to reduce I/I flow and minimize saltwater intrusion into City's collection system. Researchers have reported low biological removal caused by wastewater with TDS between 30,000 – 50,000 mg/L. (Kargi, et al, 1996). However, the City's TDS level is much lower and is not compromising the biological removal ability at this point.

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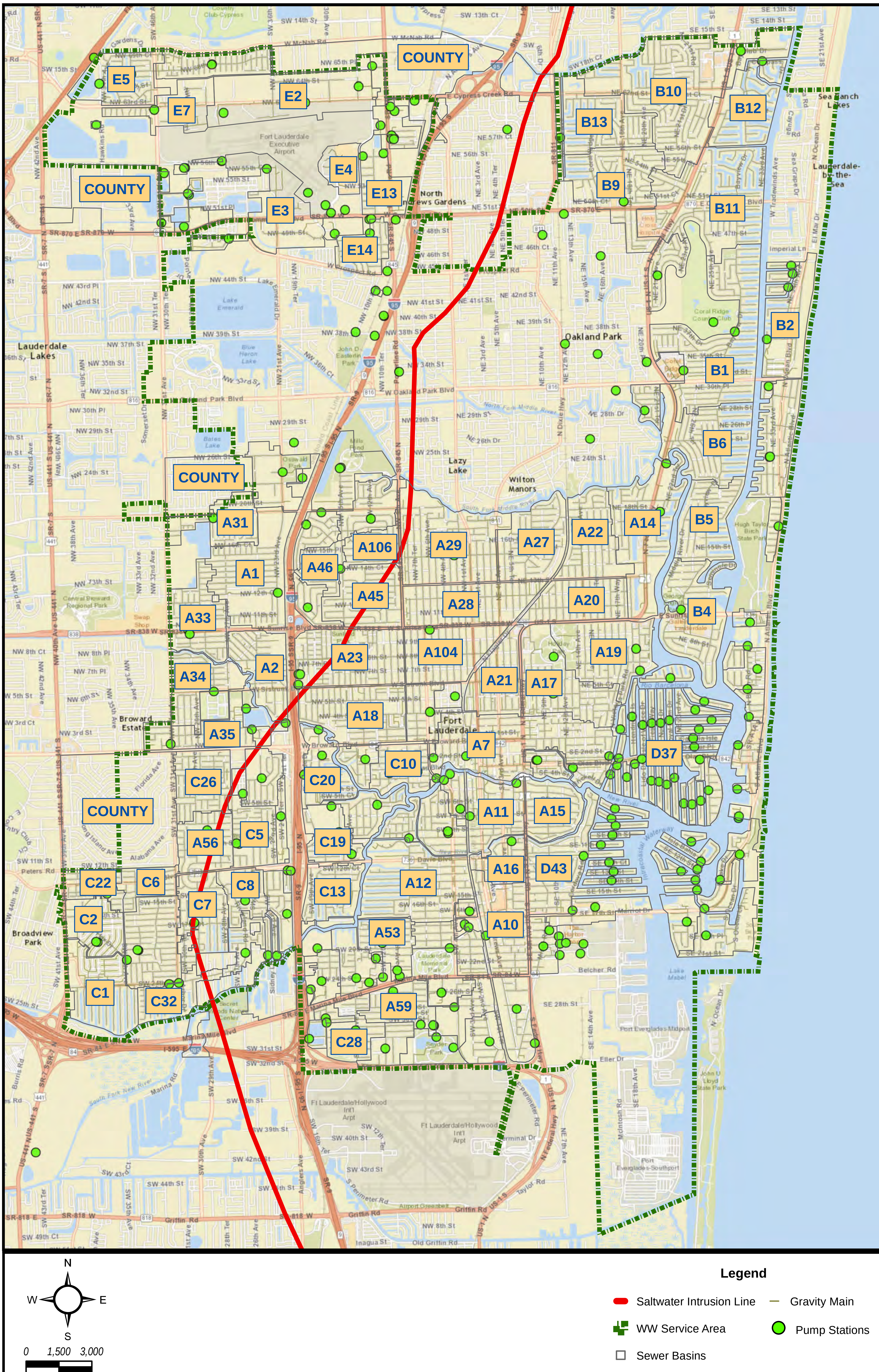

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITIES STRATEGIC MASTER PLAN
SALTWATER INTRUSION LINE

FIGURE WW13-4

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13.2.4 Storm Surge

In Southeast Florida, it is predicted that climate change will influence precipitation patterns and may also cause changes in storm surge activity compared to historical conditions. A storm surge is a coastal flood event consisting of rising water commonly associated with low-pressure weather systems (such as tropical cyclones and strong extratropical cyclones). The severity of surge impacts depends upon the shallowness and orientation of the water body relative to the storm's path, as well as timing of the tidal cycle and tidal water surface fluctuations. Therefore, any change in sea level will alter the total water surface elevation and the inland limit of inundation during storm surge events.

Rising sea level means that future storms will reach higher elevations and produce greater flood damages than past storms of the same magnitude. In an era of rising sea levels, the number and severity of flood events that cross a threshold will increase, leading to more severe damages per storm and possibly more damaging storms in a given time, even if there is no change in storm climatology from the present.

Topography of the land surface is another important element to estimate storm surge extents. Areas where elevation is less than a few feet above sea level are at particular risk from storm surge inundation. **Figure WW13-5** presents the flood hazard zones provided by Federal Emergency Management Agency (FEMA). Orange areas in the map represent high-risk flood areas that are susceptible to a 100-year flood event. Yellow areas in the map represent moderate to low risk flood areas that are susceptible to 500-year flood events and minimal flood risk. The map also includes the City’s high tide risk contours.

In addition, storm surge events can bring destructive winds that can potentially damage the City’s wastewater facilities. Power outage and backup generator failure caused by wind gusts at the critical pump stations could result in loss of service for a large portion of the City’s collection and/or transmission system.

Section WW13 accepted July 16, 2016.

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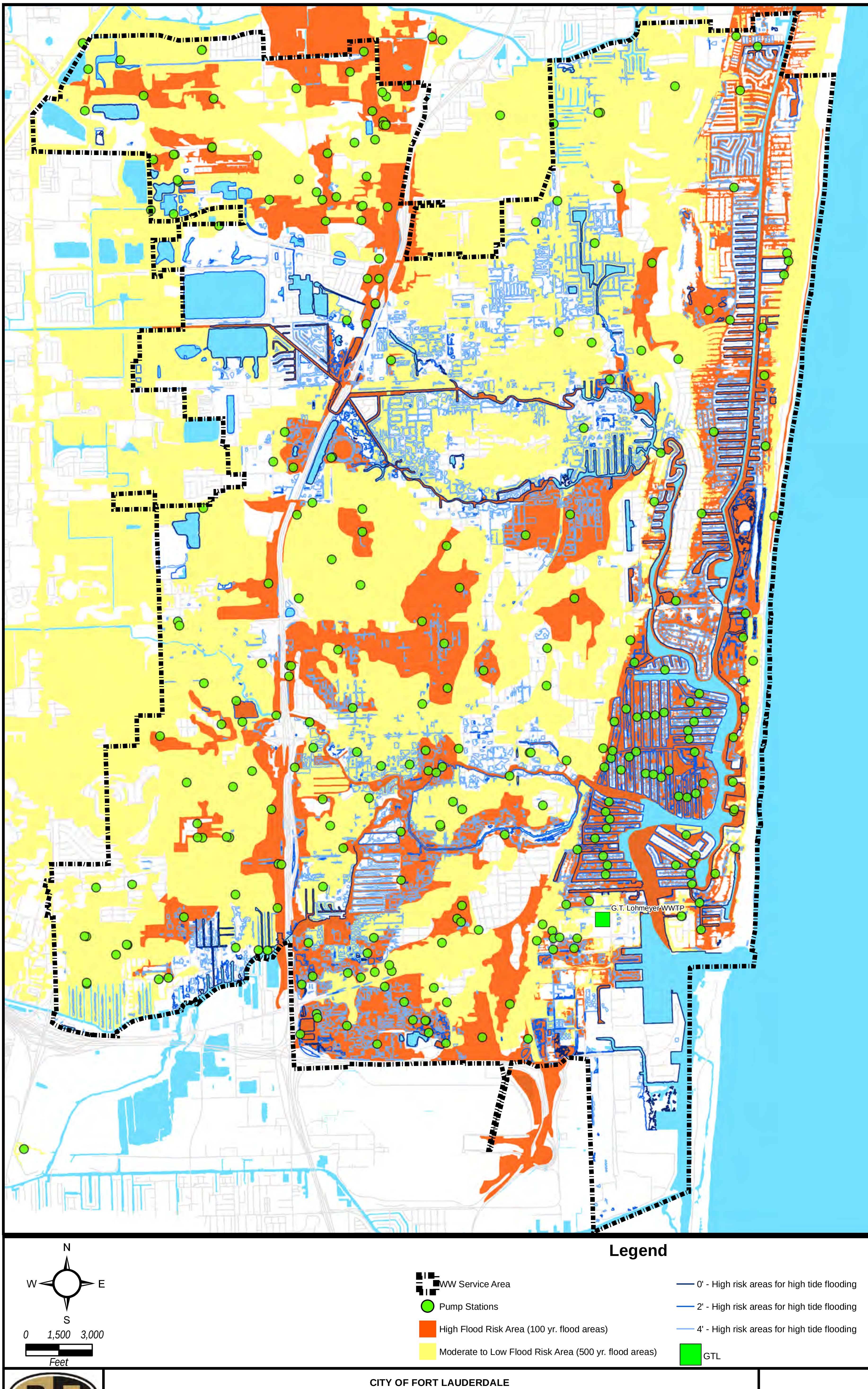

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITIES STRATEGIC MASTER PLAN
WASTEWATER SYSTEM FLOOD HAZARD MAP

FIGURE WW13 - 5

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NOAA's Sea, Lake and Overland Surge from Hurricanes Model (SLOSH Model) is a computer model developed by the National Weather Service (NWS) to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes. The SLOSH Model result is used to predict storm surge heights. **Table WW13-3** shows the predicted storm surge height for the City. The detailed result graphs can be found in **Appendix WW13-A**.

Table WW13-3. SLOSH Predicted Storm Surge Height at City

Storm Category	Storm Surge Height (ft.)	Winds (mph)
Category 1[1]	1 - 3	74 – 95
Category 2[2]	2 - 4	96 - 110
Category 3[3]	3 - 5	111 - 130
Category 4[4]	4 - 7	131 -155
Category 5[5]	5 - 8	above 155

[1] **Category 1**: Winds can be expected to product some minor damage to property. Injuries to people and animals are generally isolated and limited to flying or falling debris. During a Category 1 storm, protected glass windows generally remain intact. Some roof damage to frame homes, apartments, and shopping centers can also occur, as well as short-term power outages due to snapped power lines and downed trees.

[2] **Category 2**: Winds can be expected to product extensive property damage. Greater wind velocities mean that debris poses a greater threat to humans and animals, while the roofing, siding, and glass windows (protected and unprotected) of frame homes are more vulnerable to damage. In a Category 2 storm, significant structural damage to apartment buildings, mobile homes, and shopping centers is also expected, as well as flooding in low-lying areas. Extensive power outages ranging from a few days to a few weeks are common, and residents are encouraged to stock up on potable water as filtration systems also fail during this time.

[3] **Category 3**: Winds can cause significant damage to property, humans, and animals. Mobile and poorly constructed frame homes are often destroyed, and even well-built frame homes commonly sustain major damage. Significant damage to apartments and shopping centers (even those made of wood or steel) can be expected. Category 3 storms can also cause extensive inland flooding. Electricity and water are commonly unavailable for several days to several weeks after the storm, therefore, it is important for residents to have their own stores of canned food and water.

[4] **Category 4**: Winds can cause catastrophic damage to property, humans, and animals. Severe structural damage to frame homes, apartments, and shopping centers should be expected. Category 4 hurricanes often include long-term power outages and water shortages lasting from a few weeks to a few months, so again, it is important for any remaining residents to have a significant nonperishable food and water supply at hand.

[5] **Category 5**: Winds can cause catastrophic damage to property, humans, and animal. Complete or almost-complete destruction of mobile homes, frame homes, apartments, and shopping centers should be expected, and nearly all trees in the area will be snapped or uprooted. Power outages can last for weeks and possibly months. Long-term water shortages should be expected as well, and most of the area will be uninhabitable for weeks or months.

GTL

As mentioned previously, a maximum 1 ft. SLR is predicted within the time period applicable to the Master Plan (2035). Data presented in the flood hazard figure indicates that GTL is not included in any flood hazard zones, nor is it affected by storm surge tides up to 8-feet high (assuming a 1 ft. SLR) because GTL is built on an elevated ground (8 feet). As SLR increases beyond 1 ft., flooding will eventually become a concern at GTL. Currently, hurricane storm surges at high tide present a significant flooding concern at GTL. Planned modifications to the GTL electric systems should include protection from future sea level rise. GTL has been in operation since 1986, and there was previously a wastewater plant at the same location more than two decades earlier, known as the Port Everglades Wastewater Plant. The majority of GTL buildings have been in existence since 1986, with some buildings dating back further. The primary threat that may affect GTL during extreme weather events is wind gust. The wind pressure requirement of the 1986 Florida Building Code is 120 mph. The Florida Building Code has been updated multiple times through the years due to new weather events and better understanding of the wind gust risk. Improved roof system requirements were added in 1993; higher design wind pressure in South Florida and most coastal areas were required in both 2002 and 2010. The wind pressure requirement in the current Florida Building Code is 180 mgh. The safety of the City and the integrity of the facilities at GTL are at risk if the City experiences Category 3 or stronger storm events.

Collection System

Both above ground and below ground collection system infrastructure are vulnerable in storm surge events. Many of the City's pump stations are located close to coastal areas. Potential flooding and storm surge events place the station's electrical panels in danger. The unsealed wet well covers are susceptible to flood water entry, which contributes to the already severe I/I issue. Based on the available elevation data, 70 stations' wet well elevations were compared to their base flood elevations (BFEs). The CUSMP team utilized geographic information system (GIS) to compare pump station locations with high risk tidal contours provided by the City. Under storm surge conditions, 42 pump stations (excluding D-20) were identified to be at flood risk (refers to temporary flooding, which is different from permanent inundation caused by SLR only) due to extreme weather events. **Table WW13-A-1** shows the stations with more detailed information.

13.3 Solutions

This study shows that the City is susceptible to various climate change risks. Rising sea level represents a main threat for potential inundation to City's facilities. Current King tide events indicate climate change is a concern, and have greatly affected Las Olas Blvd and Cordova Rd areas. In the future, the combination of rising sea level and increasing temperature may generate more extreme weather events (including storm surge scenarios). The potential storm surge events can bring large quantities of water in a short period of time, resulting in inundation of elements in the City's collection and transmission system. Inundated pump stations and manholes become potential entries of inflow, which occupies valuable capacity of the City's collection system and dilutes influent. The potential storm surge events also cause severe wind gust hazard, which can damage the above ground infrastructure including control panels, generators, etc.

The GTL is located approximately 1/3 of a mile from the Intracoastal on relatively higher ground, which reduces the potential from site flooding events. The GTL has back-up power and separate, redundant power feeds to cover grid failure. Measures to be implemented are summarized in **Table WW13-4**.

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Table WW13-4. Climate Change Strategies

No.	Climate Event	Risk	Measures
1	Increasing Temperature	Minimum	Minimize carbon footprint
2	Sea Level Rise	Inundation of Manholes & Wetwells at Low-laying Areas	Manhole & Wetwell Sealing
		Increased I/I Flow due to Raised Groundwater Table (include Sewer lateral cleanouts under water allowing direct inflow)	I/I Control Plan[1]
		Less Capacity to Store Rainfall and More Runoff due to Raised Groundwater Table	Stormwater Management Plan[2]
		Flooded control panels to pumping stations installed above ground at insufficient height	Pump Station Flood/Inundation Mitigation and Beautification
		Unable to locate critical valves when submerged under tidal water	Raise grade
		Unable to access fire hydrants during flooding	Raise grade; hydrant relocation
		Increased number of F/M & W/W breaks due to ground water elevation fluctuation	I/I Control Plan[1]
3	Saltwater Intrusion	Corrosion of Equipment at GTL and at coastal located pump stations	I/I Control Plan[1]
		Increased Chlorides in Raw Wastewater	
		Contamination of Groundwater	
		Reduced Treatment Effectiveness	
4	Storm Surge	Flood Hazard (include damage to flooded panels)	Manhole & Wetwell Sealing
		Loss Of Grid Power At Facilities	Emergency Generator Program
		Catastrophic Failure of Equipment	Facility Hardening[3]
		Wind Gust Hazard	GTL Structural Evaluation

[1] Saltwater enters the collection system by infiltration through pipe joints, wall cracks and manholes leaking. An effort to mitigate I/I would also reduce the amount of saltwater that enters the sewer system. The I/I control Plan is presented in **Section WW4** to address I/I issue.

[2] As sea level rise can have impact on the stormwater system in long -term, City needs to evaluate the impact of sea level rise on the existing stormwater system and address the issue.

[3] Hardening here includes sealing of manholes, construction of floodwalls, the structural reinforcement of facilities, replacing old pipe with non-corrosive materials, and any other measures that can physically improve the system's resiliency.

13.3.1 Manhole Sealing

Manhole sealing includes inspection of all manholes for damage or leakage, repair of manhole walls and benches in poor condition, repair and sealing of chimneys in manholes, smoke testing, manhole lid liners, pickhole plugs, etc. Manhole cover dish inserts need to be installed at all low lying areas susceptible to king tide flooding, 1-4 ft. seal level rise and storm surge for hurricanes categories 1-5. Manhole sealing is addressed as part of I/I Control Plan in **Section WW4**. Manhole sealing projects are budgeted and included as part of recommended projects in **Section WW9**. Five identified gravity basins' manholes are recommended to be sealed in the next 5 years.

13.3.2 Pump Station Flood/Inundation Mitigation and Beautification

Due to the combined long-term and short-term risk of inundation caused by sea level rise and storm surge events, it is imperative to take measures to prevent undesired water from entering the collection system excessively though pump stations. The Florida Department of Environmental Protection (FDEP) regulation 62-604.400(2)(e), F.A.C. requires that the electrical and mechanical equipment be protected from physical damage by the 100-year flood, and the pumping station be designed to remain fully operational and accessible during the 25-year flood. The 100-year flood elevation is also known as the base flood elevation (BFE). Due to this requirement, the City is restrained from undergrounding pump stations' control panels and electrical equipment. At odds with the regulations, City residents frequently request to make collection system facilities such as pump stations aesthetically in harmony with the surrounding environment and neighborhoods, such as building submersible pumping equipment that is located out of public sight.

Often floodwalls are added to protect pump stations with wetwell hatches below BFE. The flood walls can prevent flood water from entering the wet wells. They can also protect the electric panels, transformers, odor control systems, and emergency generators. The floodwalls are usually block or cast-in-place concrete. The height should extend above the BFE. Once the floodwalls are constructed, steps or ladders up and over the wall can be provided to gain access into the encapsulated area. Rainwater captured within this area must be accommodated. Systems that encapsulate the entire site must comply with local and federal regulations for work within the floodplain. **Figure WW13-6** shows an example pump station protected by flood walls.

Many of the City's pump stations are located in roadways and right of ways that cannot contain walls due to verge requirements (the verge is the part of the street between the curb/road edge and the property boundary of the land which abuts the street). Also, sites that are within floodways are not eligible for floodwall construction. A floodway is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. Construction within a floodway is limited because of concerns regarding upstream increases in flood elevations that could adversely affect those areas and property. Wet well covers at pump stations in roadways, right of ways and floodways can be sealed to prevent water from entering the collection system. Seals in electrical conduits can also help prevent the panels from being damaged by water during flood events. Systems to seal wet wells from flood waters should be identified and tested during upcoming I/I field work and engineering projects. The CUSMP Team recommends the City further investigate combining pump station flood mitigation with beautification to satisfy both engineering and aesthetic needs.

Figure WW13-6. Flood Wall

13.3.3 Emergency Generator Program

The City currently has an emergency generator program. As mentioned, the GTL has emergency power and redundant power feeds. The City has emergency generators at critical pump stations as presented below in **Table WW13-5**, and a fleet of portable generators to connect to smaller stations. The critical pump stations need to continue to be inspected to ensure that the emergency generators are in working condition and built on elevated platforms.

Table WW13-5. Critical Pump Stations with Existing Generators

No.	Station #	Location
1	A	Repump Station 2100 Northwest 6th Street
2	B	Repump Station
3	D-31[1, 2]	225 South Birch Road & Cortez Street
4	D-37	305 Lido Drive
5	D-40	729 North Birch Road
6	D-54[1]	3410 Southwest 20 Court
7	E-Repump	Repump Station 1501 West Commercial Boulevard

[1] D-31 and D-54 are 20 + years old and need to be replaced.
[2] The area around D-31 may be redeveloped as part of the "Elad" project. The developer may relocate the station.

Section WW6 (Wastewater Risk) also identified critical stations that have no emergency generators. These stations are susceptible to causing critical failure during storm surge events if they lose power. **Section WW6** discussed these pump stations and made recommendations for the addition of new generators where feasible.

13.3.4 GTL Structural Evaluation

The CUSMP Team recommends the City perform a comprehensive structural evaluation of the buildings and treatment structures due to the potential wind gust hazard at GTL. The structural evaluation should focus on the components of buildings and treatment structures that are vulnerable to wind gusts. It is recommended that the City consider upgrading those buildings and structures not in compliance to meet current Florida Building Code to protect staff and wastewater treatment facilities.

13.4 Conclusion and Recommendations

Risks to the City's wastewater system associated with potential climate change and sea level rise include the following:

- Manhole and pump station flooding due to sea level rise and extreme weather events
- Increased I/I and saltwater entry into GTL due to sea level rise and saltwater intrusion
- Loss of grid power at critical pump stations due to extreme weather events
- Wind gust hazard at GTL due to extreme weather events

Measures the City can take to address impacts to the wastewater system due to potential climate change and sea level rise include the following:

- Seal identified manholes. Projects proposed in **Section WW4**.
- Consider a pump station flood mitigation and beautification program at 48 pump stations.
- Continue implementing the emergency generator program. Add back-up generators at critical pump stations as recommended in **Section WW6**.
- Inspect existing emergency generators at 10 pump stations.
- Perform GTL structural evaluation to address risk caused by wind gust hazard.
- Continue to utilize the SLOSH Model to provide guidance for both strategic planning and emergency management.

13.5 References:

1. Ben Bovarnick, Shiva Polefka, & Arpita Bhattacharyya, Rising Waters, Rising Threat - How Climate Change Endangers America's Neglected Wastewater Infrastructure, October 2014.
2. Marguerite Koch-Rose, Diana Mitsova-Boneva, Tara Root, etc. Florida Water Management and Adaptation in the Face of Climate Change, November 2011.
3. Frederick Bloetscher, Daniel E. Meeroff, & Barry N. Heimlich, Improving the Resilience of a Municipal Water Utility Against the Likely Impacts of Climate Change - Case Study: City of Pompano Beach Water Utility, September 2009.
4. Alana Edwards and Mary Beth Hartman, Risk, Resilience and Sustainability: A Case Study of Fort Lauderdale, May 2014.
5. Saltwater Intrusion and Infiltration into the King County Wastewater System, March 2011.
6. Steven R. Hilderhoff, P.E., GHD Consulting Services Inc., Pumping Station Improvements in Floodplains and Floodways,
7. Fikret Kargi and Ali R. Dincer "Effect of salt concentration on biological treatment of saline wastewater by fed-batch operation", Enzyme and Microbial Technology vol. 19, pp.529-537, 1996.

Appendix WW13-A

SLOSH Model Storm Surge Result at the City of Fort Lauderdale

Figure WW13-A-1. Maximum Storm Tide, Category 1 Hurricane hitting at high tide

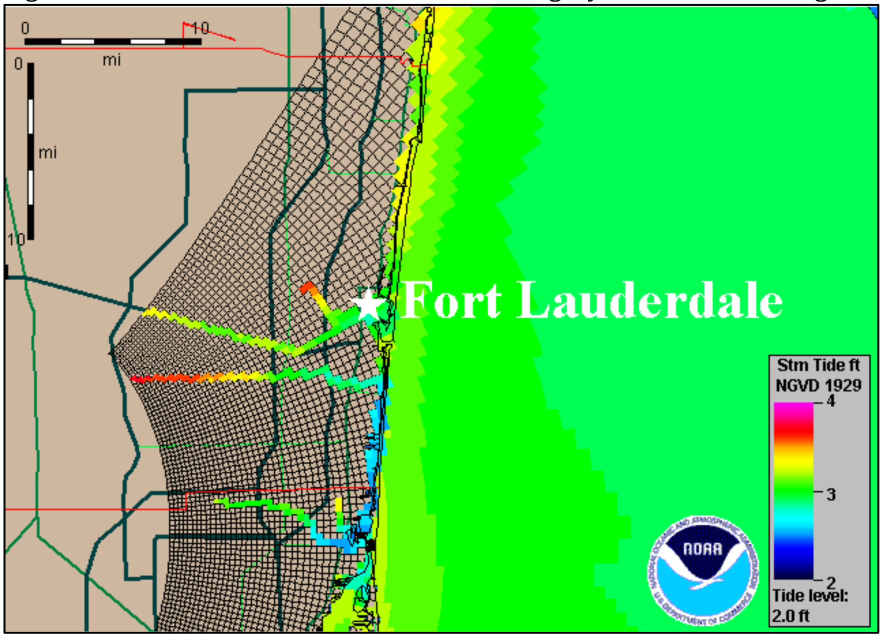


Figure WW13-A-2. Maximum Storm Tide, Category 2 Hurricane hitting at high tide

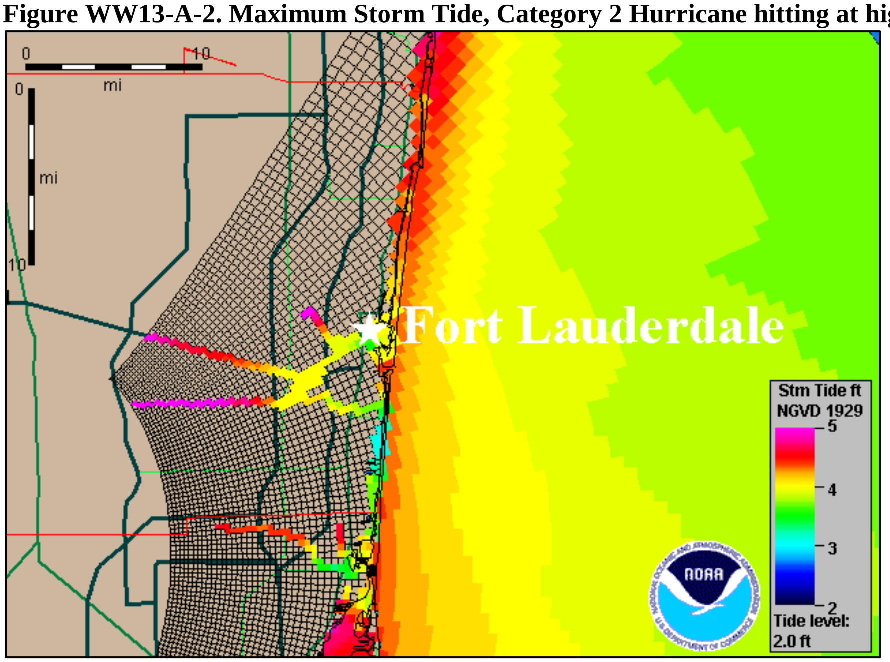


Figure WW13-A-3. Maximum Storm Tide, Category 3 Hurricane hitting at high tide

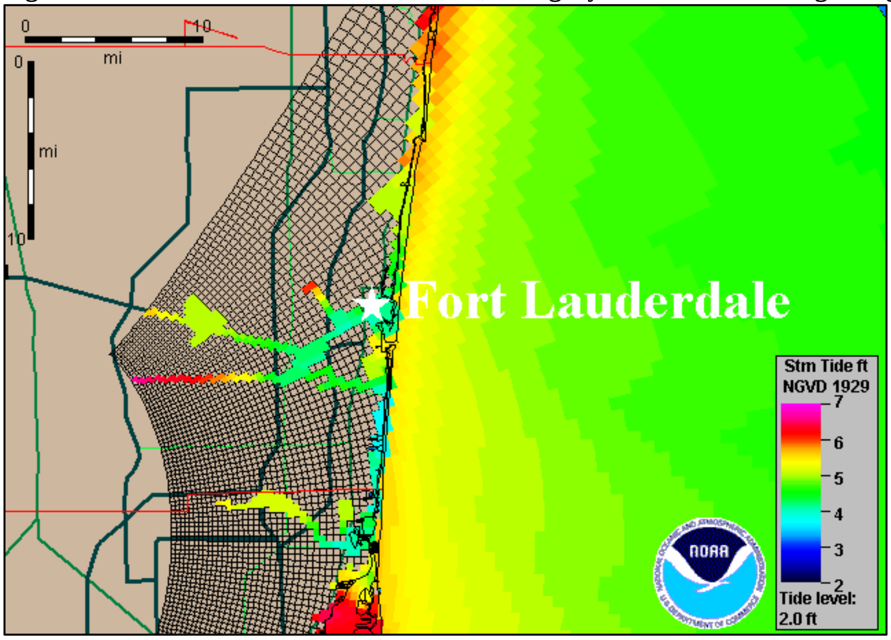
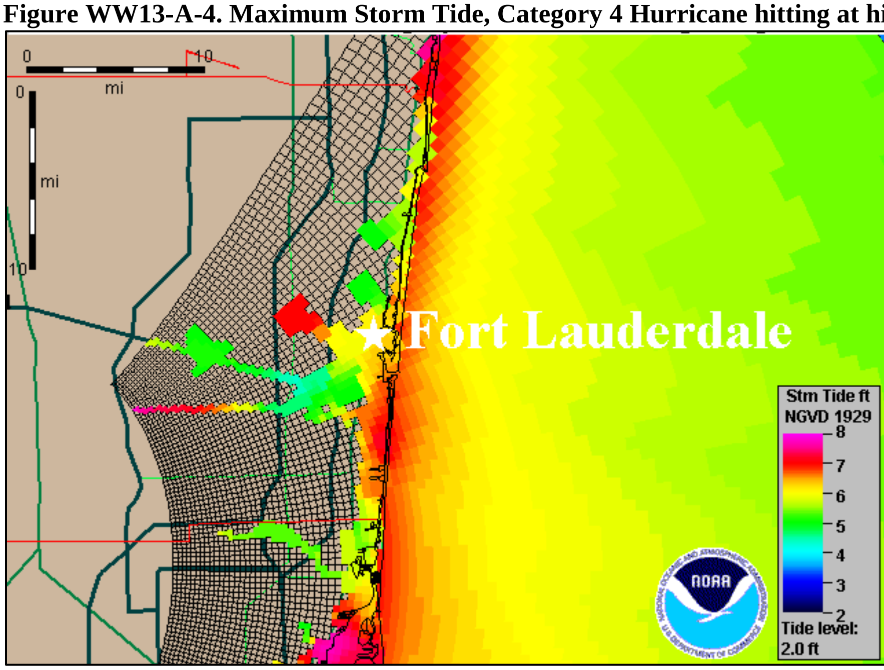


Figure WW13-A-4. Maximum Storm Tide, Category 4 Hurricane hitting at high tide



Section WW13 accepted July 16, 2016.

Figure WW13-A-5. Maximum Storm Tide, Category 5 Hurricane Making Landfall at High Tide

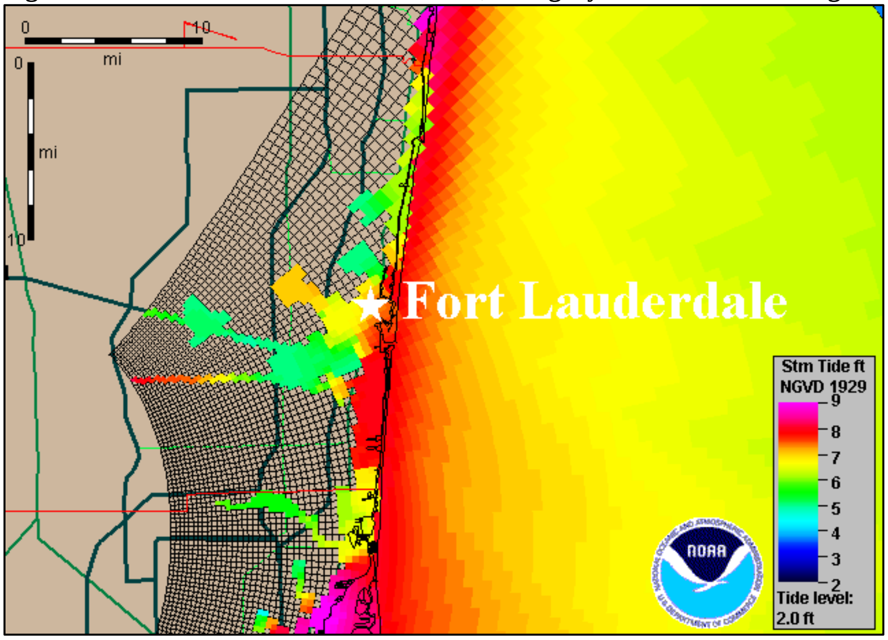


Table WW13-A-1. Identified Pump Stations and Prioritization

#	Pump Stations	Influenced by Tide	Elevation under BFE	Inundation under 1' SLR	Priority Group
1	B16	Yes	-	-	1
2	D1	Yes	-	-	
3	D2	Yes	-	-	
4	D20	Yes	-	By 2030	
5	D21	Yes	-	-	
6	D25	Yes	-	-	
7	D26	Yes	-	-	
8	D27	Yes	-	-	
9	D28	Yes	-	-	
10	D29	Yes	-	-	
11	D3	Yes	-	-	
12	D30	Yes	-	-	
13	D32	Yes	-	-	
14	D33	Yes	-	-	
15	D34	Yes	-	-	
28	D37	Yes	-	-	
16	D4	Yes	-	-	
17	D41	Yes	-	-	
60	D43	Yes	3.79'	-	
18	D45	Yes	-	-	

#	Pump Stations	Influenced by Tide	Elevation under BFE	Inundation under 1' SLR	Priority Group
20	D6	Yes	-	-	
21	D7	Yes	-	-	
22	D10	Yes	-	-	2
23	D17	Yes	-	-	
24	D18	Yes	-	-	
25	D19	Yes	-	-	
26	D22	Yes	-	-	
27	D23	Yes	-	-	
19	D5	Yes	-	-	
29	D38	Yes	-	-	
30	D39	Yes	-	-	
31	D46	Yes	-	-	
32	D47	Yes	-	-	
33	D48	Yes	-	-	
34	D49	Yes	-	-	
35	D50	Yes	-	-	
36	D51	Yes	-	-	
37	D52	Yes	-	-	
38	D8	Yes	-	-	
39	D9	Yes	-	-	
40	A104	Yes	-	-	3
41	A12	Yes	0.29'	-	
42	A19	Yes	2.5'	-	
43	A22	Yes	-	-	
44	A32	Yes	-	-	
45	A53	Yes	-	-	
46	A57	Yes	1.47'	-	
47	A59	Yes	1.65'	-	
48	B1	Yes	-	-	
49	B11	Yes	-	-	
50	B14	Yes	2'	-	
51	B2	Yes	-	-	
52	B5	Yes	-	-	
53	B6	Yes	3.08'	-	
54	C27	Yes	1.35'	-	
55	C28	Yes	1.3'	-	
56	C7	Yes	1.95'	-	
57	D31	Yes	-	-	

#	Pump Stations	Influenced by Tide	Elevation under BFE	Inundation under 1' SLR	Priority Group
58	D35	Yes	-	-	
59	D36	Yes	2'	-	
61	D53	Yes	-	-	
62	A1	-	3.17'	-	4
63	A106	-	1'	-	
64	A21	-	2.5'	-	
65	A48	-	0.2'	-	
66	A55	-	0.75'	-	
67	A56	-	0.5'	-	
68	A58	-	1.55'	-	
69	B3	Yes	-	-	
70	B4	Yes	-	-	
71	B9	-	4.25'	-	
72	C10	Yes	-	-	
73	C12	-	1.9'	-	
74	C13	Yes	-	-	
75	C14	Yes	-	-	
76	C20	-	0.96'	-	
77	C9	Yes	-	-	
78	D44	Yes	-	-	
79	E13	Yes	-	-	

[1] Substations within D-34, D-37, and D-43 areas are flooded during king tides and are included in this table.

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WW14 Wastewater Reuse Alternatives

Limited potable water supplies, as well as FDEP & SFWMD policies are increasing the importance of water conservation. Furthermore, Senate Bill (SB) 536, passed in 2014, requires municipalities to complete an evaluation on the expanded use of reclaimed water, stormwater, and surface water. The City has investigated wastewater reuse in the past as part of their efforts to further achieve environmental sustainability. This section summarizes the City's previous reuse planning efforts, re-assesses various alternatives for reuse, and develops a cost-benefit and carbon-reduction analysis.

14.1 Summary of Previous City Reuse Reports

The City's 2008 and 2012 reuse feasibility efforts, as well as the 2007 Wastewater Master Plan and previous reports, identified potential reuse alternatives for City-produced reclaimed water including:

- Reuse applied to recharge Pond Apple Slough;
- Reuse as boiler feed water by Florida Power & Light (FPL)
- Landscape irrigation of golf courses and City parks with reclaimed water supplied from satellite wastewater treatment plants utilizing membrane bioreactor (MBR) technology;
- Reuse distributed to lakes at the Prospect Wellfield;
- Reuse as a barrier against saltwater intrusion;
- Reuse for cooling water and irrigation at the Greater Fort Lauderdale Convention Center (Convention Center) provided by the GTL; and
- Reuse for irrigation at City-owned facilities supplied by and located in the vicinity of the GTL;
- Reuse from satellite wastewater treatment plants at various pump stations;
- Sending raw wastewater to neighboring utilities for treatment and reuse;
- Reuse for plant processes requiring high quality water (e.g. polymer).

14.2 Identification of Reuse Alternatives

14.2.1 Alternative 1 – GTL Upgrade and Local Area Reuse

The 2012 Feasibility Study declared eight potential reclaimed water users in the vicinity of GTL, with a total demand of approximately 0.48 million gallons per day (MGD), including:

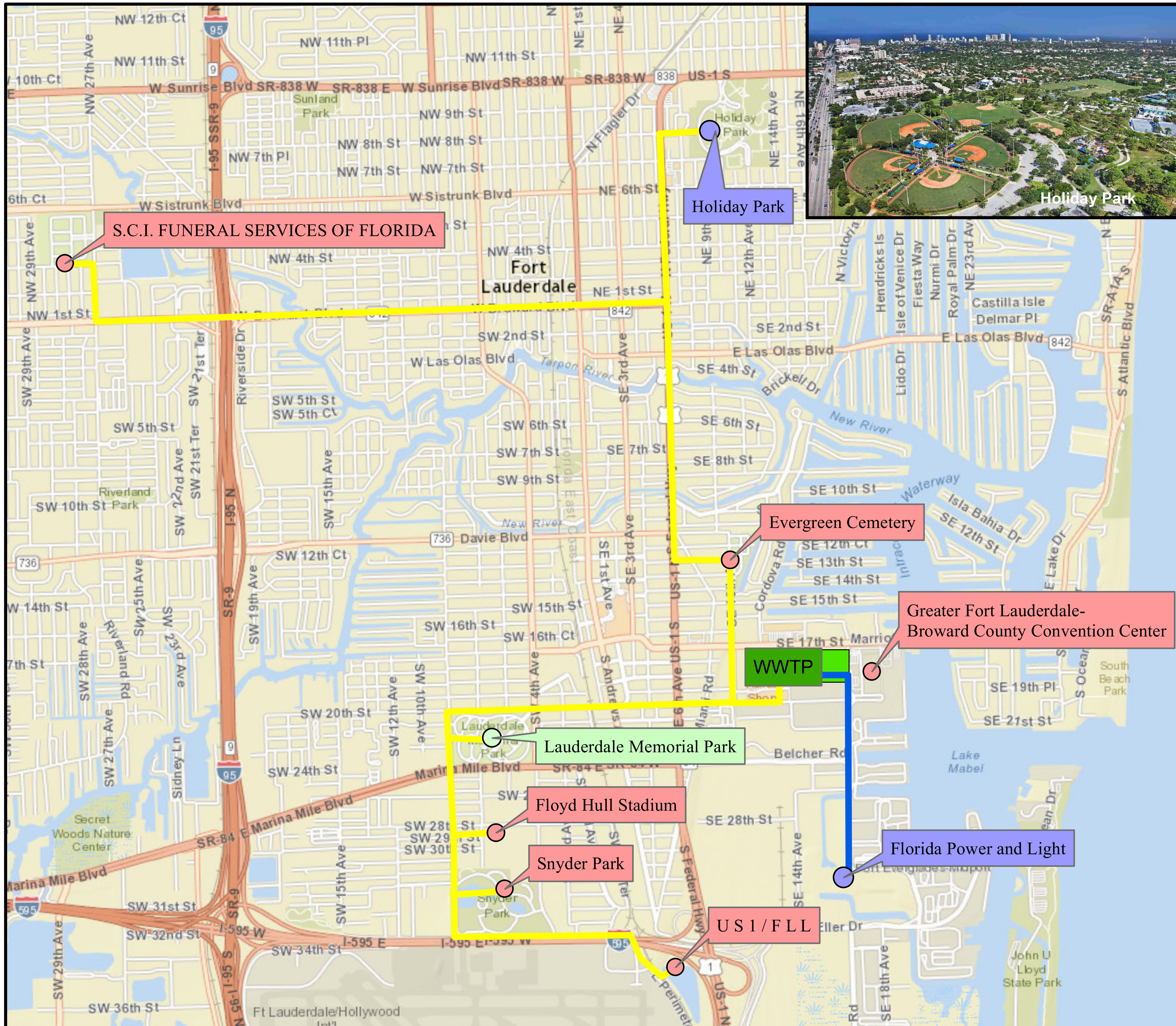
- Florida Power and Light Port Everglades Plant (FPL PE) (0.28 MGD)
- Convention Center (0.03 MGD)
- Evergreen Cemetery (0.01 MGD)
- Lauderdale Memorial Park Cemetery (0.09 MGD)
- Snyder Park (0.01 MGD)
- Floyd Hull Stadium (0.01 MGD)
- S.C.I. Funeral Services of Florida
- Highway US1 / Port Everglades Expressway

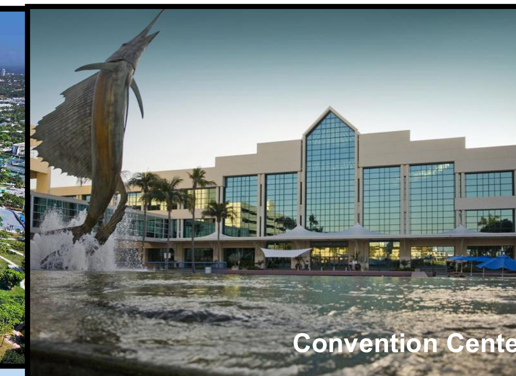
Fort Lauderdale-Hollywood International Airport may be another potential reclaimed water user in the vicinity of GTL. Other Florida airports already using reclaimed water include Tampa International Airport. As an integral part of their Sustainable Management Plan, the airport uses reclaimed water for landscape irrigation, cooling tower water supply, and at the car washes. From 2009 to 2015, reuse has saved over 294 million gallons of potable water, averaging 0.134 MGD.

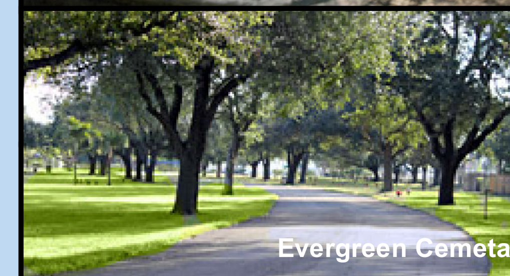
Section WW14 accepted December 16, 2016.

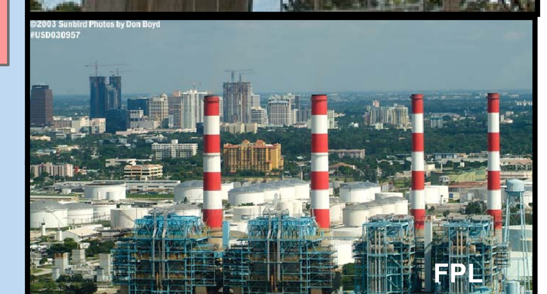
Fort Lauderdale-Hollywood International Airport would need to construct the necessary infrastructure to convert their facilities for water reuse, and the total demand needs to be determined to evaluate their feasibility as a potential recycled water user.

The 2012 Feasibility Study prepared an alternative that included treatment improvements and reclaimed water distribution pipe as shown in **Figure WW14-1**. Filtration, high-level disinfection, and salt removal treatment processing will have to be added to GTL for industrial and irrigation reuse, and could include ultraviolet light (UV) disinfection, microfiltration (MF), and reverse osmosis (RO). However, RO may not be necessary if I&I east of the salt/fresh water line is significantly reduced. Previous reuse planning cost analyses to provide reclaimed water from the GTL to the Convention Center and City-owned facilities indicated that a reuse system would be uneconomical compared to producing potable water for identical use and treatment of alternative brackish water supplies. The feasibility studies concluded that reclaimed water reuse offered intangible benefits compared to the more economic potable water production, including: potential credits/offsets applied for increasing Biscayne Aquifer withdrawals; and fostering collaborative relationships with applicable regulatory agencies in helping to realize environmental goals.









N
W E
S

0 1,500 3,000
Feet

LEGEND

Potential Public Access Reuse Users

Capacity (gpm)

- Small User (0-70)
- Medium User (71-347)
- Large User (>347)

Pipeline

- 4-Inch Proposed Reclaim Pipe
- 8-Inch Proposed Reclaim Pipe
- GTL WWTP

*This Alternative includes components from the 2012 Updated Reclaimed Water Feasibility Study

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

ALTERNATIVE 1: POTENTIAL END USERS FOR RECLAIMED WATER

FIGURE WW14-1

G:\0gis\134001 - FTL Master Plan_MXDs\CUP Offset and credit\Option 1 Potential End User rjd.mxd

14.2.2 Alternative 2 – Satellite Treatment and Reuse/Saltwater Intrusion Barrier

Alternative 2 involves satellite wastewater treatment for indirect potable water reuse and reuse as a saltwater intrusion barrier. The 2008 Reuse Feasibility Study's evaluation of using reclaimed water to recharge Pond Apple Slough or at the FPL Lauderdale Plant (average annual demand for approximately 700 gpm each), as shown in **Figure WW14-2** indicated that neither were viable options. Irrigating parks and golf courses with reclaimed water from a satellite wastewater treatment plant was considered a viable, but costly option. The potentially best candidate for reuse was the Coral Ridge Golf Course Option B, with an estimated life cycle cost of $15.58/1,000 gallons for an average demand of approximately 5 MGD. The decreased demand during the wet season and need for negotiation with the private golf course owner reduced the attractiveness of this option.

Estimated costs associated with facilities to provide 5 MGD of recharge to the Prospect Wellfield included:

- $78 million capital expenses
- $5 million for annual operation and maintenance
- $5.4 million annual capital recovery fixed cost

An estimated unit production cost of $11.52/1,000 gallons resulted for this option. The previous planning document concluded that wellfield recharge should not be pursued due to uncertainties involving regulatory issues, pilot testing, and other unknowns.

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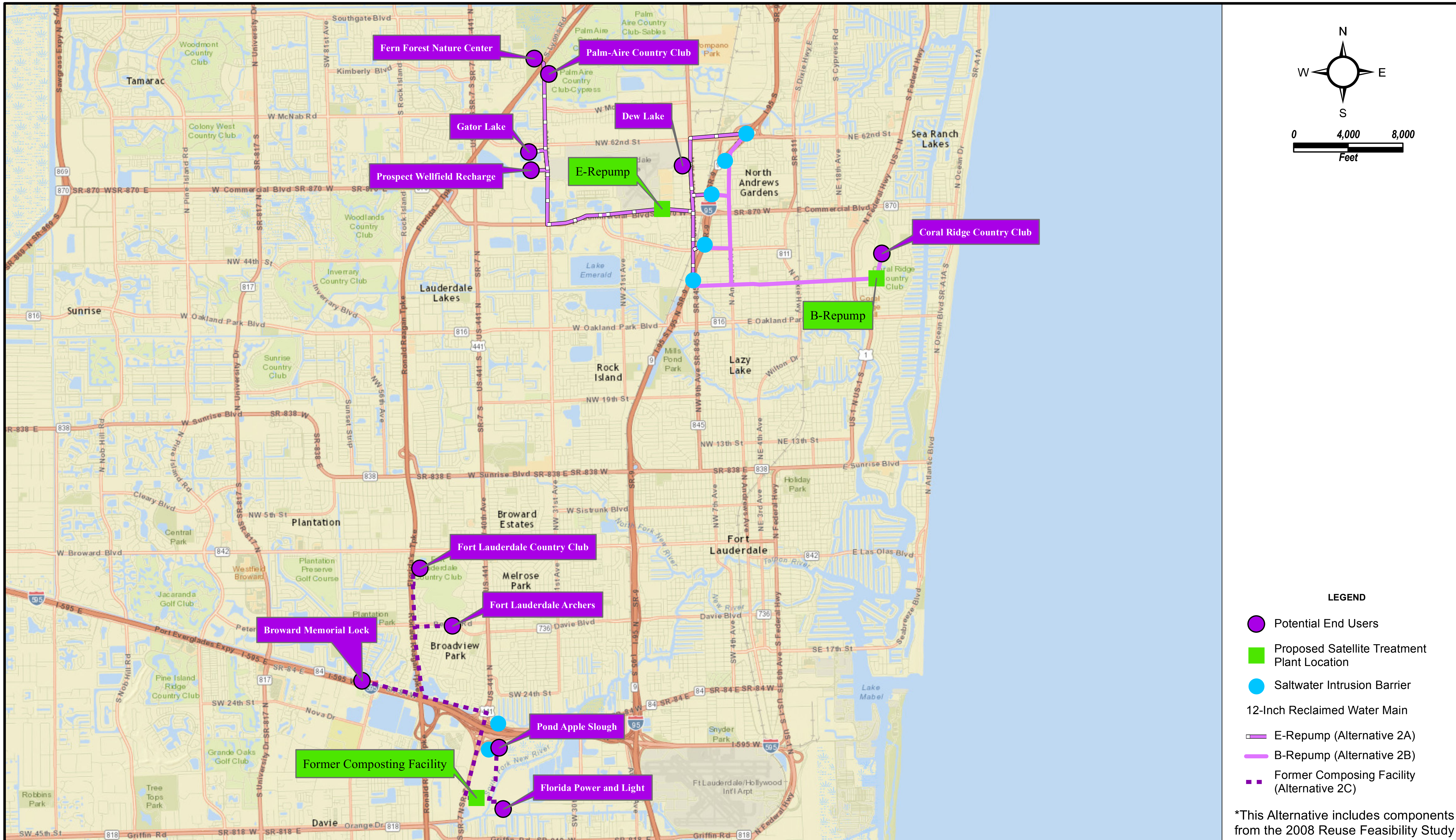

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

ALTERNATIVE 2: POTENTIAL END USERS OF SATELLITE TREATMENT FOR REUSE AND SALTWATER INTRUSION BARRIER

FIGURE WW14-2

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14.2.3 Alternative 3 – Satellite Treatment and Indirect Potable Reuse

The City of Hollywood has pilot tested indirect potable reuse and is currently in discussions with regulatory agencies to implement. In Fort Lauderdale, satellite treatment would “scalp” raw wastewater from the collection system and treat to potable drinking water standards for all parameters except salinity or total dissolved solids (TDS). However, raw wastewater and recently constructed or repaired sewer systems west of saline water bodies will be less saline, so treated water may meet salinity and TDS standards. The highly treated water would be discharged to the upper Floridan Aquifer near the Peele Dixie WTP and indirectly reused for potable water supply using reverse osmosis treatment technology (also see **Figure WW14-3**). The City of Hollywood’s pilot testing indicated successful treatment for contaminants including emerging contaminants such as endocrine disruptors. Conversely, the Sierra Club recently filed for sole source status for the Floridan Aquifer, which could preclude or significantly increase the complexity of discharge of treated wastewater into the Floridan Aquifer.

14.2.4 Alternative 4 – C-12 and C-13 Canal Interconnect Project

In 2010, the City executed an inter-local agreement with Broward County to provide a direct connection for surface water flows between the C-13 and C-12 Canals. Connecting the two canals facilitates redirection of C-13 flows that would otherwise be lost to tide. Increased C-12 flows enable enhanced water deliveries to the North Fork of the New River (North Fork). More frequent and controlled flows from the C-12 should result in improved water quality in the North Fork, which is currently considered a verified impaired waterbody by the State. However, there are currently large amounts of trash in the water which would need to be removed prior to the implementation of this project. This alternative is shown in **Figure WW14-4**.

A possibility exists that redirection of C-13 Canal flows that otherwise would be discharged to tide could be applied as offsets to enable increased Biscayne Aquifer withdrawals from City wellfields. The magnitude of potential offsets cannot be determined at this point. It will depend upon how much of the flows diverted from the C-13 to the C-12 may result in recharge of the Aquifer compared to historical conditions. This will likely involve a combination of monitoring canal flows, stages, and groundwater elevations with numerical modeling. The primary purpose of the interconnection is to divert flows from one canal to another that will still ultimately be discharged to tide; consequently, this suggests that the extent of aquifer recharge that may be applied as an offset for increased Biscayne Aquifer withdrawals would be minimal. In any case, obtaining a higher consumptive water use permitted (WUP) withdrawal would require discussions with SFWMD to revise the WUP.

It is understood that various issues encountered during construction of the interconnect resulted in delayed completion of the project. Consequently, the County is evaluating alternative construction methods. As part of the agreement with the County, the City set aside $360,000 for a 50 percent share of construction. However, the lack of an accepted plan is delaying construction. Once the County provides an accepted plan and cost estimate, additional funding will be pursued.

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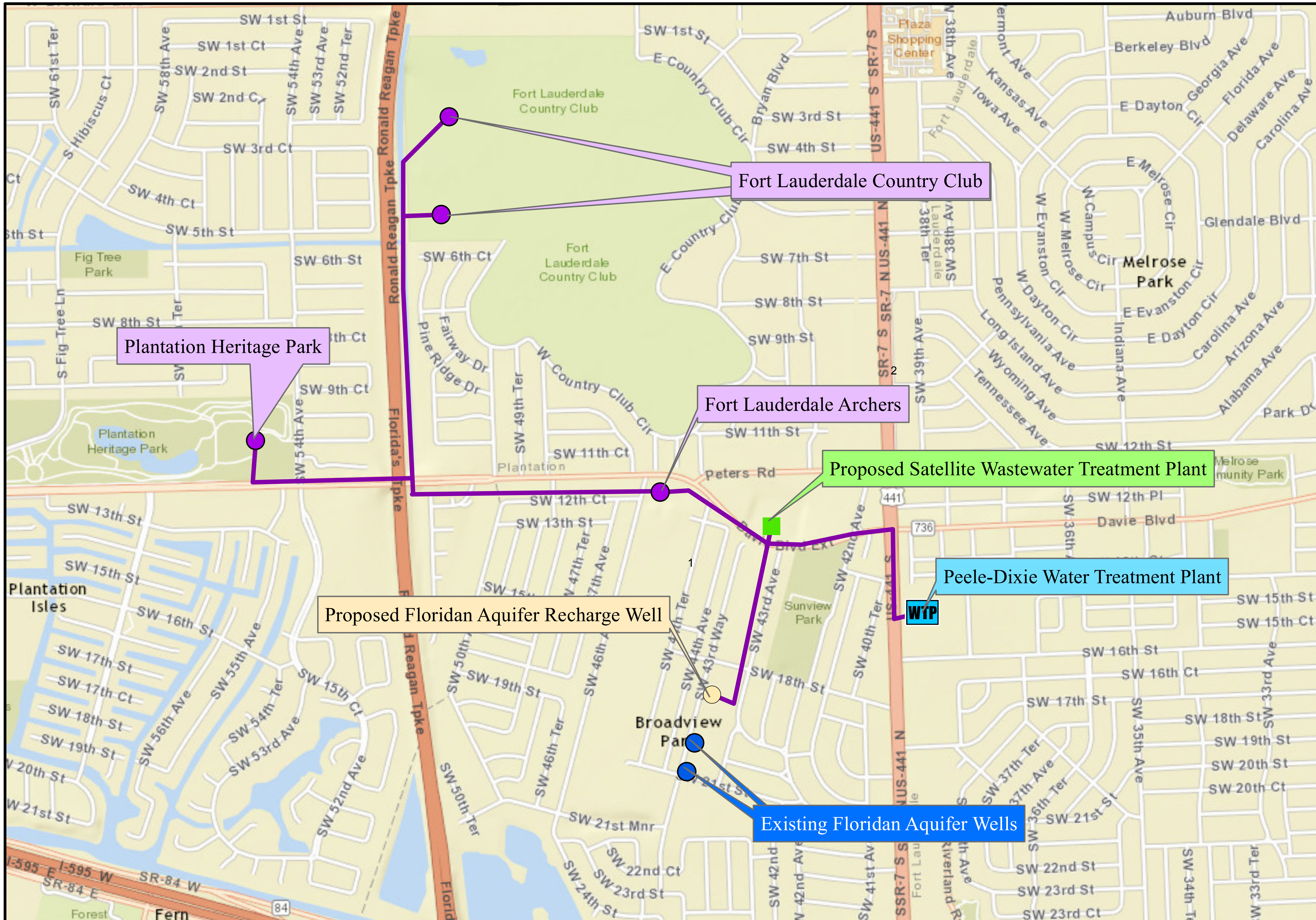

LEGEND

WaterPlant

- WTP WaterPlant
- Potential End Users
- Floridan Aquifer Recharge Well
- Proposed Fl Aquifer Recharge Well
- Proposed Satellite WWTP

Proposed Pipeline

- 12-Inch Reclaim

Notes

1. The proposed satellite WTP location shown is the location of the past Peele-Dixie WTP sludge pit. The sludge is still there and is very unstable.The land is outside the City limits in unincorporated Broward County. Further investigation would be needed to acquire the land and to stabilize and remove the sludge.

2. Further investigation is needed to evaluate the Fort Lauderdale Archers as a potential End User for reuse. This is designated by Broward County as a "Local Area of Particular Concern" which may inhibit this site as a viable option.

*This Alternative is from the 2008 Reuse Feasibility Study

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN

ALTERNATIVE 3: POTENTIAL END USERS OF SATELLITE TREATMENT FOR AQUIFER INJECTION AND REUSE

FIGURE WW14-3

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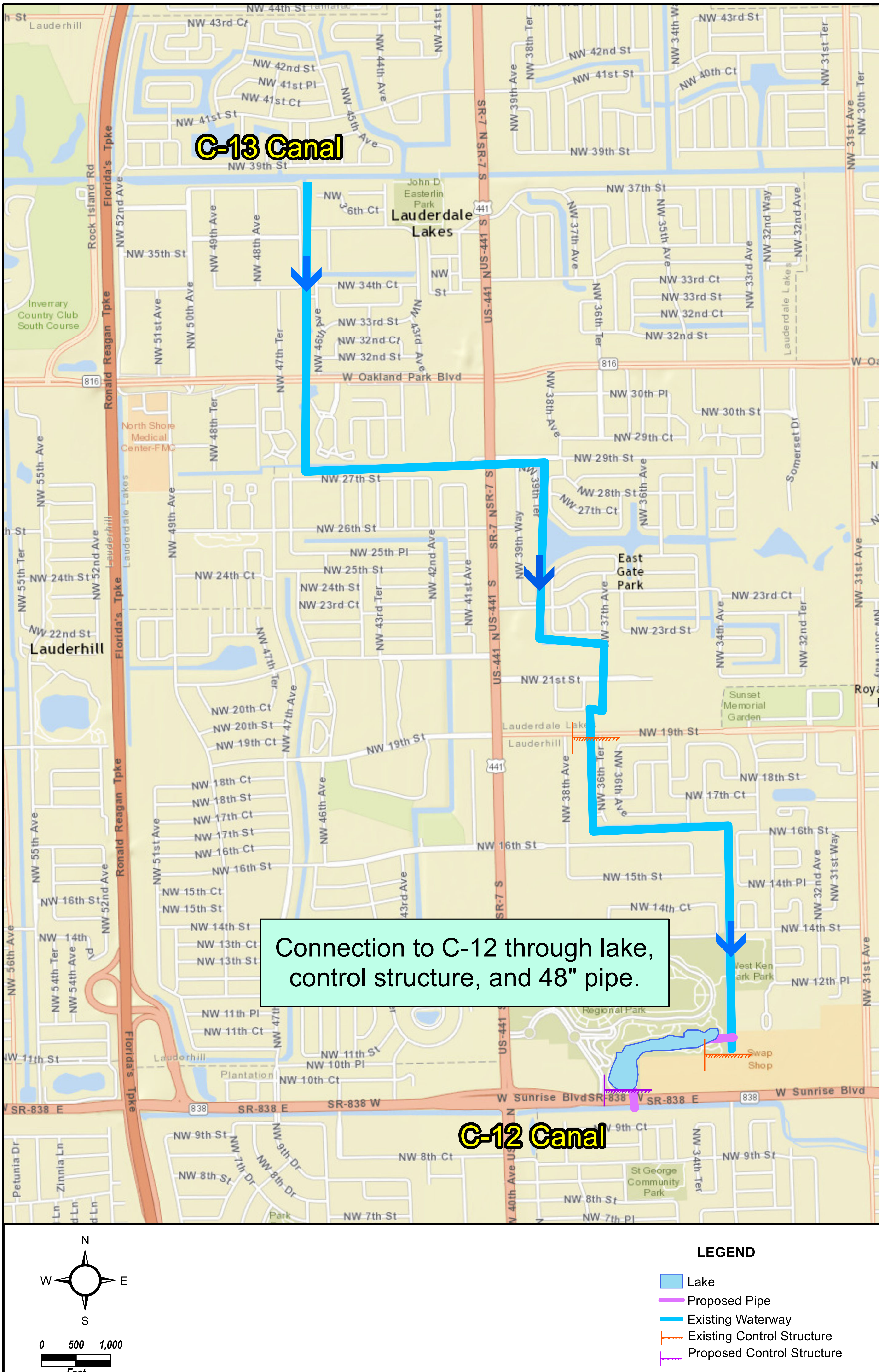

CITY OF FORT LAUDERDALE
COMPREHENSIVE UTILITY STRATEGIC MASTER PLAN
ALTERNATIVE 4: C12 AND C13 CANAL INTERCONNECT

FIGURE WW14-4

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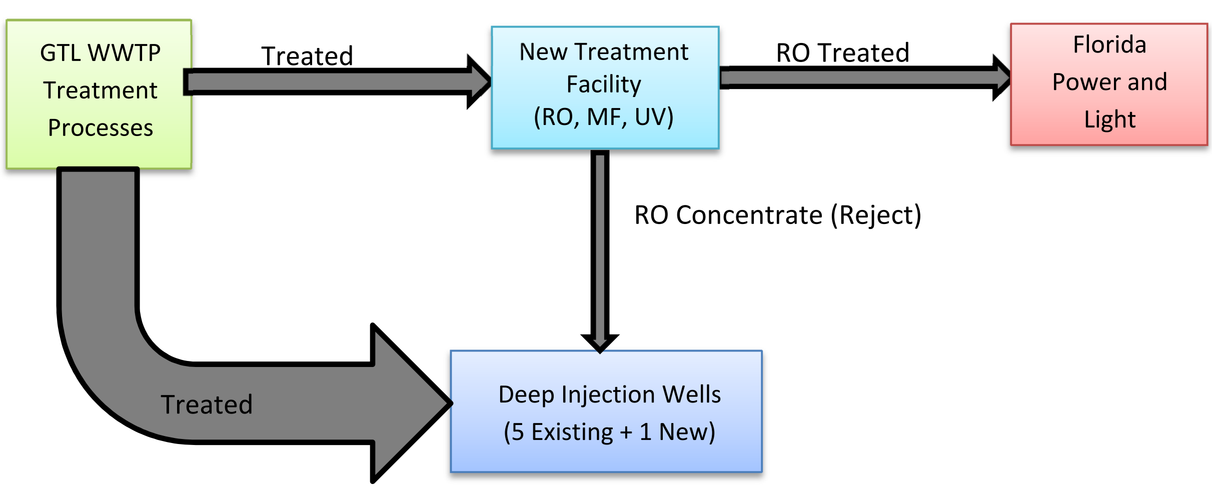
14.2.5 Alternative 5 – GTL Upgrade and 6th Effluent Deep Injection Well for Local Reuse

Alternative 5 includes a new 0.3 MGD water reclamation facility, microfiltration (MF) for suspended solids removal, reverse osmosis (RO) for dissolved solids removal, and UV for disinfection. Effluent from the GTL WWTP would be pumped to a new reclamation facility on GTL's site (possibly located on the deep injection well site or the parking area west of the pretreatment building), treated to meet reuse standards, and then transferred to the nearby Florida Power and Light plant for reuse. The City was already in discussions about laying an 8" reuse pipe between the facilities in conjunction with an electrical feed construction project. RO concentrate (rejected water and solids from the RO process) would be routed to the deep well injection system. Since RO concentrate is considered an industrial waste stream, high level disinfection is not needed for deep well injection. This concentrate could be blended with a water treated through ultra-filtration (UF) for deep well injection. The increased electrical demand from the construction of this facility would need to be offset by other energy efficiency improvements as mentioned in Section WW16 and WA13. Another source of the industrial discharge could be from regular deliveries of (lightly) contaminated water from site cleanups or other source of "industrial" water. A small amount of concentrate from the Peele-Dixie WTP could meet this need, as long as it was sent down the well on a regular basis.

This Alternative is similar to Alternative 1, except with FPL as the only end user, and with the addition of another deep injection well. Although this alternative requires building a new treatment facility, it is advantageous because it allows the 6th deep well to be constructed without high-level disinfection infrastructure for the entire GTL flow, which would incur significant costs. A schematic of this alternative is shown in **Figure WW14-5**.

The GTL WWTP operates an effluent pumping station, as well as five (5) deep injection wells. During normal operations, each of the five (5) deep injection wells has a permitted peak hour flow injection capacity of 18.7 MGD (injection velocity of 10 feet per second), resulting in a total peak hour flow disposal capacity of 93.5 MGD for the entire injection well system. The injection wells are allowed to be operated at a maximum injection rate of 22.4 MGD (injection velocity of 12 feet per second) during emergency conditions or planned testing of the wells, such as during mechanical integrity testing. Prior sections of this report explored the construction of a 6th deep injection well to meet future level of service needs, however the reduction of I/I should remain a top priority before further investigation of an additional deep injection well. This alternative provides a solution to constructing the 6th deep injection well without the addition of costly high-level disinfection.

Figure WW14-5. Alternative 5: Additional Injection Well Schematic



14.3 Cost-to-Benefit Analysis

A cost to benefit analysis provides guidance on the relative merits of alternatives. **Table WW14-1** displays the cost for the 5 reuse alternatives, compared to the cost of producing potable water. The cost per 1,000 gallons for each alternative was calculated by converting the capital cost of the project to an annualized cost, assuming a 20 year financing period at 7% interest, consistent with the 2012 Reuse Feasibility study, and adding to the annual operation and maintenance costs. The results show that at this time, it is significantly more expensive to implement reuse than it is to produce potable water. The cost of producing potable water, however, could rise in the future if the water needs to be pumped from alternative sources. However, higher WUP withdrawals could be negotiated with SFWMD with sufficient I&I reduction and canal recharge. At that time, wastewater reuse might become economically competitive.

Table WW14-1. Cost-to-Benefit Analysis Summary

Reuse Alternative	Cost per 1,000 Gallons		Cost per 1,000 Gallons to Produce Potable Water*		Net Cost to Benefit Ratio
1 - GTL Upgrade and Local Area Reuse	$7.02	vs.	$1.75	=	-$5.27
2 - Satellite Treatment and Reuse/Saltwater Intrusion Barrier	$6.29		$1.75		-$4.54
3 - Satellite Treatment and Indirect Potable Reuse	$8.23		$1.75		-$6.48
4 - C-12 and C-13 Canal Interconnect Project	--		$1.75		--
5 - Increased Treatment and 6th Deep Injection Well at GTL to Provide Reclaimed Water Local to GTL	$11.96		$1.75		-$10.21

*It was assumed that the cost to produce potable water at Fiveash is approximately $1.00 per 1,000 gallons, and the cost at Peele Dixie is approximately $2.50 per 1,000 gallons. The table displays an average of these two values.

14.4 Carbon Footprint Analysis

The City is committed to improved sustainability within their wastewater system. A truly comprehensive sustainability effort involves not only water conservation, but energy conservation and efficiency as well. Energy efficiency promotes sustainability because of the reduced emissions of carbon dioxide (CO_2) and other pollutants. The collective sum of pollutants emitted for a particular process is known as its carbon footprint. A carbon footprint analysis was completed for each of the reuse alternatives. In order to complete this analysis, the CUS Master Planning team estimated the energy added and reduced for each alternative in kilowatt hours (kWh). The Team then used a CO_2 emissions factor of 6.85991×10^{-4} tonnes CO_2 per kWh (US EPA, 2015), and converted to US tons. The results are shown in **Table WW14-2** below.

Table WW14-2. Carbon Footprint Analysis

Alternative	Energy Added (Description)		Energy Reduced (Description)		Net Carbon Footprint Reduction (tons CO_2 /day)
	Energy Added (Description)	Energy Added[1] (kWh/day)	Energy Reduced (Description)	Energy Reduced [2] (kWh)	
0 – Status Quo: Potable Water Production	--	0	--	0	0
1 - GTL Upgrade and Local Area Reuse	New RO, MF, UV, disposal, and pumping are required.	4,966	1 MGD less of potable water would need to be treated.	5,784	0.62
2 - Satellite Treatment and Reuse/Saltwater Intrusion Barrier	New treatment processes required to bring water to potable and/or reclaimed standards.	108,575	Providing reclaimed water to places such as FPL, golf courses, etc. would reduce the amount of potable water that needs to be pumped/ treated, and reduce amount of wastewater that GTL needs to treat.	110,181	1.22
3 - Satellite Treatment and Indirect Potable Reuse	New treatment processes required to bring water to potable standards.	45,450	Providing reclaimed water would reduce the amount of potable water that needs to be pumped/ treated, and reduce amount of wastewater that GTL needs to treat.	46,070	0.47
4 - C-12 and C-13 Canal Interconnect Project	None. Since no new pumps or treatment processes are required, negligible energy added.	0	Since this alternative would recharge the Biscayne aquifer with about .1 MGD, there would be no energy savings.	0	0.00
5 – Increased treatment and 6th Deep Injection Well at GTL to provide reclaimed water local to GTL	New RO, MF, UV, disposal, and pumping are required.	1,505	0.3 MGD less of potable water would need to be treated.	2,030	0.40

[1]The estimated energy quantities were obtained from the 2015 *Electricity Use and Management in the Municipal Water Supply and Wastewater Industries* by the Water Research Foundation, and from the 2012 *Electricity Use and Management in the Municipal Water Supply and Wastewater Industries* by the WateReuse Foundation, California Energy Commission, and US Bureau of Reclamation.

14.5 Wastewater Reuse Summary

Carbon footprint analyses and a cost/benefit analysis were performed on the five wastewater reuse alternatives. **Table WW14-3** presents the results of the cost and carbon footprint analyses. All capital costs are in 2015 dollars assuming a three (3) percent inflation rate. The operations and maintenance costs were assumed to be approximately 5 percent of their respective capital costs The CUS Master Planning team drew the following conclusions from this analysis:

- Previous planning efforts determined wastewater reuse as nonviable because it is uneconomical compared to the cost of producing potable water.
- Although wastewater reuse provides intangible benefits such as sustainability and establishment of good relationships with regulatory agencies, implementation of a reuse system would represent a significant, currently unjustifiable, cost investment for the City.
- Alternative 2 showed the highest reduction in carbon footprint, because it would reduce treatment energy for both potable water and wastewater. Alternatives 1 and 5 would reduce 0.62 and 0.47 tons of CO_2 per day, respectively, showing that these alternatives would reduce emissions only slightly. Overall, the carbon footprint analysis shows that wastewater reuse is capable of a small reduction in carbon footprint, even with the addition of new “high energy” processes such as RO.

Based on the above conclusions, the CUS Master Planning Team recommends the following:

- The City should pursue an aggressive program to reduce I&I prior to considering new plant construction and equipment installation.
- The City should continue with implementation of Alternative 4, because it is a low-cost option and could possibly provide a small WUP offset.
- Although Alternative 2 is very costly, the City should revisit this option in the future because it would not only provide reclaimed water to a potential variety of users, but also provide a barrier to saltwater intrusion, which is an important environmental function.
- The City should further explore the opportunity to install an 8” reuse pipe between GTL and the FPL facility. Alternative 5 is beneficial because the industrial waste stream from the proposed treatment facility would not require advanced disinfection for deep well injection. The City should focus on reduction of I/I in order to reduce wastewater flows to GTL before implementing significant capacity improvements such as a 6th deep injection well.

Table WW14-3. Final Comparison of the 5 Alternatives

Alternative[1]	Description	Capital Cost[2]/ Operating & Maintenance Cost per Year	Equivalent Cost per 1,000 Gallons	Capacity (MGD)	WUP Offset[4] (MGD)	Net Carbon Reduction (tons CO_2/day)
1	Increased treatment at GTL to provide reclaimed water local to GTL	$16,230,000 $800,000/yr	$7.02	1	0.5	0.62
2	New satellite scalping WWTP to provide local reclaimed water and injection barrier wells	$170,413,300 $9,000,000/yr	$6.29	12	6	1.22
3	New satellite scalping WWTP to provide indirect potable reuse to the Floridan aquifer	$112,584, 500 $5,800,000/yr .	$8.23	6	3	0.47
4	C12 and C13 Canal	$1,000,000 $10,000/yr.	--	--	0.1	0.00
5	Increased treatment and 6th Deep Injection Well at GTL to provide reclaimed water local to GTL	$16,590,000 $90,000/yr.	$11.96	0.3	0.15	0.40

Assumptions:
[1]Alternative 1: Capital cost was provided from the 2012 Updated Reclaimed Water Feasibility Study and O&M costs were assumed to be 5% of the capital cost.
Alternative 2: Capital Cost and O&M Costs were provided from the 2008 Feasibility Study for the Implementation of Selected Reclaimed Water Projects Within the City of Fort Lauderdale.
Alternative 3: Capital cost was provided from the 2008 Feasibility Study for the Implementation of Selected Reclaimed Water Projects Within the City of Fort Lauderdale and O&M costs were assumed to be 5% of the capital costs.
Alternative 5: Capital and O&M costs were developed from the 2008 Engineering Assistance in Updating Information on Water Supply and Reuse System Component Costs by SJRWMD.
[2]Capital Costs are in 2015 dollars and there was a 3% inflation rate per year assumed to bring the 2008 and 2012 costs to 2015.
[3]Equivalent cost per 1,000 gallons includes both capital and O&M costs.
[4]WUP Offset: The ratio of offset is determined by complex groundwater and hydrology modeling, and was estimated at 50% of the reuse capacity for the purposes of this master plan.

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WW15 Biosolids

15.1 Introduction

Biosolids are the byproduct produced from activated sludge wastewater treatment processes. The activated sludge process converts carbonaceous, oxygen-demanding matter in the wastewater into cell mass that is partially removed each day to sustain the biological treatment process. Biosolids also contain other inert solids present in the wastewater stream including various metals. The City's George T. Lohmeyer Wastewater Treatment Plant's (GTL) produces over 30,000 wet tons of biosolids annually. Biosolids, historically considered as a waste byproduct, contain nutrients valuable for growing agricultural crops. Biosolids are utilized for agricultural purposes when available, with appropriate metals content and following stabilization to minimize vector attraction. Waste-to-energy incineration facilities also use dried biosolids as biofuel, however, the local Wheelabrator incineration facility recently ended acceptance of biosolids due to cleanup and maintenance issues. The City currently sends the GTL biosolids to a contractor for stabilization and disposal via landfilling, incineration or reuse for land application as available and determined by the contractor.

This section evaluates options to reduce the quantities and costs of handling biosolids and increase the sustainability of biosolids management. The CUSMP assessed biosolids handling practices for applicability to the City and identified recommendations to improve biosolids marketability and promote beneficial reuse as a fertilizer, soil amendment, or energy source. The ultimate objective is to reduce wet tonnage hauling costs and reduce the GTL's carbon footprint.

15.2 Existing Biosolids System

Waste activated sludge (WAS) from the GTL's activated sludge treatment process is pumped to onsite WAS storage tanks, decanted for thickening, dewatered on belt filter presses, and then hauled to a contracted facility for further conditioning and disposal or reuse. The Florida Department of Environmental Protection (FDEP) classifies biosolids based on metals concentrations and pathogen and vector attraction reduction criteria as Class B, A and AA. The higher the class, the less restrictions there are on disposal/reuse requirements. Class AA is the highest class and can be used the same as commercial fertilizers with minimal restrictions. The City's biosolids leaving the GTL are unprocessed and therefore unclassified, as Class B pathogen and vector attraction reduction requirements are not achieved. The City's contract hauler processes the biosolids offsite and is responsible for classification and proper disposal/reuse. **Section 8.4.4** of **WW8 Wastewater Treatment Capacity** describes the GTL biosolids system and current practices further.

15.3 Disposal and Hauling Costs

The City has a contract with Biosolids Distribution Services, Inc. (BDS) to haul dewatered biosolids to a BDS Florida Department of Environmental Protection (FDEP) permitted facility for further conditioning and then reuse or disposal. **Table WW15-1** lists a sample of annual hauled wet sludge quantities from 2006 to 2015 and **Table WW15-2** lists the monthly associated hauling costs for 2013 through 2015. The City also has the option of landfill disposal.

With over $2,000,000 spent annually by the City to haul, process and dispose of biosolids, reducing the volume of dewatered biosolids hauled away from GTL would have an immediate economic impact and would reduce GTL's carbon footprint.

Section WW15 accepted February 3, 2017.

Table WW15-1. GTL Historical Biosolids Production Rates

Historical Biosolids Production	
Year	**Total annual wet sludge hauled (tons)**
2006	22,700
2007	23,200
2008	24,700
2009	28,400
2010	30,400
2011	29,400
2012	28,700
2013	30,600
2014	31,500
2015	31,500

Table WW15-2. 2013-2015 Dewatered Biosolids Hauling Cost

Hauling Cost			
Condition	**2013**	**2014[1]**	**2015**
Average Month	$130,696	$194,288	$182,889
Maximum Month	$183,660	$167,600	$201,385
Total Annual	$1,568,353	$2,011,203	$2,194,667

[1] 2014 biosolids cost increase due to contract expiration and renewal.

15.4 Regulatory Requirements

In Florida, biosolids are regulated by the Environmental Protection Agency (EPA) with the Biosolids Rule 40 CFR Part 503 (503 Rule). In addition to federal regulations, the State of Florida has issued its own set of rules for biosolids management and disposal. Chapter 62-640 FAC, Domestic Wastewater Residuals, provides the minimum standards for the treatment of biosolids for land application, distribution, and marketing. Chapter 62-640 FAC also establishes land application criteria and defines the requirements for agricultural practices using biosolids. In general, Chapter 62-640 FAC adopts the pollutant, pathogen, and vector attraction reduction criteria from the Part 503 Rule, however, Florida rules include additional requirements. Brief overviews of the additional requirements that affect operations are provided herein:

Chapter 62-640 FAC Subpart B – Additional Requirements

- In addition to biosolids, regulated nitrogen sources include fertilizers, reclaimed water, and animal manure in establishing land application rates
- FDEP requires a site-specific Nutrient Management Plan (NMP)

Chapter 62-640 FAC Subpart D – Additional Requirements

- Only Class AA biosolids can be marketed and distributed in Florida
- Class AA biosolids do not require a spill response plan, site registration, NMPs, or adherence to land application site criteria

Chapter 62-640 FAC Class AA Biosolids Metal Concentrations

The monthly average biosolids metal concentrations for the previous two years at GTL are below the Class AA pollutant maximum concentration limits (MCLs) as summarized in **Table WW15-3**. Based on the data, stabilized GTL biosolids would meet Class AA requirements for certification as a fertilizer.

Table WW15-3. Biosolids Metal Concentrations

Pollutant	Class AA (mg/kg dry weight)	2013 Monthly Average Concentrations (mg/kg dry weight)	2014 Monthly Average Concentrations (mg/kg dry weight)
Arsenic	41	4.40	5.98
Cadmium	39	0.82	1.02
Copper	1,500	258.25	342.75
Lead	300	15.73	21.08
Mercury	17	0.33	0.40
Nickel	420	11.75	14.90
Selenium	100	3.53	4.68
Zinc	2,800	447.50	591.00

15.5 Biosolids Process Technologies

15.5.1 Dewatering Technologies

The following is a brief overview of biosolids dewatering technologies currently commonly used in the municipal wastewater industry. While other technologies exist, the short-listed technologies are the most prevalent in the industry and can meet or exceed the City's current dewatering solids performance. Advantages and disadvantages of each technology are included to assist in selecting processes for further evaluation.

15.5.1.1 Belt Filter Press

Belt Filter Presses (BFPs) dewater biosolids by pressing the WAS in between special belts to squeeze out water. The remaining dewatered biosolids is referred to as "filter cake". This process reduces the sludge volume and water content prior to landfill disposal or additional treatment, and reduces the potential of biosolids runoff associated with land applications. GTL currently achieves 15% to 20% solids concentration using BFPs. **Table WW15-4** summarizes advantages and disadvantages of using BFPs.

Section WW15 accepted February 3, 2017.

Table WW15-4. Belt Filter Press Dewatering Advantages and Disadvantages

BELT FILTER PRESS	
Advantages	**Disadvantages**
Staffing requirements are low, especially if the equipment is large enough to process the solids in one shift.	Odors may be problematic, but can be controlled with good ventilation systems and using chemicals to neutralize the odor-causing compounds. Some manufacturers offer fully enclosed equipment to minimize odors.
Maintenance is relatively simple and can usually be completed by a wastewater treatment plant maintenance crew.	Belt presses require more operator attention if the feed solids vary in their solids concentration or organic matter. GTL operators maintain a relatively consistent solids feed and have optimized the presses to produce good cake solids (16 to 18%).
Belt presses can be started and shut down quickly compared to centrifuges, which require up to an hour to build up speed.	Wastewater solids with higher concentrations of oil and grease can result in binding the belt filter and lower solids content cake. GTL experiences a normal amount of grease inputs.
There is less energy consumption and noise associated with belt presses compared to centrifuges.	Wastewater solids must be screened and/or ground to minimize the risk of sharp objects damaging the belt.
Belts can be replaced at a relatively small percentage of the equipment cost to extend service life.	Belt washing is required at the end of each shift, or more frequently, which can be time consuming and require significant amounts of water.
There is a new technology (Orege) using compressed air that can improve belt filter press performance by increasing percent solids 2 to 4%, reducing polymer usage 20 to 40% and increasing throughput.	The Orege technology would cost $280,000 per press and there are space limitations in the City's current filter press building. Implementation would likely occur with dewatering equipment replacement.
As newer, more reliable and higher performance belts are available, they are integrated into the existing presses during scheduled belt replacement without changing equipment.	Belt filter press technology has progressed somewhat, mostly with respect to reliability; cake solids performance is similar to that of the City's existing circa 1990's presses. Note that this is also true for the other biosolids dewatering technologies evaluated.

15.5.1.2 Centrifuge

Centrifuges spin biosolids at high speeds in an enclosed bowl to separate solids and liquids. Compared to BFPs, centrifuges can increase the dry solids content by 5 to 10 percent. For the City, solids increases would be in the 5% range based on other Florida utility experience (City of Tampa study). Centrifuges require a smaller footprint and are totally enclosed, which facilitates odor control. However, centrifuges consume more electrical energy than BFPs, so operational costs will be higher than for BFPs. Increased cake solids output versus other dewatering technologies can offset the higher energy costs by reducing hauling fuel/costs and traffic. Centrifuges also require skilled maintenance personnel but do not need continuous operator attention. **Table WW15-5** summarizes the advantages and disadvantages of using centrifuges.

Section WW15 accepted February 3, 2017.

Table WW15-5. Centrifuge Dewatering Advantages and Disadvantages

CENTRIFUGE	
Advantages	**Disadvantages**
Centrifuges outperform conventional BFPs to achieve higher percent solids cake.	Centrifuges consume more electrical power.
Centrifuges require a small amount of floor space relative to their capacity.	Experience operating the equipment is required to optimize performance.
Centrifuges require minimal operator attention when operations are stable.	Visual performance can be difficult to monitor because the operator's view of centrate and feed is obstructed.
Operators experience lower exposure to pathogens, aerosols, hydrogen sulfide or other odors when compared with BFPs.	Special structural considerations must be taken into account. As with any piece of high speed rotary equipment, the base must be stationary and level due to dynamic loading.
Centrifuges are easier to clean than BFPs.	Internal parts are subject to abrasive wear and can be vulnerable to high sand content in biosolids. GTL does experience relatively high amounts of sand due to sewer defects, high I/I and an ineffective grit removal process.
Centrifuges can handle higher design loadings and produce higher solids recovery concentrations with the addition of a higher polymer dosage.	Start-up and shut down may take an hour to gradually bring the centrifuge up to speed and slow it down for clean out prior to shut down.
Major maintenance items can be easily removed and replaced. The manufacturer usually performs repair work.	Centrifuges operations are louder than BFPs operations.

15.5.1.3 Screw Press

Screw presses dewater biosolids through mechanical compression. The screw shaft increases in diameter, with a corresponding decrease in screw vane size, as the biosolids are conveyed from the enclosure inlet to the cake discharge port, resulting in increasing compression to squeeze out the water. Dewatering performance is typically higher than for BFPs when treating waste activated sludge. **Table WW15-6** summarizes the advantages and disadvantages of using screw presses.

Table WW15-6. Screw Press Dewatering Advantages and Disadvantages

SCREW PRESS	
Advantages	**Disadvantages**
Staffing requirements are low, especially if the equipment is large enough to process the solids in one shift.	Need to consider large footprint and height requirements.
Typically, marginally higher cake solids concentrations than BFPs.	Lower cake solids concentrations than centrifuge dewatering.
Enclosed system helps to contain odors.	Typically require high polymer dosing.
Lower power consumption and less noise associated with screw presses compared to centrifuges.	GTL site restrictions may preclude the use of this technology.

15.5.2 Stabilization Technologies

Biosolids stabilization techniques have advanced the last 10 to 15 years with new technologies on the horizon. **Table WW15-7** lists the available technologies and provides the categories selected for further evaluation. While there are over 15 varieties of anaerobic digestion, selecting the specific variety was not the objective. Two phased and temperature phased (TPAD) anaerobic digestion are two of the more common and recently constructed varieties, for example and used for the basis of evaluation.

Composting was not evaluated because of the odor potential with undigested biosolids, and because land requirements are similar to solar drying. Anaerobic digestion would make composting more feasible and the City could potentially collaborate with the landfill to co-compost with yard waste. Miami-Dade Water and Sewer Department (MDWASD) is moving forward with composting some of its biosolids and there is a large composting facility planned in the Pembroke Pines area.

Chemical stabilization is commonly performed by contract biosolids haulers/processors; this category was included in the contract processing/hauling option. The City currently contracts biosolids processing and disposal/reuse. There are emerging companies in Florida such as BCR/NuTerra and VitAg that are providing more robust and reliable stabilization processes and facilities than previously available; the stabilized biosolids product is beneficially reused for fertilizer for agricultural purposes. Indirect thermal drying processes have odor advantages over direct drying processed as biosolids are indirectly exposed to heat via heat exchangers as opposed to direct application of heat. For instance, indirect paddle type dryers introduce steam inside the paddles and heat is transferred to the biosolids outside the paddle via the paddle contact area. Solar drying has the advantage of utilizing renewable energy and low operations cost.

Table WW15-7. Biosolids Stabilization Technologies

BIOSOLIDS STABILIZATION TECHNOLOGIES				
Anaerobic Digestion	**Composting**	**Chemical Stabilization**	**Thermal Drying**	**Combustion/ Oxidation**
• 2 Phased (Acid/Gas) • Temperature Phased (TPAD) • Thermophilic (TAD) • Mesophilic (MAD) • Pre-pasteurized MAD • Auto Thermal TAD (ATAD) • WAS Pre-treated MAD • Series TAD • Vertad • Aerobic/Anoxic • Micronair • Aerobic Thermophilic pretreat • MAD Co-digest • Enzymic Hydrolysis MAD	• Windrow • Aerated Windrow • Open Aerated Static Pile (ASP) • Covered ASP • Enclosed ASP • Membrane Covered ASP • Agitated Bed	• Alkaline (Lime) • Neutralizer (BCR/NuTerra) • Pasteurization (RDP) • Schwing Bioset • VitAg • Lysek	• Indirect (Paddle, Disc, Auger) • Solar • Direct (Drum) • Flash • Vertical Tray • Fluidized Bed • Scalping	• Gasification • Super-critical Wet Oxidation • Fluidized Bed Incineration • Pyrolysis • Vitrification

15.5.2.1 Anaerobic Digestion

Anaerobic digestion produces a stabilized biosolids product and a methane-rich gas byproduct that can be used as a fuel source. Anaerobic bacteria digest volatile organic solids into gas and water by maintaining optimal growth conditions; zero oxygen, abundant assimilable food and higher temperatures. Key components of an anaerobic digestion system include the reaction tank (digester), microorganisms, mixing, and a heat source. A properly designed and operated digestion system will produce biosolids suitable for land application. **Table WW15-8** summarizes advantages and disadvantages of using anaerobic digesters.

Table WW15-8. Anaerobic Digestion Stabilization Advantages and Disadvantages

ANAEROBIC DIGESTION	
Advantages	**Disadvantages**
It is a net energy producing process that produces renewable energy in the form of biogas; the methane energy source can be combusted to reduce net operational costs and consumption of fossil fuels.	Combining the anaerobic process with dewatering produces a high concentration of nitrogen in the filtrate.
High volatile suspended solids are reduced by 40% to 60%: solids destruction results in reduced odors and lower disposal quantities and reduced hauling disposal costs.	The process can be easily upset and recovers slowly from upsets.
Retention times are lower than conventional aerobic digestion.	Requires skilled operators.
Low effluent biological oxygen demand (BOD).	Safety concerns with handling gas.
High pathogen reduction and produces Class A/AA biosolids.	Large footprint – no room at GTL to construct.
Reduces total biosolids mass.	High capital cost.
Ambient temperatures in Fort Lauderdale would minimize heating requirements.	Can require additional fats, oils and grease to maximize energy production.

15.5.2.2 Thermal Hydrolysis

Thermal hydrolysis is a treatment option that applies pressure and temperature to residuals prior to anaerobic digestion. The thermal hydrolysis pretreatment (THP) conditions biosolids by fracturing cellular material and long-chain fatty acids which make the biosolids more conducive to downstream digestion and dewatering processes. After digestion, the biosolids are dewatered to produce a cake that typically exceeds 30% total solids concentration. **Table WW15-9** summarizes the advantages and disadvantages of using thermal hydrolysis.

Table WW15-9. Advantages and Disadvantages

THERMAL HYDROLYSIS	
Advantages	**Disadvantages**
Improves anaerobic digestion process allowing higher loading rates and increases biogas production.	Requires constructing anaerobic digesters – no room to construct at GTL.
Increased cake solids content after dewatering.	Thermal hydrolysis with anaerobic digestion is a complex process.
Reduces the amount of biosolids produced.	Equipment involves complex processes that require specialized operator training.
Provides Class AA product when combined with anaerobic digestion.	Additional capital cost and use of energy for pressure and thermal needs that would negatively impact the City's commitment to reduce its electrical usage 20% by 2020.

15.5.2.3 Alkaline Stabilization

Alkaline Stabilization/Lime Stabilization involves raising the pH of sludge (often by adding lime) to reduce levels of pathogenic bacteria and viruses in sludge. Lime stabilized biosolids are generally suitable for agricultural application. Generally, lime stabilization is not a proprietary technology, though several manufacturers provide variations of the basic process. Typical equipment includes a wastewater solids feed/conveyance mechanism, lime storage, lime transfer conveyor, mixer, and air emission control equipment to minimize odors and dust. Designing a facility to meet Class A stabilization requirements may require additional lime storage to allow an increased lime dose, additional curing capacity, and/or the provision of supplemental heat. **Table WW15-10** summarizes the advantages and disadvantages of using the alkaline stabilization process.

15.5.3 Drying Technologies

15.5.3.1 Thermal Drying

Thermal drying uses heat to remove water from partially dewatered solids, resulting in both volume and weight reduction. Dewatered biosolids are conveyed to the drying system where the temperature of the wet solids mass is raised and most of the water is removed via evaporation, resulting in a product with approximately 90% or higher total solids. The process temperature is controlled to prevent oxidation (burning) of the organic matter. **Table WW15-11** summarizes the advantages and disadvantages of thermal drying.

Thermal dryers use either direct or indirect heat. For direct heat thermal dryers, hot air flows through the process vessel and comes into direct contact with the wet solids. With indirect heat thermal dryers, solid metal walls separate the wet solids from the heat transfer medium (steam, hot water, or oil). The availability of a significant waste heat source, e.g., from the adjacent Florida Power and Light power plant would make thermal drying more cost effective and energy efficient.

WW15-10. Advantages and Disadvantages

ALKALINE STABILIZATION	
Advantages	**Disadvantages**
Consistent with the EPA's national beneficial reuse policy producing a product suitable for a variety of uses and is usually marketable.	Wet weather operations are more complex, limited land application opportunities in South Florida.
Simple technology requiring few special skills for reliable operation.	The volume of material to be managed and moved off-site is increased by approximately 15 to 50% versus other stabilization alternatives resulting in higher hauling and disposal/reuse costs.
Construct from readily available parts.	There is potential for odor generation both at the processing and end use site.
Small land area required.	There is a potential for pathogen regrowth if the pH drops below 9.5 while the material is stored prior to use.
Flexible operation; easily started and stopped.	Increased carbon footprint, lime production is an energy intensive process.
--	Safety and liability issues with storing and handling lime including dust exposure.

Table WW15-11. Advantages and Disadvantages

THERMAL DRYING	
Advantages	**Disadvantages**
Requires a relatively small footprint compared with other stabilization processes, such as composting, alkaline stabilization, and air drying/long term storage.	Requires a large amount of energy-the system can require 1,400 - 1,800 British thermal units (BTU) per pound of water evaporated.
Can be designed to accept a variety of feed material characteristics	Potential explosive hazard from dust generated in the drying process.
Greatly reduces the volume of material that needs to be transported. The typical heat dried product is at least 90 percent solids, compared to 18 percent solids currently produced by mechanical dewatering operations.	Generates dust that can affect plant workers and neighbors in the local community and must be controlled to avoid problems during storage and transport of the product.
Reduces traffic into and out of a facility because of the smaller volume of the final biosolids product.	Requires systems that are relatively complex in comparison with other solid-processing systems and needs skilled laborers for operation and maintenance.
Generates a readily marketable, Class A/AA product.	Adds additional costs to solids treatment system.
The dry product can have more potential reuses than the current wet cake, e.g., as landfill cover supplement.	Drying undigested sludge may cause odor issues at the treatment site and at land applications if the final materials are rewetted.

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15.5.3.2 Solar Drying

Solar drying uses the sun's energy and minimal mechanical turning to remove water from dewatered solids, resulting in both volume and weight reduction. Dewatered biosolids are conveyed to a greenhouse structure for turning; most of the water is removed via evaporation, resulting in a product with 75% to 90% total solids. The greenhouse is vented to maintain optimum drying conditions and odor control is often not required. **Table WW15-12** summarizes the advantages and disadvantages of solar drying.

Solar dryers utilize the ambient heat produced from the sun and the greenhouse effects. South Florida ambient temperatures and sunshine are ideal for solar drying. While solar drying using greenhouse effects is a relatively new technology; there are multiple operating facilities in Europe, South America and the United States.

Table WW15-12. Solar Drying Advantages and Disadvantages

SOLAR DRYING	
Advantages	**Disadvantages**
Utilizes the sun's energy and very low energy associated with turning the biosolids.	Requires a large footprint, approximately 4 acres to achieve 75% solids for the City.
No prior sludge digestion/stabilization is required resulting in significant capital and operational savings.	Requires construction of a greenhouse facility offsite.
Greatly reduces the volume of material that needs to be transported. The typical solar dried product is at least 75 percent solids, compared to 18 percent solids currently produced by mechanical dewatering operations.	Would require conveyance/transportation offsite.
Reduces traffic into and out of a facility because of the smaller volume of the final biosolids product.	Drying undigested sludge may cause odor issues at the treatment site and at land applications if the final materials are rewetted.
Can produce a readily marketable, Class A/AA product.	Maintenance of large greenhouse facility.
The dry product can have more potential reuses than the current wet cake, e.g., as landfill cover supplement.	--
Very simple operation and maintenance.	--

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15.6 Biosolids Process Improvements Alternatives Evaluation

This section of the report evaluates biosolids process improvements alternatives using the technologies described herein. Based upon an evaluation of the advantages and disadvantages listed for each unit process, the following technologies were not pursued any further in the alternatives evaluation:

Alkaline Stabilization. The use of lime increases operation costs and carbon footprint and is therefore, not in alignment with the City's strategic initiatives. This technology may not reduce disposal costs, has wet weather operations issues and had an unsuccessful past experience for the City. It is acknowledged and accepted that contracting companies such as BCR/NuTerra have similar, enhanced chemical stabilization processes that have been successfully used; this technology would be acceptable for contract situations over the next 5 years.

Thermal Hydrolysis Technology. Thermal hydrolysis would be an additional cost to constructing new anaerobic digesters. In addition, to our knowledge, there is only one operating facility in the United States, at the District of Columbia Blue Plains WWTP. The evolution of this technology needs to monitored and evaluated further in a future study.

Screw Press. The large footprint required for construction would not fit within the limited space available at GTL.

All alternatives included the assumption of continued contract hauling, processing (as needed) and disposal. It was assumed that if a Class A or AA, dried biosolids material was produced that contract hauling, processing and disposal costs would be reduced 25 percent versus current disposal rates.

15.6.1 Alternative 1 – Renew Belt Filter Presses

Alternative 1 is to continue to use to the existing GTL dewatering facilities and contract out the hauling and treatment of biosolids at a Residual Management Facility (RMF). According to the City's Community Investment Plan (CIP) fiscal years (FY) 2016-2020, the seven BFPs located at GTL are scheduled for replacement during the fiscal years 2018 to 2020. Refer to **Table WW15-13** for the replacement schedule and cost.

Table WW15-13. BFP Replacement Schedule

BFP Replacement Schedule	
FY	**Replacement Cost**
2018	$843,367
2019	$843,367
2020	$843,367
Total	**$2,530,101**

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Based upon 2015 average monthly biosolids disposal fees, the projected annual cost for hauling and disposing of biosolids is approximately $2.2 million dollars. Prior to renewing the BDS contract, it is recommended the City consider qualifying alternative biosolids treatment operators for bidding if their technologies and operations could minimize costs and reliably meet City standards and regulatory requirements. The following are examples of biosolids treatment companies operating in the south Florida area:

- Synagro – recycled biosolids fertilizer
- ViTag – produces ammonium mix fertilizer from biosolids
- BCR/NuTerra - recycled biosolids fertilizer (provided proposal)

There are other companies offering various technologies for biosolids treatment and disposal. A comprehensive list of available operators should be developed prior to hauling and treatment contract renewal. GTL also has the ability to dispose of biosolids in landfills. This option should be kept open considering fewer nearby counties in south Florida are willing or have significant land available to accept classified biosolids for reuse via land application.

15.6.2 Alternative 2 – Renew BFPs with Compressed Air Enhancement

A new compressed air addition technology to improve BFP performance is available and its early stages of implementation. The company's name is Orege and the technology injects compressed air into the biosolids prior to dewatering. The Orege technology has increased percent solids output at other BFP facilities by three percent, reduced polymer consumption and increased throughput. Based on preliminary conversations with Orege the GTL would need 4 compressed air units at a cost of about $1.1M in equipment and a total capital cost of $3.0M. Orege is projecting an increase of 3% cake solids from 18% solids to 21% solids. The compressed air enhancement could reduce contract biosolids wet weight by approximately 15% thereby reducing annual contract hauling costs accordingly. This technology could possibly offset the need to consider higher energy consuming centrifuges for dewatering. The compressed air enhancement should be pilot tested to quantify the benefits and potential payback period.

15.6.3 Alternative 3 – Replace BFPs with Centrifuges

As discussed in the Dewatering Technologies section, centrifuges produce a higher solids content cake than BFPs, have a smaller footprint, and are enclosed to reduce odors. Centrifuges could reduce contract biosolids wet weight by 22% thereby reducing annual contract hauling costs accordingly. The downside is higher energy consumption that is counter to the City's strategic initiative goals to reduce power consumption. The City should consider pilot testing this technology to confirm achievable percent solids output prior to BFP replacement.

15.6.4 Alternative 4 – Anaerobic Digestion and Thermal Drying

Anaerobic digesters would be sized and constructed to meet present and projected solids handling requirements. The digested solids would be dewatered with BFPs or centrifuges prior to a thermal dryer to produce Class AA biosolids. This alternative would meet the City's goals of reducing biosolids wet tonnage and producing a beneficial reuse product. GTL should consider looking into the future availability of property adjacent to the plant to accommodate the additional space required to make this alternative feasible. For example, in the spaces between the deep injection wells there may be room to locate three 100 foot diameter tanks or there may be room available in the adjacent tank farm for use. Piping between the tanks and the GTL would be required as well as thickening to minimize digester size. Anaerobic Digestion was assumed to reduce dry solids approximately 50% through digestion. Digester gas would be captured, cleaned and used to offset approximately 30% of the thermal dryers' thermal energy needs. The addition of fats, oils and grease to the digesters would increase gas production further. Dewatering capacity would be reduced significantly by the solids destruction and thickened digester effluent.

15.6.5 Alternative 5 – Thermal Drying

An indirect thermal dryer would be installed to treat the biosolids from the existing (or replaced) BFPs. This would reduce hauling costs while avoiding the space requirements and costs of constructing anaerobic digesters. Similar to the existing dewatering process, this alternative would not realize the benefits of biosolids digestion (reduced conditioning, volume and odors). This alternative is energy intensive and would be more attractive if waste heat was available from the neighboring power plant. Thermal drying would reduce contract biosolids wet weight by 85% thereby reducing annual contract hauling costs from over $2,000,000 to less than $500,000. The dry product can have more potential reuses than the current wet cake, e.g., as a landfill cover supplement. The negative is the use of fossil fuel to dry the biosolids and the annual energy costs.

15.6.6 Alternative 6 – Solar Drying

The City of Fort Lauderdale has an ideal climate for solar drying. A solar dryer would be installed offsite to treat the biosolids from the renewed BFPs. Solar drying would reduce hauling and disposal costs while avoiding the capital and operations cost associated with stabilization; e.g., anaerobic digesters. Solar drying would increase the stability of the finished product and Class A product classification has been achieved by other facilities. This alternative would require approximately 4 acres of enclosed greenhouse land. Dewatering requirements would be similar to Alternative 1. Solar drying would reduce contract biosolids wet weight by 82% thereby reducing annual contract hauling costs from over $2,000,000 to less than $500,000. The dry product can have more potential reuses than the current wet cake, e.g., as landfill cover supplement. Transfer of the dewatered biosolids would be necessary from the GTL to the solar drying facility by contractor or City trucks. The facility could be implemented in four, one-acre phases to test efficiency.

15.6.7 Alternative 6 – Anaerobic Digestion Only

This alternative is similar to Alternative 4 without the thermal dryer. The issue with thermal dryer is net fossil fuel consumption above the biogas produced in the anaerobic digester. One possible addition to this anaerobic digestion alternative, potentially phased for the long term, is struvite harvesting. Wastewater treatment plants with anaerobic digestion can have maintenance issues with the precipitation of struvite, a phosphorus compound that combines with calcium and magnesium to form a persistent precipitant that must be cleaned and removed from biosolids processing equipment. While relatively new, several companies have implemented technologies to trigger phosphorus release from the biosolids, then recover the phosphorus in the form of struvite that is a desirable, stable, slow release fertilizer. Some struvite removal processes include a component that reduces biosolids volume up to 20% and all struvite removal reduces maintenance on biosolids processes including the digesters, holding tanks and dewatering equipment and can increase the dry solids output of the dewatering processes by up to 4 percentage points (according to manufacturer claims). The removal of phosphorus has demonstrated improved dewaterability at other struvite recovery facilities and pilot tests. The resulting struvite is a dry marketable product that can be used by the City, distributed to customers or sold.

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MDWASD recently pilot tested struvite removal processes. Ostara, Multiform Harvest, NuReSys, Phosphaq and Crystalactor are some of the companies providing struvite harvesting technologies and equipment. One con of the struvite removal is the need to feed Magnesium to seed the harvest. It is theoretically possible to utilize Peele Dixie concentrate or a nanofiltered seawater reject to alternatively provide the magnesium seed. The logistics and costs require further, more detailed evaluation and knowledge of the MDWASD experience.

15.6.8 Treatment Alternative Comparison

Table WW15-14 compares cost and feasibility for biosolids improvement alternatives. Estimated capital and O&M costs were converted to annualized costs for ease of comparison of alternatives. Feasibility rankings were based on equipment and property acquisition required, space allocation, hauling cost, and energy cost. For the feasibility scale, a scoring of 5 black circles represents the highest (excellent) ranking; 1 black circle represents the lowest (poor) ranking. As energy prices are predicted to increase 50 percent over the 20-year study period a sensitivity analysis was performed. Figure WW15-1 shows the annual operating cost for each biosolids alternative projected to increase 50% over time. Figure WW15-2 shows the total equivalent annual cost, which includes amortized capital costs, for each biosolids alternative projected to increase 50% over time.

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Table WW15-14. Biosolids Improvement Alternatives Comparison

Alternative	Advantages	Disadvantages	Estimated Annualized Cost[1]	Feasibility Scale (1=Poor, 5=Excellent)
1-BFPs Renewal	• Lowest Capital Cost	• Highest wet hauling quantity	$2,688,000[2]	4
2-BFP Renewal + Compressed Air	• ~15% reduced hauling costs vs. status quo Reduced polymer	• Orege (compressed air) requires $3M capital investment	$2,597,000[2]	4
3-Replace BFPs with Centrifuges	• ~22% reduced hauling costs vs. status quo • Reduced installation footprint	• Higher energy costs than BFPs • Potential abrasion issues with higher sand content • 2nd highest wet hauling quantity	$2,562,000[3]	4
4-Anaerobic Digestion + Thermal Drying	• ~93% reduced hauling costs vs. status quo • Generates methane energy source	• 2nd highest capital cost alternative • Requires land acquisition or utilization of deep well site • Energy input required	$2,910,000[4]	3
5-Thermal Drying	• ~85% reduced hauling costs vs. status quo Can utilize waste heat • Small footprint, can likely fit on GTL site	• High energy input required • Higher odor potential • Explosion dangers	$2,839,000[5]	4
6-Solar Drying	• ~82% reduced hauling costs vs. status quo Low energy required • Stabilized end product • Uses the sun's energy	• Requires 4 acres of land • Highest capital cost alternative	$2,926,000[6]	3
7-Anaerobic Digestion	• ~50% reduced hauling costs vs. status quo • Generates methane energy source	• 2nd highest capital cost alternative • Requires land acquisition or utilization of deep well site	$2,571,000[7]	3

Notes:

[1] Capital and operation and maintenance costs (2016 dollars) were converted to equivalent annual costs assuming 30-year service life and 5% cost of money. Capital and operating costs were derived from other similar planning efforts, recent construction projects and information from equipment manufacturers and installation costs estimates updated to January 2016 RS Means index value of 207.2. Sources include Basis of Design Biosolids Processing Facility, Miami-Dade County Water and Sewer Department (2015), City of Raleigh, Biosolids Master Plan Update (2013), City of Tampa Dewatering Pilot Test Comparison, (2014), City of Tampa Biosolids Master Plan Update (2013), Orange County Utilities Biosolids Master Plan (2012), City of St. Petersburg Biosolids Design-Build (2015), Franklin WRF Solar Drying Pre-Selection (2015), various vendor provided information including BCR/NuTerra Price Proposal, Orege Cost Information and in-house cost data. Capital costs estimates include equipment, installation, administrative, engineering and contingency costs.

[2] Base BFP operations and maintenance costs based on existing operating and published data assumed to be $42 per dry ton. Compressed air enhancement assumed to increase solids output 3% and reduce operating cost 12%.

[3] Assumes centrifuge operating and maintenance cost of $95 per dry ton.

[4] Assumes anaerobic digestion annual O&M costs of $8 per dry ton and assumes heating requirements supplied by gas production. Cost for combined heat and power systems not included. Assumes thermal drying operating and maintenance cost of $69 per dry ton and thermal fuel cost of $134 per dry ton assuming digester gas would supply 30% of the required amount understanding that digester gas would require processing and cleaning. Thickening operations and maintenance costs assumed at $40 per dry ton. $1.6M of capital cost added for offsite piping and digesters assumed to be located on deep injection well site.

[5] Assumes thermal drying operating and maintenance cost of $69 per dry ton and thermal cost of $191 per dry ton.

[6] Assumes solar drying operating and maintenance cost of $22 per dry ton.

[7] Assumes anaerobic digestion annual O&M costs of $8 per dry ton and assumes heating requirements supplied by gas production. Cost for combined heat and power (CHP) systems not included. Benefits of power generation not included. Thickening operations and maintenance costs assumed at $40 per dry ton. $1.6M of capital cost added for offsite piping and digesters assumed to be located on deep injection well site.

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Figure WW15-1. Annual Operating Cost Biosolids Alternatives Comparison

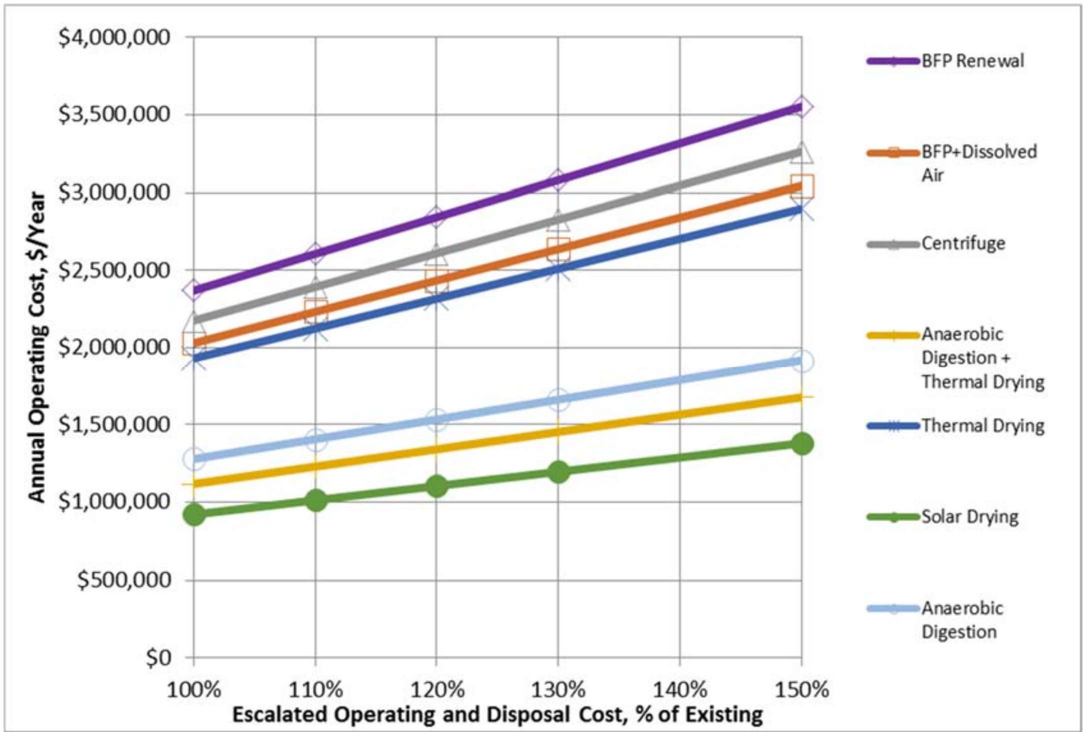
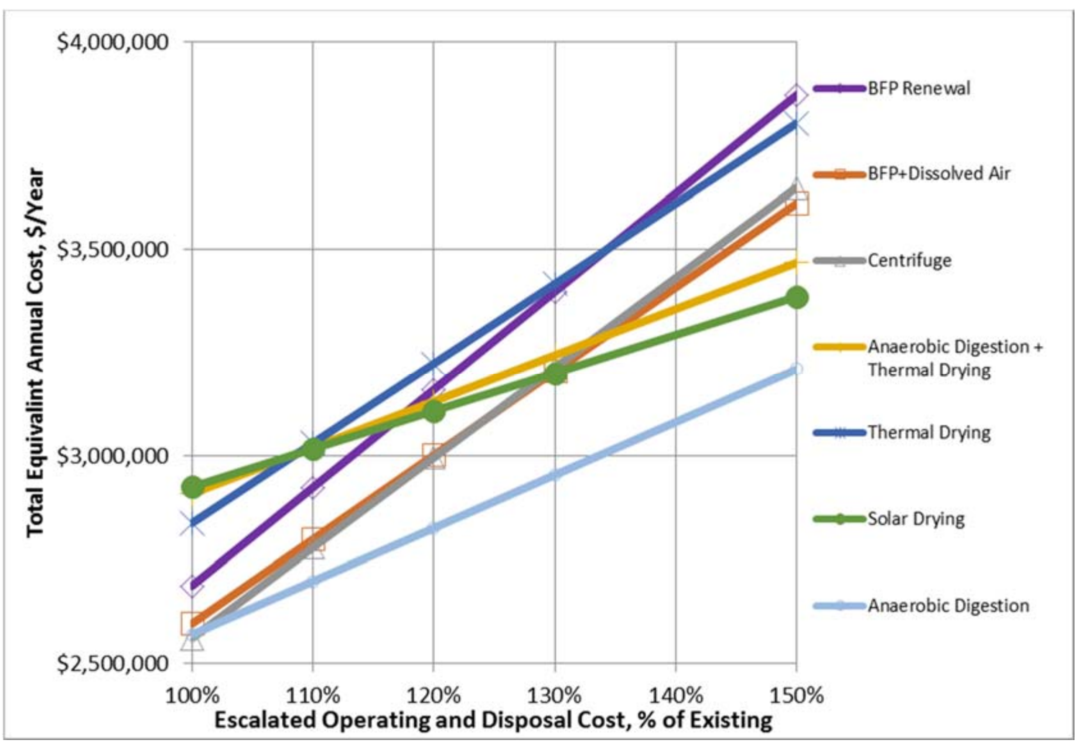


Figure WW15-2. Total Equivalent Annual Cost Biosolids Alternatives Comparison



The biosolids cost evaluation figures show that anaerobic digestion and solar drying have the lowest annual operating costs. BFP renewal, BFP + dissolved air, centrifuges and anaerobic digestion have the lowest equivalent annual costs currently (essentially equivalent). The impact of escalating power and biosolids disposal costs in the future leaves the City's current method vulnerable to the highest cost escalations. Anaerobic digestion (without thermal drying) has the lowest equivalent annual cost over the study period and solar drying also protects the City against escalating operating costs. Not coincidentally, anaerobic digestion and solar drying are the most environmentally sustainable and "green" long term solutions. **Table WW15-15** provides a cost breakdown of the evaluation.

Table WW15-15. Biosolids Alternatives Comparison Cost Breakdown

	Category	BFP Renewal Alt. 1	BFP + Compressed Air Alt. 2	Centrifuge Alt. 3	Anaerobic Digestion + Thermal Drying Alt. 4	Indirect Thermal Drying Alt. 5	Solar Drying Alt. 6	Anaerobic Digestion + BFP Compressed Air Alt. 7
Biosolids Input	Biosolids input (dry ton per year)	5,355	5,355	5,355	5,355	5,355	5,355	5,355
	Biosolids input (dry lb per day)	29,342	29,342	29,342	29,342	29,342	29,342	29,342
Construction and Capital Cost	Total Material and Construction Cost	$2,565,000	$4,565,000	$3,111,000	$9,524,000	$4,733,000	$13,558,000	$4,791,000
	Engineering, Adminstrative, Legal (20%)	$513,000	$913,000	$622,000	$1,905,000	$947,000	$2,712,000	$958,000
	Contingency (25%)	$641,000	$1,141,000	$778,000	$2,381,000	$1,183,000	$3,390,000	$1,198,000
	Program Managment (10%)	$257,000	$457,000	$311,000	$952,000	$473,000	$1,356,000	$479,000
	Thickening/Dewatering/Piping Project Cost	$0	$0	$0	$7,559,000	$3,976,000	$3,976,000	$8,671,000
	Total Capital Cost	**$3,976,000**	**$7,076,000**	**$4,822,000**	**$22,321,000**	**$11,312,000**	**$24,992,000**	**$16,097,000**
Annual Disposal Quantities and Cost	Dry tons Contract Disposed per year	5,355	5,355	5,355	2,678	5,355	5,355	2,678
	% Solids Contract Disposed	17.5%	20.5%	22.5%	90.0%	90.0%	75.0%	20.5%
	Wet tons Contract Disposed per year	30,600	26,122	23,800	2,975	5,950	7,140	13,061
	Unit Contract Disposal Cost, $/wet ton	$ 70.00	$ 70.00	$ 70.00	$ 52.50	$ 52.50	$ 52.50	$ 70.00
	Contract Disposal Cost, $/Year	$ 2,142,000	$ 1,829,000	$ 1,666,000	$ 156,000	$ 312,000	$ 375,000	$ 914,000
	O&M Costs, $/Year	$227,000	$200,000	$ 509,000	$ 622,000	$ 1,392,000	$ 119,000	$65,000
	Dewatering/Thickening/Offsite O&M Cost, $/year	$0	$0	$0	$ 340,500	$ 227,000	$ 427,000	$300,000
	Total Operating Cost, $/year	**$2,369,000**	**$2,029,000**	**$2,175,000**	**$1,118,500**	**$1,931,000**	**$921,000**	**$1,279,000**
	Capital Equivalent Annual Cost, $/Year	$319,000	$568,000	$387,000	$1,791,000	$908,000	$2,005,000	$1,292,000
	Total Annual Cost, $/Year	***$2,688,000***	***$2,597,000***	***$2,562,000***	***$2,910,000***	***$2,839,000***	***$2,926,000***	***$2,571,000***

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15.7 Summary and Recommendations

GTL dewatered biosolids are currently hauled off-site for processing and disposal by an independent contractor. The City is seeking to reduce the quantities and costs of handling biosolids, while reducing GTL's carbon footprint and promoting beneficial reuse. To meet the City's goals, the CUS Master Plan Team evaluated improvements to existing treatment processes and current contract hauling and disposal operations. Viable biosolids processing technologies and practices including dewatering, stabilization and drying were considered and evaluated. Seven alternatives were formulated and compared for feasibility and annualized costs.

The CUS Master Plan team drew the following biosolids conclusions:

1. The existing approach of belt filter press dewatering and contract hauling, processing and disposal is currently cost effective on an equivalent annual basis but has high annual costs and leaves the City vulnerable to future price increases and negative press incidents like Broward County experienced in 2015. In December 2015, Broward County's biosolids made the news for disposing on a site in another county that had no agricultural operations and was creating ponding and odor issues. While the City is likely protected via its biosolids contract, the risk of bad publicity and litigation is significant.

2. Anaerobic digestion and solar drying have significantly lower operating costs versus the other biosolids alternatives, especially considering escalating energy and biosolids disposal costs (see previous Figure WW15-1). These technologies have the lowest life cycle costs over the CUSMP planning period and are the most environmentally sustainable and "green" technologies available. The challenges with anaerobic digestion are capital cost, space at the existing GTL site, risk of pumping biosolids to and from the offsite location, and the addition of a thickening process. The challenges with solar drying are land requirements and capital cost.

3. Centrifuges would reduce contract hauling, processing and disposal costs but have higher capital costs, higher polymer consumption, higher operator training and resultant higher labor costs, and significantly higher energy consumption. Higher energy is not in alignment with City strategic initiatives, yet if solids output higher than 25 percent could be consistently demonstrated and achieved, these energy costs would be offset in reduced contract trucking costs.

4. There are emerging companies interested in collaborating with the City to contract process biosolids onsite and beneficially use for commercial agriculture. This is a step up from offsite processing but creates risks for the City regarding site access and use and potential odors. The chemical stabilization processes typically employed by companies are typically energy intensive or involve lime and may not be sustainably cost effective long term.

5. An emerging technology is available that maximizes belt filter press solids output and minimizes operating cost using compressed air injection. This technology could potentially offset the need to move to higher energy consuming centrifuge technology.

6. Thermal drying would reduce contract hauling, processing and disposal costs dramatically, however, the net consumption of fossil fuels even with the input of digester biogas is not in alignment with City strategic initiatives. The availability of significant waste heat from the nearby power plant would make this alternative much more feasible.

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7. Energy Performance Contracts (EPCs) are available to help with funding of capital intensive, energy saving projects. However, the City would minimize total cost by self-financing.

8. While other emerging biosolids technologies are available, such as struvite removal, this section focused on the major technical decisions associated with biosolids processing.

9. It is acknowledged that composting is a viable biosolids processing technology and is used by contractors and other utilities. Because the City's biosolids are not digested, this technology was discounted, but is similar to the solar drying alternative.

The CUS Master Plan team recommends the following biosolids plan and actions:

1. Proceed with either solar drying or anaerobic digestion for biosolids processing as follows:
    a. Perform siting studies for anaerobic digesters, possibly at the deep well site, and solar dryers, located offsite. Digester siting should consider that the well site is coming under the ISO 14001 umbrella, off-site staffing challenges and the risk to the monitoring wells and the pipes underground including impact of heavy construction on the wells and piping, impact of heavy construction on the monitoring wells, contractor logistics entering the port to retrieve the sludge, etc.
    b. Perform a detailed cost estimate to self-construct a solar drying facility to process biosolids including grant and private funding availability. Reserve 4 acres of land at the meter site or another similar site; this analysis assumes the City has the land available. Solar drying requires higher capital cost and land requirements but would reduce the City's biosolids contract disposal costs by approximately $1,500,000 annually. Self-construction of a solar drying facility could potentially reduce the capital cost to $16,500,000 or less (versus the estimated $21,500,000 capital cost, excluding BFP renewal) this option would be the most cost efficient life cycle project and meet the City's green strategic initiatives as the sun's energy is utilized. The solar drying could also be phased in one-acre increments to conserve capital. Planning should consider the risk of biosolids transfer to the site, siting opposition and odor control and site aesthetics.
    c. Alternatively and dependent on the results of the siting effort, move forward with implementation of anaerobic digesters. To be confirmed in preliminary design, approximately 2.5 to 3.0 million gallon digester capacity would be required plus redundancy at 3% thickened feed. Perform a detailed analysis on a cost effective thickening/dewatering plan.

2. Pilot test centrifuge versus belt filter press and belt filter press with Orege dewatering to confirm/refine dry cake percentages, polymer usage, throughput and the cost comparison presented herein. Based on the pilot results and considering the City's strategic initiative to reduce power consumption make a final decision.

3. Consider rehabilitating the existing BFPs, building and facilities to last 5 more years to delay the planned replacement. This provides capital cost savings and flexibility to shift to a more efficient biosolids processing technology immediately.

4. In the short term, continue contracting biosolids hauling and disposal. At the end of the current contract, issue a new RFQ to see if alternative biosolids handling operators have

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technologies available to further reduce costs and meet increasingly strict regulatory requirements. One such technology to include in the next biosolids hauling/disposal bid is BCR's technology that converts biosolids into a reusable product for commercial agricultural application.

5. Discuss the possibility of a regional biosolids processing facility with Broward County. This was attempted 2006 with the City of Plantation as the lead agency. Ten interested parties conducted the 2006 study but did not move forward; however, increasing costs, current regulations and decreasing land availability may generate renewed interest.

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WW16 Wastewater Energy Conservation

16.1 Introduction

The City has set goals as part of its Sustainability Action Plan (2013) to reduce power consumption 20% by the year 2020. Based on the wastewater system, including the George T. Lohmeyer (GTL) wastewater treatment facility being one of the City's highest energy consumers, the potential for reducing energy used by these facilities is high. This task includes evaluating methods of saving energy throughout the wastewater system including: energy usage associated with the wastewater collection and transmission system, the wastewater treatment systems, and the effluent disposal system. Potential energy savings by equipment replacements, operational and maintenance changes, and utilization of renewable energy or alternative fuels are considered. An evaluation of potential energy savings for building envelopes (cooling and lighting) and site lighting is also provided.

As discussed in Section WW1, infiltration and inflow (I/I) into the sanitary sewer collection/transmission system is significant (approx. 50% of influent flows). The energy used to pump and treat the excess flows is also significant. Longer pump run times throughout the system at higher flows and additional oxygen demands both contribute to additional energy being used to pump and treat the excess flows. The CUS Master Plan Team recommendations for reducing the amount of I/I as presented in Section WW3 are critical for reducing energy for the wastewater collection and treatment system.

The City is also considering refurbishing the existing cryogenic oxygen generation system or replacing with a vacuum/pressure swing absorption system (VPSA). An evaluation of the cost efficiency for replacing the existing system with a VPSA system is included.

Based on the above evaluations, recommendations for meeting the City's energy reduction goals are provided in the 20-year Community Investment Plan (CIP) section (WW9).

16.2 Wastewater Collection/Transmission System

16.2.1 Description

The City's collection/transmission system consists of gravity sewers which convey flows to pump stations that pump the wastewater flows to the GTL facility through a series of force mains and secondary pump stations.

There are approximately one hundred and eighty nine (189) wastewater pump stations which convey wastewater to the GTL facility based on information from City staff. Three (3) of the stations are larger "re-pump" stations which receive flows from multiple upstream stations and pump the wastewater to the GTL facility.

The combined total power consumption of the pump stations is approximately 9,803,000 kWh per year based on averages of power-company billing records for the years 2013 and 2014. This equates to an energy cost of approximately $784,000 per year based on the current electrical rate of $0.08/kWh for the facilities.

As indicated in paragraph 16.1, the amount of I/I entering the collection system is significant. While the inflow increases overall pump run times, the infiltration during rain events causes peak flows and pressures in the force main system which create high head pumping conditions thereby increasing the amount of energy used by the pumps.

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The City has a variety of pump station types which include: duplex stations (2 pumps) with similar size pumps, triplex stations (3 pumps) with similar size pumps, quadplex stations (4 pumps) with similar size pumps, or stations with a small pump, a medium size pump, and a larger pump. There are also a few stations with smaller “jockey” pumps and duplex pumps the same size.

16.2.2 Equipment Replacement

Other than the re-pump stations, most of the City’s existing wastewater pump station (WWPS) pumps currently operate based on fixed speeds and on/off levels in the wet wells. Stations other than the re-pump stations that currently have variable frequency drives (VFDs) are still programmed for fixed speed operation according to City staff. Installing VFDs and programming to control wastewater pump motor speeds to operate based on maximizing the usage of the wet well volumes (to equalize/reduce peak flows) can reduce energy costs for not only the pump stations but also for the GTL treatment facility. It is estimated that there is a 15% energy loss by the remote pump stations due to un-equalized peak flows in the system. As presented later in this report, the same is true for the GTL effluent pumps due to a lack of flow equalization at the plant. Portions of this 15% loss for both the remote pump stations and the GTL effluent pumps can be recovered with equalization of the collection system flows.

Focusing on the larger power consumers among the stations was considered by the CUS Master Planning Team to be critical to achieving the City’s goal of 20% energy reduction by the year 2020. **Table WW16-1** below lists the stations representing 81% of the energy consumption for the remote pump stations including the re-pump stations that consume approximately 25% of the total energy usage by the collection/transmission system facilities.

Table WW16-1. Forty (40) Highest Energy-Consuming Pump Stations

No.	Station	Type	Annual Energy Use[1] (kWh/Year)
1	B Re-pump[2]	Re-pump	1,653,000
2	A Re-pump[2]	Re-pump	657,000
3	A-7[2,3]	Triplex	637,000
4	A-11[3]	Triplex	258,000
5	A-21[2,3]	Duplex	234,000
6	B-4[3]	S/M/L	229,000
7	A-18[2]	Duplex	224,000
8	A-29	S/M/L	221,000
9	A-22	S/M/L	212,000
10	A-41[3]	Duplex	210,000
11	B-2[2]	Quadplex	178,000
12	A-19[2]	Triplex	171,000
13	D-43	Triplex	168,000
14	A-28	Jockey w/Duplex	163,000
15	B-10[3]	S/M/L	161,000
16	A-27	S/M/L	157,000
17	D-37[2,3]	Triplex	152,000
18	B-14[2,3]	Duplex	149,000
19	A-12[3]	S/M/L	142,000
20	B-9	Triplex	133,000

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No.	Station	Type	Annual Energy Use[1] (kWh/Year)
21	B-11[3]	S/M/L	132,000
22	A-14	Duplex	127,000
23	A-17[2]	Duplex	116,000
24	B-6	Duplex	116,000
25	E Re-pump[2]	Re-pump	115,000
26	A-36[2]	Duplex	113,000
27	D-40	Duplex	112,000
28	D-31[3]	S/M/L	103,000
29	A-20	S/M/L	97,000
30	A-23[3]	20	90,000
31	D-36	Duplex	90,000
32	B-1	Triplex	85,000
33	D-54	S/M/L	81,000
34	B-13	Triplex	79,000
35	A-10	Triplex	76,000
36	B-5	Duplex	72,000
37	B-23	Duplex	71,000
38	A-1	Triplex	67,000
39	A-31	S/M/L	60,000
40	D-34	Duplex	53,000
Total			7,964,000

1. Based on billing records for each pump station.
2. Stations already have VFDs on pumps; only programming required.
3. Stations on R&R List for 1-5 year upgrades; anticipating VFDs/programming to be included in design.

Of the top 40 energy using pump stations, twelve (12) are either on the current R&R list or in the process of being upgraded. Four (4) of the remaining twenty-eight (28) pump stations already have VFDs installed. The estimated cost of installing VFD panels to control 25-100HP pump motors is approximately $45,000, including replacement of the pump motor panel with a panel containing VFDs (expensive to modify panels and re-certify UL ratings in the field) and programming of the controls. The estimated cost for programming stations which already have VFDs is $10,000.

Table WW16-2 below shows the estimated project costs to replace the existing motor panels (which have across the line or reduced voltage starters) with motor panels containing VFDs and perform programming modifications to the stations which already have VFDs (only stations not currently on R&R list). **Table WW16-2** also shows the simple “return on investment” (ROI) in terms of years (payback period).

Table WW16-2. Cost Analysis for Installing VFDs and Programming

Alternative	Estimated Project Cost ($000)	Estimated Annual Savings ($000)	Simple ROI (Years)	% Energy Savings Anticipated
Replacing Starters with New VFDs/ Programming for High Energy Consumption Stations	$1,747[1]	$ 26.2[2,3] $ 27.1[4]	33	3% pump station energy[3]; 3% Effluent pump energy[4] at GTL

1. Based on (24) stations at $45K each and (4) stations at $10K each plus 30% contingency and other project costs at 20% of construction cost.
2. Based on a 15% energy consumption due to peak flows (no equalization); anticipates recovering 80% of half of the 15% energy consumption reduction due to no equalization (80%*50%*15%* 5,467 MWh * $80 /MWhr) for pump stations included.
3. This does not take into account the benefit to the stations downstream of the modified station. This could increase the energy consumption reduction from approximately 6% to as high as 8.5% of the pumping energy total.
4. Based on a 15% energy consumption for the effluent pumps at GTL due to peak flows (no equalization); anticipates recovering 50% of half of the 15% energy consumption due to no equalization (50%*50%*15%*1375 hp*.75 KW/hp*8760 h * $0.080 /kWh).

It is anticipated that an additional 3% of total pump station energy and 3% of the GTL effluent pump energy will be saved with the completion of the R&R of the stations identified in Table WW16-1.

16.2.3 Operational Changes

While the programming for VFD driven pumps to make use of the individual wet well volumes to reduce peak flows in the system provides a level of equalization in the collection system, overall system programming which coordinates the operation of the stations during peak flow periods can save even more energy. Utilities which have instituted automated systems that delay/coordinate operation of pump stations to reduce the number of pump stations operating simultaneously have seen a significant reduction of energy.

For example, the City of Winter Park Florida instituted a synchronization program of all of their pump stations approximately 5 years ago and have reportedly seen a 34% reduction in pump run times and a 40% decrease in overall energy usage.

The approximate cost to implement a system-wide synchronization program, which would include all pump stations, is estimated to be $210,000 including the station research, program development, and implementation of the programming. This estimated cost anticipates the pump stations already having full SCADA communication. Based on the anticipated additional energy cost savings developed from other utilities' experiences, the energy savings for the collection system could range from 10% to 30%.

16.2.4 Use of Renewable Energy or Alternative Fuels (Wastewater Collection/Transmission System)

The motor loads at the pump stations are too large for renewable energy sources such as wind or solar energy to be feasible for generating sufficient power. Based on the small amount of energy utilized at the pump stations for lighting and controls, no significant energy savings are anticipated if renewable energy systems for these electrical loads are provided.

Alternate fuels for the emergency power generators providing backup power to the wells, which currently run on diesel fuel, include natural gas, LP gas, and biodiesel. If natural gas is available, relying on another utility (such as a gas company) during emergencies is usually not preferred. The use of LP gas to fuel emergency generators is not common based on the high operating costs. These costs can be attributed to the significant amount of LP gas that must be used to generate power versus lower quantities of diesel.[1] The life span (rated hours) for LP gas powered generators are also usually much less than for diesel generators.[1]

Most emergency generator manufacturers now honor equipment warranties for generator engines run on biodiesel blends with up to 5% biodiesel (B5), with some engines also approved to run on blends up to 20% (B20). Storage of biodiesel blends has and continues to be an issue for intermittent use due to oxidation, moisture absorption, growth of microbes, and sediment formation (U.S. Energy Information Administration). While biodiesel is considered a renewable, clean energy source, using biodiesel blends for an emergency generator fuel source requires extensive testing and the addition of additives to prevent damage to the generator engine. While specific standards are in place for biodiesel, the quality of biodiesel blends available is inconsistent (U.S. Energy Information Administration).

16.3 Wastewater Treatment System

The GTL WWTP is currently rated to treat 56.6 MGD based on the maximum three month average daily flow (M3MADF).

The combined total power consumption of GTL is approximately 25,013,000 kWh per year based on averages of power-company billing records for the years 2013 and 2014. This equates to an energy cost of approximately $2,001,000 per year based on the current electrical rate of $0.08/kWh.

The GTL treatment processes include the following:

a. Pretreatment (Large Solids and Grit Removal)
b. Biological Treatment
c. Clarification
d. Chlorination
e. Effluent Screening
f. Effluent Disposal
g. Sludge Management

As indicated in Paragraph 16.1, significant amounts of energy are expended for pumping and treating the excess flows from I/I. It is estimated that totally eliminating I/I, which would reduce the incoming flows to the plant by approximately 50%, would reduce the GTL energy usage by 40%. Based on the current annual power consumption of $2,000,000, the annual costs could be reduced to approximately $1,200,000 per year which equates to approximately $40,000 per year per 1 MGD of I/I reduced.

The following sections address potential energy savings for each of the treatment processes. One of the processes that consumes a significant amount of energy on site is the cryogenic oxygen generation system, which provides oxygen for the biological treatment process. Based on the impact that the selection of an alternative for oxygen generation process has on the other treatment processes, the evaluation of the City's alternatives for this process are presented first.

16.4 Oxygen Generation and Feed System

16.4.1 Description

The GTL WWTP provides secondary treatment using approximately 98% pure oxygen and surface aerators to remove the carbonaceous materials (quantified as biochemical oxygen demand or BOD) from the wastewater. The "pure" oxygen is generated on-site by a cryogenic system which was originally installed in the 1970s.

The cryogenic oxygen generation system is rated for 55 tons per day (tpd) but is currently not capable of producing the full amount due to the age and condition of the system. Additional liquid oxygen, if needed, is purchased to meet process demand requirements.

The average oxygen currently supplied to the treatment system ranges from approximately 20 to 28 tons per day (tpd). The City has been spending approximately $500,000 every three (3) years for routine maintenance and repair on the cryogenic system, and the system is currently undergoing more extensive repairs.

The economic feasibility of replacing the existing cryogenic system with a media adsorption type system (Vacuum/Pressure Swing Adsorption (VPSA) was evaluated. Operational considerations based on the lower quality oxygen that a VPSA system produces (approximately 90% to 94%) are also presented in this section.

Operational changes to the system which can reduce energy and/or reduce operating costs as well as reduce capital expenditures are addressed in Sections 16.6.3.

16.4.2 Equipment Replacement

Replacement of the existing cryogenic oxygen generation system with a VPSA system would include either constructing the new VPSA system where the existing cryogenic system is located or in an alternate location. The advantage of constructing the system in an alternate location is the ability to keep the existing system operational during construction of the VPSA system so that oxygen would not have to be purchased. **Figure WW16-1** shows the potential locations for the VPSA system based on the estimated area requirements. Clearances from existing pipelines/facilities and vehicular turning requirements would need to be evaluated during design to confirm the adequacy of an alternate location. Utilizing the space that the existing cryogenic system now occupies for future traffic could also be considered.

Once the VPSA system is constructed and the existing system demolished, the liquid oxygen storage tanks would remain in place or be relocated to supply oxygen to GTL when the VPSA system is offline for maintenance.

In Section WW-1, the wastewater flow forecast analysis indicates that the calculated capacity of the plant (57.9 MGD M3MADF), which is slightly higher than the FDEP rated capacity of 56.6 MGD M3MADF, is anticipated to be sufficient past the year 2035. Based upon a future influent flow of 57.9 MGD M3MADF, current operational practices, and current feed rates, the anticipated oxygen usage over the next 20 years is approximately 23.2 tpd to 31.9 tpd. Based on some level of oxygen usage reduction resulting from I/I reduction and operational changes discussed below, VPSA systems with a capacity of 30 tpd are evaluated as part of this analysis.

VPSA systems can utilize single or multiple media beds (tanks) which are normally vertical steel low pressure vessels. **Table WW16-3** below shows the comparison between single and multiple bed systems.

Table WW16-3. Characteristics of VPSA Oxygen Systems

System Type	Operation Cycle	Buffer Tank Requirements
Single Bed System	Only Operates 20 minutes out of 45 minute "cycle"	Requires large "buffer" tank to store/supply gas while bed is in vacuum cycle
Multiple Bed System	Operates 40 minutes out of 45 minute "cycle"	Requires "buffer" tank to store/supply gas while beds switch between pressure and vacuum cycles

Most systems are a 2-bed (or multiples of 2) system due to the large gas storage volume required for a single bed system and the smaller tank and equipment requirements. The options of replacing the existing 55 tpd cryogenic system with a multiple bed 30 tpd VPSA system are evaluated below. Another advantage of a multiple bed system is the ability to "turn down" the system during periods of low oxygen requirements that occur during low nightly flows and in particular, low nightly flows during dry weather.

In all cases, the system would be fully automated including monitoring of all maintenance parameters (e.g., vibration, bearing temperature, motor temperature, etc.). VPSA systems consist of three (3) major equipment components: compressor, vacuum pump, and a duplex or triplex set of vessels for media to remove the nitrogen from the produced oxygen and argon.

Life cycle costs for the installation of a VPSA system were developed for comparison to life cycle costs for rehabilitating and operating the existing system. The estimated construction cost for installation of a VPSA system versus refurbishing the existing system is presented in **Table WW16-4**. The estimated costs are based on the average of budget estimates from multiple VPSA/cryogenic system suppliers, and include both equipment and labor costs.

While alternate locations to construct the VPSA system are presented in Paragraph 16.4.4 below to save the costs of purchasing oxygen during construction, the costs presented in **Table WW16-4** are based on the worst case scenario of constructing the new VPSA system in the same location as the existing cryogenic system. Liquid oxygen would be purchased during construction of the VPSA system or during refurbishment of the existing system. It is anticipated that the construction period for a VPSA system would be approximately 12 months and the construction period for rehabilitating the existing system would be approximately 9 months. The estimated construction costs for the alternatives presented in **Table WW16-4** include the full cost of purchasing oxygen for rehabilitating the existing system and the difference in costs to produce versus purchase oxygen during the construction period for the VPSA system.

Table WW16-4. Estimated Project Costs for Oxygen Alternatives

Cost Item	Cryogenic Rehab ($000)	VPSA 30 tpd Multiple-Bed ($000)
Demolition	50[1]	180[2]
Sitework	30[1]	120[2]
New/Rehabilitated Equipment	4,000[3]	2,550[4]
Oxygen Purchases	452[5]	602[6]
Subtotal	**4,532**	**3,452**
Contingency (30%)	1,360	1,036
Total Estimated Construction Costs	**5,892**	**4,488**
Non-Construction Project Costs (20%)	N/A	898
Total Estimated Project Costs	**5,892**	**5,386**

1. Demolition includes equipment being replaced; sitework includes miscellaneous concrete work and refurbishing the compressor/electrical building
2. Demolition is estimated $50 /per site sq.ft.; sitework at $50 per sq.ft. Proposed VPSA site is 2,400 sq.ft..
3. Based on information from Solution Werks who are currently repairing the existing system.
4. Based on estimates from equipment suppliers plus the cost of a new compressor/vacuum pump/electrical building with a 1.5 labor multiplier, 30% contingency, and 20% of the total construction cost for non-construction project costs.
5. Difference in cost to produce/purchase oxygen during construction time of 9 months (6028 tons at $75/ton).
6. Difference in cost to produce/purchase oxygen during construction time of 12 months (8030 tons at $75/ton).

Table WW16-5 below shows the estimated O & M costs for the alternatives.

Table WW16-5. Estimated O&M Costs for Oxygen Alternatives

Alternative	Total Installed HP	Estimated Annual Energy Costs ($000) [1,2]	Estimated Total Annual O & M Costs Including Energy ($000) [1-4]
Refurbish Existing 55 tpd Cryogenic System	1,400	488[5]	588
New 30 tpd Multiple-bed VPSA System	600	210	310

1. Energy costs based on 30 tpd production 16 hrs/day.
2. Uses $0.08 per kWh from weighted average cost of Service Point 1
3. Includes energy and recommended preventative maintenance/replacements.
4. Actual non-energy O&M costs will be proportional to the oxygen production but the values used here are for full production of 30 tpd.
5. Current usage estimated as approximately 80% of service point 1 or $563K per year; estimated usage based on an estimated 25% reduction with rehabilitation.

Based on the initial costs and the anticipated O & M costs, the 20 year life cycle costs of the three (3) alternatives are presented in **Table WW16-6** below.

Table WW16-6. 20 Year Life Cycle Costs for Oxygen Alternatives

Alternative	Estimated Project Cost ($000)	Estimated Annual O & M Cost ($000)	20 year Life Cycle Cost ($000)[1]
Refurbish Existing 55 tpd Cryogenic System	5,892	588	17,652
New 30 tpd Multiple-Bed VPSA System	5,386	310	11,586

1. Zero interest simple sum of 20 years O&M costs plus estimated project capital costs.

16.4.3 Advantages/Disadvantage

The advantages and disadvantages of rehabilitating the cryogenic system versus replacing the system with a VPSA system are presented in **Table WW16-7**.

Table WW16-7. Advantages and Disadvantages for Oxygen Alternatives

Alternative	Advantages	Disadvantages
Rehab Cryogenic System	- Operation remains the same - Option of recovering Nitrogen and selling available - No 'turn down" capability needed based on liquid oxygen storage - No additional noise or vibration issues	- Higher 20 year life cycle cost due to higher O & M costs - A lot of wasted oxygen; must recover and recycle headspace waste gas and excess oxygen in flows to clarifiers for energy savings - More complex operation
VPSA	- Lower 20 year life cycle cost due to lower O & M costs - Significant energy savings - More simple operation - "Turn down" capability ensures that excess oxygen is not produced during low flows - Additional nitrogen in produced oxygen can assist with preventing excess dissolved oxygen in effluent	- Operational adjustments to account for different oxygen quality are required - Noise and vibration issues have to be considered

Estimated quantities of oxygen required in the next 20 years are presented in Paragraph 16.6.3 below. With a VPSA system, it is estimated that the oxygen requirements over the next 20 years could be reduced to below 20 tpd. With a reduced oxygen demand, the existing cryogenic system could be replaced with a 20 tpd system instead of a 30 tpd system. Due to the small size of the systems, there is very little difference in the construction cost (and the 20 year life cycle cost) for a 20 tpd system as shown below in **Table WW16-8**.

Table WW16-8. Life Cycle Costs for 20 tpd VPSA Systems

Alternative	Estimated Project Cost ($000)	Estimated Annual O & M ($000)	20 year Life Cycle Cost ($000)[1]
New 20 tpd Multiple- Bed VPSA	5,376	300	11,376

[1] Zero interest simple sum of 20 years cost plus estimated project costs.

16.4.4 Site Space Availability

For rehabilitating the existing cryogenic system, no additional site space requirements are anticipated.

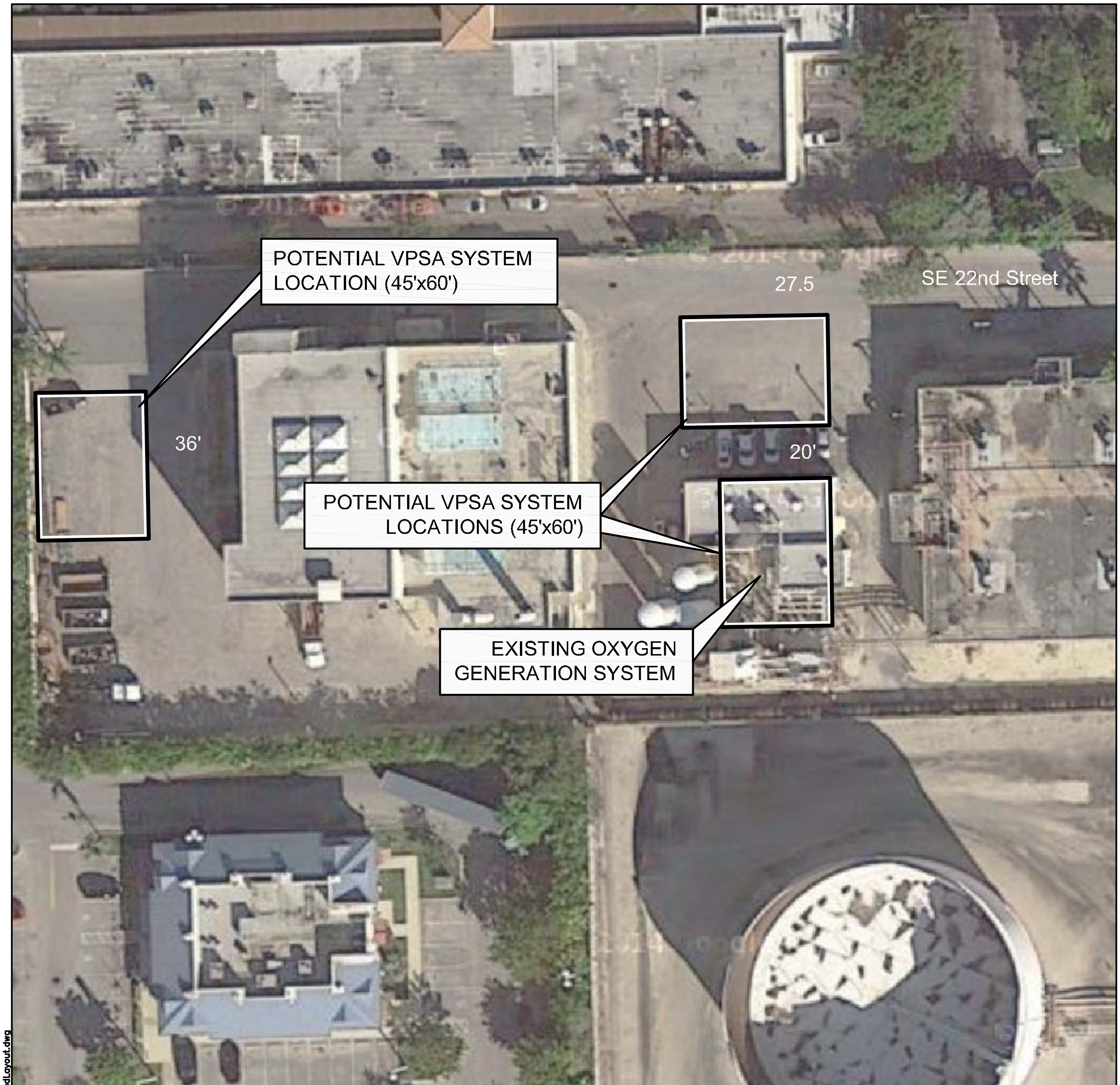
As discussed in Paragraph 16.4.2 above, locating a new VPSA system so that the existing cryogenic system could provide oxygen during construction would save money on purchasing oxygen. The approximate area requirement for a 30 tpd multiple bed system is 45' x 60'. **Figure WW16-1** shows conceptual layouts of a multiple bed system either in the same location as the existing cryogenic system, in the parking area north of the existing cryogenic system equipment, and southwest of the pretreatment building. A 54" pipe exists in the parking area north of the existing cryogenic system which would have to be avoided. As **Figure WW16-1** shows, locating the new VPSA system in this location would severely limit vehicular traffic within this area of GTL. For the location southwest of the pretreatment building, adequate sound attenuation of a new system located adjacent to the west property line is a major concern.

16.4.5 Other Considerations

The reduced quality of the oxygen produced by the VPSA system (approximately 90% to 94%) versus the quality of the oxygen produced by the cryogenic system (approximately 98%) requires the oxygen gas to be fed at higher rates. Based on the relatively small increase in flows, however, the existing feed equipment is anticipated to be capable of handling the increase in gas flows.

As discussed in Section 16.6 below, it is currently estimated that a very significant amount of oxygen is "lost" in the process in the waste gas from the biological reactors and as dissolved oxygen in the effluent. If the alternative to rehabilitate the existing cryogenic system is selected, additional operational changes would have to be made in order to conserve energy within the process such as recovering oxygen from the biological reactor waste gas stream and recycling the oxygen to the process.

The electrical equipment requirements for a VPSA system are significantly less than the cryogenic system. In Section UW2, the CUS Master Plan team recommends replacement of all major electrical equipment for the existing cryogenic system. If the VPSA system is constructed, a significant reduction in electrical construction costs is anticipated based on the reduced size of the electrical equipment for the VPSA system.



Graphic Scale in Feet

0 60' 120'

CITY OF FT. LAUDERDALE
GEORGE T. LOHMEYER WASTEWATER TREATMENT PLANT

PROPOSED 45' x 60' LAYOUT

FIGURE WW16-1

DWG: R:\Projects\134001-P Ft.Lauderdale CUSMP\Design\Drawings\Figures\ProposedLayout.dwg

16.4.6 Recommendations

Based on the 20-year life cycle costs, the reduced energy usage (and overall O&M costs), and the ease of operation for the operators, the CUS Master Plan team recommends replacing the existing cryogenic system with a 30 tpd VPSA system. Also, due to the lower capital and O & M costs and other advantages of a multiple-bed system, the installation of a multiple-bed system is recommended.

While the oxygen needs of the plant with a VPSA system in the next 20 years are estimated to be less than 20 tpd, the CUS Master Plan team recommends installation of a 30 tpd system based on the incremental difference in initial project costs and O&M costs between the 20 tpd and 30 tpd systems and the advantages of having a certain level of excess capacity.

16.5 Pretreatment

16.5.1 Description

Pretreatment at the GTL facility consists of automatic-cleaning screens and grit chambers to remove non-biological items and sand/grit from the influent. Grit management equipment such as grit pumps, grit cyclones, and grit classifiers are also included.

There are four (4) existing 6 mm Huber Rakemax multi rake bar screens mounted in channels on the pretreatment structure at GTL. The screens are less than 5 years old.

Based on information from operations personnel, the grit removal chambers remove the grit and sand in the influent within the normal range of removal capacity (minimal grit observed in biological reactors).

16.5.2 Equipment Replacement

Replacing the existing 6 mm influent screens with smaller opening screens such as 2 mm could remove up to twice the amount of non-organic material (mixed with larger organic material) contained in the influent to GTL. Smaller opening screens, however, create additional headloss which could cause hydraulic issues within the channels the existing screens at GTL are mounted in. The screenings would also contain larger amounts of organic matter which must be considered during disposal. Based on the costs to completely replace the new influent screens and other potential issues with installation of finer screens at the headworks (versus the benefits), replacing the influent screens is not considered viable. The alternative for removing and managing excess non-organic/organic materials in the process by screening the RAS and WAS flows is presented in Paragraph 16.14.3.

16.5.3 Operational Changes

No operational changes for this process were identified which would reduce energy consumption.

16.6 Biological Treatment

16.6.1 Description

Wastewater entering the GTL facility flows from the pretreatment facilities to biological reactors. There are two (2) reactors with two (2) trains within each reactor for a total of four (4) separate trains. Each train has three (3) stages of treatment with a separate covered chamber (with headspace) and a mechanical surface aerator for each stage. The headspaces of the chambers are connected between each stage. Oxygen is introduced into the process by flowing gaseous

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oxygen into the "headspace" of stage 1 of each treatment train, with the mechanical aerators mixing the oxygen into the process flows. The oxygen/carbon dioxide/argon/nitrogen gas exiting the reactors' air chambers (from stage 3) is wasted to the atmosphere.

The existing oxygen generation facility is a cryogenic system which produces highly-pure oxygen (97-98%) for use in the wastewater process. At the recommendation of CUS Master Plan Team, the City is considering replacing the system with a VPSA system due to the energy saving potential of a VPSA system and the high maintenance costs associated with the current system. An evaluation of the cost efficiency of replacing the existing cryogenic system with a VPSA system is included in Section 16.4 above.

16.6.2 Equipment Replacement

Seven (7) of the twelve (12) surface aerator motors are older, lower efficiency motors. Replacing the motors with "high efficiency" motors can reduce energy costs. **Table WW16-9** below shows the estimated project costs of replacing the motors, the estimated annual energy cost savings, and the simple ROI time period.

Table WW16-9. Cost Analysis of Replacing Standard Efficiency Motors with High Efficiency Motors

Alternative	Estimated Project Cost ($000)[1]	Estimated Annual Savings ($000)[2]	Simple ROI (Years)
Replace (7) 125 HP Motors with High Efficiency Motors	84	14	6

1. Based on $12,000 installed cost per motor.
2. Based on a 3% efficiency improvement between a 125 HP standard efficiency motor and a high efficiency motor.

Replacing the existing surface aerators with a fine bubble diffuser system for introducing oxygen into the wastewater was considered. Generally the basin water depth must be in excess of 15' to get more efficient oxygen transfer than introducing it by mechanical means when using high oxygen sources. With a basin depth at GTL of approximately 15', the reduction of oxygen requirements would be limited. Additionally, air piping and fine bubble diffusers would have to be put in every chamber (12) and additional blowers/compressors would be required to inject the air at the bottom of the chambers. The cost of installing the new equipment versus the money/energy saved is considerable (high cost versus benefit ratio).

Replacing the existing surface aerators with aerators having lower mixing blades was considered. Based on the calculated HP requirements for mixing the biological reactor train stages, the existing surface aerators should be providing adequate mixing within each chamber. While some additional mixing and oxygen transfer may occur with lower mixing blades, the cost for the change is high especially if structural modifications must be made either in the tanks or on the tops of the tanks. Aerators with lower mixing blades usually need a "volute" installed in the bottom of the chamber and the tops of the chambers must be capable of supporting the higher torque on the motors due to the lower blades.

16.6.3 Operational Changes

Conserving oxygen means conserving energy. The calculated minimum oxygen requirements of the existing system can be defined on the basis of 38.6 MGD average influent flow and 32,000

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lb/day of $cBOD_5$. This equates to a calculated BOD oxygen demand of 16 tpd based on standard wastewater calculations. Since the reactor portion of the process is being operated with a standard retention time (SRT) of only 1.5 days, the calculated oxygen requirement using standard calculation method overestimates the actual oxygen requirements as the resulting oxygen concentration requirements correspond to $cBOD_5$ instead of $cBOD_{1.5}$. The concentration of $cBOD_{1.5}$ can be estimated as approximately 50% of the associated $cBOD_5$ which means the theoretical amount of oxygen needed to satisfy BOD demands at the GTL's operational SRT is actually 8 tpd rather than 16 tpd. For other (non-BOD) oxygen demands, annual sampling has shown a nitrate concentration of about 6 mg/L in the reactors. The nitrate is an indicator of an influent ammonia concentration that would consume approximately 4.4 tpd of oxygen. Including other estimated factors of oxygen usage/concentrations, the total estimated oxygen requirement versus the amount of oxygen being fed shows a significant amount of oxygen that is lost in other, undefined ways.

Table WW16-10 shows the estimated oxygen demands/requirements and unaccounted for oxygen for current feed rates based on wastewater process modeling.

Table WW16-10. Estimated Current Oxygen Demands/Requirements

Existing Oxygen Use (tpd)[1]	
Oxygen Supply (AADF)	22.0
Influent $BOD_{1.5}$ loading[2]	8.0
O_2 for Nitrification[3]	4.4
Effluent DO (Influent Portion of Flow)[4]	1.8
Effluent DO (RAS Portion of Flow)[5]	1.8
Effluent BOD[6]	(0.3)
Unaccounted Losses	**6.3**

1. Previously reported annual average production/consumption rate was 27.5 tpd and most recently at 20 tpd.
2. AADF reported BOD_5 is 32,000 ppd which equates to 16 tpd of oxygen required. The $BOD_{1.5}$ oxygen requirement is estimated as 8.0 tpd.
3. The reported annual average concentration of nitrate from grab samples was 6 mg/L which corresponds with ammonia nitrification that would use approximately 4.4 tpd of oxygen at 38.6 MGD AADF.
4. Based on a typical DO concentration for mixed liquor without accurate oxygen controls (2.0 mg/l).
5. There is excess DO when flows leave the reactors which satisfies the demand generated by the residence time of the RAS in the clarifiers as it is becoming soluble.
6. Because of the short SRT of the solids, they are continuing to be converted to soluble cBOD while in the clarifiers, which means some of the $cBOD_{1.5}$ is lost to the effluent.

Regarding the unaccounted for oxygen, it is anticipated that a significant amount of oxygen introduced to the process is wasted as "off-gas" from the reactor "head spaces" and is entrained in the wastewater as dissolved oxygen leaving the reactors flowing to the clarifiers.

In addition to changing the oxygen generation system to a VPSA system to save energy, as recommended in the oxygen generation system alternative evaluation presented, other changes to the current operations which potentially can save oxygen (and energy) are presented below:

Operation Automation – The key to accurately dosing oxygen, which is essential to minimizing wasted oxygen, is accurate control. Fully automating the oxygen delivery system including automation and control of both the flow into the biological reactors and the reactor “head space” gases would allow the system to more accurately balance flows between the reactor trains and more accurately control the oxygen being fed to each train. Based on only two (2) of the four (4) trains in operation on a regular basis, automation and control of the flows and oxygen is not anticipated to save energy.

Return Activated Sludge (RAS) Flow Rate Reduction – An operational change which could be implemented to save oxygen with no capital costs, regardless of whether the cryogenic system is refurbished and used for oxygen production or a VPSA system is installed, is reducing RAS flow. Reduced RAS flow rates will reduce oxygen losses for the resulting lower flows throughout the treatment basins. Lower mixed liquor flow rates equate to increased hydraulic retention time that equates to increased oxygen uptake. Investigating the amount the RAS rates could be reduced based on tests on the flows’ ability to settle which could lead to both reduced oxygen usage and expended motor energy. Based on the current operation with RAS flows approximately 0.4 to 0.5Q (Q=influent plant flow), RAS flows are already on the low end of the recommended operating range; therefore, no significant energy savings are anticipated by turning the RAS flow rate lower.

Nitrification Reduction – Another operational change which could be implemented with minimum capital costs is the introduction of chemicals into the process which inhibit nitrification. Based on the nitrification process consuming as much as 20% of the total oxygen fed, the potential for energy savings is substantial. Different chemicals with different costs are available. Demonstration testing of various chemicals to determine which chemical is most effective would allow a cost analysis to be performed for feeding the chemical on a long term basis.

Table WW16-11 shows the estimated savings in oxygen production with the VPSA system (with lower DO wasted in headspace and lower DO in flows to clarifiers).

Table WW16-11. Estimated Oxygen Requirements with VPSA System and Operational Changes

Proposed (tpd)[1]		
	Current Flows (45 MGD)[8]	**Future Flows (57.9 MGD)[9]**
Influent $BOD_{1.5}$ loading[2]	8.0	9.3
O_2 for Nitrification[3]	4.4	5.1
Effluent DO (Influent Portion of Flow)[4]	1.8	2.1
Effluent DO (RAS Portion of Flow)[4]	0.9	1.0
Effluent BOD[6]	(0.3)	(0.4)
Anticipated Headspace Losses[6]	0.6	0.7
Total Production	**15.4**	**17.8**
Oxygen Production Savings Potential[7]	**30%**	

1. Based on a VPSA system and other operational adjustments presented in the above section of the report.
2. AADF reported BOD_5 is 32,000 ppd which equates to 16 tpd of oxygen required. The $BOD_{1.5}$ oxygen requirement is estimated as 8.0 tpd.
3. Potentially can be reduced to zero based on operational adjustments to reduce nitrification as noted above in this section of the report.
4. Based on a typical DO concentration for mixed liquor with accurate oxygen controls (1 mg/l). Anticipates reduced RAS flow to 0.5Q.
5. Because of the short SRT of the solids, some of the solids are continuing to be converted to soluble cBOD while in the clarifiers and some of the $cBOD_{1.5}$ is lost in the effluent.
6. Estimated based on lower concentrations of oxygen in headspaces.
7. Based on a current oxygen usage of 22 tpd.
8. Average M3MADF for 2013 and 2014 from **WW1**.
9. M3MADF 2035 projected flow from **WW1**.

Table WW16-11 above indicates that a total oxygen production need for a year 2035 M3MADF flow of 57.9 MGD (M3MADF) is only 17.8 tpd with a VPSA system and other operational adjustments implemented. A 30 tpd system is proposed based upon the need to maintain oxygen capacity for short periods of high inflows to the collection system that increase clarifier effluent losses. Based upon 2013-14 influent data, peak hourly flows as high as 90-100 MGD are received at the plant during wet periods primarily due to I/I inflow. I/I does increase the loading and nitrification requiring oxygen, and the excess supply available allows for better control during peak hourly flows based on the higher volume and increased oxygen losses.

Based on the current operation of only two (2) reactor trains at all times, providing the automation and control to direct flow to different numbers of reactor trains during different flow periods is not anticipated to save energy.

16.7 Clarification

16.7.1 Description

Wastewater flows from the biological reactors to splitter boxes, which feed eleven (11) center-fed clarifiers. The clarifiers have traditional straight-blade clarifier mechanisms and the motors are "high-efficiency" motors.

16.7.2 Equipment Replacement

Clarifiers 1-7 are square shaped and have sweeps that occasionally fail and cause the corners to go stale. Filling the corners or replacing the traditional straight-blade clarifier mechanisms (sweeps) with newer "spiral-blade" mechanisms that could effectively sweep the corner would resolve the issue and improve GTL's performance. Replacing traditional straight-blade clarifier mechanisms also provides multiple benefits to the clarification process including:

- Flotation reduction
- Reduced clogging problems
- Increased solids thickening due to the sludge inventory being moved from the outer portions of the tanks to the centers

Regarding energy reduction, the main benefit of spiral-blade clarifiers is that the RAS rate can be reduced due to the thicker solids and less clarifier turbulence which in turn reduces RAS pumping energy costs and oxygen consumption as discussed in the Biological Treatment section above. The estimated cost of replacing the existing clarifier mechanisms with spiral-blade mechanisms is presented in **Table WW16-12**, along with the expected energy savings per year and the payback period.

Table WW16-12. Cost Analysis for Installation of Spiral Blade Clarifier Mechanisms

Alternative	Estimated Project Costs[1] ($000)	Estimated Annual Savings[2] ($000)	Simple ROI (Years)	% Energy Savings Anticipated
Replacing Clarifier Mechanisms with Spiral-Blade Type	$2,305	38.2 -48.4	47-60	2% -2.5%

1. Based on (7) at 95 ft dia. and (4) at 80 ft dia. at $1,000 per diameter ft. for hardware ($985,000) plus 50% multiplier for installation and 30% contingency. Includes other non-construction costs at 20% of construction costs.
2. Theoretical savings using a 70% combined motor and hydraulic efficiency; reduces RAS from 108 HP to 54 HP plus oxygen savings due to reduced RAS estimated as 5%-10% (1-2 tpd decrease in cBOD requirements at $28 per tpd (projected operating cost of 30 tpd VPSA oxygen generation unit).

While the payback period is long, in addition to savings on RAS pumping costs and oxygen costs, the installation of spiral blade mechanisms can improve operation of the plant in other ways. One such benefit is reduction of the total suspended solids (TSS) in the effluent being injected into the disposal wells. Lower suspended solids entering the injection wells prolongs periods of cleaning (maintains lower injection pressures longer).

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16.7.3 Operational Changes

Based on the flows to the GTL plant and the clarification capacity of the system, energy usage by the effluent pumps can be reduced by utilizing only seven (7) of the clarifiers for clarification on a routine basis and using the other four (4) clarifiers for equalization storage for the effluent pumps.

The peak-hour capacity of all eleven (11) clarifiers, minus one (1) for redundancy, is approximately 100 MGD. Influent flows to the plant are less than 70 MGD during approximately 90% of wet days, and wet days are less than 30 days per year. Minute-to-minute influent flow rates exceed a 52 MGD rate less than 1% of the total operating time and exceed 50 MGD less than 5% of the time. At 55 MGD maximum 3 month daily flow, the existing eleven (11) clarifiers operate at an overflow rate of approximately 660 gpd/sqft.

If flows were diverted from the four (4) clarifiers adjacent to the effluent wet well, the overflow rates for the remaining seven (7) clarifiers would only increase to 870 gpd/sqft. Normal maximum design criteria for clarification is over 1000 gpd/sqft, and higher with spiral scraper mechanisms.

Changing some valving and adding piping from the effluent pump chambers back to the clarifiers would allow effluent flows to be diverted to a limited number of clarifiers for equalization. The additional equalization volume would allow the effluent pumps to operate at lower speeds (lower flows) during peak flow periods which would reduce pressures associated with the deep injection wells. Based on the high energy costs associated with the effluent pumps, operating at reduced pressures would save a significant amount of energy.

While the clarifiers would have to be drained and cleaned for use as effluent pump equalization, with proper automation, the off-line clarifiers could be brought on-line and fully operational within 5 minutes or less. Operations personnel, however, have indicated that foaming has been an issue in the past when flows from the reactors are directed to an empty clarifier which would have to be addressed. Determining whether the off-line clarifiers are needed during high flow periods (with only two (2) reactor trains in operation) would help with the assessment.

Table WW16-13 shows the estimated cost of changing the clarifier operation and the potential energy savings.

Table WW16-13. Cost Analysis of Using Excess Clarification Volume for Effluent Pump Equalization

Alternative	Estimated Project Costs[1] ($000)	Estimated Annual Savings[2] ($000)	Simple ROI (Years)	% Energy Savings Anticipated
Use of Four (4) Clarifiers as Effluent Equalization	390	43	9	2.0%

1. Based on 500 ft of piping, valves, and connections at $500/ft and 30% contingency. Includes non-construction costs of 20% of construction cost.
2. At an AADF of 38.6 MGD the calculated energy requirements for the effluent pumps at the average injection well pressure of 55 psig is approximately 1170 HP. The present operating HP with little equalization (based upon 6 years of daily operating flow data) is approximately 1,375 HP which indicates that approximately 15% of the current energy requirements are due to peak flow conditions. The estimated annual savings for providing equalization represents a 40% savings of the 15% additional energy due to peak flow conditions.

16.8 Chlorination

16.8.1 Description

Chlorine gas is injected into a flash mixer basin prior to the effluent being pumped to the injection wells or used for on-site reuse.

The system uses chlorine gas with the gas feed system rated at 4,800 lb/day. The GTL plant currently maintains a chlorine residual of approximately 1 mg/l in the effluent flows which are used for in-plant reuse water or disposed of in the injection wells.

16.8.2 Equipment Replacement

No equipment replacements were identified to reduce energy costs.

16.8.3 Operational Changes

No operational changes for potential energy savings were identified.

For operational cost savings, adding facilities to only maintain a chlorine residual of 1 mg/L in the reuse flows and maintain a minimum residual of 0.5 mg/L in the remainder of the effluent flows being pumped to the injection wells could reduce operational costs.

16.9 Effluent Screening

16.9.1 Description

Process flows from the chlorine mix chambers to the effluent pump station are screened by three (3) travelling water screens.

16.9.2 Equipment Replacement

No equipment replacements for potential energy savings were identified.

16.9.3 Operational Changes

No operational changes for potential energy savings were identified.

16.10 Effluent Disposal (General)

16.10.1 Description

Process flows leaving the chlorine mix chambers enter the effluent pump station chamber for pumping to five (5) deep injection wells.

The subcomponents of the effluent disposal system evaluated include the following:

a. Effluent Pump Station
b. Deep Injection Wells

16.11 Effluent Pump Station

16.11.1 Description

The effluent pump station includes five (5) dry pit centrifugal pumps driven by vertical motors on top of the chambers. There are three (3) 1,750 HP pumps and two (2) 1,250 HP pumps. All pump motors are controlled by VFDs. With no flow equalization for the plant, the pumps must pump peak hour flows. The energy used by the effluent pumps represents approximately 30% of the total energy use at GTL.

16.11.2 Equipment Replacement

The City has already captured energy cost savings to some extent by spreading electrical service points out at the GTL. Further savings could potentially be achieved with electrical modifications to feed the effluent pumps from Service Point 2 and 3 (in addition to Service Point 4). This is based on the lower cost per kWh from these service points due to further balancing the plant's power draw over a few service points rather than powering all the pumps from one service point that causes the corresponding higher charges for higher demands.

16.11.3 Operational Changes

In order to reduce energy, the CUS Master Plan team evaluated means to reduce effluent pump discharge pressures (which correspond to the injection well pressures plus system losses). Pumping at lower flow rates during peak flows can reduce both the injection well pressures and the system losses which include friction and minor losses in the piping between the pumps and the deep injection wells. As discussed in Section 16.2.2 an estimated 15% of the pumping energy is associated with the peak flow pumping conditions (above a totally equalized system with constant flows).

Changing the programming for the operation of the effluent pumps to efficiently maximize effluent chamber storage can reduce operating discharge pressures during peak flows. This programming would potentially be part of the overall programming included with other recommended projects.

Taking multiple clarifiers off-line to use as equalization for the effluent pumps as discussed in Paragraph 16.7.3 will significantly reduce the peak flow pumping rates. The effluent pump chamber would backfeed effluent by gravity through the RAS connections to the bottoms of the clarifiers. The estimated energy savings is based on saving 40% of the 15% energy used for the effluent pumps pumping peak flows.

Review of the injection well pressures (at the well heads) and the effluent pump discharge pressures indicate a consistent difference in pressures (pressure loss) of approximately 7 PSI. Since the pressure difference is similar for all flows, significant pressure losses do not appear to be occurring in the piping between the effluent pumps and the injection wells. An explanation of the constant difference of 7 PSI could be that the check valves on the discharge side of the pumps are causing some or most of the losses. Removing the check valves and programming the existing motor actuated isolation valves to close when the pumps de-energize could significantly reduce the pressure loss (and corresponding energy losses). Signals from the actuator to the SCADA system, if not already provided, would be added to confirm the valve is fully closed and fully open. With a 5 PSI reduction in discharge pressures anticipated to be achieved by removing the check valves, this would be a 9% reduction in energy for the effluent pumps and an overall 2.7% reduction of overall GTL energy usage. The estimated project cost of this alternative is $135,000. If a valve actuator fails to fully close a discharge valve for a pump when it de-energizes, flows from other operating pumps (or from the injection wells themselves if all pumps are off), would recirculate through the pump into the pump chamber until the valve is closed manually. Another option to reduce the pressure loss is to replace the check valves which would maintain the existing operation. Based on the estimated project costs for this option being the same and the reduced chance of hydraulic issues, the CUS Master Plan team recommends replacing the check valves with lower headloss valves in lieu of eliminating them.

16.12 Deep Injection Wells

16.12.1 Description

Effluent is disposed of via five (5) deep injection wells. The wells underwent a cleaning and mechanical integrity testing program in 2014/2015. All wells are utilized except at night at which time one (1) of the wells is taken off-line during low flows. The well taken off-line is rotated.

16.12.2 Equipment Replacement

No equipment replacements were identified which can save energy.

16.12.3 Operational Changes

Evaluation of the effectiveness of the recent cleaning of the wells could determine if a more rigorous cleaning program would further reduce the energy required for effluent disposal.

16.13 Sludge Management (General)

16.13.1 Description

Sludge accumulated in the clarifiers is drained to three (3) sludge pump stations where it is either pumped back to the biological reactor influent pipe (returned activated sludge; RAS) or pumped to sludge holding tanks (waste activated sludge; WAS) for transfer to the Belt Filter Presses. The subcomponents of the sludge management system evaluated include the following:

a. Sludge Pump Stations including RAS and WAS Pump Systems
b. Sludge Holding Tanks and Transfer Pump System
c. Belt Filter Press System and Polymer Feed System

16.14 Sludge Pump Stations including RAS and WAS Pump Systems

16.14.1 Description

There are three (3) sludge pump stations. Station No. 1 includes three (3) RAS pumps which pump to Biological Reactor No. 1, Station No. 2 includes three (3) WAS pumps which pump

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sludge to the sludge holding tanks, and Station No. 3 includes four (4) RAS pumps which pump to Reactor No. 1 and three (3) RAS pumps which pump to Reactor No. 2.

16.14.2 Equipment Replacement

No equipment replacements were identified which will save energy.

16.14.3 Operational Changes

Reducing RAS flows reduces pumping energy costs as well as oxygen energy costs based on the reduced pumping requirements and process flows to be treated in the biological reactors. Reducing RAS flows based on settleability requirements is discussed in the Biological Treatment section. Reducing RAS flows as a result of changing the clarifier mechanisms is discussed in Section 16.7.3. RAS rates should not be controlled proportionate to the influent but periodically adjusted to match the 2-hr settled solids volume as a fraction of clarifier effluent.

Screening of the RAS and WAS flows can significantly reduce the amount of grit and sand being pumped through the treatment process before eventually being removed through the WAS/Belt Filter Press systems.

Assuming the GTL is operating at an SRT of 1.5 days and uses 6 mm influent screens, adding a 250 micron screen on the WAS flows could reduce the biosolids to be dewatered by approximately 40% according to screen manufacturers and previous tests. Biosolids production to the belt filter press dewatering is 14.7 dry tons per day-tpd (see Section WW15) which would be reduced by approximately 6 tpd with fine screens. The current WAS flow was estimated at 1.7 MGD. However, WAS screening introduces a flow restriction into the WAS line and requires significant maintenance.

The WAS screening would reduce biosolids disposal quantities from 31,500 wet tpd to 24,255 wet tpd assuming an average of 17% solids from the belt filter press, 40% solids from the WAS screen and the above-stated 40% dry solids WAS screen removal. At the current disposal rate of $70 per wet ton, this would save the City approximately $500,000 per year in biosolids disposal costs. Other cost benefits are reduced polymer and electrical consumption reduction for biosolids dewatering.

Another energy saving biosolids idea is RAS screening. RAS circulates at 0.4 to 0.5 times the influent flow; for 40 MGD influent flow, RAS flow is 16 to 20 MGD. Screening (250 micron) a significant portion of the RAS flow, such as 10 MGD, with the remainder bypassing the screens could effectively reduce the cBOD loading and oxygen requirements. The effective SRT could be reduced to about one (1) day, or the RAS rate reduced to maintain the 1.5 day SRT. RAS screening is estimated to reduce the cBOD loading 25-30%. As cBOD is removed with the screenings by contract hauling or landfilling, mixed liquor concentrations are also reduced, while maintaining the SRT of the screened mixed liquor. A small solids handling system would support bagging for landfilling or combining with dewatered biosolids for contract hauling.

Table WW16-14 below presents the estimated project costs, annual savings, and simple rate of return (payback period) for the WAS and RAS screening alternatives.

Table WW16-14. Cost Analysis of RAS/WAS Screening Alternatives

Alternative	Estimated Project Cost ($000)	Estimated Annual Savings ($000)	ROI (months)	Estimated % Energy Savings
Add Screening to WAS Flows	225[1]	495[2]	3.8	--
Add Screening to WAS Flows and 10 MGD of RAS Flows	475[3]	495[2] 42.7[4] 20.4[5]	10	1.7%[4]

1. Anticipates one (1) 2 MGD 250 micron rotary drum screen, piping and electrical equipment.
2. Based on an estimated 30% reduction in sludge for disposal through pressing and the cost difference in disposing of 35% solids from the screening versus 17.5% solids from the filter presses at $35 per wet ton.
3. Anticipates two (2) 6 MGD screens, piping and electrical equipment.
4. Based on 50% of solids handling horsepower from WAS pumps reduced through hauling screenings.
5. Based on a 2 tpd decrease in cBOD requirements at $28 per tpd (projected operating cost of 30 tpd VPSA oxygen generation unit).

16.15 Sludge Holding Tanks and Transfer Pump System

16.15.1 Description

WAS is pumped from Sludge Pump Station No. 2 to the sludge holding tanks for dewatering prior to being pumped to the belt filter presses. The sludge transfer pumps pump the de-watered sludge from the holding tanks to the belt filter press system.

16.15.2 Equipment Replacements

No equipment replacements were identified which will save energy.

16.15.3 Operational Changes

No equipment replacements were identified which will save energy.

16.16 Belt Filter Press System and Polymer Feed System

16.16.1 Description

GTL utilizes nine (9) sludge feed pumps and seven (7) belt filter presses to produce approximately 20 dry tpd of filter “cake” with a solids concentration of approximately 18%. Eight (8) polymer feed pumps supply polymer to the process. Other components of the system are the press conveyor (third floor) and the sludge conveyor (second floor).

16.16.2 Equipment Replacement

No equipment replacements were identified for potential energy savings.

16.16.3 Operational Changes

The City already uses aged polymer that can increase biosolids dewatering percent solids up to 10%. The City is also investigating the use of a technology that injects compressed air (Orege) to increase dewatered cake solids up to 3% and reduce polymer usage 20 to 30%. Section WW15 recommends pilot testing this technology to evaluate further.

16.17 Plant Drain Pump Station

16.17.1 Description

The plant drain pump stations receive de-watering flows from the sludge storage tanks, cleaning water flows from the effluent travelling water screens, and the discharges of the scum pump stations. Domestic wastewater from the site is conveyed to the head of the plant. The plant drain pump stations discharge flow to influent box of the #2 biological reactor or the sludge pump stations if reactor #2 is unavailable.

16.17.2 Equipment Replacement

No equipment replacements were identified for potential energy savings.

16.17.3 Operational Changes

No operational changes were identified for potential energy savings.

16.18 Building Envelope

The building envelope components evaluated include the following:

a. Architectural
b. HVAC
c. Interior Lighting
d. Exterior Site Lighting

16.18.1 Architectural

Significant amounts of energy are typically expended in older buildings due to inefficiencies in the building insulation system and exterior windows. Typical items that are evaluated as part of an "energy audit" include the following:

- Roof Insulation Properties
- Reflective Roof Treatments
- Ceiling Insulation Properties
- Window Insulation Properties and Shading co-efficiencies

The CUS Master Plan team recommends that a full building envelope energy audit be performed within the next three years to determine building improvements which can assist the City in achieving a 20% energy reduction by the year 2020. Improvements relating to the above building properties are eligible for FP&L rebates (see FP&L programs discussed further in the report).

16.18.2 HVAC

The GTL has approximately 230 tons of air conditioning equipment operating within the plant, not including miscellaneous wall units feeding various offices. All of the units are conventional condenser/air handler systems with ductwork. An evaluation of the economics of converting the HVAC systems to geothermal heat pumps follows.

Heat pumps using a boiler/cooling tower system are generally more efficient than conventional fan coil systems. Geothermal heat pumps, which use the constant temperature of the earth/groundwater to provide a heat sink/source for air conditioning/heating systems, can save between 25% and 50% on HVAC energy costs compared to conventional systems[5,6]. This section of the report evaluates the economics and other factors for replacing the existing systems with geothermal heat pump systems.

There are three (3) common types of geothermal heat pump systems as follows:

1. Horizontal Closed Loop
2. Vertical Closed Loop
3. Vertical Open Loop

All of the systems use heat exchangers and cooling/heating loops to provide heat loss (for AC) and heat gain (for heating) in the circulating water. For the Horizontal Closed Loop system, high density polyethylene (HDPE) piping is run in a horizontal pattern within the ground (or in a pond). For the Vertical Closed Loop, the piping is installed vertically (both the supply and return) with the piping connected at the bottom of the vertical section.

A Vertical Open Loop system uses a number of supply wells which feed a heat exchanger within a building and discharge the heated groundwater to either the surface, a body of water, or return wells. Many states now only allow the water to be discharged back to the aquifer the water was withdrawn from due to environmental concerns. This report anticipates that the supply water will be discharged to wells.

Table WW16-15 shows the area requirements of the different systems.

Table WW16-15. Geothermal Heat Pump Systems Area Requirements

Type System	Approx. Linear Ft of Piping Required[1]	Approx. Area Required
Horizontal Closed Loop	69,600 lf[1]	8 Acres[2]
Vertical Closed Loop	81,200 lf[3]	0.5 Acres[4]
Vertical Open Loop	N/A[5]	Based on number of wells required.

1. Based on 150 lf supply and return piping per ton.
2. Based on 400 lf runs with 2 ft. spacing between runs.
3. Based on 175 lf supply and return piping per ton.
4. Based on 10 ft. deep vertical loops in 100 lf runs with 2 ft. spacing between runs.
5. Open loop systems use groundwater flow from wells.

With the limited space available at GTL, the only type of system which appears to be feasible is an open loop system. The only land requirements for an open loop system are 10 ft. x 10 ft. areas for the supply and discharge wells and room to install the piping to the wells.

Open loop systems require approximately 1.5 to 2 GPM of source water per ton[6,7] which means GTL would need supply wells producing approximately 400 GPM (and return wells with 400 GPM disposal capacity). Five (5) supply wells producing approximately 100 GPM each and five (5) return wells (1 of each for redundancy) are anticipated. The total cost of installing open loop geothermal heat pump systems at GTL is estimated to be $3,000/ton plus the costs for constructing the wells and installing well pumps at $25,000 per well for a total cost of $940,000.

The amount of energy currently used by GTL for HVAC purposes is not known which limits estimation of energy savings and calculation of payback periods for installing the geothermal systems. The CUS Master Plan team recommends replacing existing air conditioning units with

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open loop geothermal systems as they fail. This reduces the investment to the difference between the cost of a new condenser/air handler unit and the cost of a new open loop geothermal system. Two (2) of the supply and disposal wells can initially be drilled (second well for redundancy) with the other wells constructed as needed.

Other sources of “heat sinks” for basic water-to-air heat exchange for a heat pump system were also considered. They include the incoming wastewater and the effluent leaving the plant. Installing heat exchangers around portions of the piping to transfer heat from the heat pump piping is a viable energy saving alternative. Due to the expansiveness of GTL, the high number of existing underground utilities, and the various locations of the existing systems, an estimated cost for this alternative is not provided.

The CUS Master Plan team recommends the City pursue small-scale demonstrations of the alternate “heat sink” sources to determine the viability of replacing the traditional air conditioner systems with heat pumps. A survey of all HVAC systems including locations and sizes of units would be performed during the demonstration testing.

16.19 Energy Recovery/Reduction Devices

Other energy recovery/reduction devices which can impact a facility’s energy use relating to air conditioning include the following:

1. Energy Recovery Ventilators
2. Demand Controlled Ventilation
3. Thermal Energy Storage
4. ECM Motors for DX AC Systems

The cost of retrofitting existing facilities with these devices is considered significant for the amount of energy (and money) saved.

16.20 Use of Renewable Energy or Alternative Fuels (Wastewater Treatment)

As energy, prices are projected to increase by 50% over the study period the use of renewable energy and alternative fuels will become more attractive. The biosolids processing recommendation was for anaerobic digesters that generate an alternative fuel. Conversion of the digesters biogas to energy requires a combustion engine or micro-turbine. In alignment with the City’s strategic initiatives to be sustainable, the initiative to implement solar power on the GTL site should occur in the next 10 to 15 years. Solar technology will be further advanced at that time and more cost effective and sustainable than the fossil fuels combusted by power plants.

16.21 Interior Lighting

The City is in the process of changing existing interior building lighting systems to use LED lamps. Installing a lighting control system which automatically turns lights on and off based on motion sensors was considered. The GTL staff proactively practices elements of the City’s Environmental & Sustainability Management System which includes being responsible for turning lights off when leaving rooms, etc. Also, there are certain lights which need to remain on for safety purposes. Based on the above information, installing lighting control systems is not anticipated to save any significant amounts of energy.

16.22 Site Lighting

There are approximately 230 exterior high pressure sodium or metal halide light fixtures at the plant ranging from 50 to 400 watts. Based on an average fixture wattage of 175 watts, the total current site lighting power requirements are approximately 40 KW. The wattage requirements for LED lights would be approximately 40% to 60% lower than the existing lighting. **Table WW16-16** shows the estimated current power consumption for the existing site lighting and the estimated reduced power consumption using LED fixtures.

Table WW16-16. Site Lighting Energy Comparison

Lighting System	Total KW	Hour/Day	kWh/Year	$/Year[1]
Existing Metal Halide/High Pressure Sodium	40	12	210,240[2]	$16,819
LED	20[3]	12	105,120[2]	$8,410

1. Based on $0.08/kWh.
2. Includes 20% ballast draw
3. Anticipates a minimum of 50% watt reduction requirements

Conversions from high pressure sodium and metal halide lamps can be accomplished by either replacing the entire fixture or by installing a retrofit package in each fixture. The retrofit package should have separate ballast and bulb components and a fan to cool the electronics. **Table WW16-17** shows the options of installing new fixtures versus installing retrofit packages in each fixture.

Table WW16-17. Cost Difference Between New LED Fixtures vs Retrofit Kits

Option	Estimated Cost per Fixture ($)	Estimated Total Cost ($000)	Expected Savings per Year ($000)	ROI (Years)
Replace Fixtures	1100	352	11	32
Install Retrofits	450	144	11	13

The disadvantage of installing the retrofit packages is that there are issues encountered with older fixtures in fair to poor condition. Based on the age of the fixtures, it is recommended to budget sufficient money to completely replace the fixtures in order for the system to last throughout the 20-year planning period. Replacing the fixtures within the next 5 years will help the City in achieving the goal of 20% energy reduction by 2020 based on the savings representing approximately 0.4% of the GTL energy usage.

16.23 Site Water Usage

The majority of potable water demands on site other than sanitary usage are already being supplied with GTL effluent water which meets standards for public reuse. Potable water is also used for pump seal lubrication systems which require the higher quality of water. No equipment replacements or operational changes were identified which would reduce potable water usage at GTL.

16.24 FP&L Programs

Programs identified which are applicable to work performed at GTL to reduce energy costs are presented below.

16.24.1 Business Energy Efficiency Rebates

FP & L offers rebates for installation of energy-savings devices, systems, or materials. The following are applicable program incentives:

a. Ceiling Insulation - $0.15/Sq. Ft.
b. Roof Insulation - $0.05/Sq. Ft.
c. Window Treatments – Up to $1.00/Sq. Ft. depending on shading coefficients
d. Energy Recovery Ventilators – Up to $415/KW reduced
e. Thermal Energy Storage – Up to $580/KW reduced
f. Demand Controlled Ventilation – Up to $600/KW reduced
g. ECM Motors for DX Systems - $100/KW reduced

16.24.2 Rate Structures

No rate structure programs more beneficial than the rate structures currently in place were identified.

16.25 Recommendations

Based on the above evaluations, the following recommendations are presented by the CUS Master Plan team:

<u>1-5 years</u>:

- Install VFD's on (24) remote wastewater pump stations and provide programming on all stations with VFD driven pumps to maximize usage of wet well volumes. It is anticipated that the stations will have analog/digital water level measurement and PLCs capable of supporting the programming as part of the recommendations presented in Section UW2 - SCADA System.
- Install system-wide programming to synchronize the operation of all remote pump stations.
- Replace the existing cryogenic oxygen generation system with a 30 tpd multiple bed VPSA system.
- Replace (7) remaining standard efficiency surface aerator motors with high efficiency motors.
- Perform demonstration testing of chemicals to reduce nitrification.
- Replace existing clarifier mechanisms with spiral blade mechanisms on Clarifier Nos. 1, 2, and 3.

- Provide piping and controls to convert Clarifier Nos. 8, 9, 10, and 11 to equalization tanks for the effluent pumps during periods of low/medium flows.
- Replace effluent pump check valves.
- Replace site lighting with LED fixtures.
- Perform small scale demonstration of alternative sources of heat pump “heat sinks” such as the GTL influent flows and effluent flows.
- Perform a building envelope energy analysis to identify potential modifications which can save HVAC energy.

5-10 years:

- Install facilities to screen WAS flows and portion of RAS flows.
- Replace existing clarifier mechanisms with spiral blade mechanisms on Clarifier Nos. 4, 5, 6, and 7.

10 -20 years:

- Replace existing clarifier mechanisms with spiral blade mechanisms on Clarifier Nos. 8, 9, 10, and 11.

The current total energy cost for both the collection system and GTL is approximately $2,950,000 per year, with the collection system accounting for approximately 30% of the total and GTL accounting for approximately 70%. **Table WW16-18** below shows the recommendations for years 1-5 and the estimated total energy savings for the combined collection system and GTL associated with each project.

Table WW16-18. Recommendations and Estimated Energy Savings for Collection System and GTL

Recommendation	Estimated Total Annual Energy Savings	Estimated Total Annual Energy Cost Savings, $/Year
Install VFD's on (24) remote wastewater pump stations and provide programming on all stations with VFD driven pumps to maximize usage of wet well volumes.	2%	$53,300
Install system-wide programming to synchronize the operation of all remote pumps stations.	3% to 10%	$88,400 to $296,000
Replace the existing cryogenic oxygen generation system with a 30 tpd 3-bed VPSA system.	9%	$278,000
Replace (7) remaining standard efficiency surface aerator motors with high efficiency motors.	0.5%	$14,800
Perform demonstration testing of nitrification inhibiting chemicals.	---	---
Replace existing clarifier mechanisms with spiral blade mechanisms on Clarifier Nos. 1, 2, and 3.	0.4% to 0.5%	$10,400 to $13,200
Provide piping and controls to convert Clarifier Nos. 8, 9, 10, and 11 to equalization tanks for the effluent pumps during periods of low/medium flows.	1.5%	$43,000
Replace effluent pump check valves.	1.8%	$54,000
Replace site lighting with new LED fixtures.	0.3%	$8,400
Total	18.5% to 25.6%	$550,300 to $760,700

16.26 Cost Summary

Table WW16-19 below shows the project costs associated with the recommended alternatives. **Section WW9** presents the projects in the Community Investment Plan (CIP).

Table WW16-19. Project Cost Summary for Recommended Alternatives

Project Description	1-5 year Cost	5–10 year Cost	10-20 year Cost
Install VFD's on (24) remote wastewater pump stations and provide programming on (28) stations with VFD driven pumps to maximize usage of wet well volumes.	$1,747,000	$0	$0
Install system wide programming to synchronize the operation of all remote pumps stations.	$165,000	$0	$0
Replace the existing cryogenic oxygen generation system with a 30 tpd 3-bed VPSA system.	$5,386,000	$0	$0
Replace (7) standard efficiency surface aerator motors with high efficiency motors.	$84,000	$0	$0
Perform demonstration testing of chemicals to reduce nitrification.	$25,000	$0	$0
Replace existing clarifier mechanisms with spiral blade mechanisms on Clarifier Nos. 1, 2, and 3.	$667,000	$0	$0
Replace clarifier mechanisms with spiral blade mechanisms on Clarifier Nos. 4, 5, 6, and 7.	$0	$889,000	$0
Provide piping and controls to convert Clarifier Nos. 8, 9, 10, and 11 to equalization tanks for the effluent pumps during periods of low/medium flows.	$390,000	$0	$0
Add screening for WAS flows and 10 MGD of RAS flows.	$0	$475,000	$0
Replace effluent pump check valves.	$135,000	$0	$0
Replace site lighting with new LED fixtures.	$352,000	$0	$0
Perform small scale demonstration of alternative sources of heat pump "heat sinks" such as the GTL influent flows and effluent flows.	$15,000	$0	$0
Perform a building envelope energy analysis to identify potential modifications which can save HVAC energy.	$3,000	$0	$0
Solar Power and Biogas Treatment/Conversion	$0	$0	$5,000,000
Total	**$8,969,000**	**$1,364,000**	**$5,000,000**

Section WW16 accepted December 16, 2016.

References:

1. http://emergencypower.com/support/generator-buying-guide/270-propane.htm
2. http://www.eia.gov/biofuels/issues-trends/pdf/bit.pdf
3. http://www.afdc.energy.gov/fuels/biodiesel-blend.htm
4. http://www.eia.gov/biofuels/issues-trends/pdf/bit.pdf
5. http://energy.gov/energy-savers/geothermal-heat-pumps
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WW17 Wastewater Treatment Water Conservation

17.1 Introduction

The City of Fort Lauderdale (City) has set water conservation initiatives as part of its strategic planning effort for achieving the goal of reducing energy consumption and conserving water resources. This section focuses on conserving potable water utilized at the City's George T. Lohmeyer Wastewater Treatment Plant (GTL), a large regional facility with over 50 million gallons per day (MGD) capacity.

The water-billing database from the previous two years provided by the City shows GTL consumes an average of 59 gallons per minute (gpm) potable water or 84,960 gallons per day (gpd). GTL's potable water use can potentially be reduced by optimizing processes and replacing equipment and fixtures. The purpose of this section is to identify high potable water consumption equipment and processes within the wastewater treatment plant and make recommendations for water conservation at GTL.

17.2 GTL System Evaluation

The major treatment processes at GTL include influent screening, grit removal, biological treatment, clarification, chlorination, effluent screening, effluent disposal, and biosolids management. Effluent is disposed of in deep injection wells. Biosolids are stored, decanted for thickening, dewatered on belt filter presses and then contract hauled and disposed at permitted Residual Management Facilities (RMF) sites. GTL already practices conservation by using non-potable water for process and maintenance wash water. Reduction in non-potable water reuse for plant process and wash water purposes was not considered and estimated to have minimal impact on energy consumption at the GTL. **Table WW17-1** shows a list of treatment equipment/processes identified as major consumers of potable water at GTL according to staff.

Table WW17-1. Treatment Processes and Potable Water Usage

No.	Equipment/Processes	Treatment Stage	Estimated Potable Water Usage (gpd)
1	Seal water system	Multiple stages[1]	25,000
2	Polymer mixer	Sludge dewatering	10,000
3	Pure Oxygen Plant Cooling Towers	Biological treatment	12,000
4	GTL Buildings	Miscellaneous	38,000

[1] Stages include grit removal, biosolids pump station, and effluent pumps. (GTL R&R Report)
Note: There is some site irrigation capability at GTL but it is not utilized and would require repair work to be made functional. Also, the effluent is not treated to public access reuse standards and may require special restrictions.

17.2.1 Seal Water System

The seal water system provides lubrication and flushing for the mechanical seals and packing boxes in the pumps. Currently the seal water system consumes approximately 25,000 gpd of potable water. Plant effluent non-potable water has total dissolved solids, suspended solids and organic matter that can potentially corrode and burn the seals, increasing repair and replacement costs for material and labor to repair. Therefore, GTL effluent non-potable water is not an option for the seal water system and the City's decision to continue to use potable water for GTL's seal water system is appropriate.

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17.2.2 Polymer Mixing System

Polymer is added to condition biosolids prior to the dewatering process at the belt filter presses (BFP). The polymer solution contains large organic molecules that bond small solids together producing larger floc and achieving better separation of solids and liquid and hence higher solids concentrations. Currently the polymer mixer system consumes approximately 10,000 gpd of potable water.

The CUS Master Plan Team considered water conservation using non-potable GTL effluent water for polymer mixing. According to polymer manufacturers, the potential reaction of non-potable effluent water suspended solids with the polymer solution consumes polymers, which would increase the cost of the polymer and reduce its effectiveness. Additionally, polymers usually have positive or negative charge. The chlorine residual in the GTL effluent water is also higher than potable water. Chlorine residual can act as an oxidizer that reduces the charge of the polymer, resulting in a less effective polymer. Therefore, a higher polymer dose would be required if effluent water was used for mixing.

Polymer costs significantly more than potable water, the CUSMP team affirms the City's continued use of potable water for the biosolids polymer mixers.

17.2.3 Pure Oxygen System

Currently, the City's pure oxygen system consumes 12,000 gpd of potable water primarily in the cooling tower make-up water. To use reclaimed water instead of potable water, further treatment to the quality of the reclaimed water is required. A gray water treatment system was proposed to the City to treat effluent water to meet cooling tower make-up water requirements. The capital cost of the gray water system is $30,000 (12,000 gpd with two [2] 175-ton process towers for a total of 350 tons of cooling) and the unit cost of gray water is $2.65 per 1,000 gallons. Potable water costs the City $4.35 per 1,000 gallons. Also, the effect of the elevated dissolved solids in the effluent may accelerate corrosion in the cooling tower. The CUSMP Team recommends that the City evaluate the cost of maintenance and the cost of addressing the elevated dissolved solids to gain a better understanding of the cost-to-benefit effectiveness of this option.

In **Section WW16,** the CUSMP Team recommends that the City replace the current cryogenic oxygen plant with a vacuum pressure swing adsorption (VPSA) process. The recommended VPSA process does not require extra cooling water. The City could save 12,000 gpd of potable water usage by switching to VPSA system, in addition to savings of energy and maintenance cost described in **Section WW16**.

17.2.4 GTL Buildings

In addition to the treatment processes, the plant buildings also provide opportunities to save water through conventional water conservation practices. In 1992, the National Energy Policy Act mandated the use of water-efficient plumbing fixtures, as shown in **Table WW17-2**.

Table WW17-2. Water-Efficient Plumbing Fixtures

Fixture Type	Usage rate (gallons/flush (gpf)) or gallons per minute (gpm))				
	Pre-1992	1st Generation	2nd Generation	3rd Generation High-Efficiency	% Reduction from Pre-1992
Toilet	3.5 gpf	1.6 gpf	1.28 gpf[1]	Dual flush (1. 6/0. 8 gpf)	63%[2]
Urinal	2.0 gpf	1.0 gpf	0.5 gpf[1]	0.125 gpf[3]	94%
Shower Head	5.5 gpm	2.5 gpm	2.0 gpm[1]	1.75 gpm	68%
Faucet	3.0 gpm	2.2 gpm	1.5 gpm[1]	0.5 gpm	83%

1. EPA WaterSense Program Compliant
2. Based on 1.28 gpf. Dual flush can further conserve to an average 0.96 gpf based on five flushes/day/person with only one 1.6 gpf flush and four 0.8 gpf flushes.
3. No-flow urinals were not included due to cleaning concerns, but could be implemented as City policy dictates.

The CUSMP team recommends that the City replace existing plumbing fixtures with high-efficiency models mentioned above. In addition, the City should perform a pipe inspection to identify pipe leaks and repair identified leaks. The CUS Master Plan Team also recommends a water shutoff test, monitoring master meter flow with all potable water off, to assess leakage.

17.3 Conclusion and Recommendations

According to the evaluation, the CUSMP Team made the following conclusions:

- GTL consumes an average of 84,960 gpd of potable water. The seal water system, polymer mixing, and the cryogenic oxygen plant consume an estimated total of 47,000 gpd;
- The City has been actively conserving water by using treated effluent water in appropriate applications such as the preliminary treatment's washer/compactor, clarifiers, and chlorine solution for disinfection.
- The City should remain using potable water for the seal water system, hence no significant water conservation is feasible for the seal water system;
- The City should remain using potable water for the polymer mixing system because it is appropriate and economical, hence no significant water conservation is feasible for the polymer mixing system;
- Replacing the existing cryogenic oxygen system to VPSA system can save 12,000 gpd potable water consumption;
- There are opportunities to conserve water by retrofitting high-efficiency plumbing fixtures in GTL buildings.

Measures the City can take to conserve water at GTL include the following:

- Replace the existing cryogenic oxygen system with a more energy and water use efficient VPSA system as recommended in **Section WW16** (project budgeted in **Section WW9**);
- Retrofit high-efficiency plumbing fixtures into GTL buildings (project budgeted in **Section WW9**; assumed labor performed by existing City personnel);
- Perform a water shutoff test and plant wide pipe inspection to identify and repair pipe leaks (assumed costs borne by existing City personnel);
- Establish a record of monthly water bill of each facility to identify future pipe leaks and potable water use inefficiencies (assumed costs borne by existing City personnel).

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