FINAL

MASTER PLAN REPORT

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

1 OCTOBER 2018

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LIST OF ABBREVIATIONS

ADD	Average Day Demand
AFB	Air Force Base
AMD	Average Month Demand
ASR	Aquifer Storage and Recharge
AWWA	American Water Works Association
BEBR	Bureau of Economic and Business Research
CIP	Capital Improvement Plan
COF	Consequence of Failure
DLTWTF	David L. Tippin Water Treatment Facility
EPS	Extended Period Simulations
EST	Elevated Storage Tanks
FDEP	Florida Department of Environmental Protection
FF	Fire Flow
GIS	Geographic Information System
gpm	Gallons per Minute
GST	Ground Storage Tanks
HGL	Hydraulic Grade Line
HL	Head loss
HSPS	High Service Pump Station
I-75	Interstate 75
ISO	International Organization for Standardization
LOF	Likelihood of Failure
MDD	Maximum Day Demand
MG	Million Gallons
MGD	Million Gallons per Day
mi	Mile
MMD	Maximum Month Demand
PF	Peaking Factor
PHD	Peak Hour Demand
R&R	Rehabilitation and Replacement
RPS	Repump Stations
SCADA	Supervisory Controls and Data Acquisition
SOPs	Standard Operating Procedures
SWFWMD	Southwest Florida Water Management District
TBW	Tampa Bay Water
THIC	Tampa-Hillsborough Interconnect
TM	Technical Memorandum
TWD or Department	Tampa Water Department’s
USF	University of South Florida
VFD	Variable Frequency Drives
VSP	Variable Speed Pumps
WTF	Water Treatment Facility

1.0 Introduction

1.1 PURPOSE

This report summarizes the methodology, findings and recommendations of the 2018 Potable Water Master Plan Update (Master Plan) for the City of Tampa (City). Black & Veatch worked closely with the Tampa Water Department (TWD) Staff to develop this Master Plan Update, which involved a comprehensive assessment of the TWD potable water distribution system and facilities, as well as targeted reviews of the strategies and procedures used to operate the distribution system. The results of the assessments were used to define a plan for capital improvements that are needed to allow the TWD to meet future conditions and continue providing a safe and reliable drinking water supply for its customers.

The primary purposes of the Master Plan are to:

- **Update Potable Water Demand Projections:** Review and adopt population and demand projections, which will serve as the basis for the distribution system capacity assessment.
- **Review Planning Criteria:** Update the system performance criteria that are used to determine when and where improvements are needed within the distribution system
- **Update, Calibrate and Leverage the Hydraulic Model:** Update the hydraulic model based on system improvements and new facilities that have been completed since the previous model update, and calibrate the model against recent system operating data to confirm accuracy. The updated and calibrated model will then be used as a tool to evaluate the performance of the system under projected future conditions to define recommended system improvement plans.
- **Develop Capital Improvement Project Recommendations:** Provide TWD with recommended capital improvement projects forecasted through the planning year 2035 to aid TWD in the development and prioritization of improvement projects for its Capital Improvement Plan (CIP).
- **Assess and Advance Asset Management and Risk Based Management Approaches:** Review and assess the TWD asset management activities and make recommendations to provide TWD with an asset management framework based on industry best practices. Also, develop a risk prioritization approach and assign a risk score and classification to each water main in the City's service area to allow the prioritization of rehabilitation and replacement efforts to consider risks in addition to age and condition factors.

2.0 Existing System Summary

2.1 SYSTEM OVERVIEW

The City of Tampa is a thriving community, with a service population of approximately 600,000 people. The Tampa Water Department (TWD) maintains and operates a potable water distribution system that includes over 2,200 miles of water mains in three pressure zones, five repump stations, 50,000 valves, 14,000 hydrants, and one water treatment facility. The TWD service area encompasses approximately 219 square miles, all within Hillsborough County, and includes the City of Tampa and some surrounding areas of unincorporated Hillsborough County. The boundaries of the TWD service area can be seen in **Figure 2-1**.

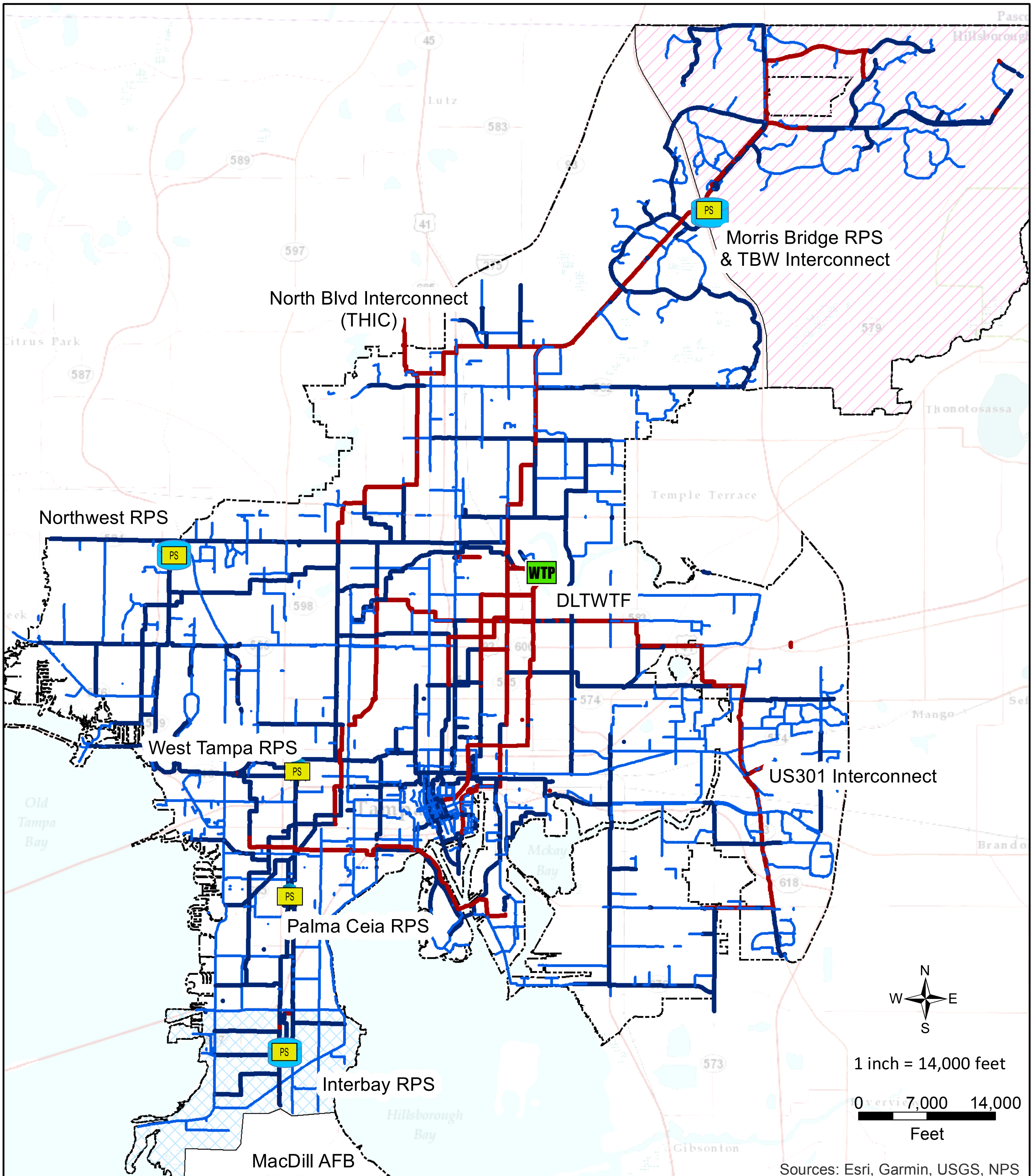
The primary source of potable water supply for the distribution system is the Hillsborough River Reservoir, which is located at the David L. Tippin Water Treatment Facility (DLTWTF). The TWD also operates an aquifer storage and recharge (ASR) program which pumps water into the groundwater aquifer during wet periods and can withdraw the supply back out during dry periods. In addition, TWD has water supply interconnects with the regional wholesale water supply authority, Tampa Bay Water, at the Morris Bridge Repump Station (RPS) and US 301 Interconnect.

The DLTWTF is TWD's only treatment facility and provides up to 120 MGD of treatment capacity. The DLTWTF has a system of clearwells for finished water storage with an effective capacity of 12.5 million gallons (MG). Following treatment, the DLTWTF's high service pump station (HSPS) delivers water to the distribution system via eight pumps on two power services.

During the Master Planning process, the TWD modified the operating strategy of the distribution system by creating three separate pressure zones: the DLTWTF, South Tampa, and North Tampa pressure zones. The boundaries for these three pressure zones are currently established by closing system valves. The pressure zones are delineated and supplied as follows:

- The North Tampa pressure zone is located in the northeast portion of the distribution system service area, and is generally north and east of where Interstate 75 crosses through the TWD services area. The North Tampa pressure zone is supplied by the Morris Bridge RPS.
- The South Tampa pressure zone is located in the southern portion of the distribution system service area. The northern boundary of this pressure zone is approximately along Gandy Blvd. The South Tampa pressure zone is fed by the Interbay RPS.
- The DLTWTF pressure zone is located in the center of the distribution system between the North Tampa and South Tampa pressure zones and encompasses the majority of the distribution system. The DLTWTF pressure zone is supplied by the DLTWTF HSPS as well as the Northwest, West Tampa and Palma Ceia RPSs.

The locations of the DLTWTF, the system RPSs, transmission and distribution system piping, and pressure zone boundaries can be seen in **Figure 2-1**. A flow diagram schematically depicting facility locations and flow directions can be seen in **Figure 2-2**.



City of Tampa Florida

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WTP WTP
PS Pump_Stations
Ground Storage Tank
Elevated Storage Tank
Service Area

Pressure_Zones
South Tampa
New Tampa

Diameter
Less than 12-inch
12 - 16-inch
16 - 24-inch
Greater than 24-inch

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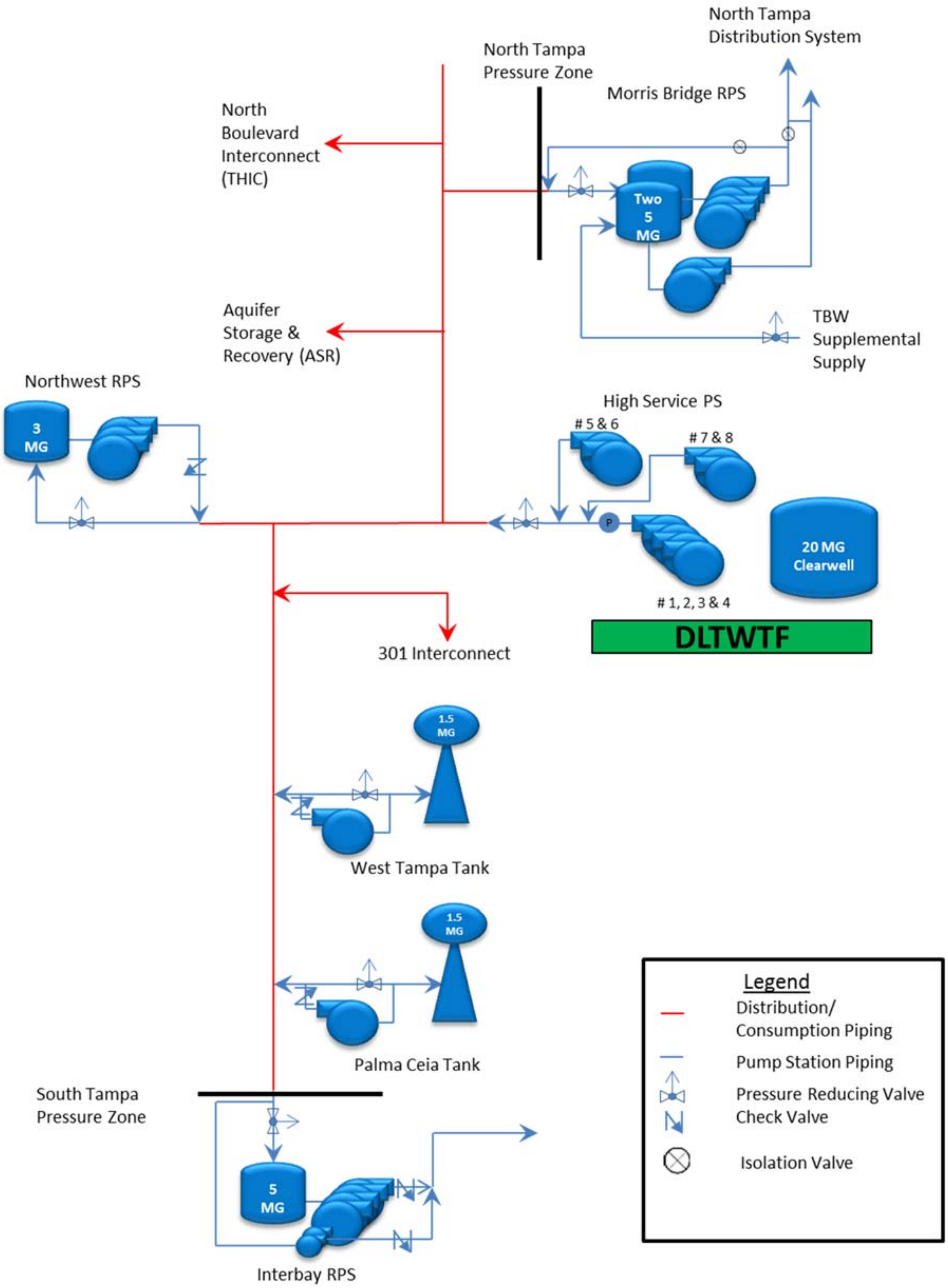
Potable Water Master Plan

Figure 2-1

Existing System

Figure 2-2: Existing System Flow Diagram



2.2 SYSTEM DESCRIPTION

This section provides information regarding the existing system infrastructure and operations that were used to develop the updated hydraulic model of the City of Tampa potable water distribution system. This section also presents the capacities and capabilities of the components that make up the potable water distribution system, including storage, pump stations, distribution piping, and system controls. The system described was used in the modeling and calibration process explained later in this report.

2.2.1 Distribution Piping

The existing distribution system has over 2,130 miles of pipelines ranging from 2-inches to 54-inches in diameter. The distribution system is well looped and gridded, which helps to maintain low velocities and headlosses throughout the system. However, the DLTWTF pressure zone also contains a significant quantity of 2-inch diameter piping, which can experience high headlosses during peak demand periods and restrict available fire flow in these areas.

A summary of the distribution system pipelines by diameter, according to the October 2015 GIS files provided by TWD, is presented in **Table 2-1**.

Table 2-1: Existing Pipeline Summary by Diameter

PIPELINE DIAMETER (INCHES)	TOTAL LENGTH (MILES)	PIPELINE DIAMETER (INCHES)	TOTAL LENGTH (MILES)
2 & 3	384	18	0.5
4	74	20	33
6	664	24	75
8	578	30	25
10	10	36	35
12	318	42	14
14	1	48	5
16	102	54	0.4
Total			2,327
Pipelines below 2-inches omitted. 2-inch and 3-inch combined			

2.2.2 Storage

After treatment at the DLTWTF, finished water is initially stored on site in five separate clearwell structures connected by piping with a total of 20 million gallons (MG) of storage capacity and an effective volume of 12.5 MG due to limitation on drawdown to limit pump cavitation and buoyancy of the tanks.

Within the distribution system there are six storage tanks: one each at Interbay, Palma Ceia, West Tampa and Northwest RPSs and two at Morris Bridge RPS. The Interbay, Northwest and Morris Bridge RPSs contain above grade ground storage tanks (GST), while the other two stations contain elevated storage tanks (EST). However, the system normally operates at a hydraulic grade line (HGL) above the top elevation of the two ESTs. Due to this condition, these elevated tanks function more like ground storage tanks, and pumps have been installed to pump water from the tanks back into the distribution, similar to the RPSs. GST and EST data, including tank bottom elevation and tank total and effective volumes are presented in **Table 2-2**.

Table 2-2: Existing Tank Capacities

LOCATION	TANK TOTAL VOLUME	TANK EFFECTIVE VOLUME	NOTES
DLTWTF Clearwell	20.0	12.5	Effective volume per TWD due to pump suction cavitation and tank buoyancy
Interbay GST	5.0	5.0	Tank effluent pipe located at the bottom of tank allowing for full usage of storage
Morris Bridge GST	10.0	7.5	Tank effluent pipe located four feet above the bottom of the tank
Northwest GST	3.0	3.0	Tank effluent pipe located at the bottom of tank allowing for full usage of storage
Palma Ceia EST	1.5	1.5	Tank effluent pipe located at the bottom of tank allowing for full usage of storage
West Tampa EST	1.5	1.5	Tank effluent pipe located at the bottom of tank allowing for full usage of storage

2.2.3 Pumping

Finished water is pumped from the clearwells by the high service pump station (HSPS) located at the DLTWTF. The target discharge pressure from the HSPS is currently 65 psi, which is set to maintain a minimum distribution system pressure of 40 psi. The distribution system contains three RPSs in the DLTWTF pressure zone. The RPSs are located relatively remote to the DLTWTF and provide the system with the ability to boost pressures during peak periods. Pumping capacity from the HSPS combined with the capacities from the Northwest, West Tampa, and Palma Ceia RPSs yield a pressure zone firm capacity of 160 MGD within the DLTWTF pressure zone.

The North Tampa pressure zone is supplied by the Morris Bridge RPS, which has a total of six pumps in two sets; Pumps 1-4 and Pumps 5&6. The firm pumping capacity of the Morris Bridge RPS is 66 MGD based on the modeled capacity of pumps #1-4 alone because the two sets of pumps cannot discharge to the same location simultaneously. However, the Morris Bridge RPS pumps are setup to allow multiple pumping configurations, including allowing pumps #5 and 6 to serve the North Tampa Zone while allowing Pumps 1-4 to discharge into the DLTWTF zone when purchasing water from Tampa Bay Water.

The South Tampa pressure zone is fed by the Interbay RPS, which also has a total of six pumps; two jockey pumps and four standard pumps. The firm pumping capacity of the Interbay RPS is 15 MGD, which is supplied by pumps #1-4 alone, because the two pump groups cannot be run concurrently.

The pumping capacity and characteristics of each pump and each RPS in the distribution system are summarized in **Table 2-3**.

Table 2-3: Existing Pump Capacities

Pump Station (Pump Type/ Install Year)	#	Maximum Capacity (gpm)	Maximum Capacity (MGD)	Rated Capacity (gpm)	Rated Capacity (MGD)	Rated TDH (ft)	Motor (Type)	Typical & Standby Power Capability	Total Pump Station Capacity: Max (MGD)	Total Pump Station Capacity: Rated (MGD)	Total Pump Station Capacity: Firm (MGD) Rated	Total Pump Station Capacity: Firm (MGD) Modeled
D.L. Tippin WTP - High Service Pump Station[1] #1-6, 1984, Dietzgen Pumps, #7-8, 1999, Ingersoll-Dresser 34KKL	1	NA	NA	13,900	20	NA	Constant	2 Utility Feeds & Generators	NA	164	134	134
	2	NA	NA	8,150	12	NA	Constant					
	3	NA	NA	7,850	11	NA	Constant					
	4	NA	NA	11,200	16	NA	Constant					
	5	NA	NA	15,800	23	NA	VFD					
	6	NA	NA	18,125	26	NA	Constant					
	7	NA	NA	18,350	26	NA	VFD					
	8	NA	NA	20,750	30	NA	VFD					
Morris Bridge Repump Station #1-4, 1973, Goulds Pumps 3420 #5, 1996, BW/IP Pump 17HQ #6, 1996, BW/IP Pump 20HQO #7, Proposed	1	14,000	20	11,100	16	152	VFD	2 Utility Feeds & Generators	101	78	62	66
	2	14,000	20	11,100	16	152	VFD					
	3	14,000	20	11,100	16	152	VFD					
	4	14,000	20	11,100	16	152	VFD					
	5	4,161	6	2,200	3	150	VFD					
	6	7,000	10	5,850	8	188	VFD					
	7	4,200	6	1,500	2	79	VFD					
Northwest Repump Station 1987	1	2,600	4	2,100	3	150	Constant	1 Utility Feed & Generator	15	12	6	8
	2	2,600	4	2,100	3	150	Constant					
	3	5,000	7	4,000	6	150	Constant					
Interbay Repump Station #1-4, 1998, Ingersoll-Dresser 8LR-14A *NOTE: #5&6 cannot operate with #1-4*	1	5,000	7	3,000	4	150	VFD	1 Utility Feed & Generator	30	16	12	15
	2	5,000	7	3,000	4	150	VFD					
	3	5,000	7	3,000	4	150	VFD					
	4	5,000	7	3,000	4	150	VFD					
	5	1,000	1	1,000	1	35	VFD					
	6	1,000	1	1,000	1	35	VFD					
West Tampa Repump 1991, Aurora Pump 90-12258	1	7,000	10	5000	7.2	50	Constant	1 Utility Feed	10	7	0	0
Palma Ceia Repump 2000, Aurora Pump 410-HSC-1200	1	6,500	9	5000	7.2	45	Constant	1 Utility Feed	9	7	0	0

1. Rated capacity of the DLTWTF pumps are unclear on the pump curves and are assumed values in this table.

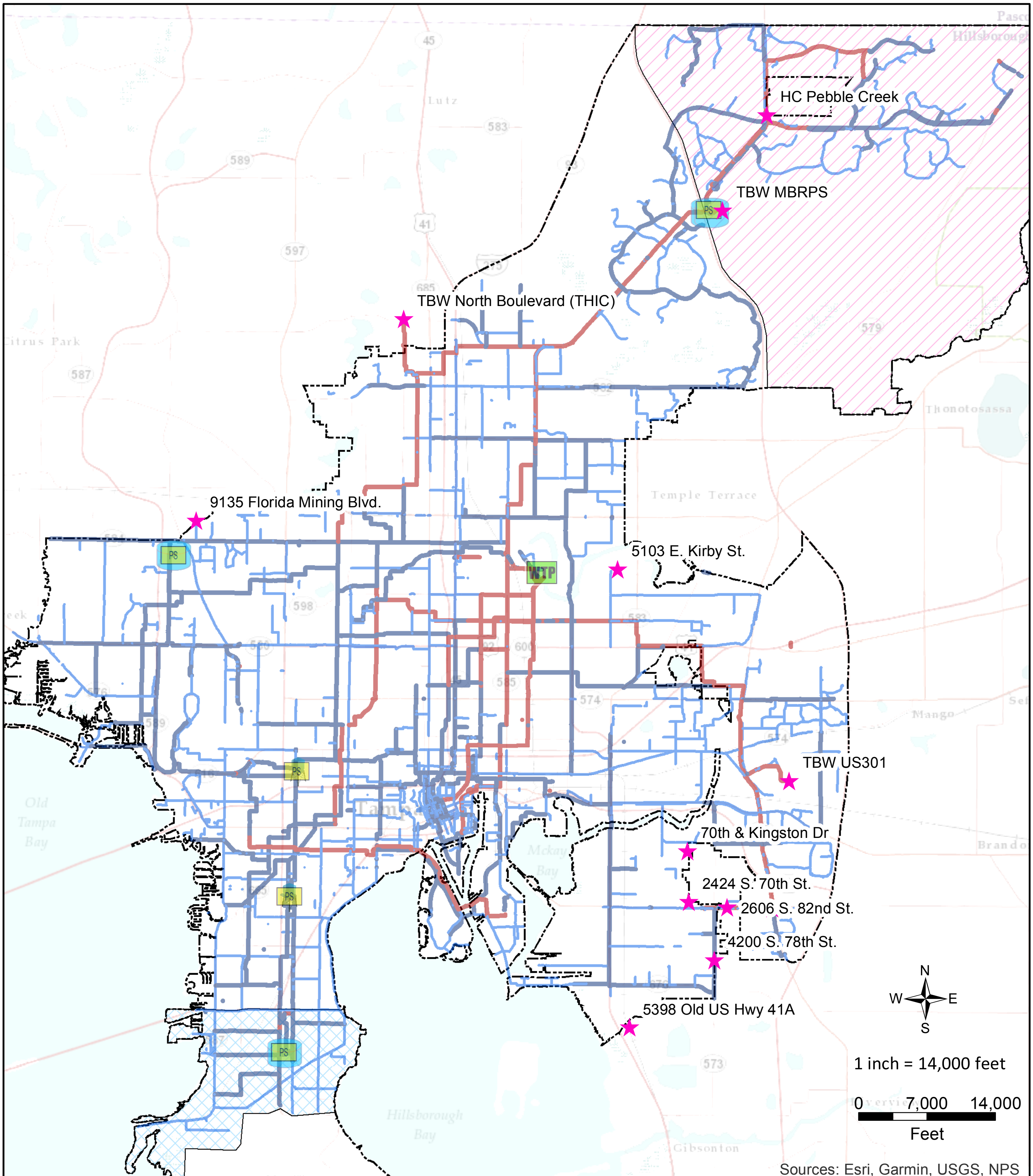
2.2.4 Interconnections

The City of Tampa has two water supply interconnections and several wholesale water delivery interconnections. The two water supply interconnections are with Tampa Bay Water (TBW); 40 MGD at the Morris Bridge RPS and 30 MGD at the US 301 emergency interconnect. The two largest wholesale water delivery connections are at the Tampa-Hillsborough Interconnect (THIC) also known as the North Boulevard Interconnect supplying water to Hillsborough County, and at the MacDill Airforce Base (AFB). The other wholesale connections are with developments within Hillsborough County and are metered with a residential master meter read monthly rather than a flow meter connected to SCADA. **Figure 2-3** illustrates the location of the Interconnections and wholesale customers.

2.2.5 Planned Improvements

The TWD already has significant distribution system improvements planned for completion prior to the 2020 planning year. These improvements are assumed to be existing in the model for planning year 2020 and future planning years. These planned improvements include:

- **The CIAC transmission pipeline**. The CIAC pipeline is a 36-inch transmission main from the DLTWTF HSPS to just south of the Palma Ceia RPS. The CIAC pipeline supplies additional flow south of Kennedy Blvd and increases pressure in the southern DLTWTF pressure zone.
- **The KBar pipeline**. The KBar pipeline is location in the northeast extents of the North Tampa pressure zone and connects two dead-ends, increasing looping and available fire flow in the periphery of the service area while decreasing water age.
- **Morris Bridge RPS upgrades**. A 7th pump will expand the firm capacity of the Morris Bridge RPS and yard piping upgrades will allow multiple pumping configurations, including allowing the station to supply a portion of the DLTWTF zone.



WTP
Pump_Stations
Ground Storage Tank
Elevated Storage Tank

Diameter
Less than 12-inch
12 - 16-inch
16 - 24-inch
Greater than 24-inch

South Tampa
New Tampa
Service Area
Interconnections

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Figure 2-3

Wholesale & Interconnections

3.0 Population and Demand Projections

3.1 POPULATION PROJECTIONS

Population projections are a critical component of master plans. Updating the hydraulic model included loading new demand projections as well as the updating the spatial allocation of the demands. Black & Veatch compared multiple population projection estimates to reach consensus with the TWD on what to use for the Master Plan. Sources included the Southwest Florida Water Management District (SWFWMD) which uses the University of Florida Bureau of Economic and Business Research (BEBR) data from 2014 and included population spatially distributed across the service area based on parcels; the Exhibit K document prepared by the Tampa Water Department using the high and low Florida Demographic Estimations; and the TBW 2014 Demand projections which use forecasting models that also incorporate factors such as weather and socioeconomic projections.

The SWFWMD estimates were considered to be the "low" population estimate with the Florida Demographic Estimations population projection in Exhibit K considered to be the "high" population estimate. A comparison of the two population projections for planning years analyzed in this Master Plan Update are presented in **Table 3-1**. Additional information regarding population projections is presented in Appendix A, Population & Demand Projections Technical Memorandum.

Table 3-1: Population Projection Summary

PLANNING YEAR	"LOW" PROJECTIONS	"HIGH" PROJECTIONS
2015	598,720	608,747
2020	611,383	651,733
2025	623,894	691,240
2035	633,422	761,822

3.2 DEMAND PROJECTIONS

The same data sources used for the population projections were used to determine the demand projections; SWFWMD, TWD Exhibit K high, TWD Exhibit K low, and TBW 2014 Projections. The different demand forecasts are shown in **Figure 3-1** and summarized in **Table 3-2**. The comparison of the four demand projection methodologies and sources provide a window of likely scenarios. The average of the scenarios was selected for use in the Potable Water Master Plan. The solid black line shown in **Figure 3-1** displays the average of all the projections and was selected by TWD for the Master Plan Update. The use of the average demand projections increases the confidence that the analysis will yield applicable results and support conservative, but defendable capital improvement projects.

Figure 3-1: Demand Projection Comparison

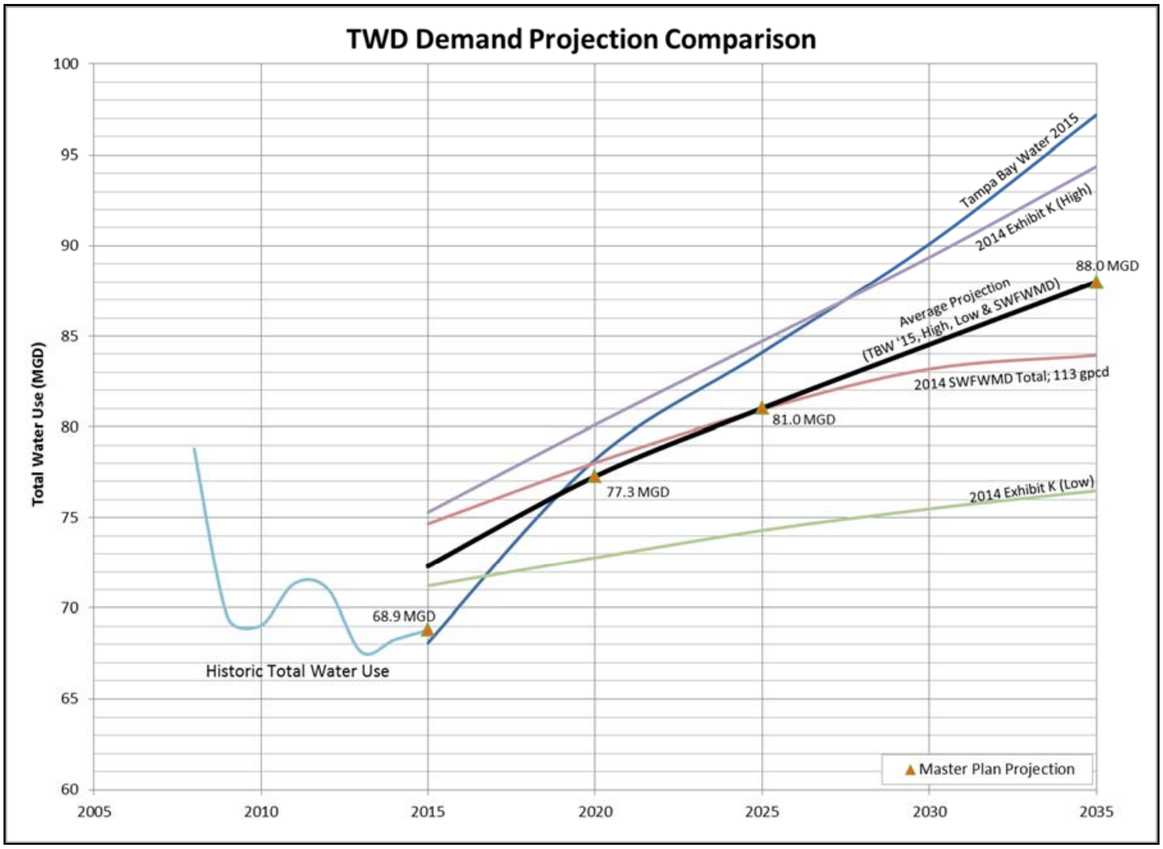


Table 3-2: Summary of Projected Demands

YEAR	TWD EXHIBIT K - HIGH	TBW	SWFWMD	TWD EXHIBIT K – LOW	AVERAGE
2015	75.3	68.1	74.7	71.2	72.3[1]
2020	80.1	78.2	78.0	72.8	77.3
2025	84.7	84.1	81.0	74.3	81.0
2030	89.4	90.1	83.2	75.5	84.5
2035	94.4	97.2	83.9	76.5	88.0

1. Actual 2015 demand was 68.9 MGD. The actual demands will be used for the existing system analysis, while the remaining projected demands will be used for future analysis

3.3 NON-REVENUE WATER

Distribution system demands are comprised of several different uses and are either consumed by customers, referred to as consumption demand and are metered for billing purposes, or are “lost” through water quality flushing, leaks, main breaks, and meter inaccuracies. These “losses” are referred to as non-revenue water.

Non-revenue water (NRW) demands are quantities of water lost from the system which are comprised of several categories including: water quality flushing, leakage, main breaks, and meter inaccuracies (apparent losses). NRW is monitored monthly by TWD by comparing total water production and total water consumption. A detailed review of water consumption and production records found that NRW had a five-year average (2011-2015) of 11% of total water demand. The NRW was broken down into each source as shown in **Table 3-3**.

Table 3-3: NRW Category Average % Breakdown

NRW CATEGORY	PERCENT OF NRW
Water Quality Flushing	8%
Meter Inaccuracies (apparent losses)	17%
Main Breaks & Leaking	75%
Total	100%

NRW was then allocated to each planning year based on the 11% assumption. The adopted planning years demands and non-revenue water losses are shown in **Table 3-4**. Additional details on the calculation and breakdowns of non-revenue water are available in Appendix A, Population & Demand Projections Technical Memorandum.

Table 3-4: NRW per Planning Year

YEAR	TOTAL PROJECTED DEMAND (MGD)	CONSUMPTION DEMAND (MGD)	NON-REVENUE WATER DEMAND (MGD)	WQ FLUSHING (MGD)	METER INACCURACIES (MGD)	MAIN BREAKS / LEAKAGE (MGD)
2015 (Base)*	68.9	64.4	4.5	0.4	0.8	3.4
2020	77.3	68.8	8.5	0.7	1.4	6.4
2025	81.0	72.0	8.9	0.7	1.5	6.7
2035	88.0	78.3	9.7	0.8	1.6	7.3

*NOTE: 2015 (Base) demands are based on the actual demands recorded (consumptive and NRW).

3.4 DEMAND RATIOS

The average day demand (ADD) for each planning year was based on the projected demands and NRW as described above. However, water utilities, including TWD, typically plan for several additional demand conditions including: maximum day demand (MDD) and peak hour demand (PHD). In addition to being used to size new facilities, these conditions are also used to determine the condition of the system utilizing a number of different criteria. For example, FDEP requires pumping capacity to meet or exceed the MDD or PHD plus fire flow depending on the type of storage available.

Demand ratios, often referred to as peaking factors, are useful for increasing or decreasing average system demands to match different demand scenarios. This process is used in hydraulic modeling for modifying applied ADD system demands. A summary of demand ratios for the system as one pressure zone was calculated from a 5-year horizon (2011-2015) and is presented below in **Table 3-5**. The PHD:MDD peaking factors were determined on a per pressure zone basis as a result of the diurnal pattern calculation described further in the section.

Table 3-5: System-wide Demand Ratio Summary

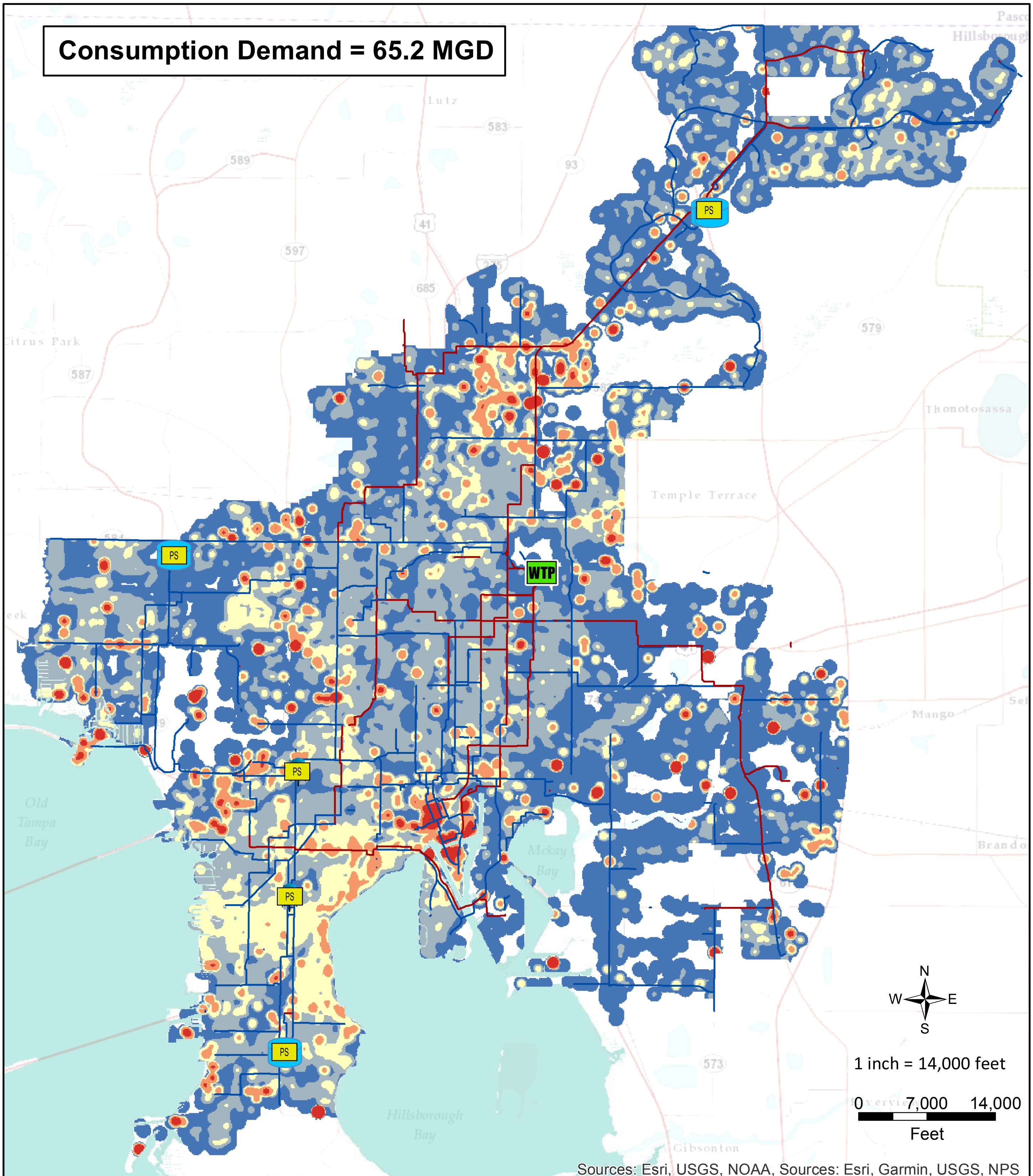
PRESSURE ZONE	MDD:ADD	PHD:MDD	PHD:ADD
DLTWTF	1.56	1.42	2.22
North Tampa	1.56	1.63	2.54
South Tampa	1.56	1.37	2.14

3.4.1 Demand Update and Spatial Allocation

Customer billing records are the most current and accurate way to assign real base consumption demands to the hydraulic model. The spatial allocation of demands is almost as important as the demand calculations themselves. To accurately model demands and their impacts on the distribution system, it is important to accurately locate those demands. To determine the location or spatial allocation of the consumption demands, a combination of geocoded customer billing records provided by TWD and population projections by parcel provided by SWFWMD were used. Geocoded records were imported and applied directly to the nearest pipe and node in the model. Non-revenue water demands, which accounted for eleven percent of total demands, were typically allocated equally across the distribution system. The exception to this occurs where NRW demands are well known, such as at flushing program locations, or where data indicates significant NRW demands have existed, such as in older parts of the system where main breaks are common. Future planning year demand allocations build on the base year consumption allocation, assuming existing use will remain and augmenting with future use based on increases in use derived from the population projections. The base year demand allocation is shown in **Figure 3-2**, and the NRW allocation is shown in **Figure 3-3**. **Table 3-6** summarizes the demands used for the system analysis and subsequent improvement identifications.

Table 3-6: Demand Projections

PRESSURE ZONE	DEMAND BY PLANNING YEAR (MGD)											
	2015			2020			2025			2035		
	ADD	MDD	PHD	ADD	MDD	PHD	ADD	MDD	PHD	ADD	MDD	PHD
North Tampa	4.8	7.4	10.5	6.1	9.5	13.5	7.0	10.8	15.4	8.3	13.0	18.5
South Tampa	4.6	7.2	11.7	5.1	7.9	12.9	5.2	8.1	13.2	5.4	8.4	13.6
DLTWTF	59.6	93.0	127.4	66.1	103.2	141.3	68.8	107.3	147.0	74.3	115.9	158.8
Total	69.0	107.6	-	77.3	120.6	-	80.9	126.2	-	88.0	137.3	-



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WTP	WTP	
PS	Pump Stations	
	Ground Storage Tank	
	Elevated Storage Tank	

Diameter

- 16 - 24-inch
- Greater than 24-inch
- Service Area

2015 Demand Density

- Low Density
- Med-Low Density
- Medium Density
- Med-High Density
- High Density

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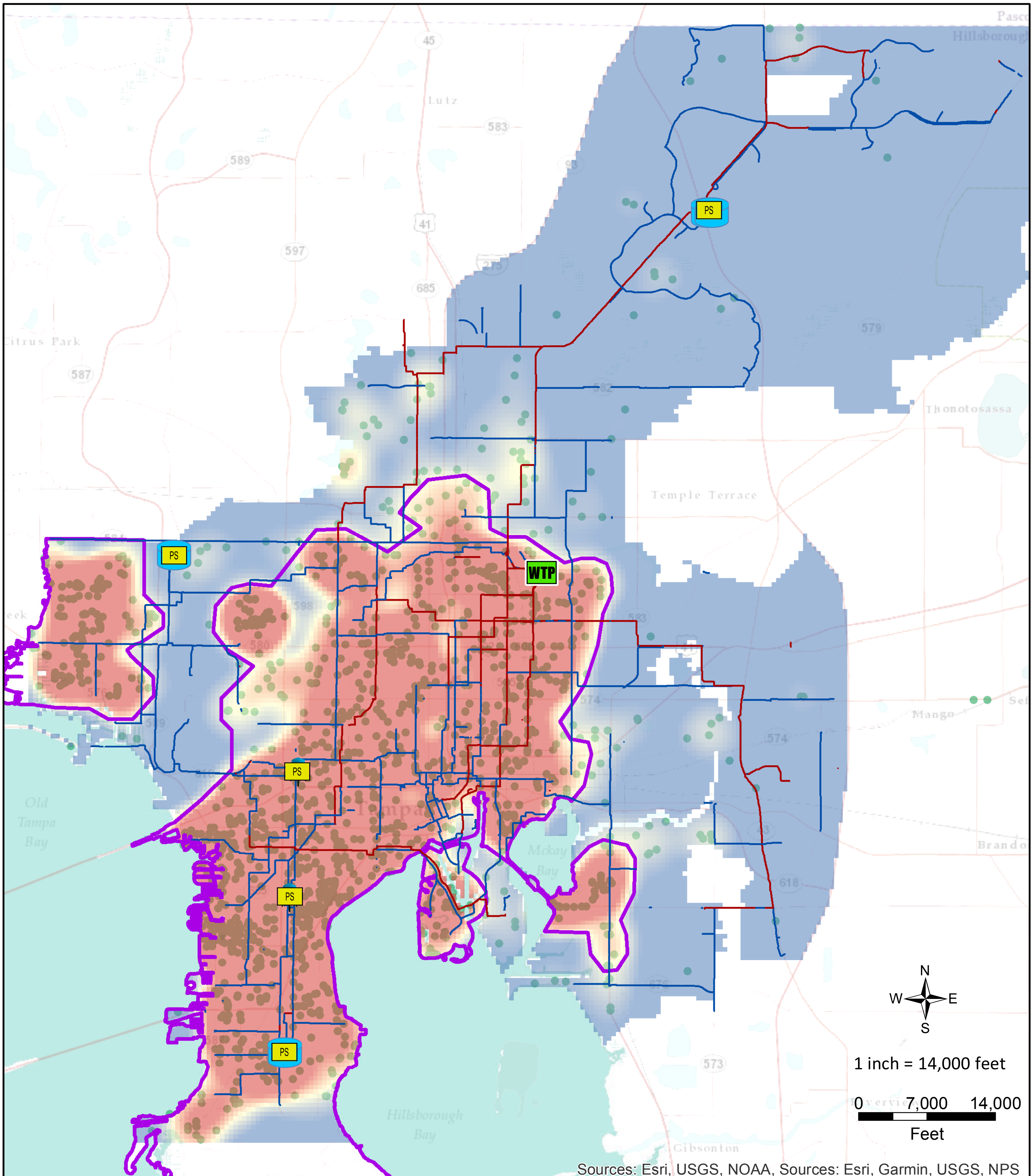
Figure 3-2

Base Year (2015) Consumption Allocation



City of Tampa Florida

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WTP	WTP
PS	Pump Stations
	Ground Storage Tank
	Elevated Storage Tank

Diameter
- 16 - 24-inch
- Greater than 24-inch
- Main Breaks ('10-'14)

- Service Area
- Leaking NRW Extents

Main Break Density
- High : Density
- Low : Density

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Potable Water Master Plan

Figure 3-3

NRW Main Break & Leakage Allocation

3.4.2 Diurnal Pattern Update

In order to conduct a 24-hour extended period simulation (EPS) analysis, it was necessary to define diurnal demand patterns for each pressure zone that represent the existing system demand patterns as close as possible. This was accomplished through a mass balance calculation using the available SCADA data to relate pump station flows and changes in tank levels to determine system, facility, and pressure zone demands.

The selected MDD analysis pattern for each of the three pressure zones (DLTWTF, North Tampa, and South Tampa) are illustrated in **Figure 3-4** through **Figure 3-6**. An additional diurnal pattern was developed to represent the time-specific pattern of demands from MacDill Air Force Base (AFB), which draws water from the TWD system to fill its reservoirs and operate its water system. **Figure 3-7** illustrates the selected MacDill AFB demand pattern. The date selection process for demand data and the data processing and aggregation to compile and combine multiple days of data into a single pattern for each pressure zone is detailed in Appendix B, Distribution System Improvements Technical Memorandum.

Figure 3-4: DLTWTF MDD Diurnal Pattern

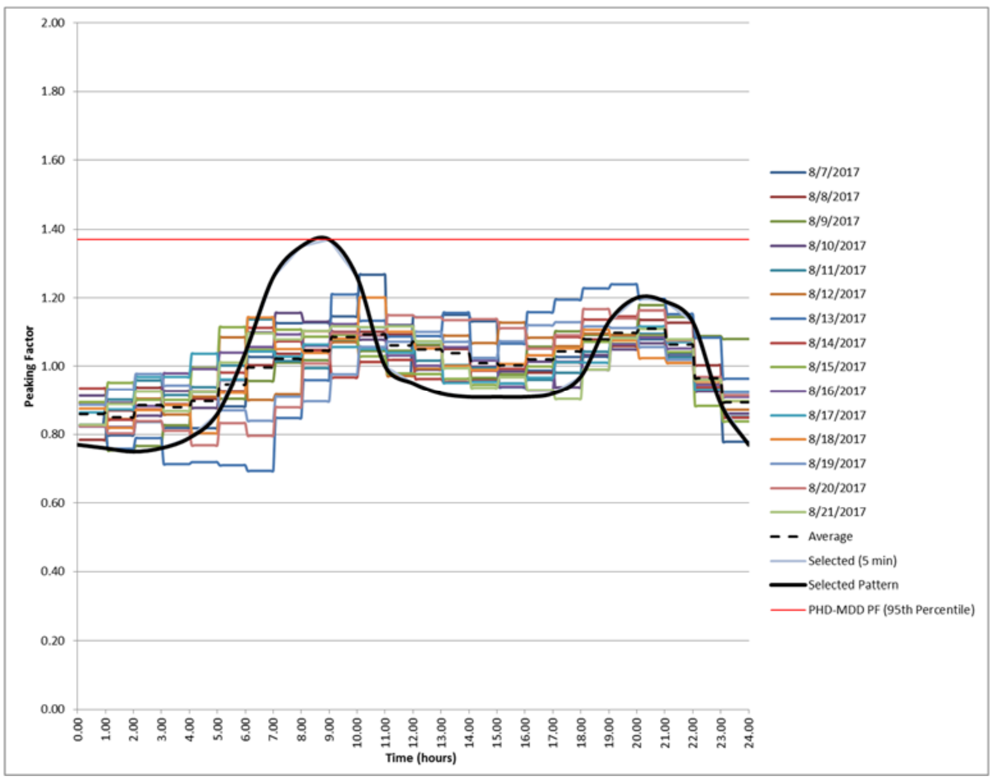


Figure 3-5: North Tampa MDD Diurnal Pattern

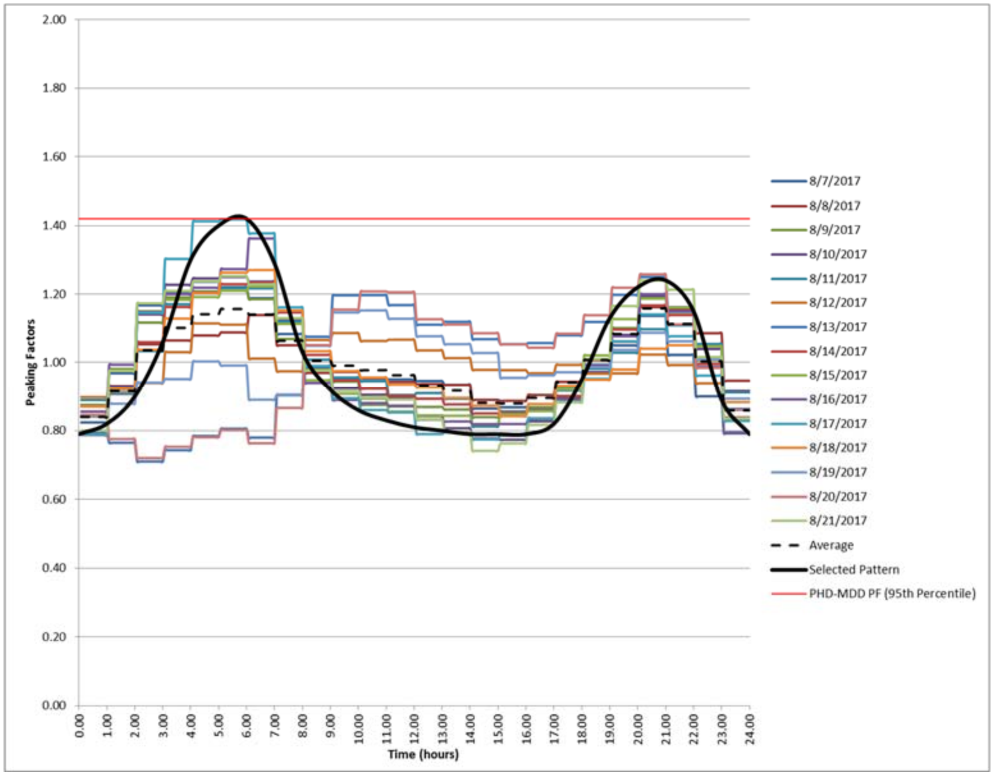


Figure 3-6: South Tampa MDD Diurnal Pattern

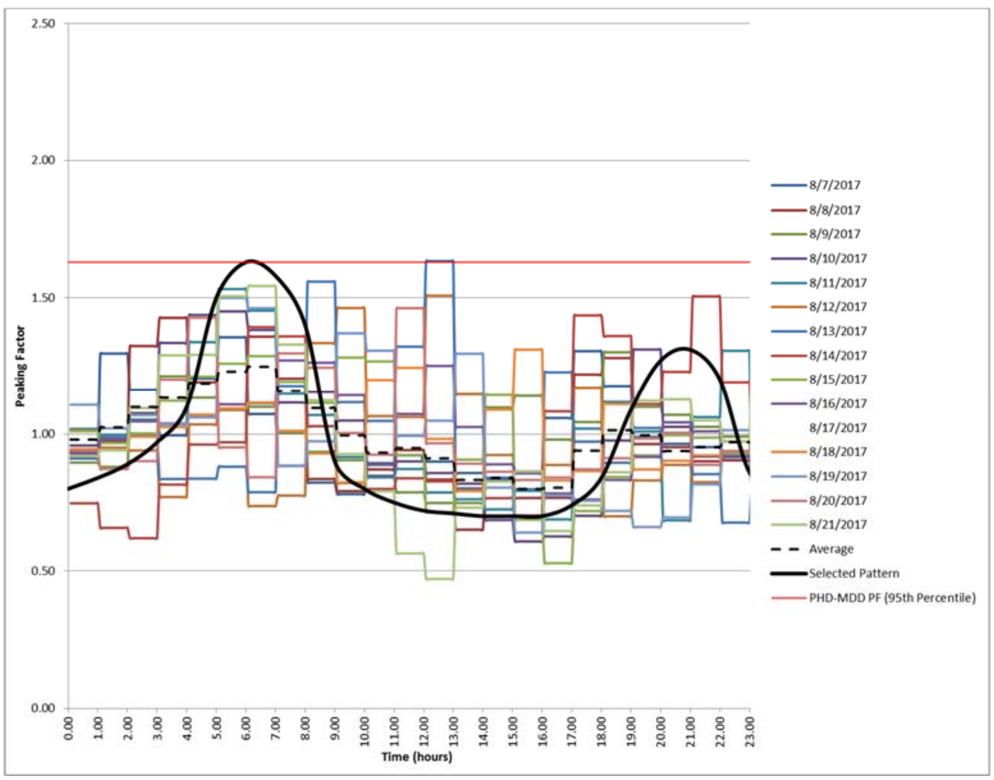


Figure 3-7: MacDill MDD Diurnal Pattern

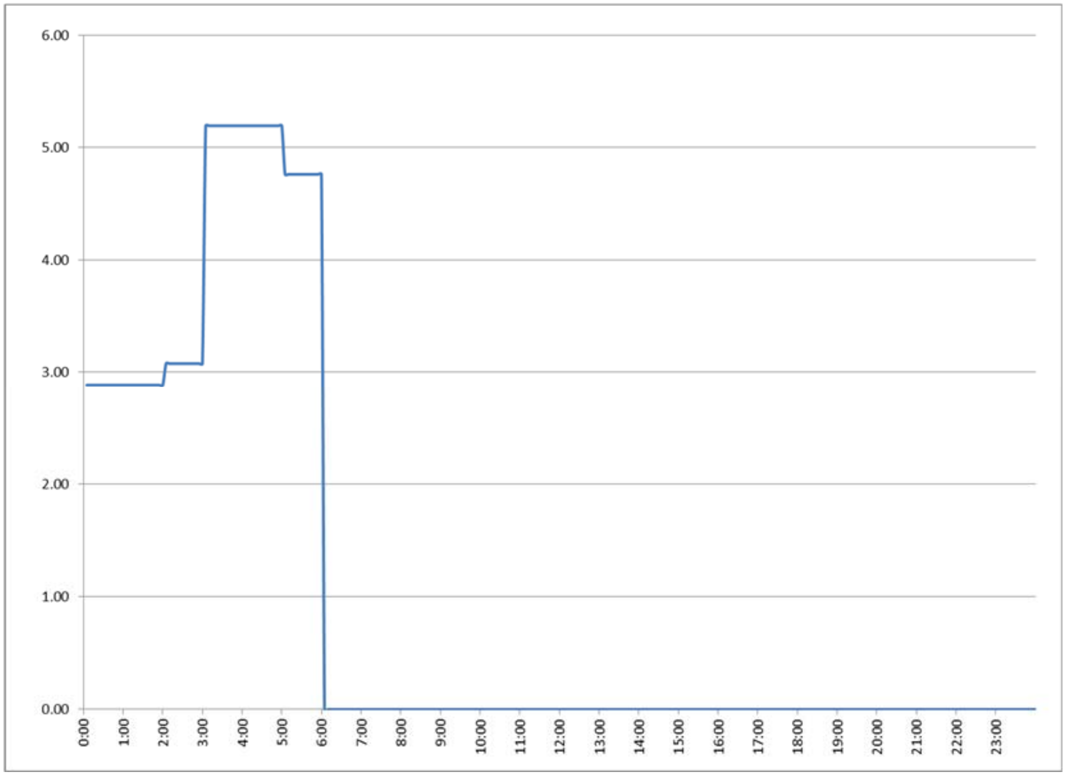
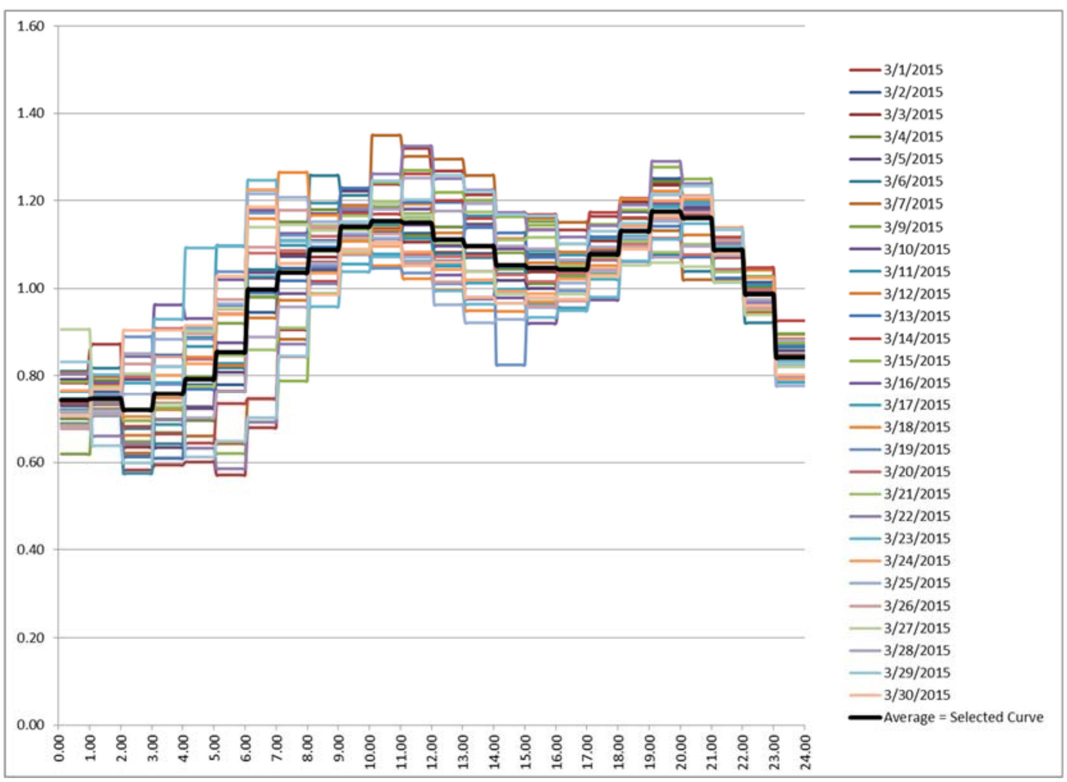


Figure 3-8: System-wide ADD Diurnal Pattern



4.0 Hydraulic Model Update and Calibration

The TWD maintains a hydraulic model (model) of its potable water distribution system to conduct various analyses on the capabilities and capacities of the system. Black & Veatch updated the City's hydraulic model with 2015 water demand information and prepared the model for extended period simulations (EPS). A 24-hour EPS is the preferred calibration methodology and provides a clear indication of the ability of the hydraulic model to simulate system operating conditions under a number of settings. In addition, Black & Veatch completed a model calibration process to compare and validate the updated hydraulic model results with actual system operating data that was collected by the City.

Since the previous 2009 master plan and during this 2018 Master Plan update, the TWD has made a significant operational change, switching from operating their system as one large pressure zone, to three pressure zones. In the new operating configuration, pressure zone boundaries were established and the Interbay and Morris Bridge RPSs are used to supply water to the two new pressure zones. There are two hydraulic model calibration technical memorandums included in Appendix C that reflect the change in the system configuration. The results provided in this section of the report are for the most recent calibration effort reflecting the three pressure zone configuration.

4.1 MODEL UPDATE

In order for the TWD to more fully use the capabilities of its hydraulic model in analyzing its distribution system, the model needed to be updated to allow for EPS. To be accurate, EPS simulations require significantly more information, and the update of the TWD's model for EPS required a number of changes including: collecting and applying system customer demand information, selecting system monitoring data and using that data to calculate changes in system demands at regular intervals to produce diurnal patterns, and collecting information regarding controls and operations of tank fill valves and the system's pump stations. The model also required the addition of new and updated facilities.

4.2 CALIBRATION FIELD DATA

The TWD records and maintains Supervisory Controls and Data Acquisition (SCADA) data at each of the major system facilities, including the five RPSs and several permanent pressure loggers throughout the distribution system. The availability of this data allowed Black & Veatch to conduct an EPS model calibration of the distribution system following the update of the model. Data from 28 permanent SCADA pressure loggers and nine temporary hydrant pressure loggers was also available for the calibration effort. **Table 4-1** summarizes the available SCADA data.

To calibrate the model for EPS, a date had to be selected for the required 24 hours of data. September 5, 2017 was selected from the available data range (August 23-September 7, 2017) due to its data consistency, small amount of SCADA data gaps, and high water demand. Diurnal demand patterns for the specific calibration data period were generated following the same process used to generate the diurnal patterns for the pressure zones. Calibration field data and diurnal demand pattern development and application are explained in further detail in Appendix C-b Recalibration Technical Memorandum.

Table 4-1: Available SCADA Data

PUMP STATION, TANK OR LOGGER	PUMP STATUS	PUMP SPEED	TOTAL FLOW	INDIVIDUAL PUMP FLOW	DISCHARGE PRESSURE	TANK LEVEL
D.L. Tippin WTF	Limited (missing data on 6, 7, & 8)	Limited (missing data on 5, 7, & 8)	Yes	-	Yes	N/A
Interbay RPS	Limited (lots of "Bad" readings)	Limited (lots of "Bad" readings, missing jockey pumps)	Yes (had a few "Bad" reading which were assumed to be zero)	-	Yes	Yes
Morris Bridge RPS	Yes (looks like there is an error with 3 & 4, assumed off)	No	Yes	No	Yes	Yes
Northwest RPS	No	N/A	Yes	No	Yes	Yes
Palma Ceia RPS	No	N/A	No	No	Yes	Yes
West Tampa RPS	Yes	N/A	No	No	Yes	Yes
North Boulevard Connection	Yes	No	Yes	No	Yes	N/A
Aquifer Storage Recovery (ASR) Recharge Flow	No	N/A	No	Yes	No	N/A

4.3 CALIBRATION GOALS

The calibration of the system hydraulic model included a total of 10 facility points of calibration (flow & tank levels) and 35 points of calibration at the permanent and temporary pressure loggers conducted over 288 different time steps. To determine the accuracy of the calibration, Black & Veatch set a number of goals and limits that are consistent with best practices for calibrating hydraulic models for water distribution systems. The calibration goals are summarized in **Table 4-2**. Refer to Appendix C-a, Model Update and Calibration Technical Memorandum, for a description of recommended calibration goals.

Table 4-2: Calibration Goals

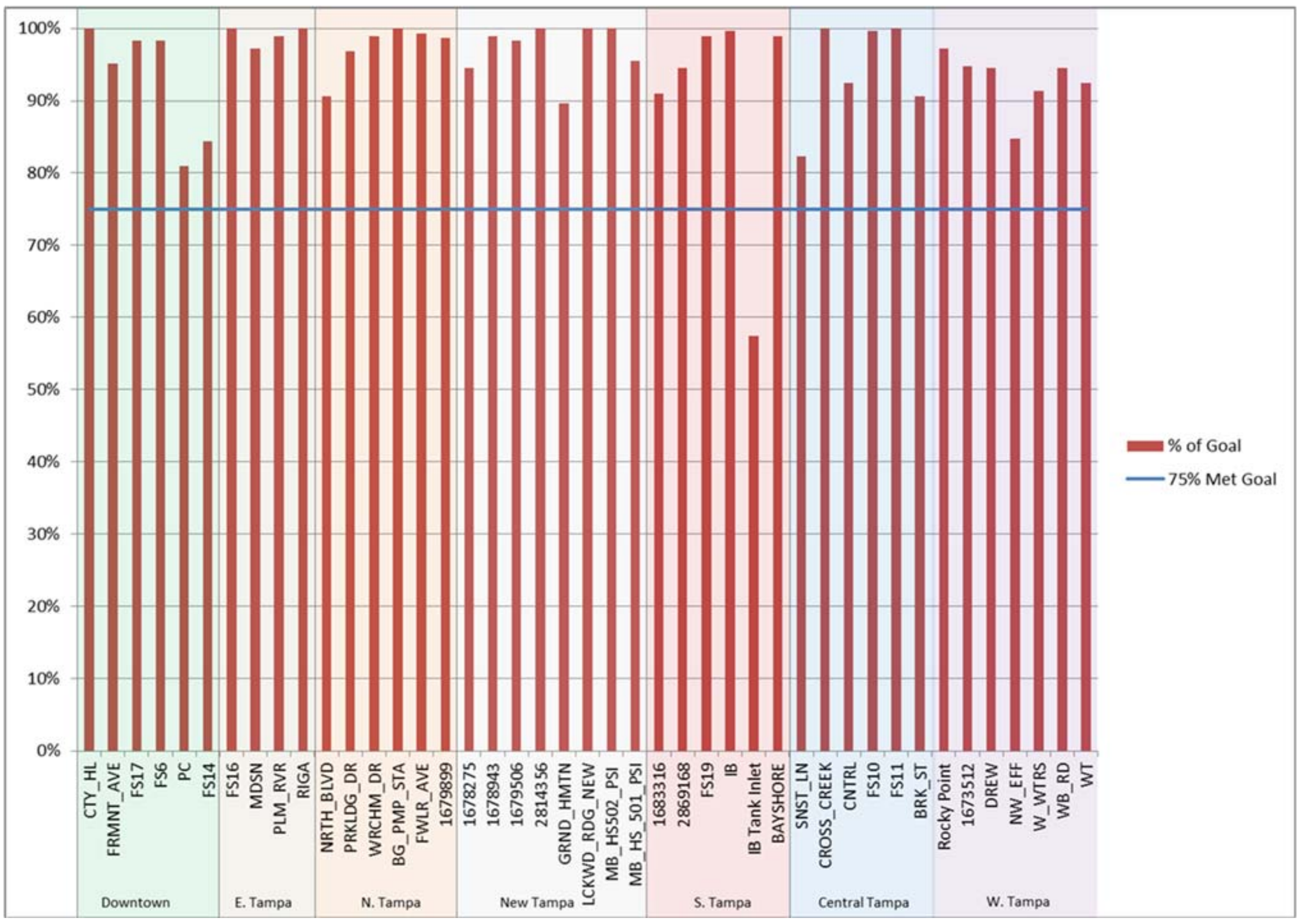
CALIBRATION POINT TYPE	LOCATION	CALIBRATION GOAL
Tank Level	Interbay, Morris Bridge, Northwest, Palma Ceia and West Tampa	+/- 3 ft.
Flow	DLTWTF, Interbay, Morris Bridge, Northwest, ASR Recharge	+/- 10%
Pressures	Various locations	+/- 3 psi

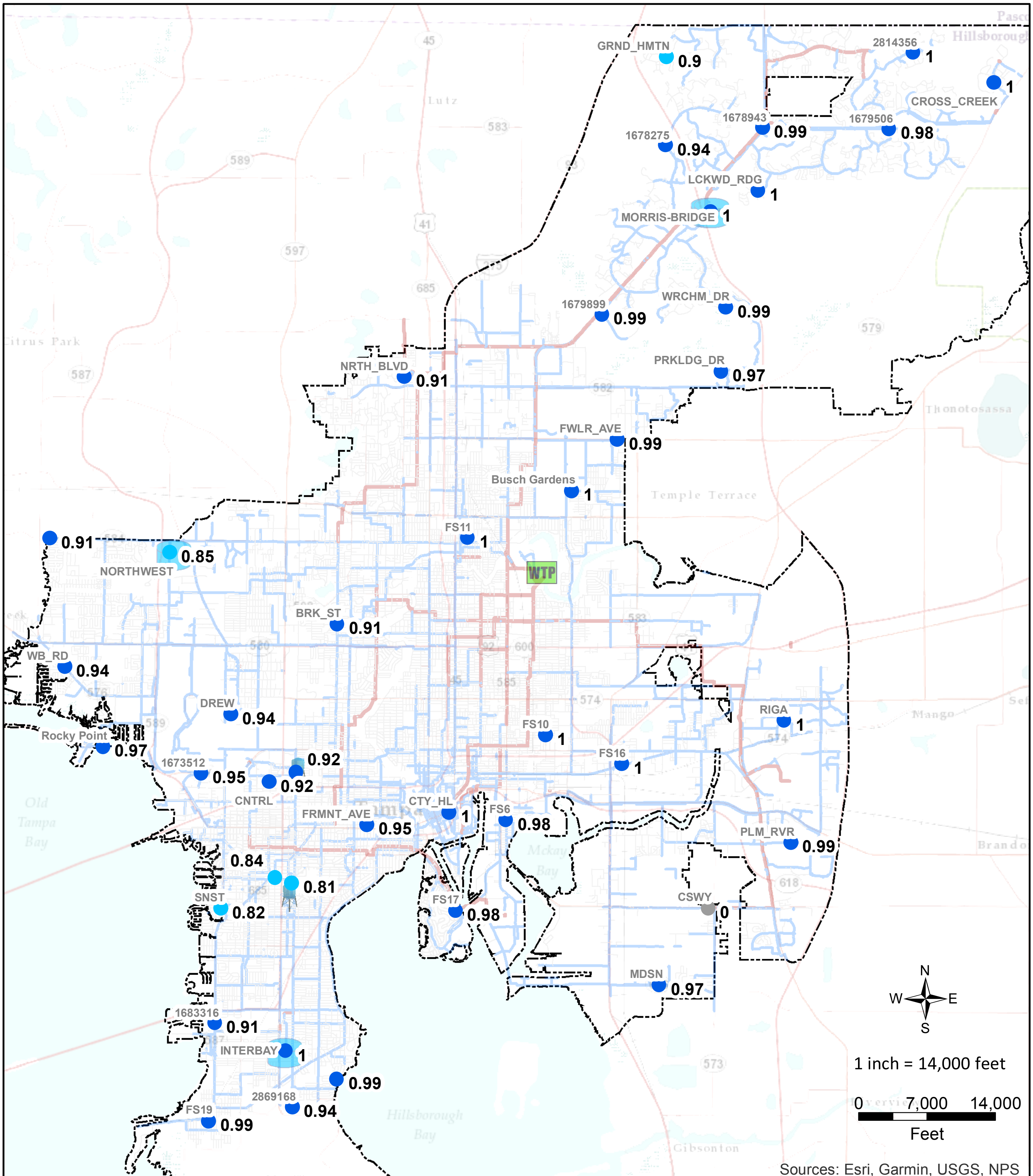
4.4 CALIBRATION RESULTS AND CONCLUSIONS

The results of calibration show a well calibrated model with a very high correlation between the field SCADA data, the tank levels, and pumped flows. One hundred percent of the 2880 data points covering all the facility locations were within the calibration goals. Likewise, the calibration results of the pressure points also had a good correlation with closely matching daily patterns and 95% of the 12,427 data points were within the calibration goal. Time series plots for pump station, tank level, and pressure point calibration data are included in Attachment 1 of Appendix C-b, Hydraulic Model Recalibration TM. **Figure 4-1** and **Figure 4-2** illustrate the accuracy of the calibration results.

The following steps might be helpful in increasing the percent of goal met: surveying the elevation of each SCADA points and installing AMR/AMI for better demand allocation.

Figure 4-1: Pressure Logger % of Goal Results





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% of Points that Met Goal

- Removed from Calibration
- Less the 50%
- 50% to 75%
- 75% to 80%
- 80% to 90%
- 90% to 100%

Diameter

- Less than 12-inch
- 12 - 24-inch
- Greater than 24-inch
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 4-2

Recalibration Results Summary

5.0 Distribution System Assessment

Using the calibrated hydraulic model, Black & Veatch performed a comprehensive distribution system analysis. The analysis includes assessments of the system's performance under a variety of scenarios including: MDD, PHD, Fire Flow (FF) and Asset Failures. These scenarios were run primarily for the base year (2015) and final future planning year (2035), with consideration of phasing of improvements for the two interims planning years (2020 and 2025). Scenarios were developed and analyzed based on the existing system configuration as well as a variety of proposed configurations. However, only the performances of the existing system scenarios are presented here.

The system analysis evaluates the adequacy of the existing distribution system and highlights areas requiring improvements (presented in Section 6) to meet the system performance criteria established by the TWD. The results of the distribution system assessment are summarized in the remainder of this section of the report. Additional details regarding the assessment of the distribution system are also provided in Appendix D, Distribution System Assessment Technical Memorandum.

5.1 PERFORMANCE CRITERIA

Black & Veatch worked with the TWD to establish the desired system performance criteria, which were used as the basis for determining if improvements are needed to meet the projected increases in system demands over the planning horizon. The criteria are based on various water system design guidelines and consider references such as existing and proposed regulations (e.g. FDEP regulations). **Table 5-1** summarizes the performance criteria on which the system was evaluated.

5.2 DISTRIBUTION SYSTEM ASSESSMENT RESULTS

Black & Veatch analyzed the existing distribution system for the purpose of identifying system capacity, operational, resiliency, and reliability needs across various planning years. More than twenty-five scenarios were selected to analyze the existing and planned distribution systems. Discussions of the analysis approach, observations and conclusions of the system analysis are presented in the following sub-sections.

5.2.1 Pumping Facilities

The capacities of the pumping facilities were analyzed using an Excel-based desktop model for each planning year to evaluate the adequacy of the existing facilities and to identify any deficiencies in capacity based on regulations and the performance criteria. The results of the desktop pumping facilities capacity analyses are presented in **Table 5-2**.

Table 5-1: Distribution System Performance Criteria

Parameter	Criteria / Description	Performance Goal	Comments
1. Demand Peaking Factor	MDD: ADD	**95th confidence interval (only exceeded 1 year out of 20 years)** [B&V]	- Ratio to be calculated based on actual system data from 2004 - 2015. - PHD: MDD data is not available for the period and will be based on 95th Percentile of 5 years (2011-2015)
	# Years of Historic Data	**12**	- 12 years were selected to include the last drought conditions in 2007.
2. Pump Station Capacity	Supply + Remote Pump Stations (w/out elevated storage)	**Firm Capacity > PHD + Fire Flow (per service area)** [F.A.C 62-555.320(15)(a)]	- Firm Capacity > PHD + Fire Demand, unless elevated finished drinking water storage is provided [F.A.C. 62-555.320 (15)(a)] - Firm Capacity + useful elevated storage capacity > greater of PHD for 4 hours or MDD+FF [F.A.C 62-555.320(15)(b)] - Firm capacity per pressure zone is the capacity with the largest pump out of service per pressure zone. • North Tampa Zone, South Tampa (Interbay) and DLT Zone - Existing Elevated tanks cannot be counted for F.A.C 62-555.320(15)(a) as they do not float on the system. - If elevated tank improvements were made to allow the tanks to float on the system, the criterion may be reduced to meet F.A.C. 62-555.320(15)(b). This can be evaluated as a potential improvement option.
	Supply + Remote Pump Stations (w/elevated storage)	**Firm Capacity > MDD + Fire Flow (per service area)** [F.A.C 62-555.320(16)(b)]	
3. Storage Volume	Total Storage (per pressure zone)	**> 25% of the System's MDD + Fire Flow (Reserve)** [F.A.C. 62-555.320 (19)(a)]	- Unless a demonstration showing that the useful finished water storage capacity (minus fire protection) is sufficient for operational equalization [F.A.C. 62-555.320(19)(b)1] - Unless a demonstration showing that the water system's total useful finished water storage capacity (minus fire protection) is sufficient to meet the water systems PHD for 4 consecutive hours [F.A.C. 62-555.320(19)(b)2] - Equalization storage should be 15-20% of max daily use. [Lindeburg] - Per discussion with the City, total storage does not include additional emergency storage due to existing WQ concerns.
	Fire Reserve	**3,500 gpm for 3 hours (per service area)**	- Minimum fire flow = 1,000 gpm for 1 hour [Florida Fire Code, Table 18.4.5.1.2] - Fire Flow between 1,500 gpm & 2,750 gpm = a duration of 2 hours; 3,000 & 3,750 gpm = a duration of 3 hours [Florida Fire Code]
4. Pressure	Minimum Pressure – Peak hour demand conditions. (Non-Fire, Non-Emergency)	**> 50 psi Transmission** **> 40 psi Distribution** **> 25 psi Metered Discharge** [TWD Tech Manual, 3.2.A.2]	- > 20 psi [F.A.C. 62-555.320 (15)(b)] - Minimum pressure at the tap should be 25 psi. Minimum pressures at fire hydrants should be 60 psi, possibly higher in commercial and industrial districts [Lindeburg] - Metered discharge pressure is on the private side of the customer meter and is not represented in the model
	Maximum Pressure	**< 75 psi**	- Florida 2010 Plumbing Code requires a service line PRV if the pressures within the building exceeds 80 psi.
5. Fire Flow	System Demand/Supply	**MDD**	- If fire protection is being provided the design capacity should be fire flow plus maximum day demand. MDD+FF [F.A.C. 62-555.320(15)(a)] - PHD+FF was not selected due to existing WQ concerns which would increase with oversized water mains.
	Minimum Flow	**1,000 gpm (residential)** **3,500 gpm for 3 hours (commercial & Industrial)** [exceeds TWD Tech Manual, 3.2.A.3.c]	- Residential fire flow can be reduced to 500 gpm if building has automatic sprinkler systems and greater than 30ft separation between buildings [18.4.5.1.23, Florida Fire Code] - 1,000 gpm for 1 hour (residential) & 3,000 gpm for 3 hours (commercial & industrial) [TWD Tech Manual, 3.2.A.3.c]
	Maximum Flow	**3,500gpm for 3 hours** [ISO & AWWA M31]	The maximum flow is the maximum fire flow required from the TWD system. For system customers with fire flow requirements greater than what can be provided by the TWD system, it is assumed that those customers will construct private fire protection systems as needed to meet their own fire service needs.
	Minimum Residual Pressure	**> 25 psi** [TWD Tech Manual, 3.2]	Minimum residual pressures = 20 psi. [F.A.C. 62-555.320 (15)(a)]
6. Pipe Capacity	Maximum Velocity	**< 5 ft./sec at peak hour demands (normal, non-fire conditions)** **< 10 ft./sec at MDD+FF demands** [TWD Tech Manual, 3.2]	- This parameter is used to identify pipes that may be contributing to pressure and/or flow deficiencies. - Considered a secondary criterion to trigger consideration for improvement, but not automatically triggering an improvement
7. Headloss Gradient	Maximum Head loss (HL) per 1,000 Feet	**< 3ft (Mains >=16-inch diameter)** **< 5ft (Mains <16-inch diameter)**	- This parameter is used to identify pipes that may be contributing to pressure and/or flow deficiencies. - Considered a secondary criterion to trigger consideration for improvement, but not automatically triggering an improvement

Table 5-2: Pump Station Regulatory Capacity Assessment

PRESSURE ZONE	PUMPING FACILITY	MAX CAPACITY (MGD)	M. FIRM CAPACITY (MGD)	PERFORMANCE CRITERIA (MGD) PHD + Fire Flow[4][5]				MEETS CRITERIA (Y/N)				DEFICIENT CAPACITY (MGD)	YEAR IMPROVEMENT REQUIRED
				2015	2020	2025	2035	2015	2020	2025	2035		
New Tampa[1]	Morris Bridge RPS Pumps #1-4	102	66.0	15.6	18.6	20.4	23.5	Y	Y	Y	Y	N/A	N/A
South Tampa	Interbay RPS[2]	28	15.0	16.8	17.9	18.2	18.7	N	N	N	N	3.7	2015
DLTWTF[3]	DLTWTF Total	198.5	160.2	137.8	163.8	170.9	185.2	Y	N	N	N	25.0	2020
	High Service	*164*	*134*										
	Northwest	*15*	*12*										
	West Tampa	*10*	*7*										
	Palma Ceia	*9*	*7*										

1. Total Firm Capacity = 62 MGD; Pumps #1-4 and Pumps #5&6 cannot operate at the same time and the firm capacity of Pumps #1-4 = 48 MGD. Pumps #1-4 are required to meet regulations
2. Interbay firm capacity exclude the two small jockey pumps due to pump station configuration
3. DLTWTF firm capacity is based upon the largest pump at the DLTWTF being out of service. The remainder of the pumps within this pressure zone ar operational.
4. The demand on the DLTWTF inlcudes the MDD of North Tampa and South Tampa due to the constant filling of the tanks
5. PHD + Fire Flow for each Plan Year is the PHD in MGD plus the Fire Flow of 3,500 gpm converted to MGD or 5.0 MGD

- The Morris Bridge RPS, which supplies the North Tampa pressure zone, currently has 66 MGD of firm capacity. This capacity is well in excess of the PHD plus FF of the North Tampa pressure zone.
- The Interbay RPS, which supplies the South Tampa pressure zone, currently has 15 MGD of firm capacity. This capacity is deficient under the 2015 planning year scenario by nearly 2 MGD and the deficiency increases to nearly 4 MGD in the 2035 planning year. Additional pump capacity or other augmentations to the South Tampa pressure zone are required to meet the pumping capacity criteria.
- The DLTWTF pressure zone is served by four pump stations. The primary source of pumping capacity is the DLTWTF HSPS (HSPS). The HSPS is supplemented by the Northwest, West Tampa and Palma Ceia RPSs located throughout the distribution system. The combined firm pumping capacity of these facilities is 160.2 MGD. This capacity meets criteria under the 2015 planning year but is deficient from 2020 through the remainder of the planning horizon. The pumping capacity deficiency for the DLTWTF pressure zone reaches as high as 25 MGD by 2035 under the static capacity analysis. However, the EPS hydraulic model analysis showed that in order to supply the system under PHD conditions, flow from the DLTWTF HSPS could reached as high as 175 MGD without changes to the operating scheme for the RPSs. The existing firm capacity of the HSPS is 134 MGD, resulting in a capacity deficiency of 41 MGD by 2035 if no other improvements are made. The TWD currently has plans to expand the DLTWTF to a firm capacity of 153 MGD. However, the hydraulic modeling analysis of future system conditions indicates that an expansion of the HSPS to a firm capacity of 153 MGD alone will not be sufficient to address the pumping capacity requirements projected through year 2035. Additional HSPS pumping capacity and other potential improvements to the DLTWTF pressure zone were evaluated and are described in Section 6 of this report.

5.2.2 Potable Water Storage

The capacities of the storage facilities were analyzed using an Excel-based desktop model for each planning year to evaluate the adequacy of the existing facilities and to identify any deficiencies in capacity based on the performance criteria. The results of the initial storage facilities capacity analyses are presented in **Table 5-3**.

Table 5-3: Potable Water Storage Regulatory Capacity Assessment

PRESSURE ZONE	STORAGE FACILITY	TOTAL VOLUME (MG)	EFFECTIVE VOLUME (MG)	Minimum Storage Volume (MG) 25% of MDD + Fire Reserve[1]				MEETS CRITERIA (Y/N)				DEFICIENT VOLUME (MG)	YEAR IMPROVEMENT REQUIRED
				2015	2020	2025	2035	2015	2020	2025	2035		
New Tampa	Morris Bridge RPS	10.0	7.5	2.5	3.0	3.3	3.9	Y	Y	Y	Y	N/A	N/A
South Tampa	Interbay RPS	5.0	5.0	2.4	2.6	2.7	2.7	Y	Y	Y	Y	N/A	N/A
DLTWTF	DLTWTF Total	26.0	18.5	23.9	26.4	27.4	29.6	No per FAC 62-555.320(19)(a). See detailed storage analysis for further explantion of minimum criteria.				11.1	2016
	Clearwell	*20.0*	*12.5*										
	Northwest	*3.0*	*3.0*										
	West Tampa	*1.5*	*1.5*										
	Palma Ceia	*1.5*	*1.5*										
	Deficient Storage without considering the Morris Bridge excess volume (MG)							5.4	7.9	8.9	11.1		
	Deficient Storage considering the Morris Bridge excess volume (MG)							0.4	3.4	4.8	7.5		

1. Fire Reserve storage required is 3500 gpm for 3 hours or 0.63 MG

- The Morris Bridge RPS, which provides storage for the North Tampa pressure zone, currently has 7.5 million gallons (MG) of effective storage volume between two GSTs. This capacity is well in excess of the storage requirement for the North Tampa pressure zone, with approximately 3.6 MG of surplus capacity in 2035.
- The Interbay RPS, which provides storage for the South Tampa pressure zone, currently has 5 MG of effective storage volume provided by a single GST. This capacity is well in excess of the storage requirement for the South Tampa pressure zone, with approximately 2.3 MG of surplus capacity in 2035.
- The DLTWTF pressure zone effective storage volume is deficient under the 2015 planning year scenario by 5.4 MG and increases to 11.1 MG by 2035 based on FAC 62-555.320(19)(a). However, a detailed storage analysis was completed in accordance with FAC 62-555.320(19)(b)2 and it was determined that existing system storage can meet the minimum criteria under the 2035 PHD conditions for four consecutive hours with the DLTWTF HSPS peak flow at 140 MGD. A more detailed description of the analysis is provided in Appendix D; Distribution System Improvements Technical Memorandum.

5.2.3 Distribution System Capacity and Operation

The hydraulic capacity of the distribution system piping network was analyzed for each planning year based on the performance criteria. This analysis identifies undersized pipelines that may be impacting the system's ability to deliver required flow or pressure under MDD conditions. The analysis showed that most of the distribution system maintains adequate minimum pressures during a MDD EPS simulation and does not significantly exceed maximum pressure criteria. The largest collection of low pressures in the system existed within the southern portion of the DLTWTF zone in the 2015 planning year. However, the modeling analysis predicts that the addition of the planned CIAC improvements will effectively address the low pressure issues in the southern portion of the DLTWTF zone. Additional locations of low pressures include the eastern boundary of the service area near the University of South Florida (USF) and the western boundary of the service area north of the Northwest RPS. An assessment of these areas indicates that the ground elevations in these two areas are higher than other portions of the service area, and that distribution system pipe improvements are unlikely to sufficiently address the low pressure in these two areas. **Table 5-4** presents the results for compliance with the minimum and maximum pressure criteria at all model junctions for each planning year during a MDD scenario.

Table 5-4: Percent of the System Meeting Pressure Criteria

#	SCENARIO NAME	MINIMUM PRESSURES			MAX. PRESSURES	
		> 30 psi	> 40 psi	> 50 psi	> 75 psi	> 85 psi
1	Base MDD Analysis	98.6%	91.5%	67.7%	15.6%	0.0%
2	2020 MDD Analysis	99.6%	94.3%	69.8%	17.6%	0.0%
3	2025 MDD Analysis	99.5%	93.2%	65.0%	16.4%	0.0%
4	2035 MDD Analysis	98.5%	88.9%	52.3%	9.8%	0.0%

The system capacity analysis also reviewed pipe velocity and headloss results for each planning year. High velocities in pipelines can lead to high headlosses and lower system pressures. The performance criteria for velocity and headloss were established to help identify existing and potential causes of pressure problems throughout the system. The results of this assessment show that the large majority of the distribution system operates well within the performance criteria and that outside of the planned improvements, the system does not require significant distribution or transmission capacity improvements. **Table 5-5** presents the results for compliance with the maximum velocity and headloss criteria for all modeled pipes 4-inches and larger for each planning year during a MDD scenario.

Table 5-5: Percent of the System Meeting Velocity and Headloss Criteria

#	Scenario Name	Max. Velocity	Max. Headloss[1]	
		< 5 fps	< 3 ft / 1000ft	< 5 ft / 1000ft
1	Base MDD Analysis	99.8%	97.2%	95.2%
2	2020 MDD Analysis	99.7%	97.7%	96.0%
3	2025 MDD Analysis	99.8%	97.2%	95.7%
4	2035 MDD Analysis	99.7%	95.7%	94.7%

[1] <3 ft/1000 ft criteria applies to pipes >= 16-inch. <5 ft/1000 ft criteria applies to pipes <16-inch

5.2.4 Fire Flow

In addition to meeting the MDD demands and pressures, the water distribution system must also be able to provide large volumes of water in a concentrated area during a fire event, while still maintaining minimum pressure requirements throughout the distribution system. This is known as fire flow (FF) demand. The amount of fire flow required varies based on the Florida Fire Code guidelines, which consider the structure's size, use, and building materials. The fire flow analysis used MDD plus FF of 1,000 gpm for residential areas and 3,500 gpm for commercial areas while maintaining a minimum residual pressure of 25 psi in the system. **Table 5-6** summarizes the extent of the distribution system that met the fire flow goals for water mains 6-inches and larger. The City has a program to replace 2-inch diameter pipes, which should continue to be administered to provide improved fire flow supply coverage.

Table 5-6: Percent of the System Meeting Fire Flow Goals

#	SCENARIO NAME	RESIDENTIAL (1,000 GPM)	COMMERCIAL / INDUSTRAL (3,500 GPM)
1	Base MDD+FF Analysis	95%	61%
2	2020 MDD+FF Analysis	97%	62%
3	2025 MDD+FF Analysis	91%	51%
4	2035 MDD+FF Analysis	87%	50%

NOTE: increased coverage is due to the addition of the planned CIAC & KBar pipelines.

There are some residential fire flow deficiencies which exist sporadically throughout the system, and a variety of improvements discussed in Section 6 were identified to provide complete residential fire flow coverage. However, to be sensitive not to oversize the distribution system piping and avoid increasing water age within the system, Black & Veatch recommends that a separate analysis of the required commercial fire flow be conducted and commercial fire flow corridors be identified before significant fire flow improvements are planned.

5.2.5 Water Age

A water age analysis for the base year (2015) was performed as part of the distribution system analyses to set a baseline for comparing water ages in future year analyses. Generally, the model results show that the water age of the system is less than 5 days with small pockets around the tanks that have ages up to 10 days. Additionally, the water age in each of the small pressure zones is in the 5 to 10-day range. This is attributed to all of the supply to these small zones going through the ground storage tanks. Additional information related to water age is available in Appendix B, Distribution System Improvements Technical Memorandum.

5.2.6 Resilience and Redundancy

Several scenarios exploring the system's redundancy and resilience to key asset was to failures were also analyzed. The assets reviewed included the DLTWTF HSPS, all of the RPSs, and critical transmission pipelines. The results showed that, in general, the system has a good level of resiliency, with most key facilities covered by some or complete redundancy. A summary of the results of the resilience analyses are presented below.

- The DLTWTF and HSPS are the most critical facilities to the operation of the entire potable water system. If the DLTWTF or HSPS are out of service, the system currently has a maximum of 70 MGD of alternate supply capacity available via regular and emergency interconnects with Tampa Bay Water, and 31 MG of effective storage. In simulations of scenarios where the DLTWTF is out of service, reservoirs quickly empty and portions of the system do not have access to supply. To provide the system with sufficient redundancy to accommodate an outage at the DLTWTF and/or

HSPS, additional storage and/or pumping capacity, as well as emergency water supply sources, would need to be established.

- The Morris Bridge RPS is the primary source of supply for the North Tampa pressure zone and with the modifications currently under construction, the facility will have complete redundancy during normal operations (and when the TWD is not purchasing water from TBW). The current improvements being implemented at the Morris Bridge RPS include a bypass around the GSTs that will allow the TBW interconnect to discharge to the North Tampa pressure zone. The improvements will also allow for the two sets of pumps at the Morris Bridge RPS to discharge into the North Tampa pressure zone and the DLTWTF zone concurrently.
- The Northwest, West Tampa and Palma Ceia RPSs are currently redundant to each other. However, as the water demands continue to increase in the future, each station becomes more critical and the level of redundancy decreases.
- The Interbay RPS is the primary source of supply for the South Tampa pressure zone and is currently considered to have complete redundancy, although the redundancy provided requires some system changes and would not occur instantaneously. In the event of a failure of the Interbay RPS, the zone boundary can be opened as the DLTWTF pressure zone has adequate pressures and supply capacity to feed the zone. Some improvements in the distribution system at the pressure zone boundary could be made to make the backup supply provided by the DLTWTF pressure zone occur instantaneously upon a loss of the Interbay RPS.
- The 48/54-inch transmission main located primarily along Bruce B Downs Blvd., which supplies water from the DLTWTF pressure zone to the Morris Bridge RPS, is the only major transmission main supplying water to the Morris Bridge RPS and North Tampa. Redundancy for a failure of this pipeline is provided via the TBW Morris Bridge WTP point of connection. Without the Morris Bridge WTP point of connection or this 48/54-inch transmission main along Bruce B Downs Blvd., the water supply to the North Tampa pressure zone would be limited by a long network of 8-inch and 16-inch diameter pipelines between the DLTWTF and North Tampa pressure zones.

6.0 Distribution System Improvements

The assessment of the distribution system revealed that the system contains some deficiencies due to projected growth over the planning horizon. The distribution capacity improvements are divided into three categories: Operational Improvements, Capacity Improvements (which includes fire flow improvements), and Resilience / Redundancy Improvements.

6.1 OPERATIONAL IMPROVMENTS

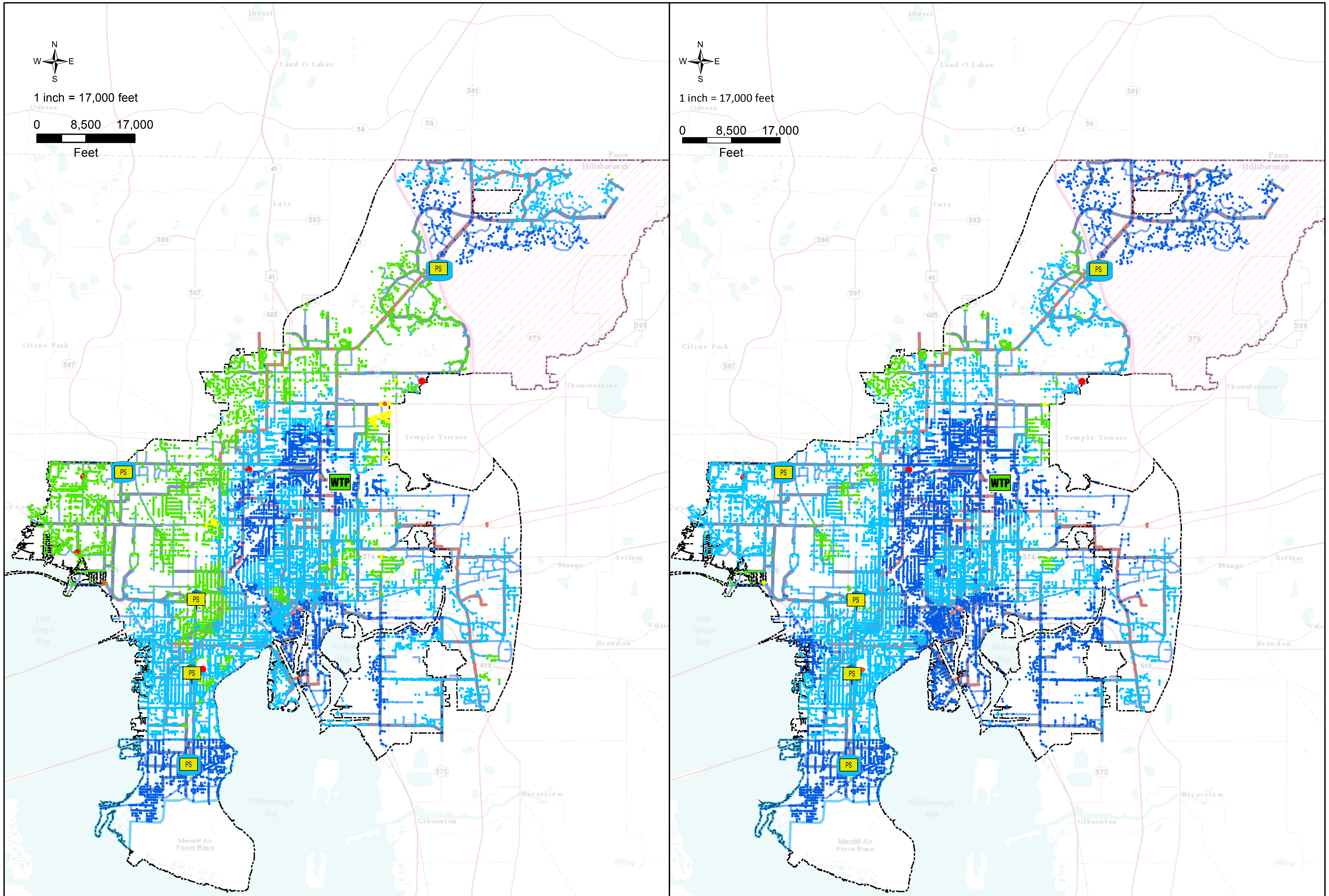
6.1.1 DLTWTF HSPS Discharge Pressure

The DLTWTF HSPS currently operates with a discharge pressure of 65 psi, which results in multiple areas within the DLTWTF pressure zone having a residual pressure below or just above the minimum pressure criteria of 40 psi. Increasing the HSPS discharge pressure would increase pressures throughout the zone and result in a much larger percentage of the zone meeting the TWD's defined pressure criteria under all demand scenarios.

Increasing the HSPS discharge pressure by 5 psi brings the vast majority of the system pressures into compliance with the system pressure criteria under all demand scenarios. However, increasing the system pressures is not without risks. A 5-psi increase in the distribution system pressures should be well within the original design pressure ratings of the piping throughout the system, however, the City's system is aging, and increasing the system pressures by 5 psi could result in an increased frequency of pipe breaks. To minimize the potential risk for an increased amount of pipe breaks in the system, Black & Veatch recommends that any potential increases in system pressures are undertaken incrementally to allow the TWD to observe how the distribution system reacts to small increases in pressure. Minimum system pressures and conformance with minimum pressure criteria based on this change in operations is illustrated in **Figure 6-1** and described in more detail in Appendix B, Distribution System Improvements Technical Memorandum.

6.1.2 DLTWTF Pressure Zone Repump Station Controls

The system assessment identified that the DLTWTF HSPS capacity will be deficient within the short-term planning horizon, and that previously planned capacity expansions from the current firm capacity of 134 MGD to 153 MGD will not be sufficient over the long-term planning horizon (through 2035) without other pumping and storage improvements in the pressure zone. As part of the improvements development process, the entire DLTWTF zone was reviewed for its impact on demands on the HSPS. The current operating strategy for the system involves the HSPS maintaining a pressure set point and the discharge flowrate increasing or decreasing automatically to maintain the pressure set point as the demands in the pressure zone increase or decrease. The other RPSs in the DLTWTF pressure zone operate at full speed on their pump curves and do not automatically ramp up and down in speed in order to maintain a target pressure set-point. This results in the HSPS experiencing a wide range of discharge flowrate conditions to meet the diurnal fluctuations in system demands. Additional review of the DLTWTF pressure zone indicates that the operating strategy for the Northwest, West Tampa, and Palma Ceia pump stations can be modified in the future to handle some of the diurnal demand fluctuations in the system to limit the amount of variance in the discharge flowrates from the HSPS, and reduce the maximum firm capacity needs for the DLTWTF HSPS.



Planning Year 2035
Existing System Assessment - 65 psi HSPS Discharge Pressure
Minimum Pressures

Proposed Planning Year 2035
MDD with 24Hr EPS - 70 psi HSPS Discharge Pressure
Minimum Pressures

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Figure 6-1

Proposed HSPS Discharge Pressure Changes

- WTP
- Pump Stations
- Ground Storage Tank
- Elevated Storage Tank

Minimum Pressures

MIN_PRESSURE

- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

wMain

Diameter

- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

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The TWD can use the Northwest, Palma Ceia, and West Tampa RPS's to decrease the reliance on the DTWLTF HSPS to handle system peak hour demands by updating the operating and control strategies for these facilities. Black & Veatch recommends that the TWD implement a monitoring and controls system that will activate the RPS's based on the output flow of the DLTWTF HSPS and/or local pressure settings. The recommended system would be automated and would activate the RPS's to minimize the peak flow at the HSPS, as well as rotate which RPSs are being used to ensure even run time on pumps and cycling of the storage tanks.

Should the City not wish to install an automated system, a system that monitors the HSPS flow and provides operators with pre-set indicators and a defined control strategy for operators to follow could be similarly effective. The modeling analysis indicates that modifying the RPS pump controls can reduce the required additional capacity of the DLTWTF HSPS for planning year 2035 by 13 MGD.

6.1.3 Distribution System Monitoring

For TWD operators and engineers to better understand system operations and to document and memorialize operational data, Black & Veatch recommends that the TWD install flow meters at the Palma Ceia and West Tamps RPSs. in addition, the TWD could perform field pump tests to generate accurate pump curves, document pump efficiencies and improve the understanding of pump flows at different tank levels and system pressure conditions.

Black & Veatch also recommends that power monitors be installed at all RPSs to begin the collection and monitoring of data on the power consumption and pump efficiencies at each facility.

6.2 CAPACITY IMPROVEMENTS

6.2.1 Pumping Capacity Improvements

As discussed in previous sections and presented in Appendix B, Distribution System Improvements Technical Memorandum, the DLTWTF and South Tampa pressure zones both require augmentations to the system to correct deficiencies in available pumping capacity.

Interbay Repump Station

The results indicate that the South Tampa pressure zone pumping capacity is currently deficient and additional pumping capacity, approximately 4 MGD, is required to provide 3,500 gpm for fire flow. There are two options available to remedy the deficient pumping capacity; 1) install an additional pump at the Interbay RPS with a capacity of 4 MGD; 2) Install check valves along the pressure zone boundary (Gandy Blvd.) to allow flow from the neighboring DLTWTF zone to supply the South Tampa pressure zone during low pressures and supplement the pump capacity in the event of reduced pressures from fire demands during a peak demand period. Black & Veatch recommends the second option of installing check valves along the pressure zone boundary to address fire flow and resilience concerns. The resilience impacts are discussed further in subsequent sections.

High Service Pump Station

Black & Veatch recommends that the planned DLTWTF HSPS expansion to a firm capacity of 140 MGD identified in the DL Tippin WTF Master plan be increased to 153 MGD. In addition, it is also recommended that the HSPS expansion design consider provisions to easily expand the firm capacity to the recommended 2035 firm capacity requirement of 167 MGD. This recommendation is one of several recommendations that alter and augment the operation of the DLTWTF pressure zone. An additional recommendation includes increasing the available storage in the DLTWTF pressure zone with elevated storage tanks, which will reduce the demand on the HSPS during peak demand periods. These recommendations are detailed later in this section. Should the recommended elevated storage tank improvements within the DLTWTF pressure zone not be implemented, the required capacity at the DLTWTF HSPS would increase. Details of the potential for additional required capacity are included in Appendix B, Distribution System Improvements Technical Memorandum.

6.2.2 Storage Capacity Improvements

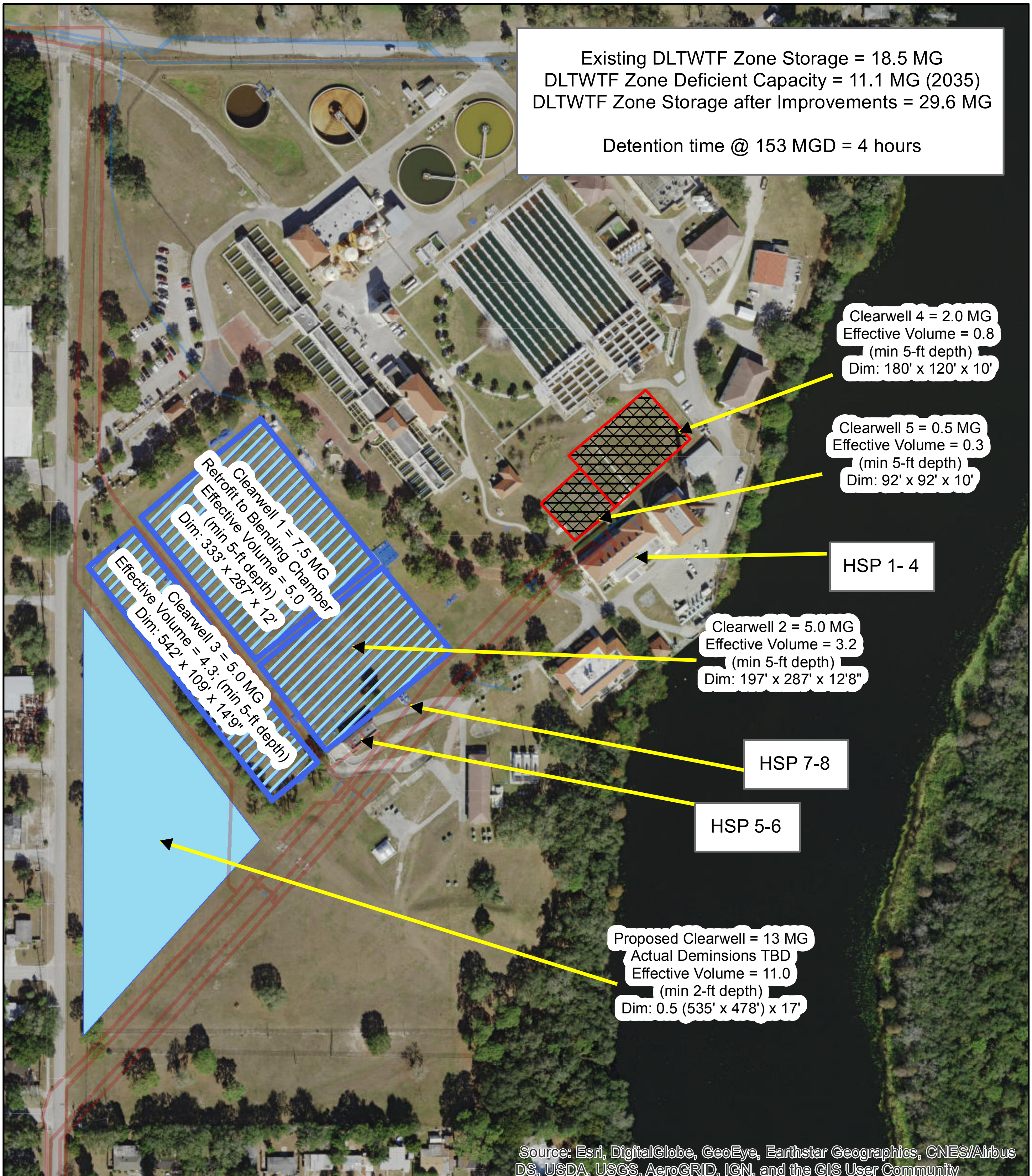
Clearwell Storage

The DLTWTF was initially constructed in the 1920s and has been expanded over the years to accommodate the City's growth. As such, there are currently five separate clearwell structures connected with piping, which supply eight pumps at three various locations that discharge into the distribution system. According to the *2017 David L. Tippin Water Treatment Facility Master Plan*, the changes in design, system demands, and configuration have resulted in a clearwell and pump combination that only allow for 12.5 MG of the 20.0 MG storage capacity to be available without causing cavitation in a few of the pumps and potential buoyancy problems with the below grade clearwell tanks. In addition, the blending chamber which feeds the clearwell was designed for lower flows, and at high flows the chamber pressurizes and starts to leak into the filter gallery.

These issues, combined with the projected increase in HSPS flows described above (140 – 167 MGD), have led to a recommendation in the *2017 David L. Tippin Water Treatment Facility Master Plan* to abandon the two oldest clearwell structures (2.0 and 0.5 MG tanks), the existing blending chamber, and pumps 1-6; repurpose the existing 7.5 MG clearwell to be a blending chamber; construct a new 5.0 MG clearwell; and add pumping capacity to reach 140 MGD firm capacity to be completed before 2025. Based on the system analysis, additional storage capacity beyond the proposed new 5.0 MG clearwell should be considered as part of this proposed project.

Accounting for the proposed modifications to the existing clearwell structures, a new 13 MG tank would increase the total storage capacity of the DLTWTF pressure zone to 31.5 MG, exceeding the FAC requirements in 62-555.320(19)(a) and allowing for 4.5 to 5 hours of supply capacity should the treatment system be out of service. Therefore, Black & Veatch recommends increasing the proposed additional storage at the DLTWTF site from 5.0 MG to 13.0 MG. NOTE: this accounts for the reduction in volume from the proposed demolition of the 2.0 and 0.5 MG clearwells.

Figure 6-2 illustrates the potential location for the additional clearwell storage. Additional assessments should be completed to confirm appropriate locations, dimensions and features of the recommended clearwell capacity expansions.



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wMain Diameter

- Less than 12-inch
- 12 - 24-inch
- Greater than 24-inch

Clearwell Status

- Demolish
- Existing
- Proposed

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Figure 6-2

DLTWTF Clearwell Storage Improvements

Black & Veatch also recommends beginning the collection of data related to the groundwater level on the site in anticipation of the design of a new clearwell structure and the current buoyancy issues that limit the drawdown levels and useable storage capacity of the existing clearwells.

Distribution System Storage

Black & Veatch also recommends that two new elevated storages tanks be added (Broadway; 2.0-MG and Nebraska; 3.5-MG) to improve system resiliency, which is discussed further in the section and in Appendix B, Distribution System Improvements Technical Memorandum. These tanks are not required based on State regulations, but they provide additional benefits of protecting the system from transient pressures, reducing the capacity requirements for the DLTWTF HSPS, and allowing the Northwest, West Tampa and Palma Ceia RPSs to be taken out of service for maintenance as demands increase in the future.

6.2.3 Water Main Capacity Improvements

The assessment of the distribution system revealed that the hydraulic capacity of the existing distribution system piping is predominantly satisfactory based on the demands projected through the planning year 2035. Transmission and distribution mains appear to be properly sized and well distributed throughout the system.

TPA and TIA Master Meters

Black & Veatch completed an investigation of the potential to install master meters at the Tampa Port Authority (TPA) and the Tampa International Airport (TIA) to isolate the onsite water mains and transfer ownership of those mains to the respective customers as described in Appendix E, TPA and TIA Master Meter Technical Memorandum. This is an effort to simplify maintenance of the water mains, which is complicated due to access restrictions at these locations. The investigation showed that the water mains in the TPA and TIA sites could be isolated from the system without significant impacts to the surrounding distribution system. Therefore, installation of the master meters is assumed to be installed as part of the system analysis and identification of improvements.

Water Main Capacity Improvements

Due to the overall strong performance of the distribution system based on the velocity and headloss criteria, the system assessment resulted in the identification of a limited number of improvements to address areas within the system exhibiting high headloss, some of which contribute to areas of low pressure. **Table 6-1** summarizes the improvements. These improvements are not impacted by the installation of additional storage within the DLTWTF zone and are independent of pipeline projects recommended later in this chapter to improve available fire flow within the distribution system. Refer to Appendix B for more detailed descriptions of each project.

Table 6-1: Water Main Capacity Improvement Summary

PROJECT ID	REPLACE / NEW	PROPSOED DIAMETER	LENGTH	PLAN YEAR PROPOSED	COMMENTS
CP003	Replacement	12-inch 16-inch	1 mile 200 feet	2020	Reduces 2020 peak hour headloss gradient (headloss/1,000 ft.) in the pipelines from 5.4 to 1.3
CP004	New	12-inch	1 mile	2025	>2.5 psi pressure increase
CP005	New	8-inch 12-inch	800 feet 2 miles	2035	Reduces 2035 peak hour headloss gradient from 15.1 to 4.9 in 2035

6.2.4 Fire Flow Capacity Improvements

Thirty-three fire flow improvements were identified to ensure that residential area fire flow requirements were met through the planning year 2035. An additional six fire flow improvements were identified to improve available fire flow conditions in commercial zones through the planning year 2035. Fire flow improvements are described in further detail in Appendix B, Distribution System Improvements Technical Memorandum.

As mentioned above, only pipelines 6-inches and larger, which were not dead ends, were reviewed for available fire flow since hydrants are not installed on lines smaller than 6-inches. The TWD distribution system contains a significant number of 2-inch pipelines, which are incapable of delivering adequate fire flows. The TWD has a program in place to replace smaller diameter pipe, and it is recommended that the TWD continue to execute this program to provide residential fire flow to their entire service area.

Table 6-2: Fire Flow Improvement Summary

PROJECT ID	REPLACE / NEW	PROPSOED DIAMETER	LENGTH	FF INCREASE (GPM)	COMMENTS
FF0-01	Replacement	12-inch	2,100 ft.	2,500	Increases FF from 1,100 to 3,500 gpm
FF0-02	Replacement	12-inch	4,600 ft.	1,100	Increases FF from 1,200 to 2,300 gpm
FF0-03	Replacement	8-inch	1,250 ft.	640	Increases FF from 600 to 1,240 gpm
FF0-04	Replacement	12-inch	4,600 ft.	330	Increases FF from 670 to 1,000 gpm
FF0-05	New	12-inch	1,200 ft.	1,140	Increases FF from 1,400 to 2,540 gpm
FF0-06	Replacement	16-inch	1 mile	1,250	Increases FF from 1,900 to 2,750 gpm
FF0-07	Replacement	12-inch	3,300 ft.	450	Increases FF from 800 to 1,250 gpm
FF0-08	Replacement	8-inch	800 ft.	400	Increases FF from 810 to 1,210 gpm
FF0-09	Replacement	12-inch	1,400 ft.	330	Increases FF from 800 to 1,130 gpm
FF0-10	New	12-inch	1,100 ft.	830	Increases FF from 860 to 1,690 gpm
FF0-11	Replacement	8-inch	800 ft.	480	Increases FF from 870 to 1,350 gpm
FF0-12	Replacement	8-inch	800 ft.	580	Increases FF from 910 to 1,490 gpm

PROJECT ID	REPLACE / NEW	PROPSOED DIAMETER	LENGTH	FF INCREASE (GPM)	COMMENTS
FF0-13	Replacement	12-inch	900 ft.	220	Increases FF from 780 to 1,000 gpm
FF0-14	Replacement	8-inch	1,900 ft.	890	Increases FF from 920 to 1,810 gpm
FF0-15	Replacement	12-inch	2,800 ft.	630	Increases FF from 920 to 1,550 gpm
FF0-16	Replacement	12-inch	600 ft.	270	Increases FF from 980 to 1,150 gpm
FF1-00	New	8-inch	50 ft.	2,070	Increases FF from 380 to 2,450 gpm
FF1-01	New	16-inch	120 ft.	510	Increases FF from 690 to 1,200 gpm
FF1-02	New	12-inch	10 ft.	4,170	Increases FF from 1,030 to 5,200 gpm
FF1-03	New	16-inch	10 ft.	1,430	Increases FF from 1,100 to 2,530 gpm
FF1-04	New	6-inch	10 ft.	2,900	Connect 6-inch dead ends for improvement of neighborhood FF
FF1-05	New	8-inch	20 ft.	590	Increases FF from 930 to 1,510 gpm
FF1-06	New	20-inch	60 ft.	250	Connect 20-inch and 16-inch dead ends for improvement of neighborhood FF
FF1-07	New	6-inch	10 ft.	1,600	Connect 6-inch dead ends for improvement of neighborhood FF
FF2-00	Replacement	12-inch	600 ft.	3,780	Increases FF from 90 to 3,870 gpm
FF2-01	Replacement	8-inch	2,500 ft.	2,360	Increases FF from 120 to 2,480 gpm
FF2-02	Replacement	8-inch	1,000 ft.	1,510	Increases FF from 380 to 1,890 gpm
FF2-03	Replacement	8-inch	300 ft.	4,190	Increases FF from 430 to 4,620 gpm
FF2-04	Replacement	8-inch	50 ft.	2,280	Increases FF from 420 to 2,700 gpm
FF2-05	Replacement	6-inch	2,200 ft.	1,750	Increases FF from 410 to 2,160 gpm
FF2-06	Replacement	12-inch	20 ft.	3,110	Increases FF from 500 to 3,610 gpm
FF2-07	Replacement	8-inch	20 ft.	1,450	Increases FF from 480 to 1,930 gpm
FF2-08	Replacement	8-inch	2,300 ft.	3,940	Increases FF from 640 to 4,580 gpm
FF2-09	Replacement	8-inch	1,100 ft.	4,350	Increases FF from 550 to 4,900 gpm
FF2-91	Replacement	6-inch	700 ft.	770	Increases FF from 980 to 1,750 gpm

- General (FF0-##) – projects to increase available fire flow resulting from long dead ends, under sized or limited transmission capacity, or a long distance from existing transmission capacity
- Disconnects / New Connections (FF1-##) – projects to increase available fire flow, primarily on dead-end pipelines, by connecting to nearby pipes, and/or increasing looping in the direct vicinity of the project.
- Pipe Size Flow Restrictions (FF2-##) – projects to increase available fire flow caused by connections to or being in the immediate proximity of 2-inch and 3-inch diameter pipe within the distribution network

6.3 RESILIENCE AND REDUNDANCY IMPROVEMENTS

Resilience is the capacity to recover quickly from a negative event. In the case of water utilities, a negative event can come in many forms due to both acute shocks and chronic stresses from anything from security threats to storm surges from hurricanes to power outages.

Resilience needs were assessed from the acute shock perspective of losing one of the TWD major facilities. Several scenarios were analyzed to determine if the distribution system has sufficient redundancy to be resilient to single asset failures within the distribution system and the results of those analyses are presented in assessment section of this report. The proposed improvements are presented below and discussed in more detail in Appendix B, Distribution System Improvements Technical Memorandum. Improvements were identified with the goal of creating complete redundancy for each facility as well as ensuring the system was resilient to each failure by being able to maintain the ability to meet system performance criteria.

6.3.1 Interbay RPS

The Interbay RPS is the sole source of water for the South Tampa pressure zone, however, that is a recent development due to the closing of several valves along the Gandy Blvd. to create a pressure zone boundary. Should the Interbay RPS experience an unexpected outage, those same valves could be opened and the zone could be absorbed into the DLTWTF zone and supplied by the DLTWTF and other RPSs. To make that transition process much quicker and less manually intensive, Black & Veatch recommends installing check valves at select locations along the pressure zone boundary, which would automatically open if the pressures within the South Tampa pressure zone were less than the pressures within the DLTWTF zone along the boundary area. These valves could be equipped with sensors to alert the operations staff when they open. The TWD may also wish to include features that would provide the ability to bypass and isolate the check valves to provide increased operational flexibility.

6.3.2 Morris Bridge RPS and 54-inch Transmission Main

With the addition of the planned improvements at the Morris Bridge RPS and the TBW interconnect, the Morris Bridge RPS is now completely redundant, and no new improvements are recommended. If the RPS fails, the bypass for the TBW interconnect can then supply the North Tampa pressure zone with up to 40 MGD directly or the valves isolating the North Tampa zone can be opened and supplied by the DLTWTF zone.

Similarly, if the 48-inch/54-inch transmission main, which normally supplies flow to the Morris Bridge RPS, fails, the TBW interconnect can be activated and used to supply the pressure zone. Depending on where the break occurs, Pumps 1-4 can also discharge south to absorb the portion of the DLTWTF zone isolated from supply.

If TWD did not want to rely upon the TBW interconnect to provide redundancy for the North Tampa pressure zone in the event of a failure of the 48-inch/54-inch transmission main or Morris Bridge RPS, Black & Veatch would recommend installing a new water main parallel to the 48-inch/54-inch water main that supplies the Morris Bridge RPS. This project has been included in the CIP and could be implemented to further improve the reliability of supply to the North Tampa pressure zone.

6.3.3 Northwest, West Tampa and Palma Ceia RPSs

The Northwest, West Tampa, and Palma Ceia RPSs have complete redundancy under the existing system demands. However, with the increased demands in 2035, the RPSs become more critical. Losing any of the three RPS's during a MDD can result in the distribution system not meeting the City's minimum system pressure criteria; however, the system remains in compliance with minimum regulatory pressures. Additional elevated storage or a new RPS would allow for complete redundancy for 24-hours for the West Tampa and Palma Ceia RPS's and would increase the resiliency of the distribution system.

In addition to the new storage, one additional water main improvement project is needed to increase east-west transmission capacity for complete redundancy of the Northwest RPS. The water main improvement project consists of a combined 7,900-ft of 16-inch and 20-inch pipe along Hillsborough Ave.

6.3.4 DLTWTF High Service Pump Station

An event that results in the inability to operate the DLTWTF and associated HSPS would have the greatest negative impacts to the operation of the system. It is assumed that TWD would communicate with customers to request reduced water consumption during this type of scenario to keep demands to ADD conditions or less, rather than MDD. Based on this assumption and a 24-hour DLTWTF failure scenario, the TWD could make the following system configuration changes:

- The TWD would activate all of the interconnections with neighboring utilities allowing for a supply of 70 MGD from Tampa Bay Water (40 MGD at Morris Bridge and 30 MGD at US301).
- Pumps 1-4 at Morris Bridge would be activated to pump south into the DLTWTF pressure zone. This would provide around 40 MGD to the DLTWTF zone while the North Tampa zone relies on the storage volume of the two tanks.
- The supply to Interbay and Morris Bridge RPSs from the DLTWTF pressure zone would stop or be reduced to about 0.5 MGD based on 2035 ADD.

Under these conditions and without additional supply and/or storage in the DLTWTF zone, the system could meet the existing ADD for 24 hours, but would still need an additional 5.5 MGD by 2035. The additional supply can come in the form of additional storage or additional interconnections with neighboring utilities. Black & Veatch recommends a combination of additional storage, which will also increase redundancy of the RPSs, and an additional 6 MGD interconnect with Hillsborough County or Tampa Bay Water.

One such location could be with Hillsborough County just north of the Northwest RPS. The interconnection flow could discharge directly into the distribution system, if feasible based on the County's operational pressures, or into the Northwest tank. Note that this option requires negotiations and cooperation with each utility.

6.4 IMPACTS TO WATER AGE

6.4.1 Impacts of Proposed Improvements on Water Age

Most of the proposed improvements have negligible impacts on water age, with the exception of the proposed Broadway EST. This improvement increases the water age in the southeast portion of the system to approximately 10 days, which is an increase of 5 days. The tank should be designed with a motorized isolation valve and pump to force turnover during low demand periods. The phasing of the tank should also coincide with increased demands throughout the DLTWTF zone and not be constructed before the system conditions warrant it to avoid potential water age/water quality impacts.

6.5 SUMMARY OF RECOMMENDED IMPROVEMENTS

Table 6-3 below summarizes the recommended and prioritized improvements for the distribution system and **Figure 6-3** illustrates their locations. **Figure 6-4** through **Figure 6-6** illustrate the pressures and velocities throughout the distribution system before and after improvements. The figures show an obvious increase in pressures across the system, a minor and almost unnoticeable increase in system velocities and a decrease in water age, except for the North Tampa Pressure zone where the two tanks at the MBRPS are now being used.

Table 6-3: Recommended Improvements

CIP #	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR
1	IB, NW and MB Tank Inlet Sleeve Valves	Installation of sleeve valves with flow control functions at the inlet to the Interbay, Northwest and Morris Bridge Tanks	Three Pressure Zone Configuration	Capital: Operational flexibility	2019
2	DLTWTF Discharge Pressure	Increase DLTWTF HSPS discharge pressure to 70 psi; slowly / incrementally	Min pressures	Operational / Controls	2018
3	RPS controls modifications	Modify the NWRPS, WTRPS and PCRPS to operate during peak demand periods rather than time of day	Increased reliance on DLTWTF HSPS	Operational / Controls	2018
4	DLTWTF Blending Chamber, Clearwell and HSPS Upgrades	Demo 2.0 MG and 0.5 MG clearwells, convert 7.5 MG clearwell to blending chamber, install new 13.0 MG clearwell, demo pumps 1-6 and install new 153 MGD HSPS firm capacity	Sum of the MDDs for each pressure zone greater than 140 MGD	R&R and Expansion	2020
5	HSPS Expansion	Install additional pumping capacity at the new HSPS building total new capacity = 167 MGD firm capacity	DLTWTF Pressure Zone Demands greater than 153 MGD	Performance Criteria: Pump Capacity Expansion	2030
6	Northeast (Nebraska) EST	Installation of a new EST in the north portion of the DLTWTF	DLTWTF Pressure Zone PHD greater than 153 MGD	Resilience	2025
7	Southeast (Broadway) EST	Installation of a new EST in the north portion of the DLTWTF	DLTWTF Pressure Zone PHD greater than 160 MGD	Resilience	2030
8	Commercial Fire Flow Study	Perform an analysis of the required commercial fire flow needs be conducted and commercial fire flow corridors be identified	Fire Flow Demands	Study	2018
9	South Tampa Check Valves	Install check valves along South Tampa Pressure Zone (along Gandy Blvd)	Fire Flow Demands	Resilience	TBD
10	Hillsborough County Interconnect	Interconnect with Hillsborough County in the northwest portion of the system	DLTWTF Pressure Zone OHD greater than 167 MGD	Resilience	2030

CIP #	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR
		either directly into the distribution system or the Northwest Tank			
11	West Tampa and Palma Ceia Flow Meters	Install flow monitors on the effluent side of the West Tampa and Palma Ceia RPS's and connect to the data historian	Data Collection	Operational / Controls	2018
12	RPS Power Monitors	Install power monitors on all RPS equipment and connect to the data historian	Data Collection	Operational / Controls	2018
13	DLTWTF Clearwell Groundwater Level Study	Collection of data related to the groundwater level on the site in anticipation of the design of a new clearwell structure	DLTWTF Blending Chamber, Clearwell and HSPS Upgrade Project	Capacity	2018
14	Water Quality Model Calibration Study	Collect water quality data throughout the system in order to conduct a calibration of the existing water quality model	Water Quality	Study	2018
15	R-01 Hillsborough Ave WM	6,000-ft of 12-inch pipe along Hillsborough Ave.	DLTWTF Pressure Zone Demands greater than 125 MGD	Resilience	2025
16	CP003	12-inch; 1 Mile 16-inch; 200 feet	System Pressures	Capacity	2020
17	CP004	12-inch; 1 mile	System Pressures	Capacity	2025
18	CP005	8-inch; 800 feet 12-inch; 2 miles	System Pressures	Capacity	2035
19	FF0-01	12-inch; 4,600 feet	Opportunistic	Fire Flow	2018
20	FF0-02	8-inch; 1,250 feet	Opportunistic	Fire Flow	2018
21	FF0-03	12-inch; 4,600 feet	Opportunistic	Fire Flow	2018
22	FF0-04	12-inch; 1,200 feet	Opportunistic	Fire Flow	2018
23	FF0-05	16-inch; 1 mile	Opportunistic	Fire Flow	2018
24	FF0-06	12-inch; 3,300 feet	Opportunistic	Fire Flow	2018
25	FF0-07	8-inch; 800 feet	Opportunistic	Fire Flow	2018
26	FF0-08	12-inch; 1,400 feet	Opportunistic	Fire Flow	2018
27	FF0-09	12-inch; 1,100 feet	Opportunistic	Fire Flow	2018
28	FF0-10	8-inch; 800 feet	Opportunistic	Fire Flow	2018
29	FF0-11	8-inch; 800 feet	Opportunistic	Fire Flow	2018
30	FF0-12	12-inch; 900 feet	Opportunistic	Fire Flow	2018
31	FF0-13	8-inch; 1,900 feet	Opportunistic	Fire Flow	2018
32	FF0-14	12-inch; 2,800 feet	Opportunistic	Fire Flow	2018
33	FF0-15	12-inch; 600 feet	Opportunistic	Fire Flow	2018
34	FF0-16	8-inch; 50 feet	Opportunistic	Fire Flow	2018

CIP #	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR
35	FF1-00	16-inch; 120 feet	Opportunistic	Fire Flow	2018
36	FF1-01	12-inch; 10 feet	Opportunistic	Fire Flow	2018
37	FF1-02	16-inch; 10 feet	Opportunistic	Fire Flow	2018
38	FF1-03	6-inch; 10 feet	Opportunistic	Fire Flow	2018
39	FF1-04	8-inch; 20 feet	Opportunistic	Fire Flow	2018
40	FF1-05	20-inch; 60 feet	Opportunistic	Fire Flow	2018
41	FF1-06	6-inch; 10 feet	Opportunistic	Fire Flow	2025
42	FF1-07	12-inch; 600 feet	Opportunistic	Fire Flow	2025
43	FF2-00	8-inch; 2,500 feet	Opportunistic	Fire Flow	2018
44	FF2-01	8-inch; 1,000 feet	Opportunistic	Fire Flow	2018
45	FF2-02	8-inch; 300 feet	Opportunistic	Fire Flow	2018
46	FF2-03	8-inch; 50 feet	Opportunistic	Fire Flow	2018
47	FF2-04	6-inch; 2,200 feet	Opportunistic	Fire Flow	2018
48	FF2-05	12-inch; 20 feet	Opportunistic	Fire Flow	2018
49	FF2-06	8-inch; 20 feet	Opportunistic	Fire Flow	2018
50	FF2-07	8-inch; 2,300 feet	Opportunistic	Fire Flow	2018
51	FF2-08	8-inch; 1,100 feet	Opportunistic	Fire Flow	2018
52	FF2-09	6-inch; 700 feet	Opportunistic	Fire Flow	2018
53	FF2-91	12-inch; 4,600 feet	Opportunistic	Fire Flow	2018

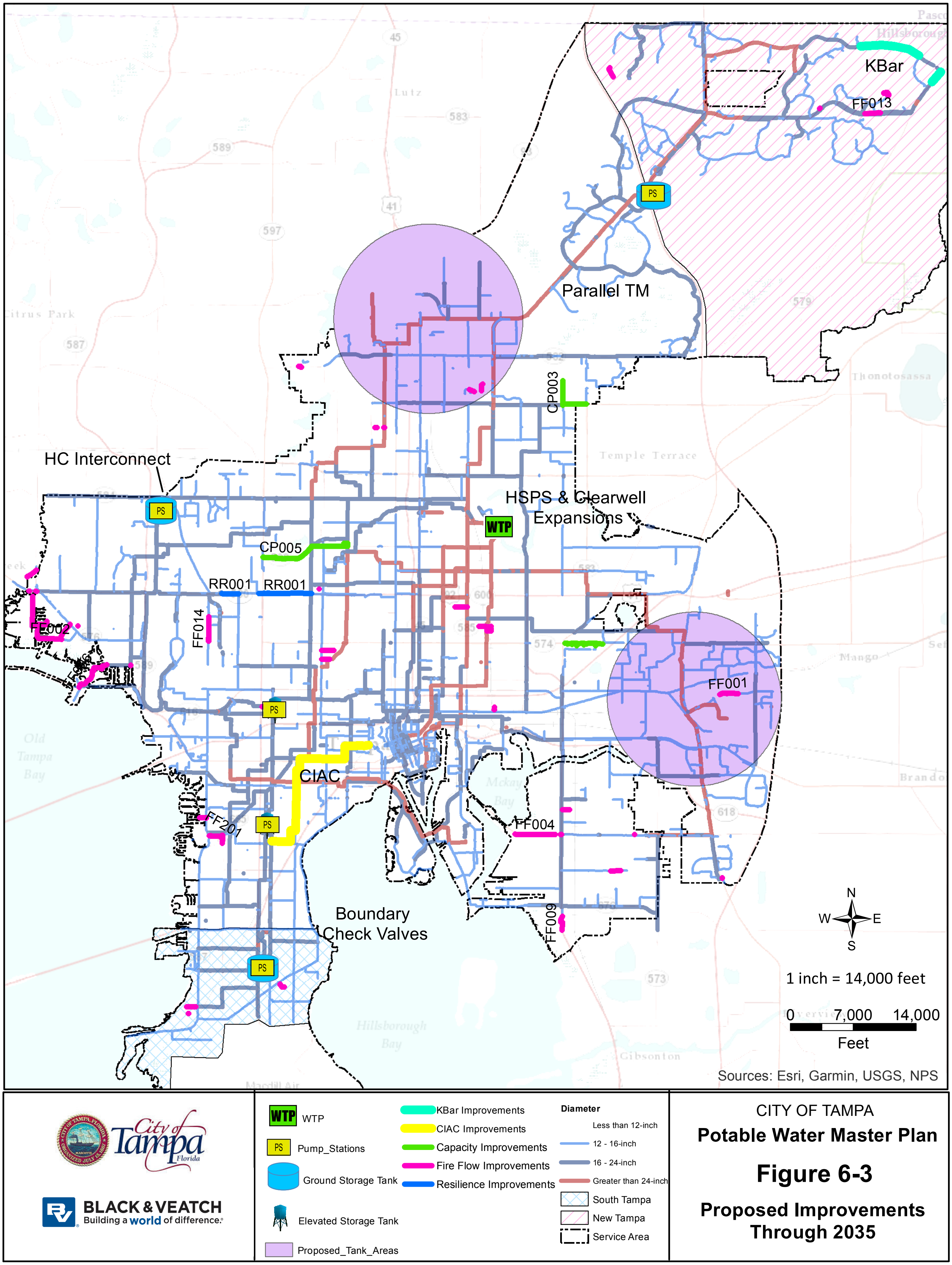

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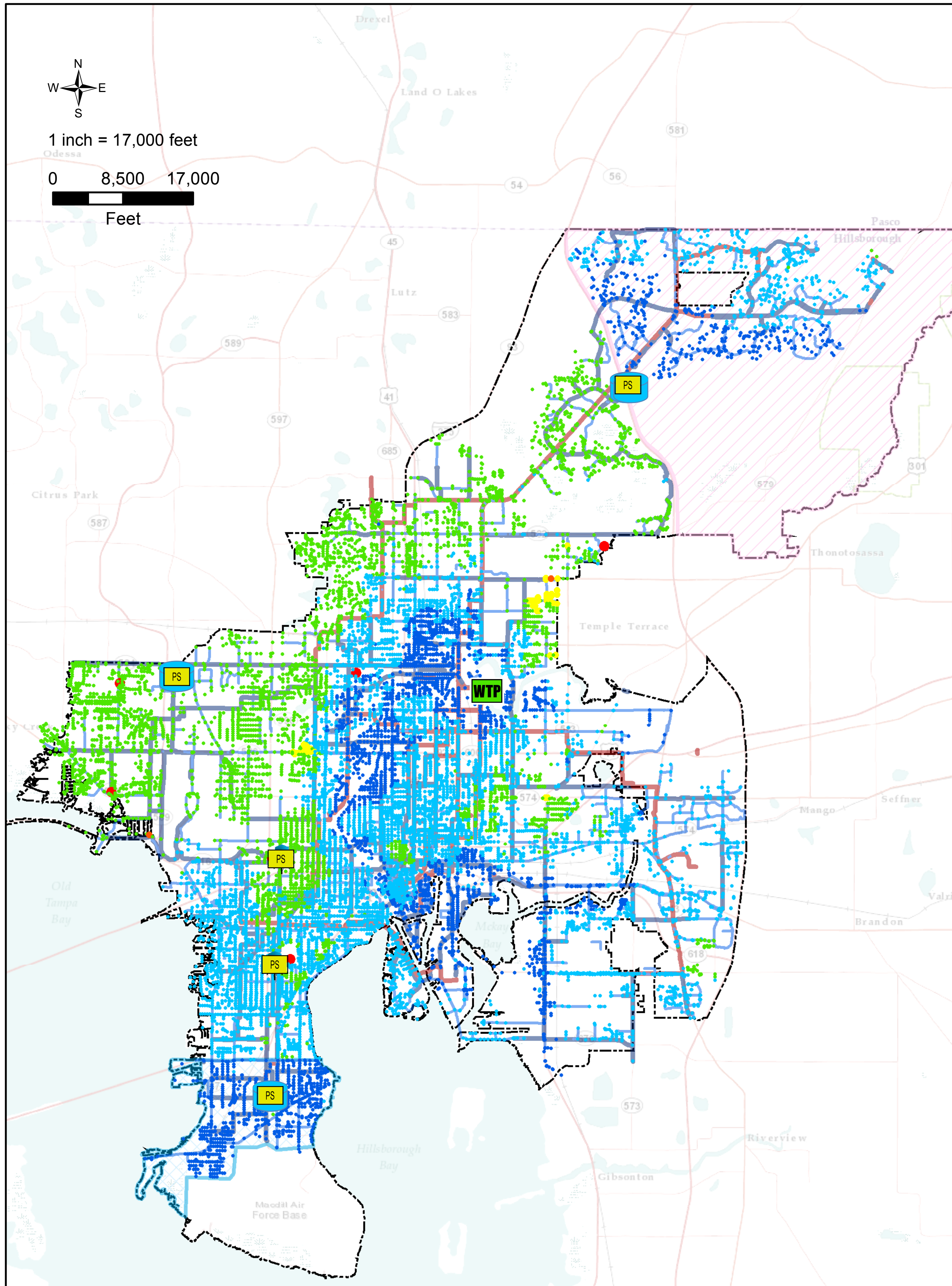
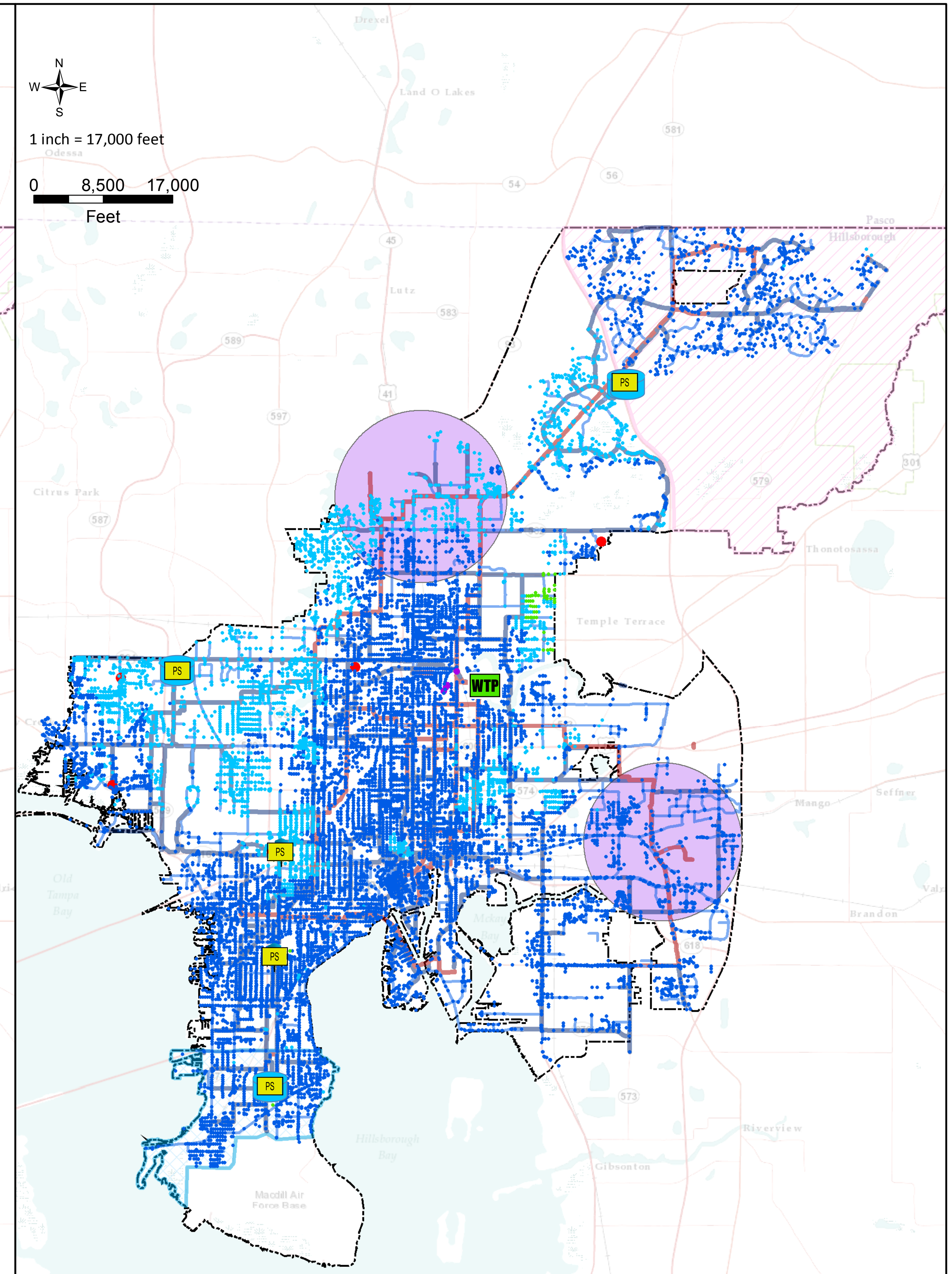
Figure 6-3

Proposed Improvements Through 2035



Planning Year 2035
Existing System Assessment
Minimum Pressures



Proposed Planning Year 2035
MDD with 24Hr EPS
Minimum Pressures

CITY OF TAMPA

Potable Water Master Plan

Figure 6-4

Proposed Planning Year 2035
MDD with 24Hr EPS
Minimum Pressures

WTP
Pump Stations
Ground Storage Tank
Elevated Storage Tank

Minimum Pressures

MIN_PRESSURE

- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

wMain

Diameter

- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch

Proposed_Tank_Areas
South Tampa
New Tampa
Service Area

City of Tampa Florida

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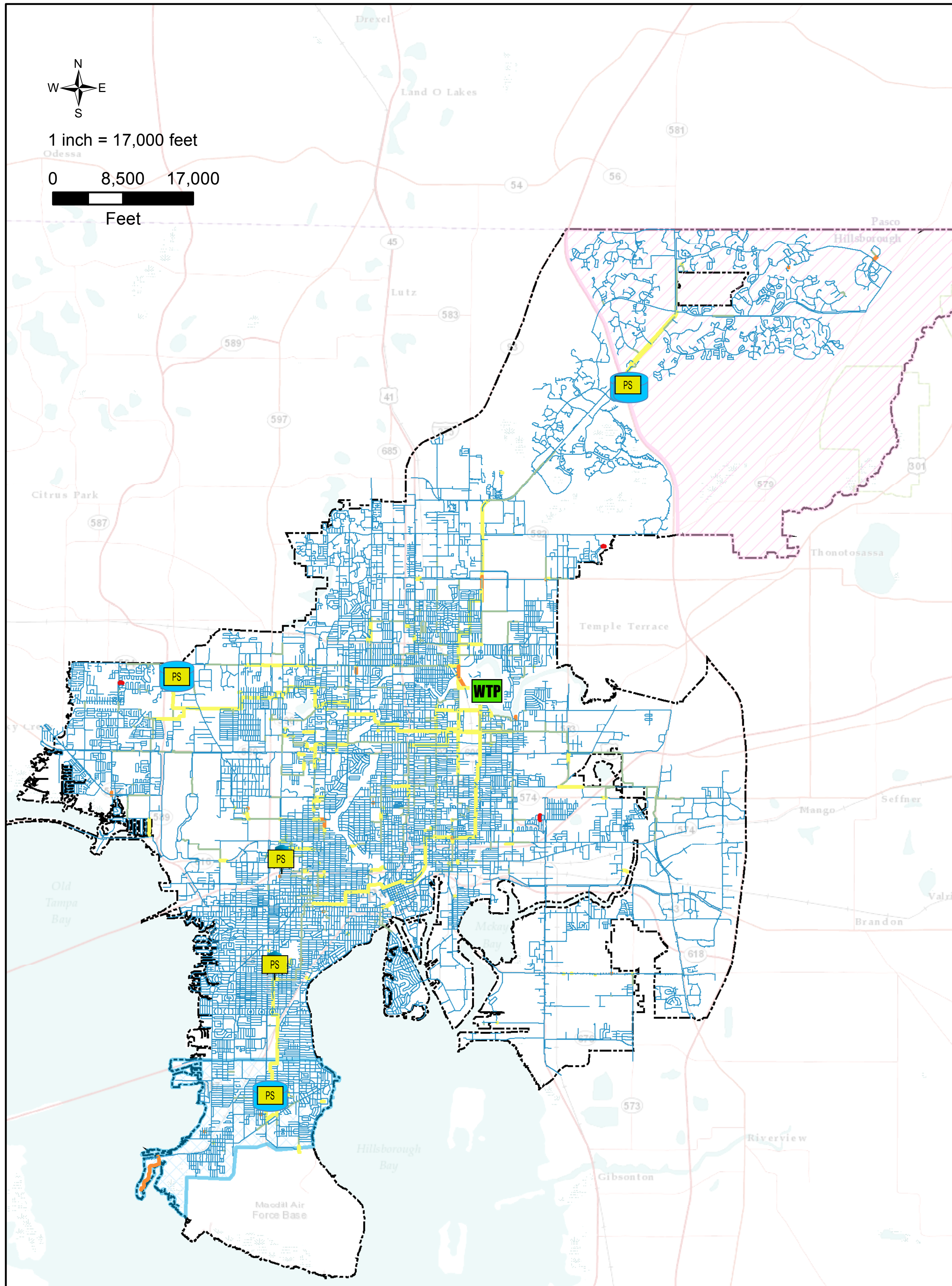
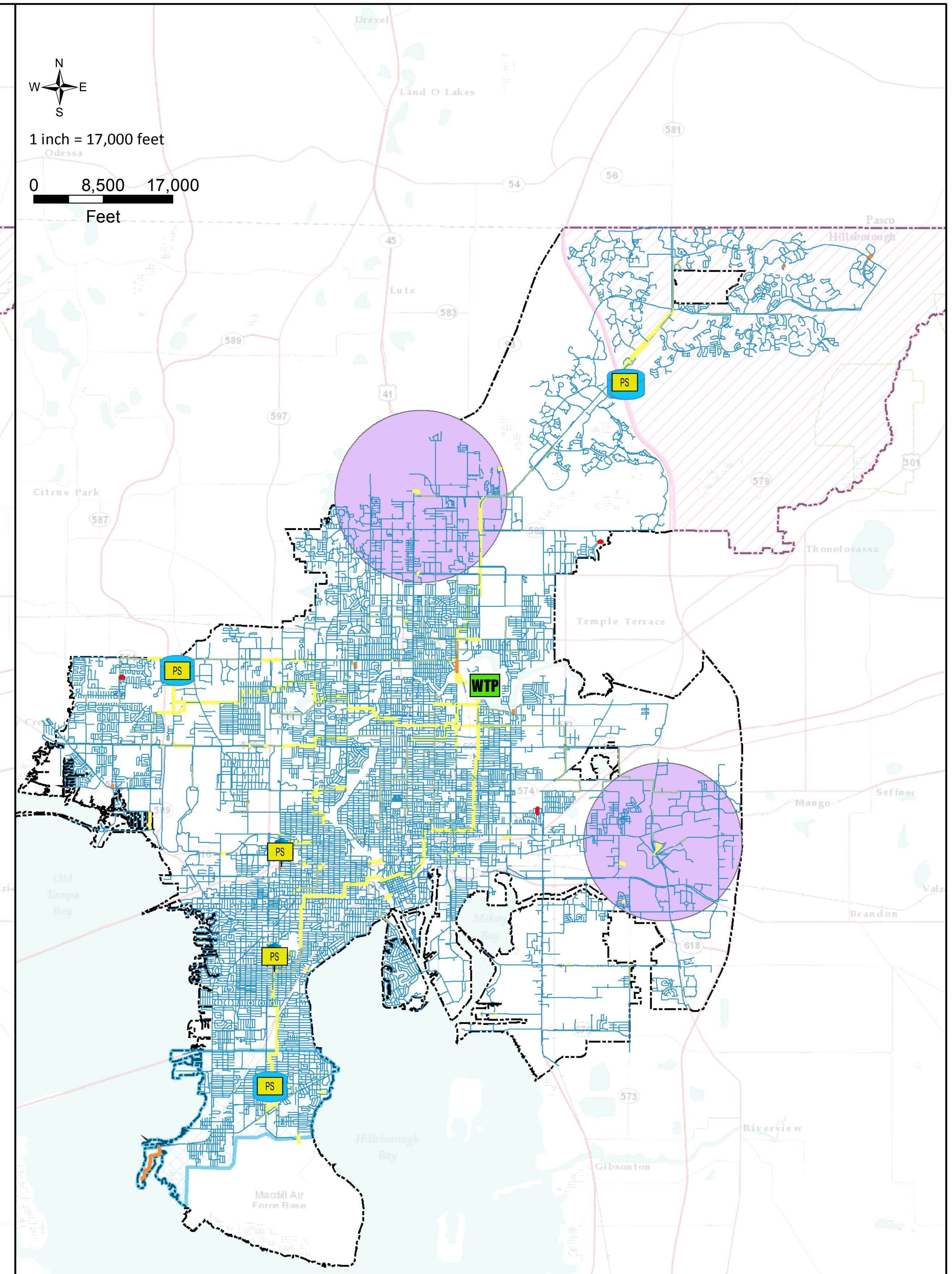


Planning Year 2035
Existing System Assessment
Maximum Velocity



Proposed Planning Year 2035
MDD with 24Hr EPS
Maximum Velocity

CITY OF TAMPA

Potable Water Master Plan

Figure 6-5

Proposed Planning Year 2035
MDD with 24Hr EPS
Maximum Velocity

- WTP
- Pump Stations
- Ground Storage Tank
- Elevated Storage Tank

Max Velocity

Max. Velocity

- Less than 2 fps
- 2 - 3 fps
- 3 - 5 fps
- 5 - 10 fps
- Greater than 10 fps
- Proposed_Tank_Areas
- South Tampa
- New Tampa
- Service Area

City of Tampa Florida

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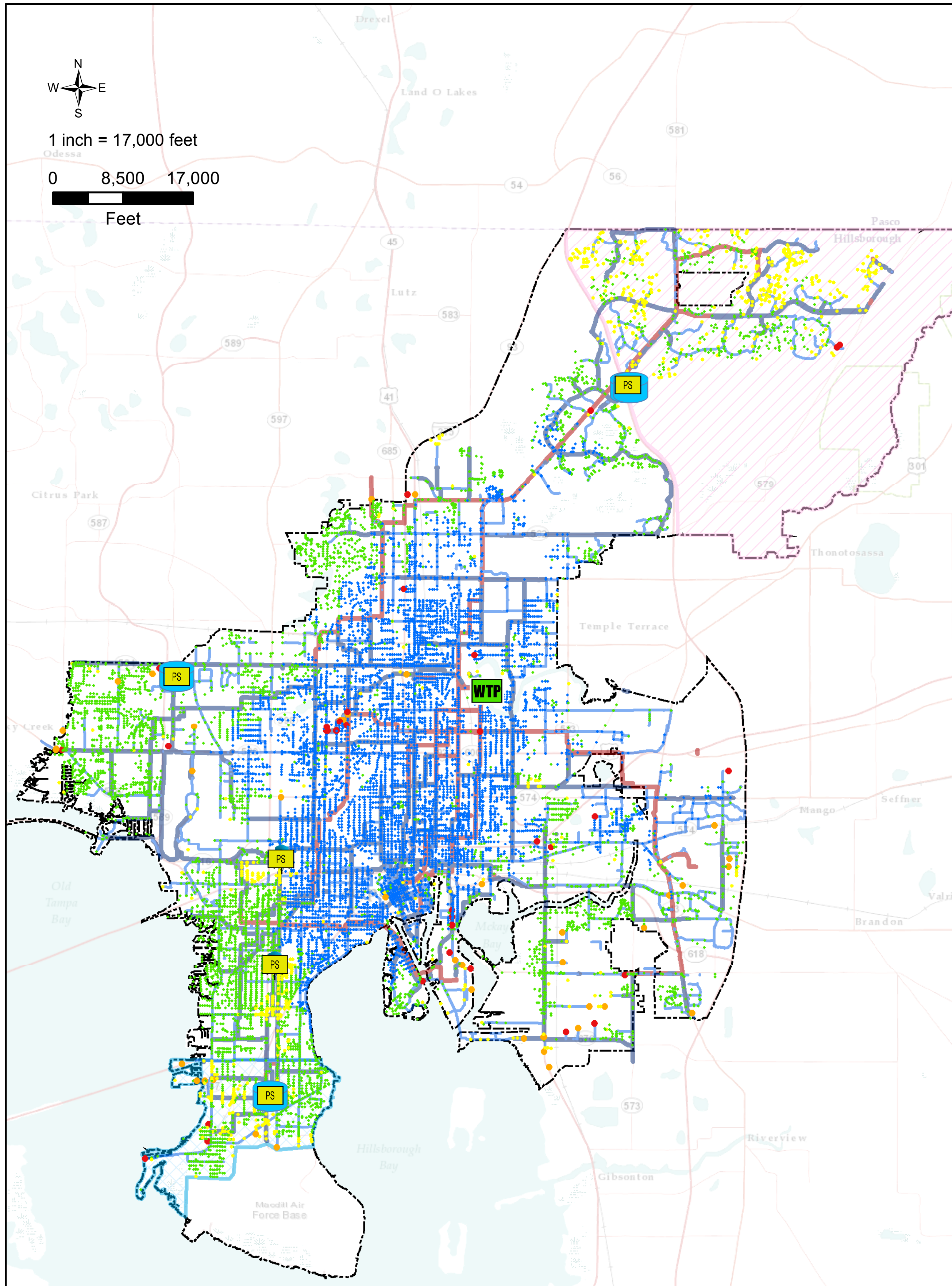
CITY OF TAMPA

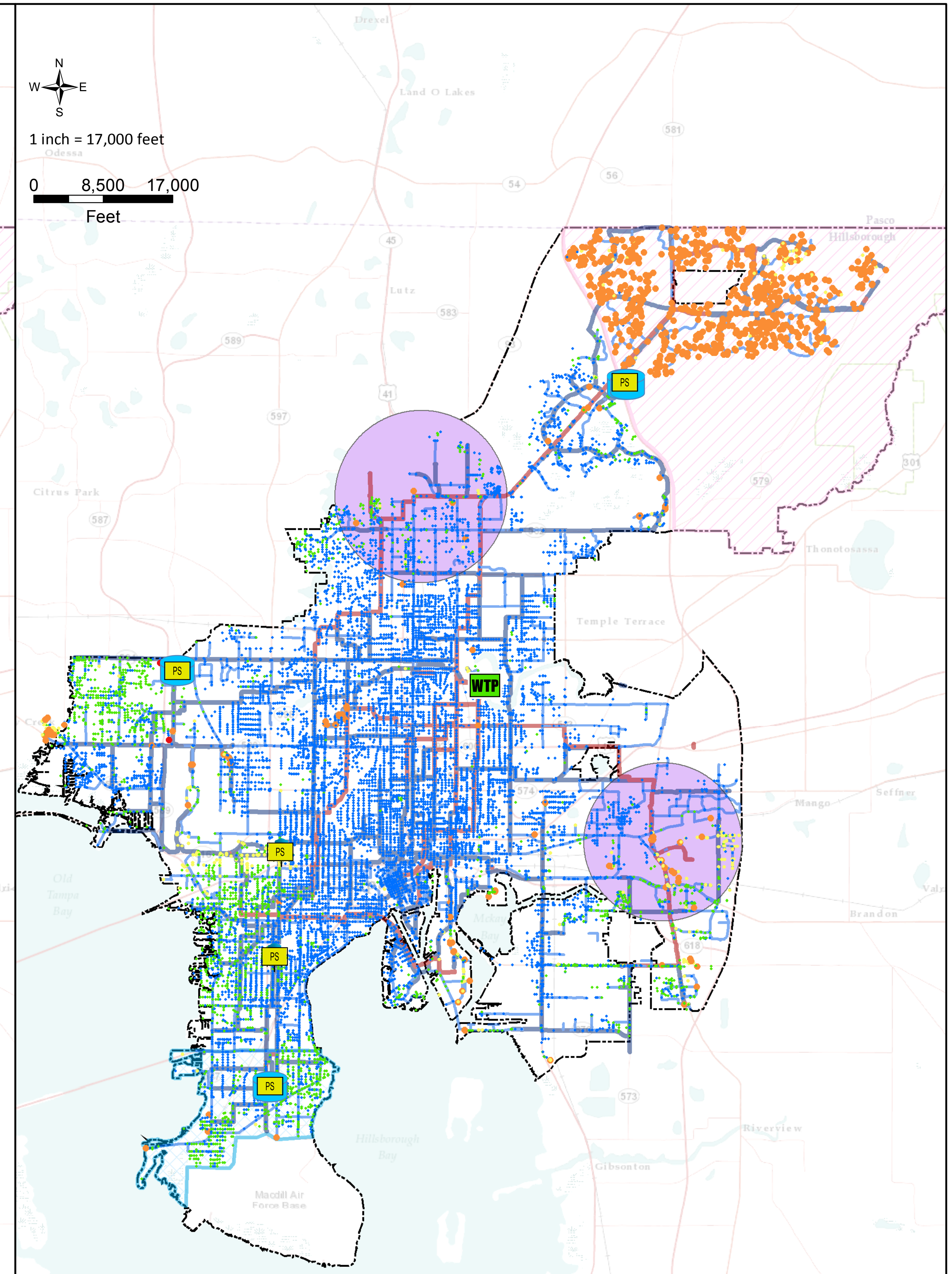
Potable Water Master Plan

Figure 6-6

Proposed Planning Year 2035 ADD Water Age



Planning Year 2015
Existing System Assessment
Water Age



Proposed Planning Year 2035
Proposed System
Water Age Increase

WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Water Age Increase

Water Age Increase

Less than 1 day

1 - 5 days

5 - 10 days

10 - 20 days

Greater than 20 days

wMain

Diameter

< 12-inch

12 - 16-inch

16 - 24-inch

> 24-inch

Proposed_Tank_Areas

South Tampa

New Tampa

Service Area

City of Tampa Florida

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7.0 Asset Management Program Development

7.1 INTRODUCTION

Black & Veatch has performed an asset management maturity assessment of the City of Tampa's Water Department (the Department) as part of the potable water distribution master plan project. The assessment is based on the requirements of the international asset management standard ISO (International Organization for Standardization) 55001:2014 Asset Management – Management System Requirements and focuses on the Department's water operations. To undertake this assessment, the Black & Veatch team reviewed documents and information provided by City staff, and facilitated six group interviews with City staff.

The assessment included the following activities:

- Review of documentation and processes provided by staff
- Group interviews
- Identification of key gaps and improvement opportunities

7.2 ISO 5500X STANDARDS

The ISO 5500X standards were published in January 2014 following several key global meetings, working groups and sub-project team meetings involving more than 30 participating and 10 observing members in its development and based on the globally recognized standard for best practice asset management, PAS 55.

The ISO 5500X series consists of three standards:

- ISO 55000 Asset management—Overview, principles, and terminology
- ISO 55001 Asset management—Management systems—Requirements
- ISO 55002 Asset management—Management systems—Guidelines for the application of ISO 55001

The objective of ISO 55001 is to guide and influence the design of an organization's asset management activities by embedding a number of key concepts and fundamental principles within a framework (referred to by ISO 55001 as a management system) for asset management. According to ISO 55001 the fundamental principles of asset management are:

Value. Assets exist to provide value to the organization and to stakeholders.

Alignment. Asset management translates the organization's strategic objectives into asset management decisions, plans and activities.

Leadership. Leadership and commitment from all levels of management is essential for establishing and improving asset management within the organization.

Assurance. Asset management gives assurance that assets will fulfil their required purpose through effective governance.

The asset management system described by ISO 55001 consists of an organization's asset management policy, asset management strategy, asset management objectives, asset management plan(s) and the activities, processes and organizational structures necessary for their development, implementation and continual improvement. The asset management system includes organizational structure, roles and responsibilities, standards, information management systems, processes, and resources. **Figure 7-1** below provides an outline of an asset management system.

Figure 7-1: Components of an Asset Management System

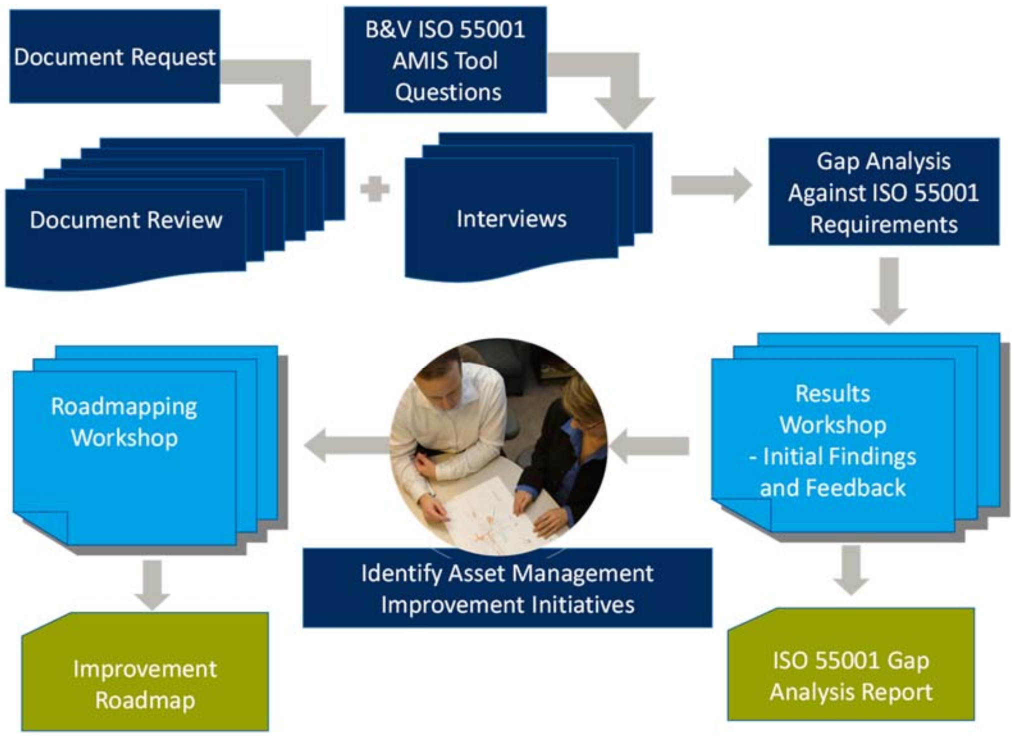
7.3 ASSESSMENT APPROACH

Black & Veatch's overall assessment approach is shown in **Figure 7-2**. To undertake this assessment, the Black & Veatch team reviewed documents and information provided by City staff, which included the 2012 strategic plan (status report 2015), organization chart, and samples of reports, communications, policies, and procedures. A list of the documents provided is included in Appendix E, ISO 55001 Assessment Report. A total of seven group interviews were held with City of Tampa's Water Department staff:

- Group 1 – Production Division Operations and Maintenance
- Group 2 – Management Team with focus on Strategy and Framework
- Group 3 – Design and Construction Management
- Group 4 – Planning
- Group 5 – Information Management
- Group 6 – Distribution System Operations and Maintenance

- Group 7 – Finance and Accounting

Figure 7-2: Overview of Assessment Approach



Each of the elements of ISO 55001 was assessed based on the evidence provided by the document review and the interviews, with each element scored on a scale of 0 to 4. The scoring system is shown in **Figure 7-3** below, with a score of 3 being in compliance with the ISO 55001 requirements (following "good practice"). A score of 4 indicates that the organization's asset management maturity is "beyond ISO 55001" requirements, where asset management practices are optimized and/or the organization is employing leading practice. To achieve full compliance with ISO 55001, an organization must score a 3 in each of the elements.

Figure 7-3: ISO 55001 Asset Management Maturity Scale

Maturity level 0	Maturity level 1	Maturity Level 2	Maturity Level 3	Beyond ISO 55001	
The organization has not recognized the need for this requirement and/or there is no evidence of commitment to put it in place.	The organization has identified the need for this requirement, and there is evidence of intent to progress it.	The organization has identified the means of systematically and consistently achieving the requirements, and can demonstrate that these are being progresses with credible and resourced plans in place.	The organization can demonstrate that it systematically and consistently achieves relevant requirements set out in ISO 55001.	The organization can demonstrate that it is systematically and consistently optimizing its asset management practice, in line with the organization's objectives and operating context.	The organization can demonstrate that it employs the leading practices and achieves maximum value from the management of its assets, in line with the organization's objectives and operating context.

7.4 ASSESSMENT RESULTS

Overall, the City of Tampa's Water Department achieved an average asset management maturity score of 1.6, which is in the "Aware" zone of the maturity scale. This score is typical of a utility that has some elements of good practice asset management in place but has identified the need to improve its asset management approach. Information on individual element scores is shown in Appendix F, ISO 55001 Assessment Report. **Figure 7-4** illustrates the results of the maturity assessment.

The Department leadership has recognized the need to implement a formal asset management program, and has commenced the process with the Water Master Plan and this gap assessment. The 2012 Strategic Plan includes some goals and objectives specific to asset management, some of which have been implemented such as the Geographic Information System (GIS) conversion to ArcGIS and the recent implementation of the InfoMaster software to support the risk assessment and rehabilitation planning and budgeting for the distribution system.

The Department has a number of good foundational elements on which to build: a planning process is in place with the CIP and master plan, key performance indicators are reported to the public, training is well managed with a skills matrix to determine training needs, the Water Treatment Facility has well defined Standard Operating Procedures (SOPs) in place, and there are processes to respond to incidents. However, the Department lacks an overarching asset management framework, strategy and objectives, and asset management plans, that combined result in lower scores in a number of areas.

Having sufficient staffing levels and resources are critical for successfully implementing and maintaining a successful asset management program. The gap assessment identified that it takes significant effort to obtain additional resources and there is no formal process to determine resource needs for the Department. Support groups from other City departments need to be developed as well, and top management support is required from the Public Works and Utility Services Administrator and Mayor.

Improvement recommendations were made to close the identified gaps, and these are further developed into initiatives in the Asset Management Implementation Plan.

7.5 ASSET MANAGEMENT IMPLEMENTATION PLAN

To aid in the implementation of an asset management framework that is aligned with the ISO 55001 requirements, Black & Veatch has developed an asset management implementation plan. The Asset Management Implementation Plan consists of an action plan and schedule for implementing improvements to the City of Tampa Water Department's approach to asset management.

The asset management initiatives consist of:

1. Update Water Department Strategic Plan
2. Form AM Steering Committee
3. Develop AM Framework (including Policy, Strategy and Objectives)
4. Develop Water Department Resourcing Plan

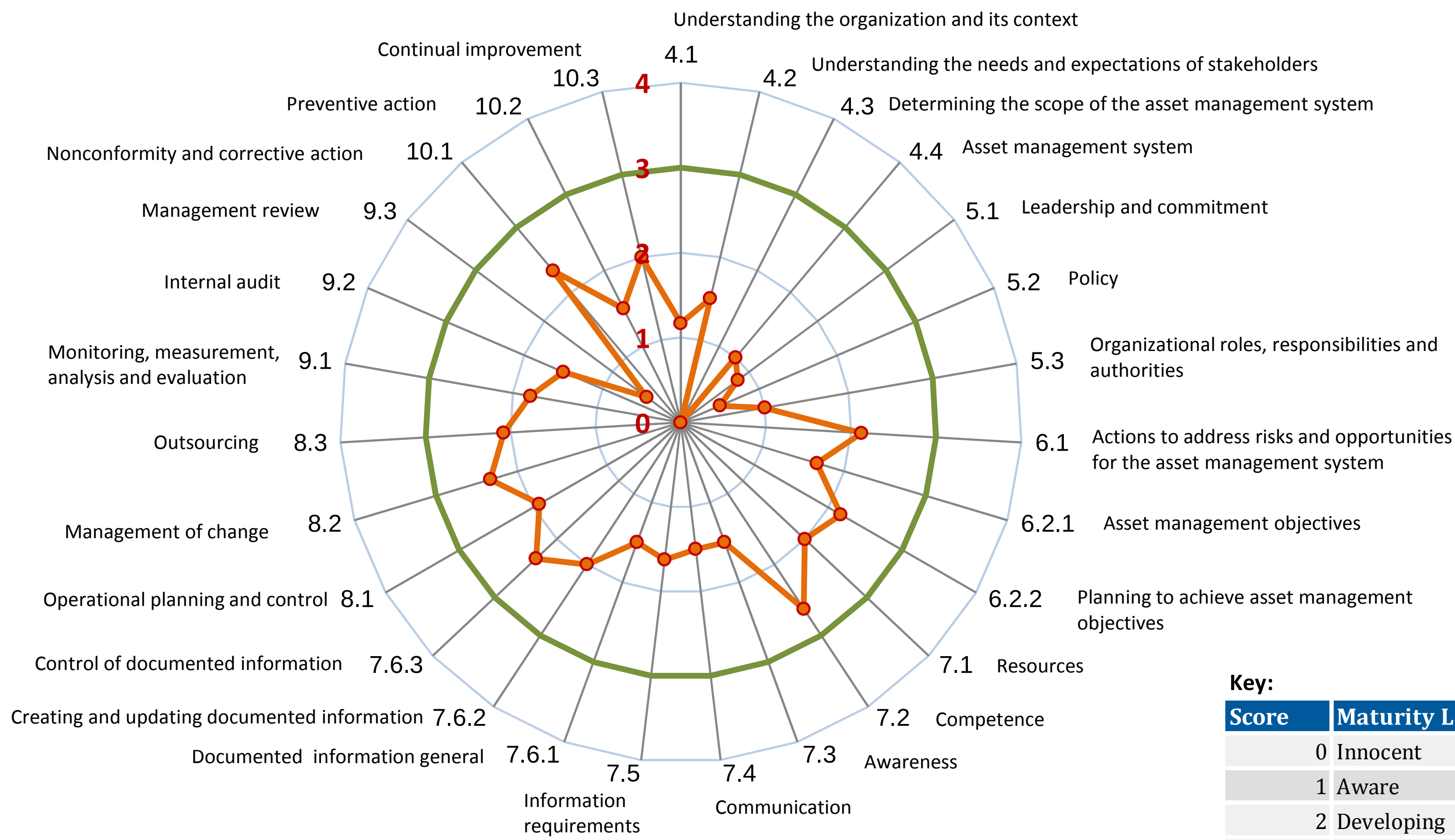
5. Develop Water Department Communications Plan
6. Develop Key Performance Indicators
7. Data Needs Assessment
8. Implement Data Management Processes
9. Update Water Department Policies and SOPs
10. Develop SOP for Incident Response, Investigation and Corrective Action
11. Update technical specifications
12. Implement Facilities Risk Management
13. Emergency Response Improvements
14. Develop Asset Management Plans
15. Implement Utility Management System
16. Contract Management Improvements
17. Production CMMS Improvements
18. Implement Cost Accounting

The action plan lists out each of the initiatives, with specific actions and recommendations, the timeframe for completion, and the priority of the action. A high-level consideration of resources needed to implement the initiative is included, and a Department lead has been assigned to each action.

The action plan and schedule are included in the Asset Management Implementation Plan Technical Memorandum, which is included as Appendix G.

Figure 7-4: ISO 55001 Maturity Assessment Results

Average Maturity Score = 1.6 (Aware)



Key:

Score	Maturity Level
0	Innocent
1	Aware
2	Developing
3	Competent
4	Optimizing / Excellent

8.0 Risk Based Pipeline Prioritization

8.1 INTRODUCTION

Black & Veatch incorporated a risk-based prioritization approach to assign a risk score and classification to each water main within the TWD's potable water service area. The resulting risk scores and classifications will be used to prioritize the City's potable water main rehabilitation and replacement projects. As part of this effort, Black & Veatch also performed a data quality review and survival curve analysis, which are further described in this section.

8.2 RISK BASED PRIORITIZATION APPROACH

The City is leveraging Innovyze's InfoMaster software to improve its risk-based prioritization for potable water main rehabilitation and replacement projects. The risk-based prioritization model incorporates the City's available GIS information and selected risk factors. The risk factors include a variety of likelihood of failure (LOF) and consequence of failure (COF) criteria as listed in **Table 8-1**. Black & Veatch participated in workshops with the TWD to develop and agree upon the relative importance and scoring scheme for each criterion considering level of service to customers, economics, public health, and public safety.

A scoring range of 1 to 5, where 5 is most likely to fail or has the greatest consequence of failure, was used for the LOF and COF factors to align with InfoMaster's standard 5x5 risk matrix. A weighting factor was applied to each scoring criteria to determine the overall risk score of each individual pipe. A preliminary scoring scheme was used to accommodate the City's CIP budget schedule. The final scoring scheme will be implemented by the City in future updates using results from the potable water system hydraulic model. Appendix H, Risked Based Prioritization Technical Memorandum, includes further details on the selected criteria.

Table 8-1: Likelihood of Failure and Consequence of Failure Criteria

CATEGORY	SELECTED CRITERIA	
Likelihood of Failure (LOF)	Breaks on Individual Pipe Segments	
	Remaining Life	
	Aggressive Soil Area	
Consequence of Failure (COF)	**Social / Health / Safety**	**Economics**
	Critical Customer Impact	Right-of-Way Ownership and Crossings
	Population Density	Water Demand
	Repeatable Breaks on Individual Pipe Segments	Diameter
	Contaminated Soil	Interconnect Location
	Additional Fire Hydrants	2015 Planned Paving Projects
	* Modeled Velocity/High Head Loss	
	* Available Fire Flow	
	* Service Main Replacements	
* Future criteria based on availability of model data		

8.3 SURVIVAL CURVE DEVELOPMENT

Survival curves were developed for each pipe material to estimate the life expectancy for the TWD water mains. The estimated life expectancy was used to estimate the remaining life for each water main to support the risk-based prioritization for the TWD water mains. To ensure the results from the survival curve analysis were as accurate as possible, a data quality review was performed on the material and installation dates. The 2012 AWWA Buried No Longer publication (2012 AWWA Report), which documents "historic production and use of water pipe by material", was used as a guide to identify pipes where the material and installation data did not align with the general timeframe for use. Pipes identified outside the general timeframe for use and associated main breaks were excluded from the survival curve analysis. Appendix I, Water Main Data Quality Review and Survival Curve Development Technical Memorandum, provides further details on the data quality review and survival curve analysis.

8.3.1 Data Quality Review

Based on review of the installation date and material, **Table 8-2,**

Table 8-3**,** and

Table 8-4 provide a summary of the total number of pipe segments that were identified for further review by TWD. Appendix I, Water Main Data Quality Review and Survival Curve Development Technical Memorandum, includes figures identifying the pipe segments for review.

Table 8-2: Pipe Segments with TWD Assigned Installation Date Discrepancy

MATERIAL	PIPES IDENTIFIED FOR REVIEW		TOTAL PIPE COUNT	TOTAL LENGTH (MI)	PERCENTAGE OF PIPES TO BE REVIEWED	
	PIPE COUNT	LENGTH (MI)			% TOTAL COUNT	% TOTAL LENGTH
Asbestos Cement	27	0.2	295	11.2	9%	2%
Cast Iron (1) (2)	1,210	20.2	33,034	930.0	4%	2%
Copper	22	0.3	116	1.2	19%	23%
Ductile Iron Pipe	669	13.9	39,562	904.8	2%	2%
Fiberglass Reinforced	1	0.2	1	0.2	100%	100%
Galvanized Pipe	6	0.1	108	1.6	6%	5%
High Density Polyethylene	35	0.8	1,868	33.8	2%	2%
Polyvinyl Chloride (1)	31	0.7	6,157	155.0	1%	0.5%
Unlined Cast Iron (1)	126	2.1	6,056	124.6	2%	2%
Total	**2,127**	**38.5**	**87,197**	**2162.5**	**2%**	**2%**

(1) Includes pipes not owned by the City of Tampa (6 pipe segments total, 1 CAS, 4 PVC, 1 UCI)
(2) Includes 1 inactive pipe

Table 8-3: Pipe Segments with Assumed Installation Date

MATERIAL	PIPES IDENTIFIED FOR REVIEW		TOTAL PIPE COUNT	TOTAL LENGTH (MI)	PERCENTAGE OF PIPES TO BE REVIEWED	
	PIPE COUNT (1)	LENGTH (MI)			% TOTAL COUNT	% TOTAL LENGTH
Asbestos Cement	22	1.1	295	11.2	7%	10%
Cast Iron (1) (2)	6,523	165.7	33,034	930.0	20%	18%
Concrete Segments (Bolted)	1	0.001	2	0.001	50%	72%
Copper	20	0.1	116	1.2	17%	8%
Ductile Iron Pipe (1) (2)	6,186	126.2	39,562	904.8	16%	14%
Galvanized Pipe (1)	61	1.3	108	1.6	56%	77%
High Density Polyethylene (2)	441	7.5	1,868	33.8	24%	22%
Polyvinyl Chloride (1) (2)	259	8.4	6,157	155.0	4%	5%
Steel	1	0.1	3	0.2	33%	45%
Transite	3	0.1	3	0.1	100%	100%
Unlined Cast Iron (1) (2)	5,150	103.3	6,056	124.6	85%	83%
Total	**18,667**	**413.9**	**87,204**	**2162.6**	**21%**	**19%**

(1) Includes pipes not owned by the City of Tampa (283 pipe segments total, 8 CAS, 21 DIP, 2 GP, 28 PVC, 224 UCI)
(2) Includes inactive pipes (115 pipe segments total, 7 CAS, 79 DIP, 5 HDPE, 2 PVC, 22 UCI)

Table 8-4: Minimal Remaining Active Pipe Segments

MATERIAL	PIPES IDENTIFIED FOR REVIEW	
	TOTAL COUNT (1)	LENGTH (MI)
Clay Tile	2	0.0003
Concrete Segments (Bolted)	2	0.001
Fiberglass Reinforced	1	0.25
Polyethylene	5	0.13
Steel	3	0.17
Transite	3	0.13
Total	**16**	**0.55**

8.3.2 Data Improvement Recommendations

Black & Veatch recommends that TWD perform a detailed review to confirm and/or update the material type and/or installation date for the 23% of pipe segments that either (1) did not align with the 2012 AWWA Report timeframes, (2) are missing an installation date and an assumption was made, or (3) have a material type of clay tile, concrete segments (bolted), polyethylene, steel, and transite. Main breaks associated with any pipe identified for further review should also be reviewed for confirmation of the correct pipe and/or update of the identified break pipe material on the break record.

As part of continually improving the GIS data source used for reporting, modeling, and asset management, additional data quality reviews can be performed by TWD as described below to confirm and/or update the master data:

1. Pipes with duplicate facility IDs: Renumber pipes with duplicate facility IDs to ensure each facility ID is unique.
2. Pipe assigned to Main Breaks
   - Each main break record within FY2000-FY2015 was assigned to a pipe as part of the main break analysis effort performed by Black & Veatch using multiple confidence level criteria. The assigned pipe should be confirmed for all main breaks.
3. Water mains that may be included in the wLateral feature class
   - Water mains that are included in the wLateral feature class should be removed and added to the wMains feature class.
4. Service lines that may be included in the wMains feature class
   - Service lines that are included in the wMains feature class should be removed and added to the wLaterals feature class.
5. Splits in pipes where a node (valve, hydrant, or fitting) is not located
   - Determine if a valve, hydrant, or fitting is missing at two adjoining pipes or if the pipe segments should be merged as a single pipe.
6. Pipes not split at a node (valve, hydrant, or fitting)
   - Determine if a pipe should be split at an existing node or if the pipe is a duplicate and should be removed.
7. Multiple pipes in the same location
   - Review if overlapping pipe(s) should be inactive
   - Review for pipe duplication (individual pipe segments between nodes may have been added and the original pipe segment may have not been deleted)

8.3.3 Survival Curve Analysis

The survival curve analysis follows the Kaplan-Meier methodology and incorporates the total observed population of water mains for each pipe material, the age of each water main as of year 2015, and the main break occurrences between years 2000 and 2015 to develop a hazard curve and survival curve. The average life expectancies are based on the 50th percentile of the Weibull estimated survival probability. The average life expectancies for pipe materials that did not have sufficient data to support the survival curve analysis are based on the 2012 AWWA Report or assumed, as applicable. **Table 8-5** provides the estimated life expectancy results for each pipe material.

Table 8-5: Average Life Expectancy

MATERIAL	AVERAGE LIFE EXPECTANCY (YEARS)		
	WEIBULL SURVIVAL PROBABILITY (1)	AWWA – 2012 REPORT (2)	SELECTED
Asbestos Cement	46	90	46
Cast Iron	86	110	86
Copper	40	*Not Available*	40
Concrete Segments (Bolted)	*Not Available*	105 (2)	105
Clay Tile (4)	*Not Available*	*Not Available*	100
Ductile Iron	88	80	88
Fiberglass Reinforced	*Not Available*	55 (2)	77 (3)
Galvanized Pipe	101	*Not Available*	101
High Density Polyethylene	78	*Not Available*	78
Polyethylene	*Not Available*	55 (2)	77 (3)
Polyvinyl Chloride	77	55	77
Steel	*Not Available*	70	70
Transite	*Not Available*	90 (2)	46 (3)
Unlined Cast Iron	80	*Not Available*	80

(1) Average life expectancies are based on the "Modified" pipe population for each pipe material and are estimated at the 50th percentile of the Weibull survival probability curve.
(2) The 2012 AWWA Report average life expectancy is assumed to be 50th percentile. The AWWA report does not include life expectancy for all pipe materials. The following assumptions were made to estimate the remaining life for each pipe material.
Concrete Segments (Bolted) – Assumed similar to Conc & PCCP
Fiberglass Reinforced – Assumed similar to PVC
Polyethylene – Assumed similar to PVC
Transite – Assumed similar to Asbestos
(3) Pipe materials that did not have break history were not included in the survival curve analysis. The following assumptions were made in order to estimate the remaining life for each pipe material based on the Weibull survival probability curve estimates.
Fiberglass Reinforced – Assumed similar to PVC
Polyethylene – Assumed similar to PVC
Transite – Assumed similar to Asbestos
(4) Clay Tile was assumed to have an average life expectancy of 100 years.

8.4 RISK ANALYSIS

Each individual water main segment was analyzed and ranked based on both a calculated risk score and risk classification. The overall risk score was calculated by multiplying the total LOF score and the total COF score. The total LOF and COF scores are determined by multiplying each individual factor score by the assigned weighting and then summing, respectfully. The weightings for each LOF and COF criteria are shown in **Table 8-6**.

Table 8-6: Criteria Weightings

CRITERIA	PRELIMINARY SCORING WEIGHT
Likelihood of Failure	
Breaks on Individual Pipe Segments	45%
Remaining Life	45%
Aggressive Soil Area	10%
Consequence of Failure	
Critical Customer Impact	15%
Population Density	10%
Repeatable Breaks on Individual Pipe Segments	5%
Contaminated Soil	10%
Additional Fire Hydrants	5%
Right-of-Way Ownership and Crossings	10%
Water Demand	15%
Diameter	15%
Interconnect Location	10%
2015 Planned Paving Projects	5%

To determine the risk classification for each water main segment, the bi-directional distribution risk assessment method using a 5x5 risk matrix is utilized. The risk classifications range from negligible to extreme as shown in **Figure 8-1**. The risk classification for each water main segment is based on where the LOF and COF scores intersect within the matrix.

Figure 8-1: Overall Risk Score Classification Matrix

	LOF - Low	LOF - M. Low	LOF - Medium	LOF - M. High	LOF - High
COF - High	Medium	Medium	High	Extreme	Extreme
COF - M. High	Medium	Medium	High	High	Extreme
COF - Medium	Low	Medium	Medium	High	High
COF - M. Low	Negligible	Low	Medium	Medium	High
COF - Low	Negligible	Negligible	Low	Medium	High

8.5 ANALYSIS RESULTS

8.5.1 Overall Risk Scoring Results

The results of the COF and LOF analysis are shown in **Figure 8-2**. Water main segments not active or owned by the TWD were not included in the results. Further detail regarding the overall risk scoring results is included in Appendix H, Risked Based Prioritization Technical Memorandum.

Figure 8-2: Bi-Directional Risk Matrix Results

COF and LOF Contribution

	LOF - Low	LOF - M. Low	LOF - Medium	LOF - M. High	LOF - High
COF - High	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles
COF - M. High	293 Pipes, 16.9 miles	118 Pipes, 6.3 miles	64 Pipes, 3.1 miles	9 Pipes, 0.4 miles	1 Pipes, 0.0 miles
COF - Medium	10391 Pipes, 308.0 miles	1707 Pipes, 70.4 miles	3080 Pipes, 83.0 miles	388 Pipes, 19.2 miles	95 Pipes, 5.1 miles
COF - M. Low	54200 Pipes, 1187.4 miles	4939 Pipes, 169.8 miles	10463 Pipes, 230.3 miles	502 Pipes, 30.8 miles	268 Pipes, 14.3 miles
COF - Low	79 Pipes, 1.0 miles	15 Pipes, 0.1 miles	3 Pipes, 0.1 miles	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles

8.5.2 Linear Asset R&R Gap Analysis Results

To support the TWD in future decision making towards water distribution rehabilitation and replacement (R&R) system planning, a gap analysis was performed based on current funding versus total and annual replacement cost needs. Valve, fire line service, hydrant, and distribution main replacement needs were included in the analysis. **Table 8-7** and **Figure 8-3** through **Figure 8-5** provide a summary of the gap analysis results. Assumptions used to support the gap analysis are provided in Appendix H, Risked Based Prioritization Technical Memorandum.

Table 8-7: Total and Annual Replacement Costs

CATEGORY TYPE	TOTAL COUNT/ LENGTH (MI)	TOTAL REPLACEMENT COST	REPLACEMENT / REHABILITATION SCHEDULE	ANNUAL COST
Valve	49,704	$904,772,541	20-year (Replace)	$45,239,000
Fire Line Services	2,571	$40,880,323	86-year (Replace)	$475,000
Hydrant	14,094	$581,096	20-year (Rehab)	$29,000
Distribution Mains	2,146 mi	$3,448,968,221	Varies (Replace)	--

Assumptions:
1 Base/Fee/Rate charges assumed to increase at a rate matching inflation. All dollar values shown in 2018 dollars.
2 Developer funded pipeline R&R rate is reduced by 50% to account for pipes being taken out of service prior to the pipe being in service for its entire projected lifespan.
3 Domestic & irrigation service replacements are included in the pipeline R&R $/ft. estimates

Figure 8-3: Annual Replacement Cost (Years 2018- 2103) vs Current Funding Rate

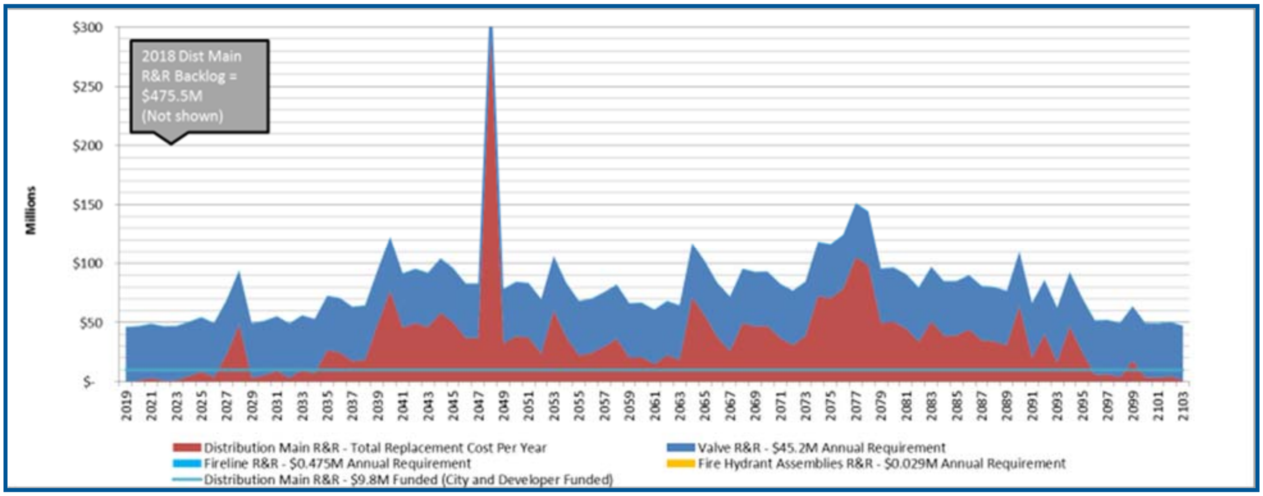


Figure 8-4: Annual Replacement Cost (Years 2018 - 2037) vs Current Funding Rate

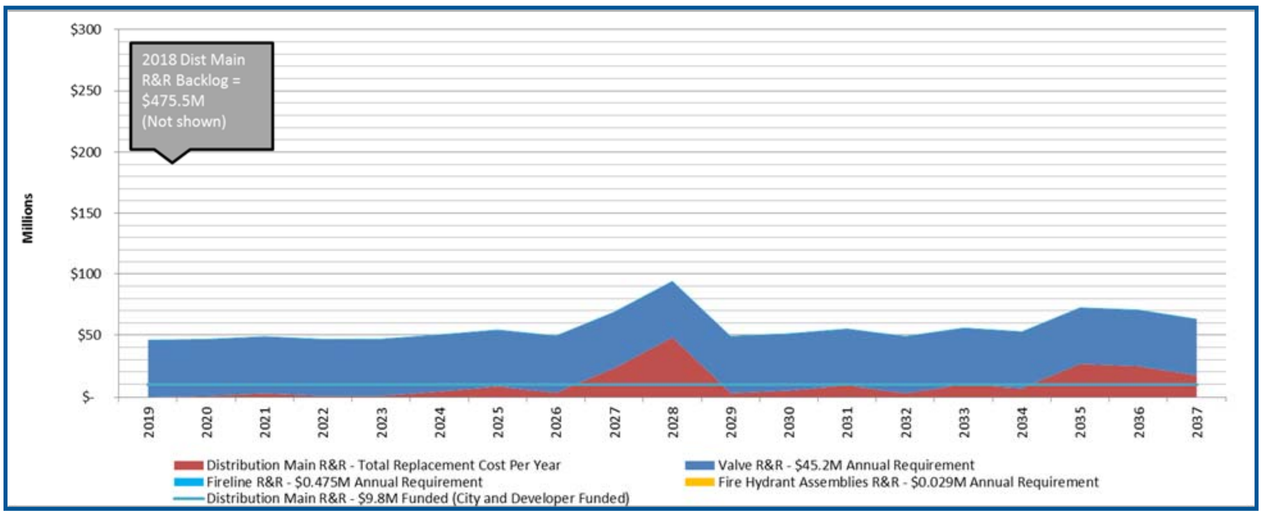
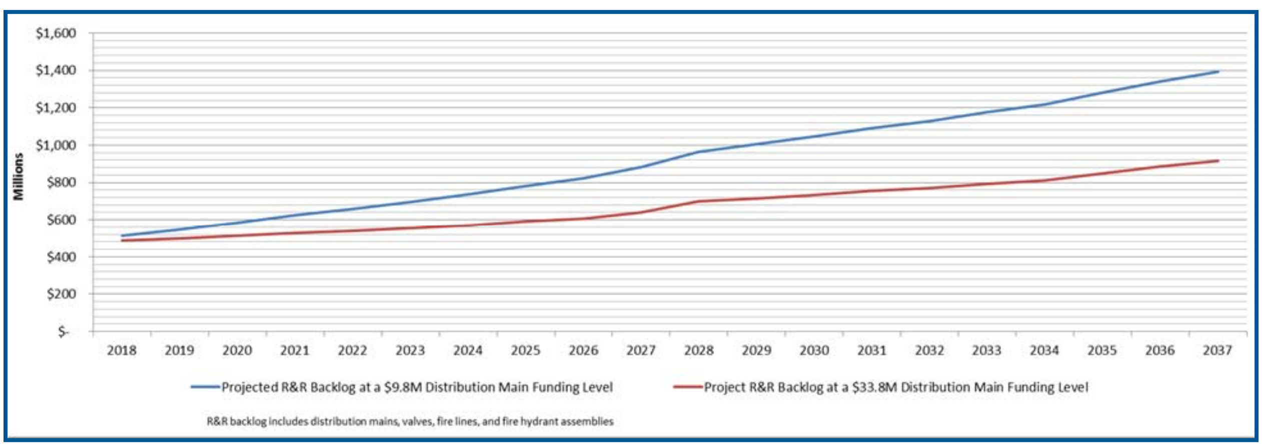


Figure 8-5: Projected R&R Backlog at Various Distribution Main Funding Levels



Note: Funding levels are based on distribution main replacement costs needed up to year 2037

8.5.3 Valve Replacement Decision Tool

Black & Veatch developed a spreadsheet tool to support the TWD in standardizing the decision-making process for valve replacement. Two options were considered for evaluation:

- Option A represents immediate valve replacement, with later pipe and valve replacement. The immediate valve replacement cost (present value) and cost of pipe and valve replacement at end of the life (present value) are summed together for a total present value cost and comparison to Option B.
- Option B represents immediate pipe and valve replacement. The cost for immediate pipe and valve replacement (present value) is calculated for comparison to Option A. This option would be economical when the remaining life of the pipe is limited.

Appendix H, Risked Based Prioritization Technical Memorandum provides further details on the set-up and calculations used in the spreadsheet template. The spreadsheet tool was provided to the TWD separately in Microsoft Excel format. The cost for valve replacement has not been included in the list of CIP projects are part of this Master Plan. The TWD is investigating the true service life of the valves and methods to extend the service life.

9.0 Capital Improvement Planning

Once the recommended improvement projects were identified and preliminary implementation planning years established, Black & Veatch estimated the cost for each improvement project. Black & Veatch then adjusted the implementation date, in conjunction with the TWD through a series of workshops. The following section describes the unit costs established, the proposed capital improvement plan and the cash flow required to implement the improvements.

9.1 WATER MAIN UNIT COSTS

Black & Veatch worked with the TWD to prepare unit cost information and assumptions for the variety of types of water main improvements to be used to develop planning-level opinions of probable project costs. The unit costs were based on the 2015 bid tab provided by the TWD on-call contractor. **Table 9-1** summarizes the unit costs per diameter and items included in the unit cost are comprised of the following:

- Restoration: Type I and II, in and out of the street
- Pipe Material: PVC, Ductile Iron
- Pipework Additions over 2,450-ft span: restraints, tees, sleeves, fire hydrant assemblies, valves, protection posts, meter services
- Markups: 30% Contingency and 15% Engineering Fee

Table 9-1: Water Main Unit Costs

Diameter (in)	Unit Cost with Contingency ($/LF)
4	$201.00
6	$224.00
8	$238.00
12	$286.00
16	$465.00
20	$554.00
24	$794.00
30	$969.00
36	$1,169.00
42	$1,436.00
48	$1,970.00

9.2 CAPITAL IMPROVEMENT PLAN

The non-rehabilitation and replacement (R&R) portion of the distribution system capital improvement plan through 2035 includes 55 separate improvement projects at a total project cost of $129M, including a 2.5% inflation rate beginning in 2024 outside of the short-term CIP. Black & Veatch provided detailed cost estimate assumptions for each project to TWD in a CIP spreadsheet file. **Table 9-2** summarizes the CIP per planning year.

Table 9-2: Capital Improvement Plan Summary

CIP #	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR	COSTS WITH INFLATION
Short-Term Capital Improvement Projects through 2024						**$65,980,530**
2	DLTWTF Discharge Pressure	Increase DLTWTF HSPS discharge pressure to 70 psi; slowly / incrementally	Min pressures	Operational / Controls	2018	$ -
3	RPS controls modifications	Modify the NWRPS, WTRPS and PCRPS to operate during peak demand periods rather than time of day	Increased reliance on DLTWTF HSPS	Operational / Controls	2018	$65,000
8	Commercial Fire Flow Study	Perform an analysis of the required commercial fire flow needs be conducted and commercial fire flow corridors be identified	Fire Flow Demands	Study	2018	$50,000
11	West Tampa and Palma Ceia Flow Meters	Install flow monitors on the effluent side of the West Tampa and Palma Ceia RPS's and connect to the data historian	Data Collection	Operational / Controls	2018	$1,046,000
12	RPS Power Monitors	Install power monitors on all RPS equipment and connect to the data historian	Data Collection	Operational / Controls	2018	$18,500
13	DLTWTF Clearwell Groundwater Level Study	Collection of data related to the groundwater level on the site in anticipation of the design of a new clearwell structure	DLTWTF Blending Chamber, Clearwell and HSPS Upgrade Project	Capacity	2018	$50,000
14	Water Quality Model Calibration Study	Collect water quality data throughout the system in order to conduct a calibration of the existing water quality model	Water Quality	Study	2018	$200,000
1	IB, NW and MB Tank Inlet Sleeve Valves	Installation of sleeve valves with flow control functions at the inlet to the Interbay, Northwest and Morris Bridge Tanks	Three Pressure Zone Configuration	Capital: Operational flexibility	2019	$2,230,000
9	South Tampa Check Valves	Install check valves along South Tampa Pressure Zone (along Gandy Blvd)	Fire Flow Demands	Resilience	2019	$957,000
4	DLTWTF Blending Chamber, Clearwell and HSPS Upgrades	Demo 2.0 MG and 0.5 MG clearwells, convert 7.5 MG clearwell to blending chamber, install new 13.0 MG clearwell, demo pumps 1-6 and install new 153 MGD HSPS	Sum of the MDDs for each pressure zone greater than 140 MGD	R&R and Expansion	2020	$59,500,000
16	CP003	12-inch; 5,392 feet 16-inch; 200 feet	System Pressures	Capacity	2020	$1,872,000

CIP #	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR	COSTS WITH INFLATION
Mid-Term Capital Improvement Projects 2025-2030						**$35,664,974**
6	Northeast (Nebraska) EST	Installation of a new EST in the north portion of the DLTWTF	DLTWTF Pressure Zone Demands greater than 130 MGD	Resilience	2025	$12,273,267
15	R-01 Hillsborough Ave WM	6,000-ft of 12-inch pipe along Hillsborough Ave.	DLTWTF Pressure Zone Demands greater than 125 MGD	Resilience	2025	$9,401,986
17	CP004	8-inch; 3,546 feet 12-inch; 4,219 feet	System Pressures	Capacity	2025	$2,651,842
19	FF0-01	12-inch; 2,900 feet	Opportunistic	Fire Flow	2025	$1,059,583
20	FF0-02	12-inch; 4,600 feet	Opportunistic	Fire Flow	2025	$1,720,452
22	FF0-04	12-inch; 4,650 feet	Opportunistic	Fire Flow	2025	$1,753,214
25	FF0-07	12-inch; 4,260 feet	Opportunistic	Fire Flow	2025	$1,588,942
26	FF0-08	8-inch; 800 feet	Opportunistic	Fire Flow	2025	$253,130
41	FF1-06	6-inch; 10 feet	Opportunistic	Fire Flow	2025	$2,194
42	FF1-07	12-inch; 600 feet	Opportunistic	Fire Flow	2025	$229,023
21	FF0-03	12-inch; 1,610 feet	Opportunistic	Fire Flow	2026	$617,162
23	FF0-05	12-inch; 1,200	Opportunistic	Fire Flow	2027	$467,727
24	FF0-06	16-inch; 1 mile	Opportunistic	Fire Flow	2028	$3,495,922
27	FF0-09	12-inch; 1,850 feet	Opportunistic	Fire Flow	2029	$769,257
28	FF0-10	12-inch; 1,150 feet	Opportunistic	Fire Flow	2029	$477,470
29	FF0-11	8-inch; 800 feet	Opportunistic	Fire Flow	2029	$278,524
30	FF0-12	8-inch; 800 feet	Opportunistic	Fire Flow	2029	$278,524

CIP #	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR	COSTS WITH INFLATION
31	FF0-13	12-inch; 900 feet	Opportunistic	Fire Flow	2029	$371,365
Long -Term Capital Improvement Projects 2030 - 2035						**$62,886,623**
5	HSPS Expansion	Install additional pumping capacity at the new HSPS building total new capacity = 167 MGD	DLTWTF Pressure Zone Demands greater than 153 MGD	Performance Criteria: Pump Capacity	2030	$4,891,280
10	Hillsborough County Interconnect	Interconnect with Hillsborough County in the northwest portion of the system either directly into the distribution system or the Northwest Tank	DLTWTF Pressure Zone Demands greater than 140 MGD	Resilience	2030	$1,753,928
32	FF0-14	12-inch; 100 feet	Opportunistic	Fire Flow	2030	$54,365
33	FF0-15	12-inch; 2,800 feet	Opportunistic	Fire Flow	2030	$1,182,059
34	FF0-16	12-inch; 450 feet	Opportunistic	Fire Flow	2030	$190,216
35	FF1-00	8-inch; 310 feet	Opportunistic	Fire Flow	2030	$108,695
36	FF1-01	16-inch; 140 feet	Opportunistic	Fire Flow	2030	$96,345
37	FF1-02	16-inch; 10 feet	Opportunistic	Fire Flow	2030	$11,113
43	FF2-00	8-inch; 500 feet 12-inch; 650 feet	Opportunistic	Fire Flow	2031	$459,343
44	FF2-01	8-inch; 2,500 feet	Opportunistic	Fire Flow	2031	$904,767
45	FF2-02	8-inch; 1,300 feet	Opportunistic	Fire Flow	2031	$473,263
46	FF2-03	8-inch; 300 feet	Opportunistic	Fire Flow	2031	$108,822
47	FF2-04	8-inch; 50 feet	Opportunistic	Fire Flow	2031	$22,789
48	FF2-05	6-inch; 2,200 feet	Opportunistic	Fire Flow	2032	$770,092
49	FF2-06	12-inch; 20 feet	Opportunistic	Fire Flow	2032	$14,261
50	FF2-07	8-inch; 20 feet	Opportunistic	Fire Flow	2032	$12,963
51	FF2-08	8-inch; 2,300 feet	Opportunistic	Fire Flow	2032	$855,658
52	FF2-09	8-inch; 1,350 feet	Opportunistic	Fire Flow	2032	$499,134
53	FF2-10	6-inch; 700 feet	Opportunistic	Fire Flow	2033	$248,395

CIP #	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR	COSTS WITH INFLATION
7	Southeast (Broadway) EST	Installation of a new EST in the south portion of the DLTWTF	DLTWTF Pressure Zone Demands greater than 135 MGD	Resilience	2035	$9,918,429
18	CP005	12-inch; 2 miles	System Pressures	Capacity	2035	$5,369,060
54	BBD Parallel Water Main	12-inch; 1,650 feet 30-inch; 14,106 feet 36-inch; 8,949 feet	When the MB TBW Interconnect is used for normal daily water supply	Resilience	2035	$33,598,658

9.3 CASH FLOW

The CIP for distribution system improvements involves a number of significant capital cost projects through the 2035 planning horizon. In addition, there are a number of distribution system pipeline R&R projects that have been prioritized for implementation throughout the planning horizon and beyond. **Figure 9-1** illustrates the required cash flow over the planning horizon assuming all design costs are encumbered at the beginning of the design period and all construction costs are encumbered at the beginning of the construction period. This method of encumbering costs increases the variable appearance of the graphs. **Figure 9-2** provides the same information but at a different scale, and without the R&R costs, to more clearly show the breakdown of the costs for each year.

Figure 9-1: 2018 – 2035 Cash Flow

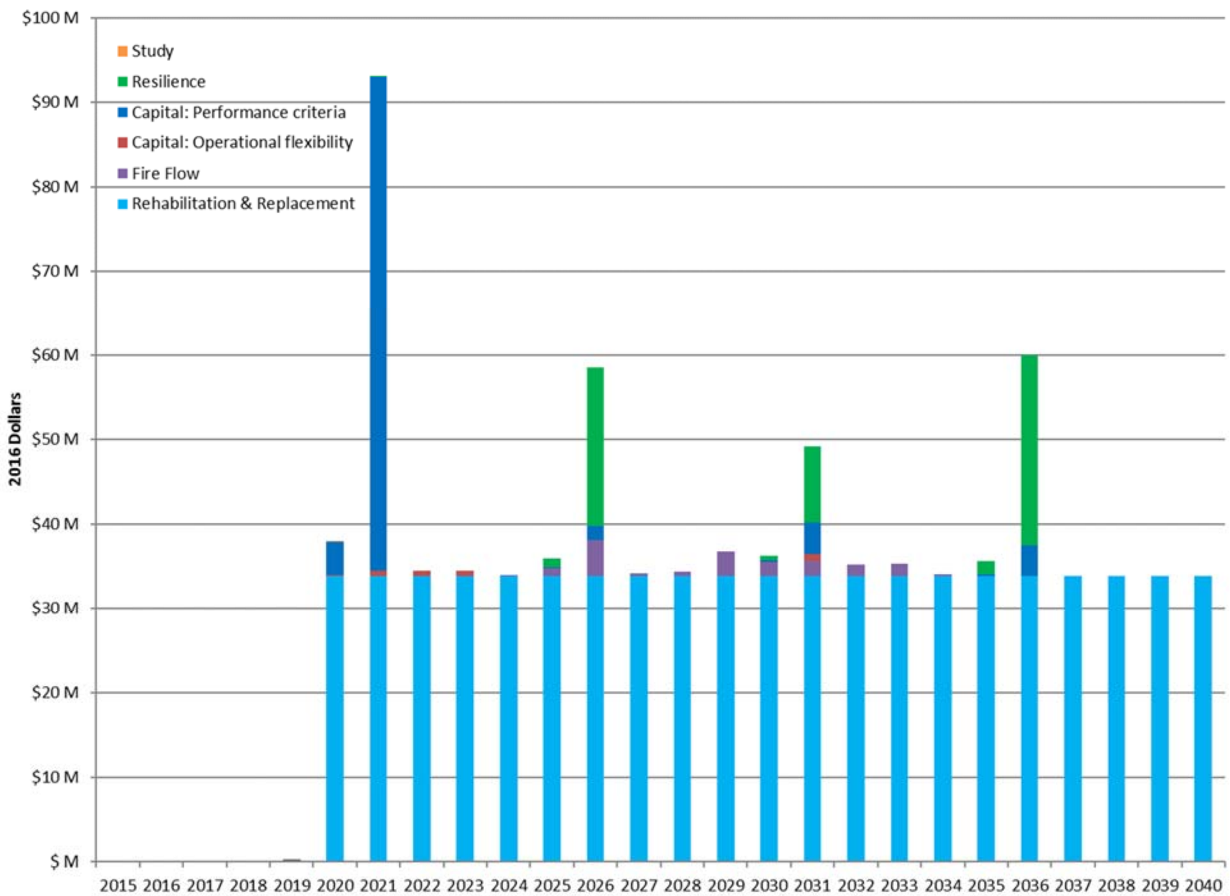
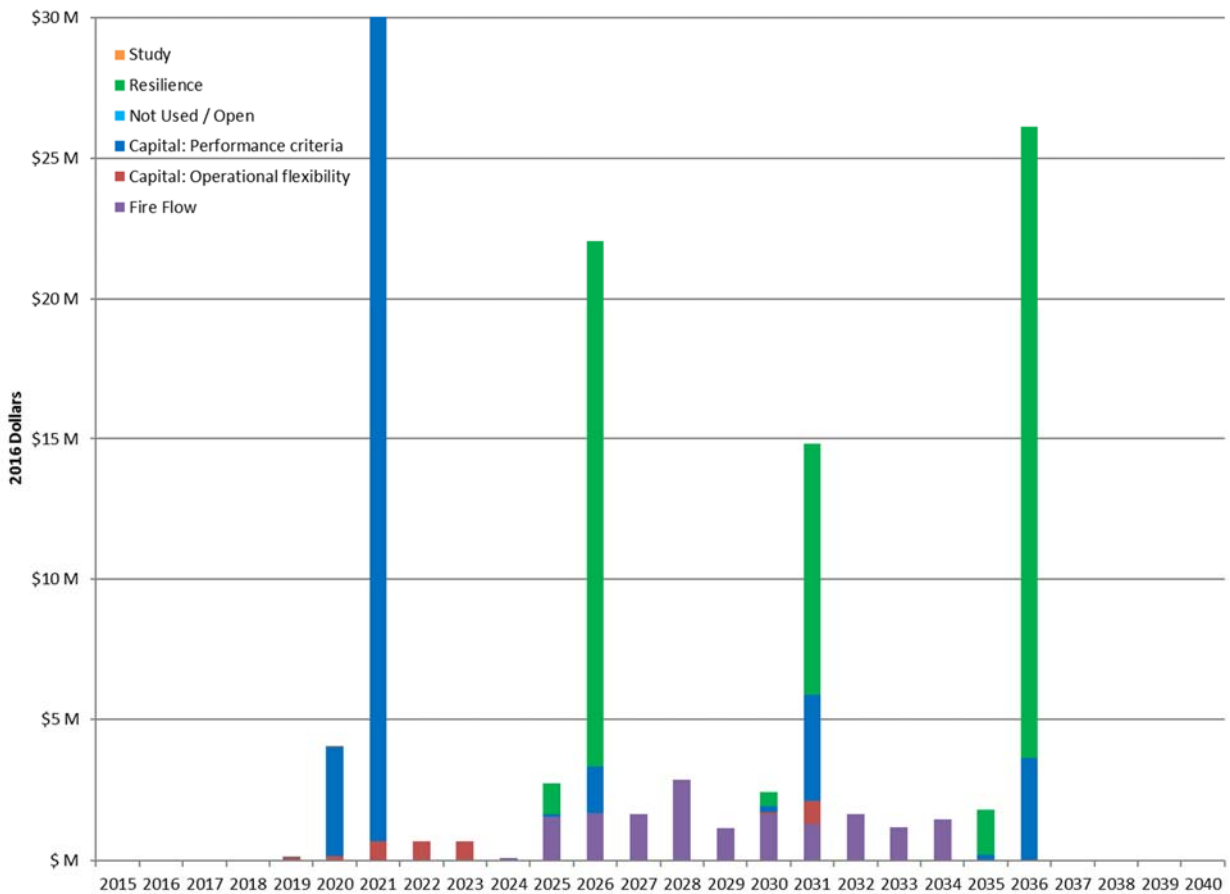


Figure 9-2: 2018 – 2035 Cash Flow ($30M Scale) without R&R



Appendix A

Population and Demand Projection Technical Memorandum

FINAL

POPULATION & DEMAND PROJECTIONS

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

30 JUNE 2016

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1. Introduction

Distribution system demands are comprised of several different uses and are either consumed by customers, referred to as consumption demand and are metered for billing purposes, or are "lost" through water quality flushing, leaks, main breaks and meter inaccuracies, and referred to as non-revenue water (NRW). Since the NRW is unmetered, it can be calculated on an annual average basis using a mass or flow balance principle such that the water leaving the pressurized distribution system must equal the water entering the system. Therefore,

Flow from (WTF HSPS ± Interconnects) = Demand from Customer Consumption + NRW

The following sections document how the total system demands were calculated and projected for the base and future planning years (2015, 2020, 2025 and 2035), and how those demands are spatially allocated throughout the distribution system.

2. Average Day Demand Projection

The following is a summary of the data collected and formulas used to calculate the various demand projections considered for the Tampa Potable Water Master Plan. Ultimately the demand projection used for the system analysis was an average of the four sources available; Southwest Florida Water Management District (SWFWMD) 2015 projections, Tampa Bay Water (TBW) 2015 projections, Exhibit K low and high projections prepared for TBW by the Tampa Water Department (TWD).

2.1 SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT PROJECTIONS

2.1.1 Population Estimates/Projections

Population projections are based on the University of Florida Bureau of Economic and Business Research (BEBR) provided projections from 2014. The populations are distributed spatially based on property parcels and summarized in a shapefile. Since there are so many commuters and tourist related demands in the State of Florida, SWFWMD uses an annual average functional population to estimate the needs for future infrastructure growth and is defined per the formula below. Estimates of resident population are used to determine the permanent population of the City that is not affected by seasonal trends. Estimates of seasonal population are used to determine the population of the City at peak season, taking into account the influx of part-time residents throughout the year. The seasonal population is used when necessary to calculate the additional demand on public services resulting from this influx. When the resident population, seasonal population, tourist population (annual average) and net commuter population are combined, this value is referred to as "functional population".

Functional Population = Permanent&Seasonal + Tourist + Net Commuter

2.1.2 Demand Projections

SWFWMD tracks per capita demand yearly based on the Water Use Permit reports. The following formulas define the water use for utilities.

Withdrawals (WD) + Imported Water (IM) = Gross Water Use + Exported Water (EX) + Treatment Losses (TL)
Where, Treatment Losses (TL) = Losses at WTF, ASR Discharges and WQ Flushing Losses
And, WQ Flushing = Treatment Loss (TL) – Losses at WTF – ASR Discharges

For the purposes of this comparison,

<u>Distribution System Requirements</u> (Total Water Use) = Gross Water Use + Exported Water (EX) + WQ Flushing

Where,

Gross Water Use = Functional Population x Per Capita Demand OR
Gross Water Use = Withdrawals (WD) + Imported Water (IM) - Exported Water (EX) - Treatment Losses (TL)
Per Capita Demand (actual yearly) = Gross Water Use / Function Population <u>Estimate</u>

Future projections are calculated using an average per capita demand and the projected functional population projections.

Per Capita Demand (future) = 5 year average (2008 – 2012) = 113 gpcd
Exported Water (future) = 7 year maximum (2008 – 2014) = 3.4 MGD
WQ Flushing (future) = 5 year average (2010 – 2014) = 0.7 MGD

Total Water Use Projected = (Functional Population Projection x Ave. Per Capita Demand) + Exported Water+ WQ Flushing

Table 1 below summarizes the population and demand projections based on the SWFWMD method.

Table 1. SWFWMD Projections

YEAR	FUNCTIONAL POPULATION ESTIMATE[1]	SWFWMD 2013 PROJECTIONS[1]	GROSS WATER DEMAND[2] (MGD)	EXPORTED WATER DEMAND[3] (MGD)	WQ FLUSHING LOSSES[4] (MGD)	TOTAL WATER DEMAND[5] (MGD)
2005	655,993	-	75.4			-
2008	657,313	-	77.0	1.8	0.05	78.8
2009	648,577	-	65.4	3.4	0.7	69.5
2010	559,752	-	65.2	3.2	0.7	69.0
2011	587,684	-	68.3	2.3	0.7	71.3
2012	587,782	-	68.0	2.3	0.7	71.0
2013	590,523	-	64.6	2.3	0.7	67.6
2014	603,107	-	65.3	2.3	0.7	68.3
2015	-	624,396	70.5	3.4	0.7	**74.7**
2020	-	654,208	73.9	3.4	0.7	**78.0**
2025	-	680,107	76.8	3.4	0.7	**81.0**
2030	-	699,798	79.1	3.4	0.7	**83.2**
2035	-	706,527	79.8	3.4	0.7	**83.9**

1. Obtained from SWFWMD Shapefile for parcels within the City of Tampa service area
2. Calculated based on City of Tampa 5-year average (113 gpcd)
3. Based on City of Tampa 7 year maximum (3.4 MGD)
4. Based on City of Tampa 5-year average (0.7 MGD)
5. Calculated by adding the Gross + Exported + WQ

2.2 EXHIBIT K - PREPARED FOR TAMPA BAY WATER

The Exhibit K document prepared by the Tampa Water Department (TWD) provides a range of potential future supply needed by the TWD from TBW. The TWD calculates the future high and low system demand based on a number of factors and then subtracts the supply provided directly by the TWD through the D.L. Tippin Water Treatment Facility (DLTWRF or WRF) to calculate the supply needed from TBW. The information below documents the process to calculate the total system demand.

2.2.1 Population Estimates/Projections

Two population projections are calculated for Exhibit K; the low is based on the growth rates provided by SWFWMD from the 2013 projections and the high is based on the growth rates provided by the Florida Demographic Estimations. **Table 2** below summarizes the population projections used for the low demand projections. The growth rates were calculated from the data provided by SWFWMD and applied to the real population estimate of 2012 to recalculate the population projections. The 2030 growth rate was applied to the 2035 projection since that data was not available.

Table 2. Exhibit K - Low Population Projections

YEAR	POPULATION ESTIMATE[1]	2013 PROJECTIONS[2]	GROWTH RATE (5 YEARS)[3]	ADJUSTED PROJECTIONS[4]
2005	-	655,993	-	-
2010	-	665,474	1.4%	-
2012	587,782	NA	NA	-
2015	-	686,114	3.1%	598,720
2020	-	700,625	2.1%	611,383
2025	-	714,962	2.0%	623,894
2030	-	722,778	1.1%	630,714
2035	-	NA	1.1%	633,422

1. Data from the 20150105 exhibit K Projections Spreadsheet, Historic Raw Data & Trending Tab, column F – Service Area Population
2. Data from the 20150105 exhibit K Projections Spreadsheet, SWFWMD Projection Tab, column B
3. Data from the 20150105 exhibit K Projections Spreadsheet, SWFWMD Projection Tab, column H
4. Data from the 20150105 exhibit K Projections Spreadsheet, Historic Raw Data & Trending Tab, column Q – Service Area Population

Table 3 below summarizes the population projections used for the high demand projections. The growth rates were calculated from the data provided by the Florida Demographic Estimations and applied to the real population estimate of 2013 to recalculate the population projections. The 2030 growth rate was applied to the 2035 projection since that data was not available.

Table 3. Exhibit K - High Population Projections

YEAR	POPULATION ESTIMATE[1]	YEARLY GROWTH RATE[2]	ADJUSTED PROJECTIONS[3]
2013	590,523	-	-
2014	593,282	-	-
2015	-	2.61%	**608,747**
2016	-	1.42%	617,391
2017	-	1.41%	626,097
2018	-	1.38%	634,737
2019	-	1.35%	643,306
2020	-	1.31%	**651,733**
2021	-	1.27%	660,010
2022	-	1.22%	668,062
2023	-	1.18%	675,945
2024	-	1.14%	683,651
2025	-	1.11%	**691,240**
2026	-	1.07%	698,636
2027	-	1.04%	705,902
2028	-	1.01%	713,031
2029	-	0.98%	720,019
2030	-	0.95%	**726,859**
2035	-	0.95%	**761,822**

1. Data from the 20150105 exhibit K Projections Spreadsheet, Historic Raw Data & Trending Tab, column F – Service Area Population
2. Data from the 20150105 exhibit K Projections Spreadsheet, Florida Demographic Estimating Tab, column C – Growth Rate
3. Data from the 20150105 exhibit K Projections Spreadsheet, Historic Raw Data & Trending Tab, column AN – Service Area Population

2.2.2 Demand Projections

Exhibit K uses the following formula to calculate the projected total system demands.

Total Water Use Projected = Residential (R+A) + Commercial/Industrial (C+I) + Distribution Water Loss – Reuse Offset

Where, R = Residential; A = Apartment; C = Commercial; I = Industrial → RCI Codes = Code dictating rate structure
Residential (R+A) = Service Area Population x Per Capita Demand; Per Capita Demand = 25 yr. average (76.7 gpcd)
Commercial/Industrial (C+I) = 5 yr. average 2009-2013 (22.5 MGD in 2013)
Water Loss = 5 yr. average 2009-2013 (7.5 % in 2013)
Reuse Offset = 3 yr. average 2011-2013 (2.7 MGD in 2013)

For the <u>Low Demand</u> projections the following were assumed increases in demand:

Residential (R+A) = Constant @ 76.7 gpcd
Commercial/Industrial (C+I) = 0.5% increase per year starting at 22.5 MGD in 2013
Water Loss = Constant @ 7.5 %
Reuse Offset = 1.0% increase per year starting at 2.7 MGD in 2013

For the <u>High Demand</u> projections the following were assumed increases in demand:

Residential (R+A) = Constant @ 76.7 gpcd
Commercial/Industrial (C+I) = 1.0% increase per year starting at 22.5 MGD in 2013
Water Loss = Constant @ 7.5 %
Reuse Offset = No Reuse Offset was accounted for

Table 4 below summarizes the population and demand projections based on the Exhibit K methods.

Table 4. Exhibit K Demand Projections

YEAR	LOW PROJECTIONS						HIGH PROJECTIONS					
	POPULATION	R+A	C+I	WATER LOSS	REUSE OFFSET	TOTAL (MGD)	POPULATION	R+A	C+I	WATER LOSS	REUSE OFFSET	TOTAL (MGD)
START FACTOR		76.7 GPCD	22.5 MGD	7.5%	2.7 MGD			76.7 GPCD	22.5 MGD	7.5%	0 MGD	
GROWTH		0%	0.5%	0%	1.0%			0%	1.0%	0%	0.0%	
2015	598,720	45.9	22.5	5.5	2.8	71.2	608,747	46.7	23.0	5.6	0.0	75.3
2020	611,383	46.9	23.1	5.6	2.9	72.8	651,540	50.0	24.2	6.0	0.0	80.1
2025	623,894	47.9	23.7	5.8	3.0	74.3	691,035	53.0	25.4	6.3	0.0	84.7
2030	630,714	48.4	24.4	5.9	3.2	75.5	726,644	55.7	27.0	6.7	0.0	89.4
2035	633,442	48.6	25.3	5.9	3.3	76.5	761,822	58.4	28.9	7.0	0.0	94.4

2.3 TAMPA BAY WATER 2014 DEMANDS

TBW prepares an annual Demand Forecast Evaluation and Update to project the amount of water supply needed within their service area. The annual updates are based on the long-term demand forecasting models using three sector-specific econometric models. Each model generates demand forecasts based on weather and socioeconomic projections. The demand forecast for the City of Tampa with a 2014 base year is summarized the **Table 5** below.

Table 5. TBW - High Population Projections

YEAR	TOTAL DEMAND (MGD)
2015	68.1
2020	78.2
2025	84.1
2030	90.1
2035	97.2

2.4 DEMAND PROJECTION COMPARISON & SELECTION

The comparison of the four demand projection methodologies and sources provides a window of likely scenarios. The average of the scenarios was selected for the Potable Water Master Plan and increases the confidence that the analysis will yield applicable results. **Table 6** below summarizes the different demand projections and **Figure 1** illustrates the range of possibilities.

Table 6. Summary of Projected Demands

YEAR	EXHIBIT K - HIGH (TABLE 4)	TBW (TABLE 5)	SWFWMD (TABLE 1)	EXHIBIT K – LOW (TABLE 4)	AVERAGE
2015	75.3	68.1	74.7	71.2	72.3[1]
2020	80.1	78.2	78.0	72.8	77.3
2025	84.7	84.1	81.0	74.3	81.0
2030	89.4	90.1	83.2	75.5	84.5
2035	94.4	97.2	83.9	76.5	88.0

1. Actual 2015 demand was 68.9 MGD. The actual demands will be used for the existing system analysis, while the remaining projected demands will be used for future analysis

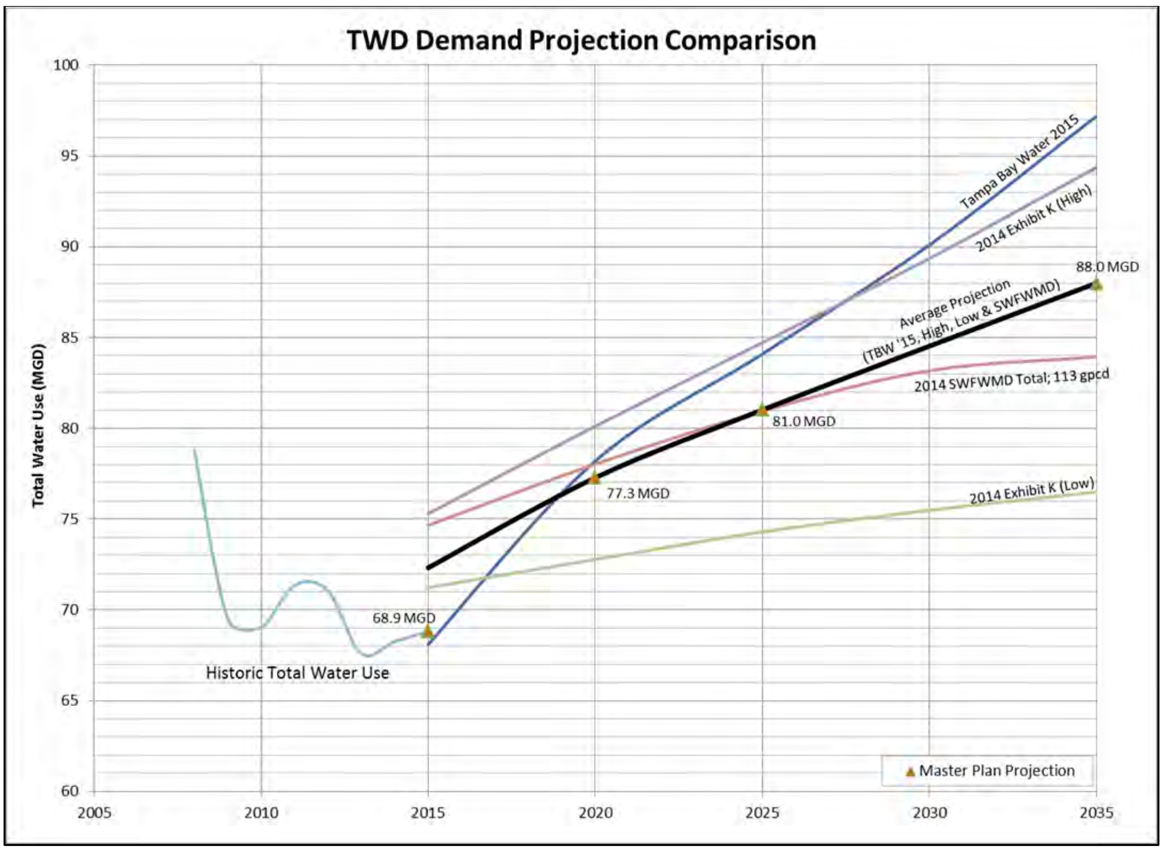


Figure 1. Demand Projection Comparison

The Average Projection shown with the solid black line was selected by the TWD for use during the 2015 Water Master Plan.

3. Non-Revenue Water Demands

3.1 NON-REVENUE WATER CONTRIBUTION

Non-revenue water is monitored monthly by TWD and is summarized in **Table 7** below. The monthly percent of NRW contribution has been as high as 24% of total water produced within the last five years. However, the five year average is 11.0%, which is what will be used for future planning purposes.

Table 7. NRW Historic Contribution Percent of Total

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
2011	24.0	3.0	5.1	9.3	14.3	21.3	10.5	14.3	9.0	11.8	15.5	11.2	12.4
2012	18.0	11.3	11.4	12.5	14.5	23.7	13.4	13.2	-1.6	5.0	5.1	5.1	11.0
2013	14.8	13.0	10.7	12.8	4.7	14.0	13.4	13.7	-1.7	5.5	7.2	6.7	9.6
2014	14.6	6.7	10.0	1.8	3.9	15.7	15.4	16.5	6.2	18.7	12.8	19.0	11.8
2015	12.7	10.3	6.3	12.0	0.0	19.4	12.9	16.9	8.7	12.6	4.4	7.0	10.3
Minimum	12.7	3.0	5.1	1.8	0.0	14.0	10.5	13.2	-1.7	5.0	4.4	5.1	9.6
Maximum	24.0	13.0	11.4	12.8	14.5	23.7	15.4	16.9	9.0	18.7	15.5	19.0	12.4
Average	16.8	8.9	8.7	9.7	7.5	18.8	13.1	14.9	4.1	10.7	9.0	9.8	11.0

NOTE: Data source is the "Percent Non-Revenue Producing" column of the Non-Revenue Producing Water Reports; negative values are most likely from discrepancies between the billing/meter reading cycle and the production data.

3.2 NON-REVENUE WATER BREAKDOWN

As described in the introduction, the NRW demands are comprised of water lost from the system comprised of several categories. These categories include water quality flushing, leakage, main breaks and meter inaccuracies (apparent losses). Based on data extracted from the Monthly Production Reports (MPR) and the Water Use Permit (WUP) Annual Reports to SWFWMD from 2010 – 2014, the summary of raw data and average percent contribution that each NRW category contributes to the total NRW demand is summarized in **Table 8**, **Table 9** and **Table 10.**

Table 8. NRW Category 5-year Flow Breakdown

NRW CATEGORY	SOURCE	2010	2011	2012	2013	2014
Total NRW Volume (gpd)	WUP Report, Part B Row 12	5,168,829	5,245,702	4,652,108	3,077,658	3,697,945
WQ Flushing (kgal)	Water Production Report, Row 29	75,285	56,723	34,542	249,797	109,807
WQ Flushing (gpd)	Conversion kgal → gpd	206,260	155,405	94,636	684,375	300,841
Meter Inaccuracies (gpd)	WUP Report: Section X	1,202,529	760,454	364,521	613,821	740,461
Main Break & Leaking (gpd)	= Total NRW – WQ – Meter Inaccuracies	3,760,040	4,329,843	4,192,951	1,779,462	2,656,643

Table 9. NRW Category 5-year % Breakdown

NRW CATEGORY	2010	2011	2012	2013	2014	AVERAGE
WQ Flushing % of NRW	3.99%	2.96%	2.03%	22.24%	8.14%	7.87%
Meter Inaccuracies % of NRW	23.27%	14.50%	7.84%	19.94%	20.02%	17.11%
Main Break & Leaking % of NRW	72.74%	82.54%	90.13%	57.82%	71.84%	75.02%

NOTE: Calculated from data in Table 8.

Table 10. NRW Category Average % Breakdown

NRW CATEGORY	PERCENT OF NRW
Water Quality Flushing	8%
Meter Inaccuracies (apparent losses)	17%
Main Breaks & Leaking	75%
Total	100%
NOTE: Summarized from Table 9.	

4. Demand Ratios & Seasonality

The average day demand (ADD) for each planning year was calculated and selected above. However, that is only part of the demand profile required for the system analysis. Typical demand conditions recorded and monitored by water utilities include ADD, maximum day demand (MDD), peak hour demand (PHD), average month demand (AMD) and maximum month demand (MMD). These conditions are typically used to determine the condition of the system and are measured against a number of different criteria. For example, most utilities require pumping capacity to meet at least the MDD or PHD depending on the type of available storage, and once the actual MDD or PHD approach the pumping capacity, it might be appropriate to consider a pump upgrade. Therefore, planning level analyses use these different demands to predict when system upgrades will be needed.

4.1 DISTRIBUTION DEMAND RATIO

According to the monthly production reports, the accountable distribution flow for the City of Tampa equals the flow pumped by the high service pump station minus the water to the treatment plants, minus the system flush water, minus the recharge flow transferred into the aquifer storage and recovery system (ASR), which uses the distribution system as a transmission system to transfer treated water from the WTF to the injection wells and is intermittent throughout the year. The TWD controls when recharge is sent to the injection wells and the volume or flow recharged. The TWD will typically recharge the wells during wet weather months when there is an abundant surface water supply. Since the flow sent to the ASR is TWD controlled and does not occur throughout the year or seemingly during the maximum months for the accountable distribution flow, two sets of demand ratios should be calculated; MDD-1 customer demand ratios (accountable flow) and MDD-2 HSPS demand ratios. Including the ASR flow in the calculations could under estimate the true demands. The accountable distribution flow is the flow that should be used to calculate the various peaking factors as it shows the true variation in demands by customers. **Table 11** summarizes the maximum day treated water pumped into the distribution system for the previous five years, while **Table 12** summarizes the maximum rate treated water pumped into the distribution system at the high service pump station. These values, which are taken from the Monthly Production Reports, are used for determining the demand ratios. **Table 13** below summarizes the various historic demand scenarios for the last five years.

Table 11. Maximum Day Treated Water Pumped Summary

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
2011	92.3	84.5	75.1	**73.7**	**80.2**	**80.7**	85.7	93.1	94.7	**94.2**	**90.7**	**89.6**
2012	**94.3**	**88.4**	77.5	76.5	84.0	91.1	85.7	94.4	84.2	**89.1**	**88.5**	**92.7**
2013	**90.1**	87.2	82.4	78.0	80.3	78.7	83.1	84.6	**88.8**	**86.7**	**87.5**	**83.2**
2014	**87.1**	**85.8**	82.1	75.4	75.7	76.8	85.1	87.6	84.9	80.7	**92.4**	**92.4**
2015	**91.8**	**87.4**	83.2	77.1	76.0	81.5	80.9	90.4	89.7	**87.7**	**84.2**	**84.9**

1. Data source = 2011 – 2015 Monthly Production Reports Line 22.
2. Data in bold includes flow to the ASR recharge system

Table 12. Maximum Rate Treated Water Pumped Summary

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
2011	107.2	113.8	92.3	**88.9**	**110.9**	**96.7**	101.2	116.3	117.2	**104.2**	**130.5**	**106.5**
2012	**114.7**	**105.9**	91.8	108.9	115.3	110.7	101.2	132.3	99.8	**107.2**	**102.1**	**112.1**
2013	**103.1**	99.4	92.7	88.4	92.7	90.4	104.7	104.1	**97.2**	**99.8**	**154.5**	**103.3**
2014	**104.3**	**116.2**	104.8	102.3	96.1	91.4	99.4	106.7	97.5	94.7	**123.6**	**163.4**
2015	**131.1**	**101.5**	92.8	93.9	93.2	92.1	95.3	113.8	98.2	**97.6**	**95.6**	**95.6**

1. Data source = 2011 – 2015 Monthly Production Reports Line 23.
2. Data in bold includes flow to the ASR recharge system

Table 13. 5-Year Historic Flows

FISCAL YEAR	ADD-1[1] (MGD)	ADD-2[2] (MGD)	MMD[3] (MGD)	MDD-1[4] (MGD)	MDD-2[5] (MGD)	PHD-1[6] (MGD)	PHD-2[7] (MGD)
2011	71.3	74.2	80.3 (May)	94.7 (Jun)	94.2 (Jul)	117.2 (Jun)	130.4 (Aug)
2012	71.0	76.0	85.6 (Oct)	94.4 (May)	94.3 (Oct)	132.3 (May)	114.7 (Oct)
2013	67.6	71.8	79.0 (Oct)	87.2 (Nov)	90.1 (Oct)	104.7 (May)	154.5 (Aug)
2014	68.3	70.3	79.1 (Sep)	87.5 (May)	92.4 (Aug)	106.7 (May)	163.4 (Sep)
2015	68.4	71.6	78.5 (Oct)	90.4 (May)	91.8 (Oct)	113.8 (May)	131.1 (Oct)
Minimum	67.6	70.3	78.5	87.2	90.1	104.7	114.7
Maximum	71.3	76.0	85.6	94.7	94.3	132.3	163.4
Average	69.3	72.8	80.5	90.8	92.6	114.9	138.8
Std Dev	1.702	2.285	2.927	3.612	1.759	10.961	19.763

1. Accountable Distribution Flows – Calculated from Monthly Production Data; does not include flushing or ASR recharge demands; Line 33 from the Monthly Production Reports.
2. HSPW Flows: From Line 21 of the Monthly Production Reports, including flushing and ASR recharge demands
3. From Line 21 of the Monthly Production Reports, Maximum Month
4. From Table 11, does not include flushing and ASR recharge demands
5. From Table 11; includes flushing and ASR recharge demands
6. From Table 12; does not include flushing and ASR recharge demands
7. From Table 12; includes flushing and ASR recharge demands

Demand ratios, aka peaking factors, can be used to increase or decrease system demands to match the different demand scenarios. [For example, customer billing data can inherently provide very accurate ADD and MMD system consumption demands and spatial allocation and a MDD/ADD peaking factor multiplied by the billing meter ADD can result in an accurate spatially allocated MDD.] **Table 14** summarizes the five year historic demand ratios for the City of Tampa. This information will be used to select the MDD and PHD ratios used during system analysis.

Figure 2 illustrates the monthly production rate for the last five years with the 5-yr monthly average production rate and 5-year average production rates. The ASR recharge flow rate has been subtracted from all production rates shown, and the wholesale supply at Morris Bridge has been included. The figure suggests that the maximum month typically occurs in May, but can vary anywhere between March and September. The 5-year average demand ratios will be used to determine the system analysis demands.

Table 14. Demand Ratio Summary

YEAR	MDD-1/ ADD-1	PHD-1/ ADD-1	MMD/ ADD-1	MDD-1/ MMD	PHD-1/ MMD	MDD-2/ ADD-2	PHD-2/ ADD-2
	(DOES NOT INCLUDE ASR)					(INCLUDES ASR)	
2011	1.33	1.64	1.13	1.18	1.46	1.27	1.76
2012	1.33	1.86	1.21	1.10	1.55	1.24	1.51
2013	1.29	1.55	1.17	1.10	1.33	1.25	2.15
2014	1.28	1.56	1.16	1.11	1.35	1.31	2.32
2015	1.32	1.66	1.15	1.15	1.45	1.28	1.83
Minimum	1.28	1.55	1.13	1.10	1.33	1.24	1.51
Maximum	1.33	1.86	1.21	1.18	1.55	1.31	2.32
Average	1.31	1.66	1.16	1.13	1.43	1.27	1.91
Std Dev	0.02	0.13	0.03	0.04	0.09	0.03	0.32

NOTE: Data for calculations taken from Table 13

4.2 NON-REVENUE WATER SEASONALITY

The total percentage of NRW and the contribution of each category to the whole are not constant and change throughout the year. **Figure 3** illustrates the historic NRW flows for the last five years juxtaposed with the average number of main breaks per month. It shows that there is a seasonal fluctuation to the NRW flow rates, but that the flows do not necessarily correlate to the quantity of main breaks. **Figure 4** illustrates the average NRW flow and percentage in comparison to the average accountable distribution flow. Interestingly the maximum NRW month does not occur during the same month as the maximum demand month. Due to limitations in historic customer meter reading frequency, TWD has elected not to use seasonal variations in NRW, but rather to use the five year average NRW percent discussed above.

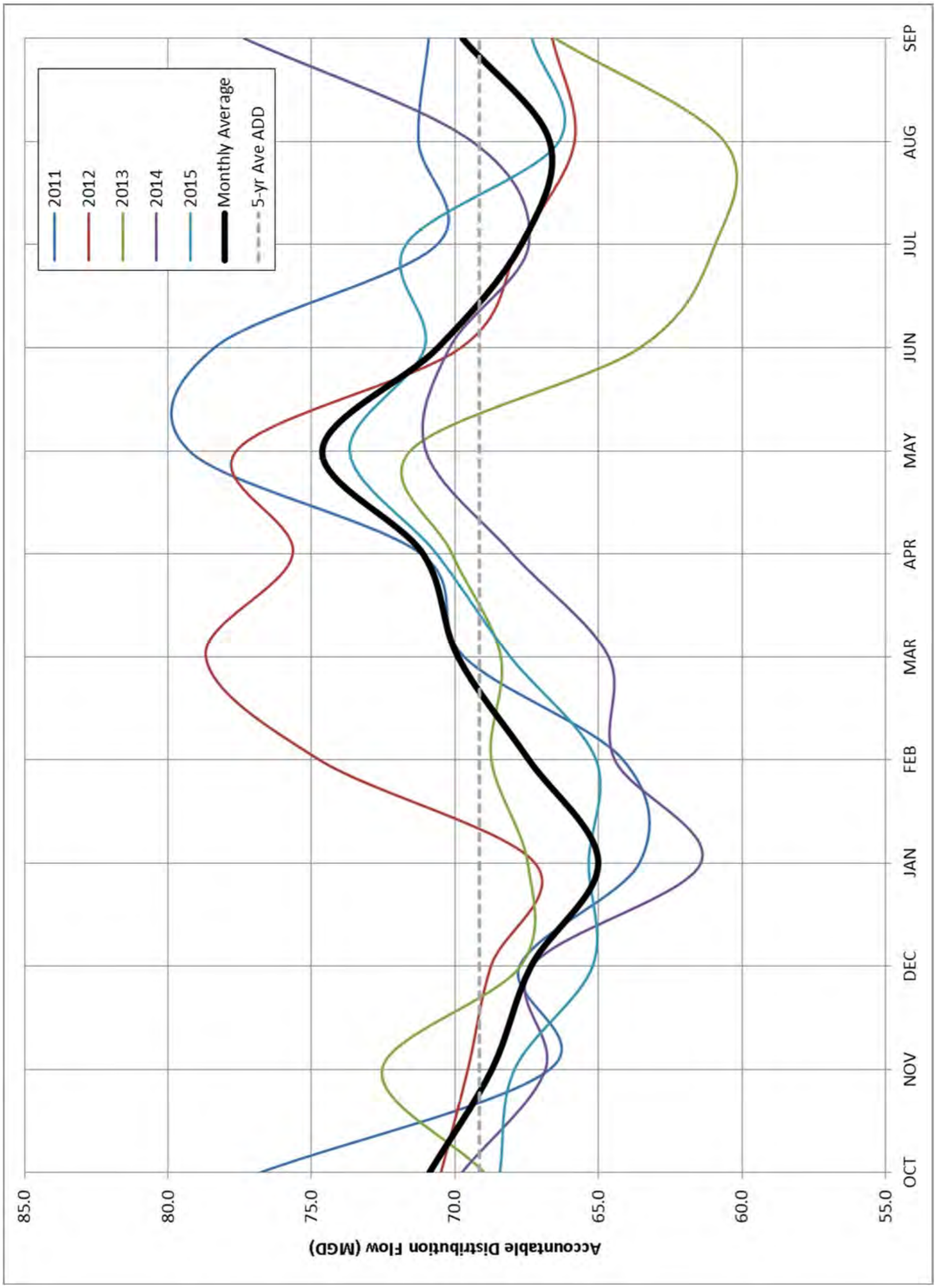


Figure 2. Five Year Monthly Production Comparison

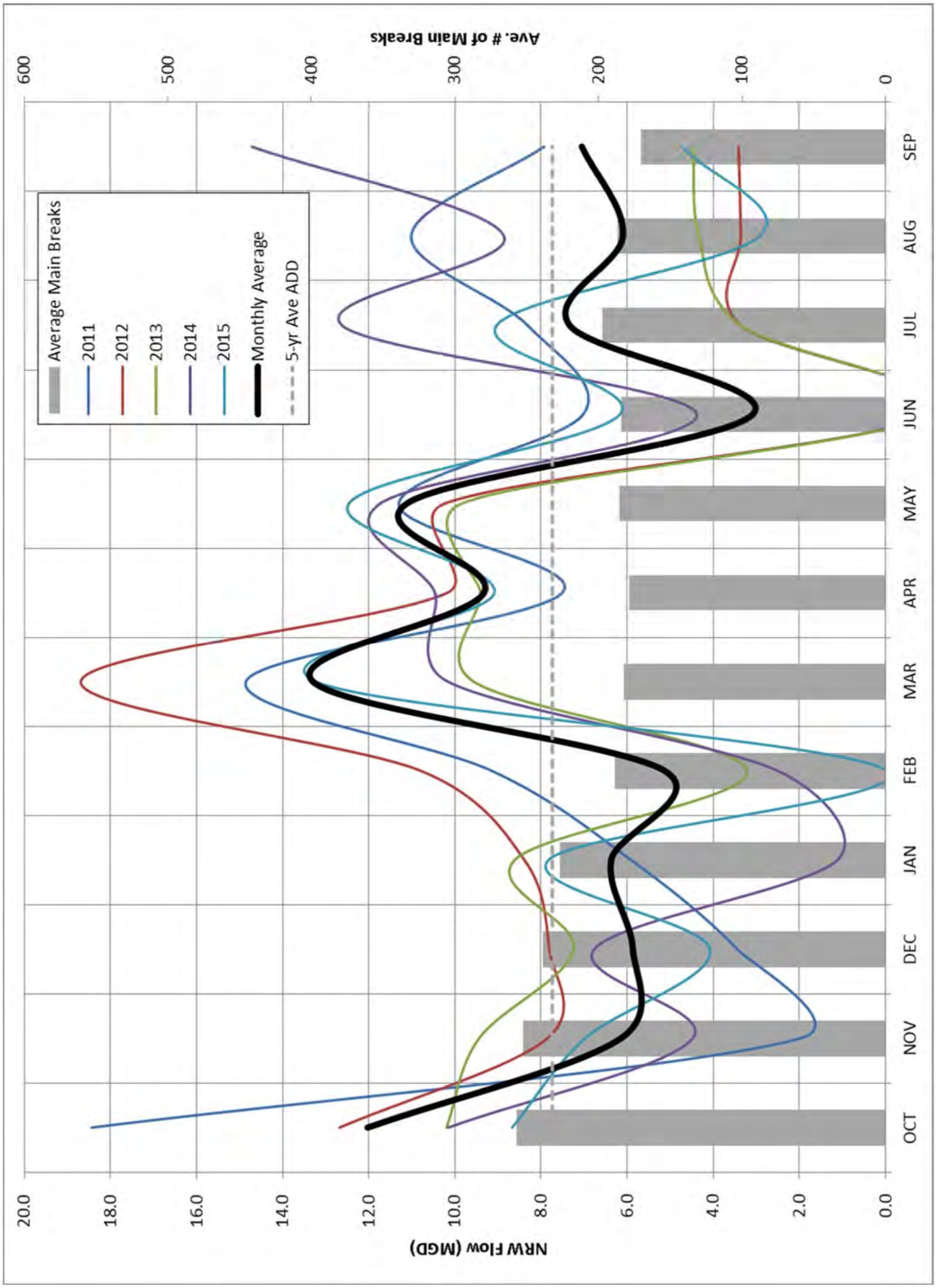


Figure 3. Historic NRW Flows

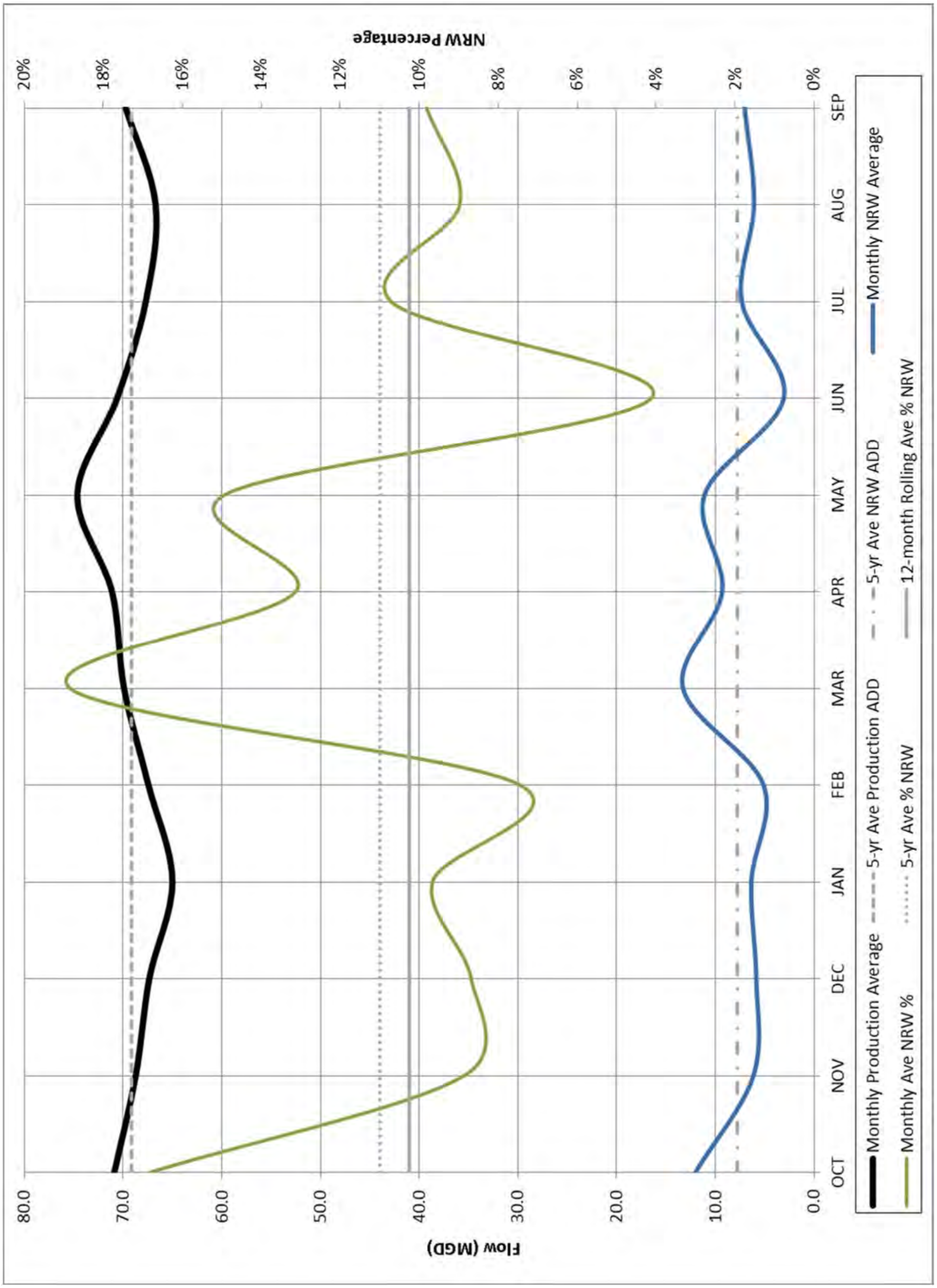


Figure 4. NRW Average Percentage

5. Average Day Demand Spatial Allocation

The spatial allocation of the demand is almost as important as the total demand calculations. To accurately model the existing and future demands and their impacts on the distribution system, it is important to know where those demands are located. The demand ratios (peaking factors) above will be used to increase the allocated ADD described in this section to either MDD or PHD depending on the analysis.

Existing water consumption and unmetered water losses will be allocated to the hydraulic model based on customer billing data, GIS, and pipe break data. For each customer account, the average annual consumption was allocated to model junction nodes based on billing data for 1-year of record. Each customer meter is geospatially located and linked to the specific account demand via the account number. The geospatially accurate consumption information will then be loaded to the model by assigning the consumption to the closest model pipe and weighted by distance to the closest junction. The unmetered demand portion will be calculated based on the comparison between the WTF and imported water records and the customer billing consumption, and then allocated based on on type as described in the sections below.

5.1 CONSUMPTION DEMAND ALLOCATION

Eighty-nine percent of the total distribution demands are metered consumption demands. To determine the location or spatial allocation of the consumption demands a combination of geocoded customer billing records provided by TWD and population projections by parcel provided by SWFWMD were used. The following sections provide the description of the process used to allocate the base year and planning year demands. For the purpose of this Master Plan, the base year is considered to be fiscal year '14/'15 (FY15) which is October 2014 – September 2015.

5.1.1 Base Year Allocation

The geocoded customer billing records are the most current and accurate way to assign real base consumption demands to the hydraulic model. The billing records differentiate the difference between residential and commercial demands and the variations in demand within each billing category. In contrast, the average per capita demand encompasses all uses into one number. Since each billing meter record is geocoded to the centroid of the customer's property parcel and displayed in a shapefile which includes the monthly consumption for each meter for the year, it will be directly imported into the hydraulic model and allocated to the model pipe closest to the parcel centroid and then to the nearest junction/node.

5.1.2 Planning Year Allocation

To keep the detailed and accurate allocation of the billing meters throughout the future planning scenarios, the consumption demand allocation for the planning years must build on the base year consumption allocation. To do that, both the billing meter shapefile and the SWFWMD population shapefiles were used. The assumption was made that the existing customers would continue to consume water at the same rate and location as they were in FY15 through planning year 2035. Therefore, the planning year consumption is calculated as the FY15 metered consumption plus the Future Consumption, where the future consumption increase is proportional to the SWFWMD projected functional population increase for each parcel. The population growth is represented by the SWFWMD parcel shapefile and is equal to the planning year population minus the 2015 population per parcel. If the resulting population is zero, then there was no growth within the parcel; likewise if the resulting population value is greater than zero, then there was growth within the parcel. The following formulas were used to determine the planning year consumption allocations.

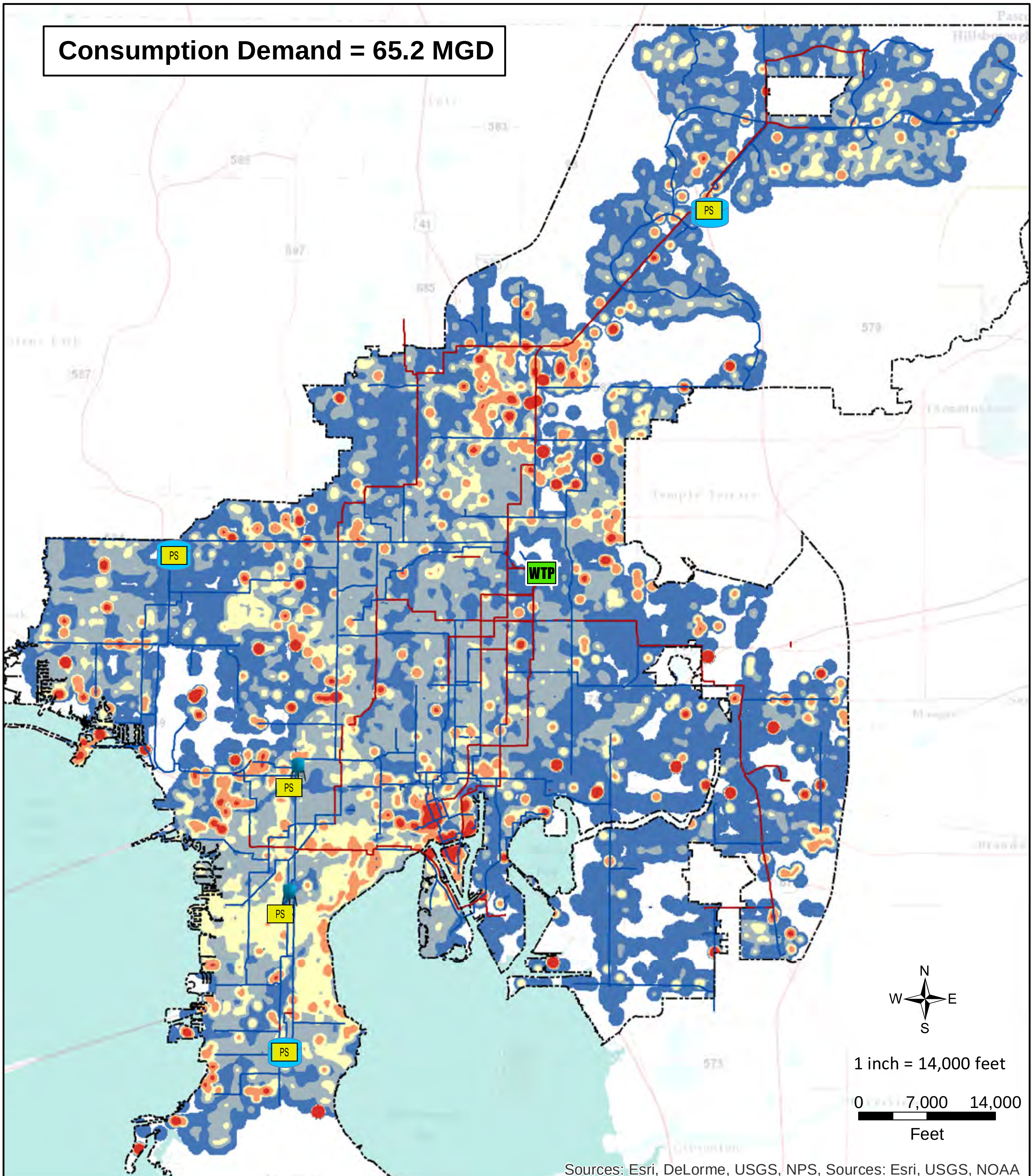
Total Projected Annual Ave. Consumption = Total Projected System Demands – Total NRW Demands
= FY15 Metered Data + Future Consumption

∴Future Consumption = Total Projected System Demands – NRW Demands – FY15 Billing Data
NRW Demands = 11 Percent of the Total System Demands based on historic data in Table 7
Total Projected System Demands are from Table 6

Population Growth (based on SWFWMD Parcels) = Planning Year Population – 2015 Population
Per Capita Consumption = Future Consumption / Population Growth

Future Consumption per Parcel = Population Growth per Parcel x Per Capita Consumption

Ultimately, the shapefile representing the FY15 billing data and the future consumption would be merged together to represent the total average consumption for each planning year. That shapefile would be used to spatially allocate the consumption demands into the model as described above. The figures represent the consumption allocated for the base year and consumption growth for the future planning years. The total system demands are shown on similar figures and located in **Appendix A**.



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WTP

PS Pump Stations

Ground Storage Tank

Elevated Storage Tank

Diameter

16 - 24-inch

Greater than 24-inch

Service Area

2015 Demand Density

Low Density

Med-Low Density

Medium Density

Med-High Density

High Density

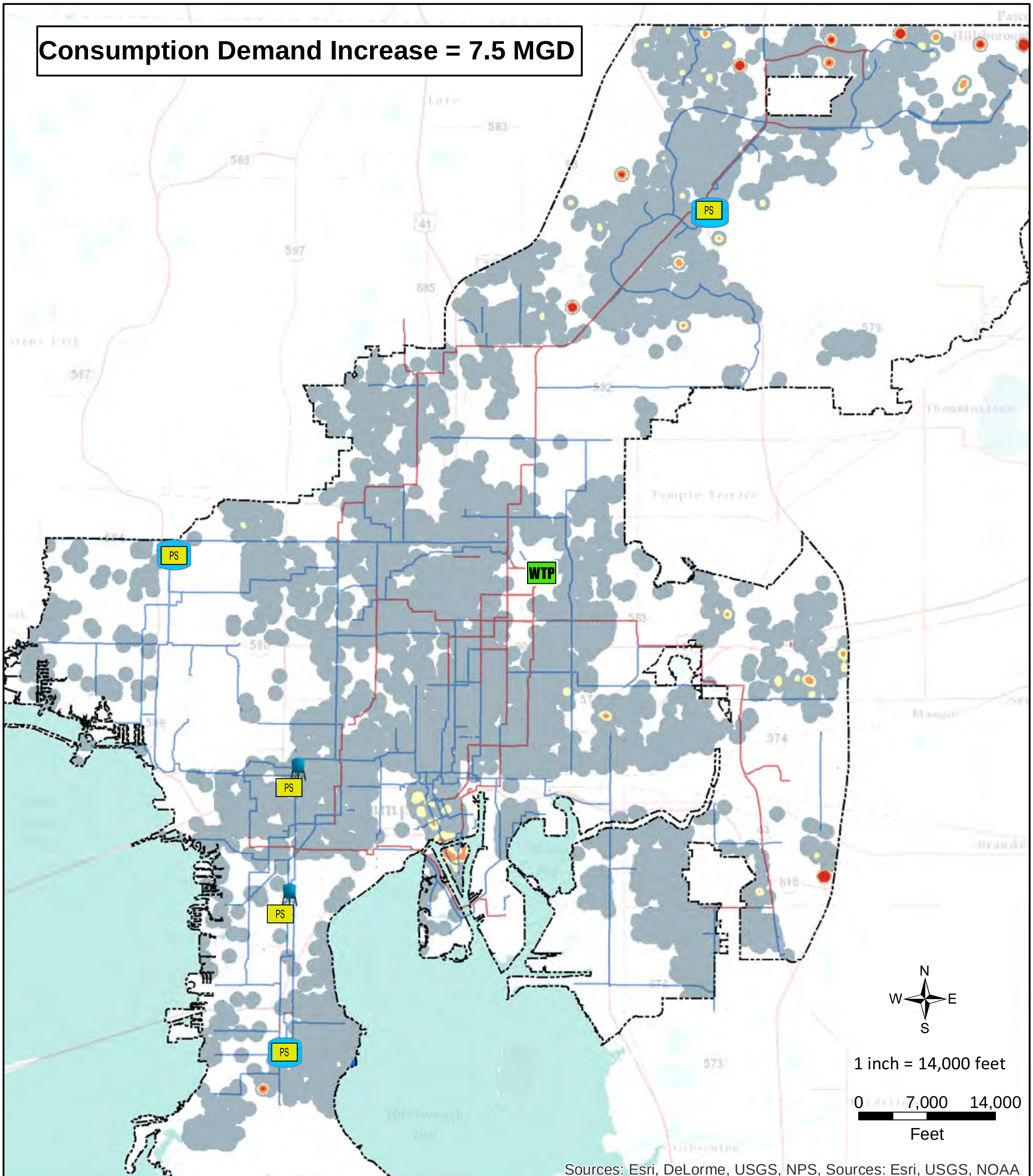
CITY OF TAMPA

Potable Water Master Plan

Figure 5

Base Year (2015) Consumption Allocation

Consumption Demand Increase = 7.5 MGD



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WTP (1)

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Diameter

16 - 24-inch

Greater than 24-inch

Service Area

2020 Demand Inc. Density

Decreasing

Low (0.025)

Medium (0.05)

Med-High (0.10)

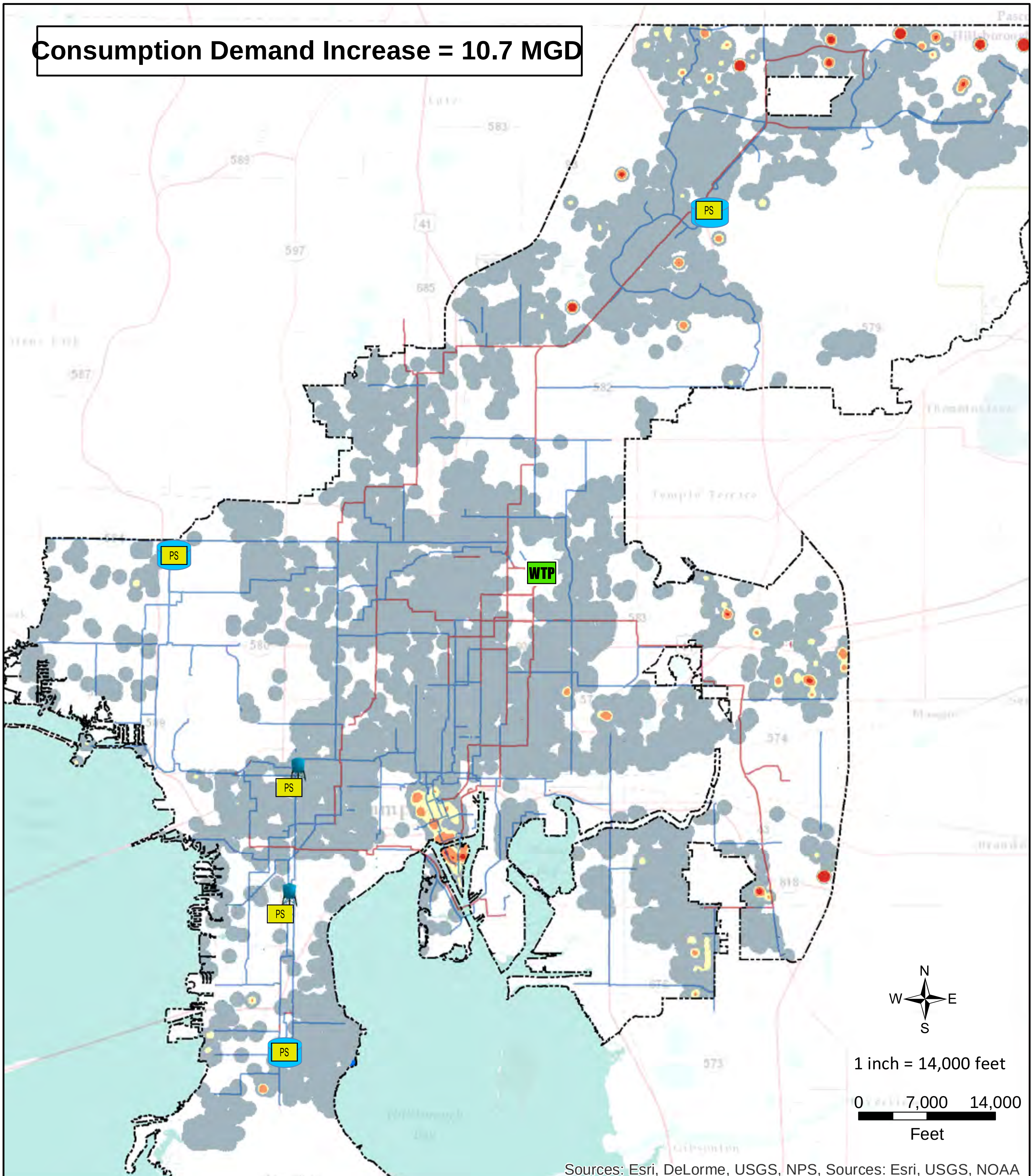
High (1.1)

CITY OF TAMPA

Potable Water Master Plan

Figure 6

Consumption Increase BY 2015 to PY 2020



WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Diameter

16 - 24-inch

Greater than 24-inch

Service Area

2025 Demand Inc. Density

Decreasing

Low (0.0275)

Medium (0.05)

Med-High (0.10)

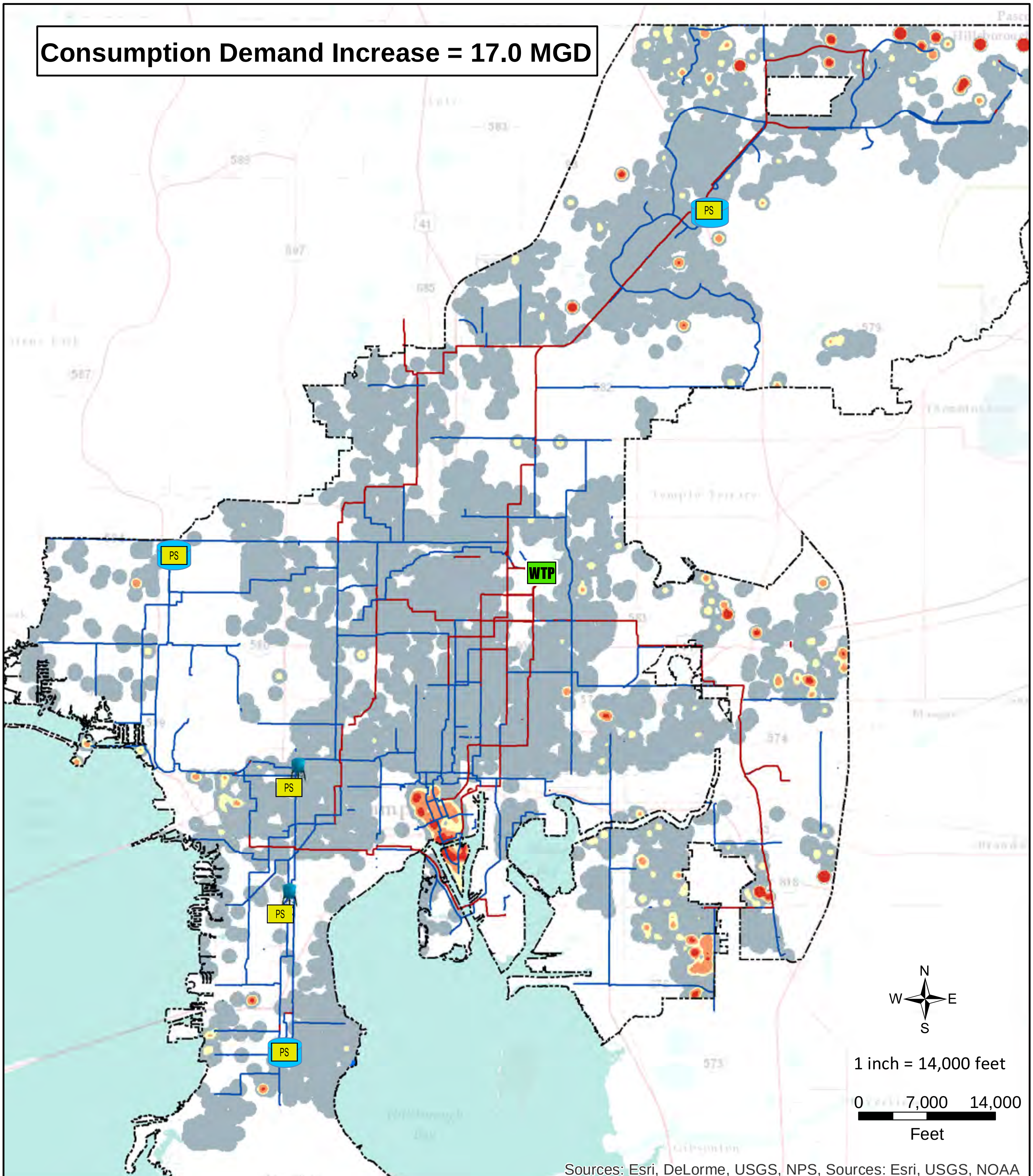
High (1.1)

CITY OF TAMPA

Potable Water Master Plan

Figure 7

Consumption Increase BY 2015 to PY 2025



WTP – WTP
PS – Pump Stations
Ground Storage Tank
Elevated Storage Tank

Diameter
- 16 - 24-inch
- Greater than 24-inch
- Service Area

2035 Demand Inc. Density
- Decreasing
- Low (0.025)
- Medium (0.05)
- Med-High (0.10)
- High (1.1)

CITY OF TAMPA

Potable Water Master Plan

Figure 8

Consumption Increase BY 2015 to PY 2035

5.2 NON-REVENUE WATER DEMAND ALLOCATION

NRW is typically eleven percent of the total distribution flows and is allocated equally across the distribution system, unless there is a justifiable reason to apply the NRW demand to a specific location. For example, the location of the main breaks and leakage are closely recorded by the TWD and the data shows that the breaks are concentrated in the older parts of the system. It is therefore justifiable to allocate the NRW from main breaks and leakage (75% of the total NRW from **Table 10**) to that concentrated area. To show this phenomenon, main break data from 2010 – 2014 was used in GIS to create a kernel density figure, similar to the figures created for the consumption demand allocation, to illustrate the portion of the system with a higher density of main breaks. It was assumed that those areas would continue to experience a higher rate of breaks, thus the NRW associated with main breaks and leakage would be limited to those areas. The NRW associated with main breaks and leakage will be evenly allocated within those limits.

The City tracks water quality flushing volumes monthly in an excel spreadsheet and the flushing locations vary month to month based on water quality needs. Due to the varying locations and overall small contribution demand the flushing demands (8% of the total NRW from **Table 10** which equals 0.88% of the total demands) will be allocated evenly across the distribution system.

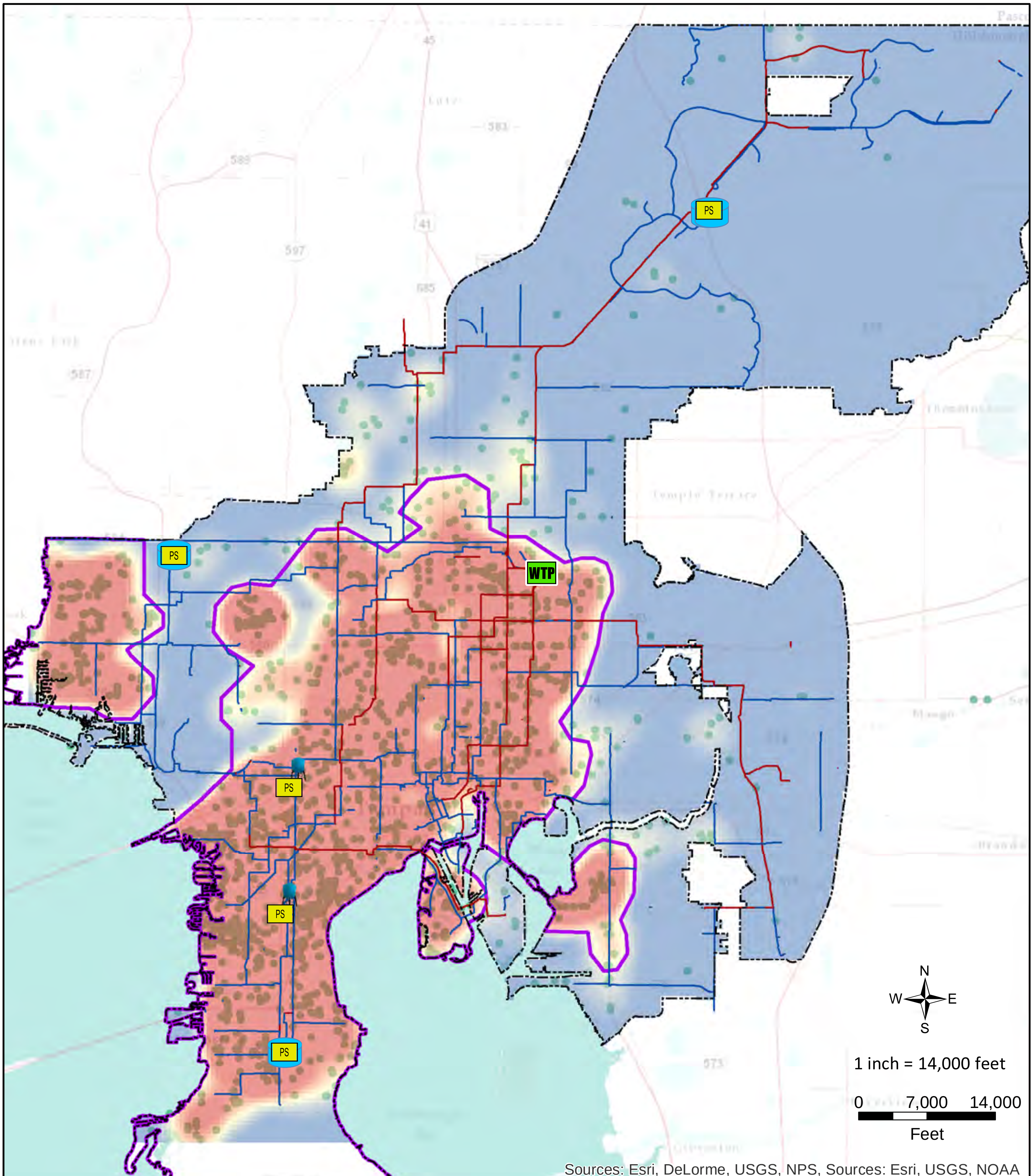
All flow meters, no matter the size or manufacture, are susceptible to inaccuracies. However unlike the main break and water quality flushing volumes, meter inaccuracies, or apparent losses, are not isolated to a specific area and increase or decrease per meter based on the flow passing through the meter. Therefore the NRW associated with meter inaccuracies (17% of the total NRW from **Table 10**) will be allocated proportionally in comparison to the consumption demands across the distribution system.

Table 15 summarizes the NRW for each planning year based on the percentages summarized in **Table 10**. **Figure 9** illustrates the concertation of main breaks which is the location to allocate the NRW associated with main breaks and leakage.

Table 15. NRW Per Planning Year

YEAR	TOTAL PROJECTED DEMAND (MGD)	CONSUMPTION DEMAND (MGD)	NON-REVENUE WATER DEMAND (MGD)	WQ FLUSHING (MGD)	METER INACCURACIES (MGD)	MAIN BREAKS / LEAKAGE (MGD)
SOURCE	TABLE 6	92.5%	11% (HIST. AVE.)	PERCENTAGE FROM TABLE 10		
2015 (Base)*	68.9	64.4	4.5	0.4	0.8	3.4
2020	77.3	68.8	8.5	0.7	1.4	6.4
2025	81.0	72.0	8.9	0.7	1.5	6.7
2035	88.0	78.3	9.7	0.8	1.6	7.3

*NOTE: 2015 (Base) demands are based on the actual demands recorded (consumptive and NRW).



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WTP — WTP
PS — Pump Stations
Ground Storage Tank
Elevated Storage Tank

Diameter
16 - 24-inch
Greater than 24-inch
Main Breaks ('10-'14)

Service Area
Leaking NRW Extents

Main Break Density
High : Density
Low : Density

CITY OF TAMPA

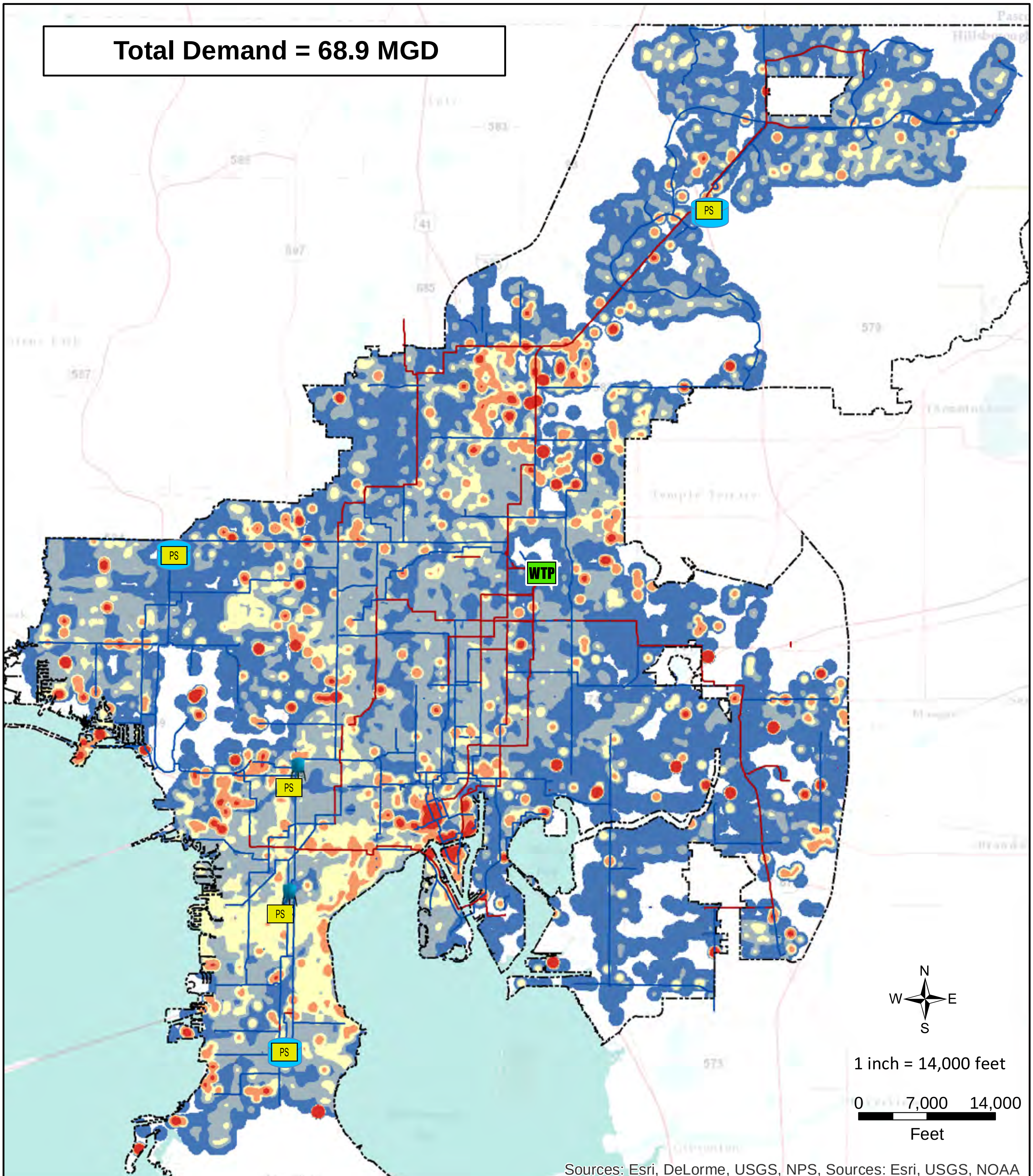
Potable Water Master Plan

Figure 9

NRW Main Break & Leakage Allocation

Appendix A

Total Projected System Demand Figures



WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank

Diameter
16 - 24-inch
Greater than 24-inch
Service Area

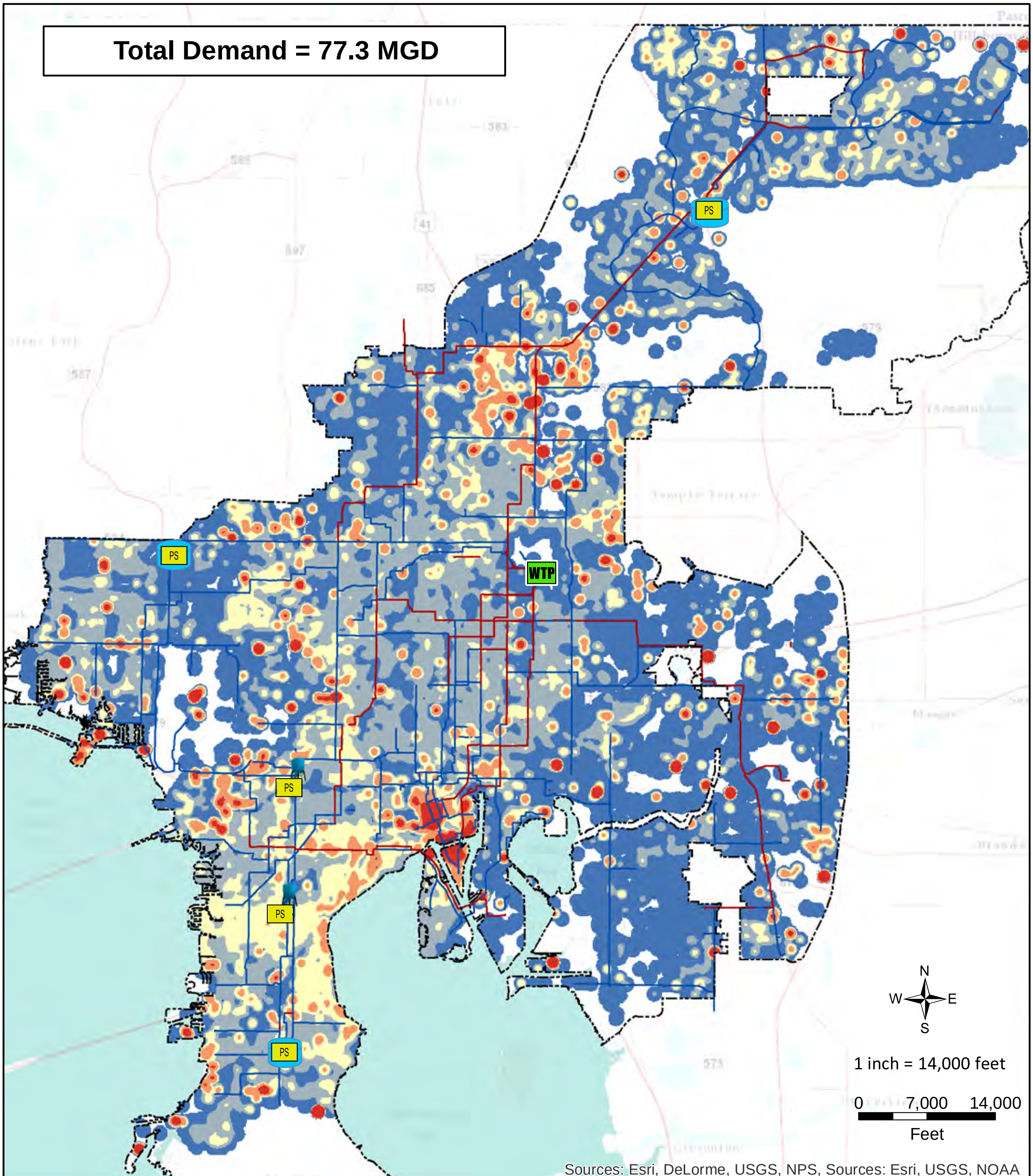
2015 Demand Density
Low Density
Med-Low Density
Medium Density
Med-High Density
High Density

CITY OF TAMPA

Potable Water Master Plan

Figure A1

Base Year (2015) Demand Allocation



WTP

PS Pump Stations

Ground Storage Tank

Elevated Storage Tank

Diameter

16 - 24-inch

Greater than 24-inch

Service Area

2020 Demand Density

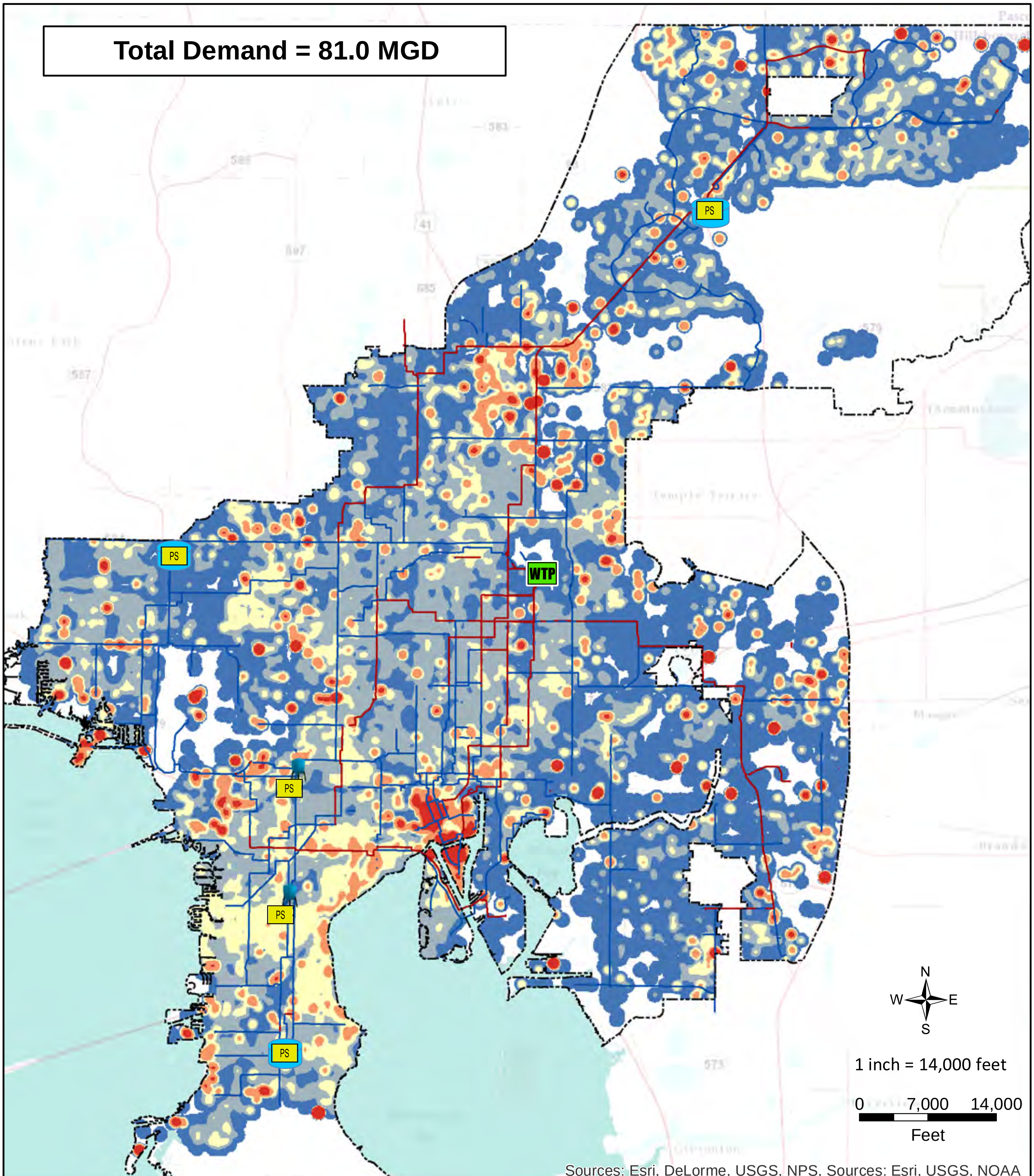
- Low Density
- Med-Low Density
- Medium Density
- Med-High Density
- High Density

CITY OF TAMPA

Potable Water Master Plan

Figure A2

Planning Year 2020 Demand Allocation



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WTP	WTP
PS	Pump Stations
	Ground Storage Tank
	Elevated Storage Tank

Diameter

- 16 - 24-inch
- Greater than 24-inch
- Service Area

2025 Demand Density

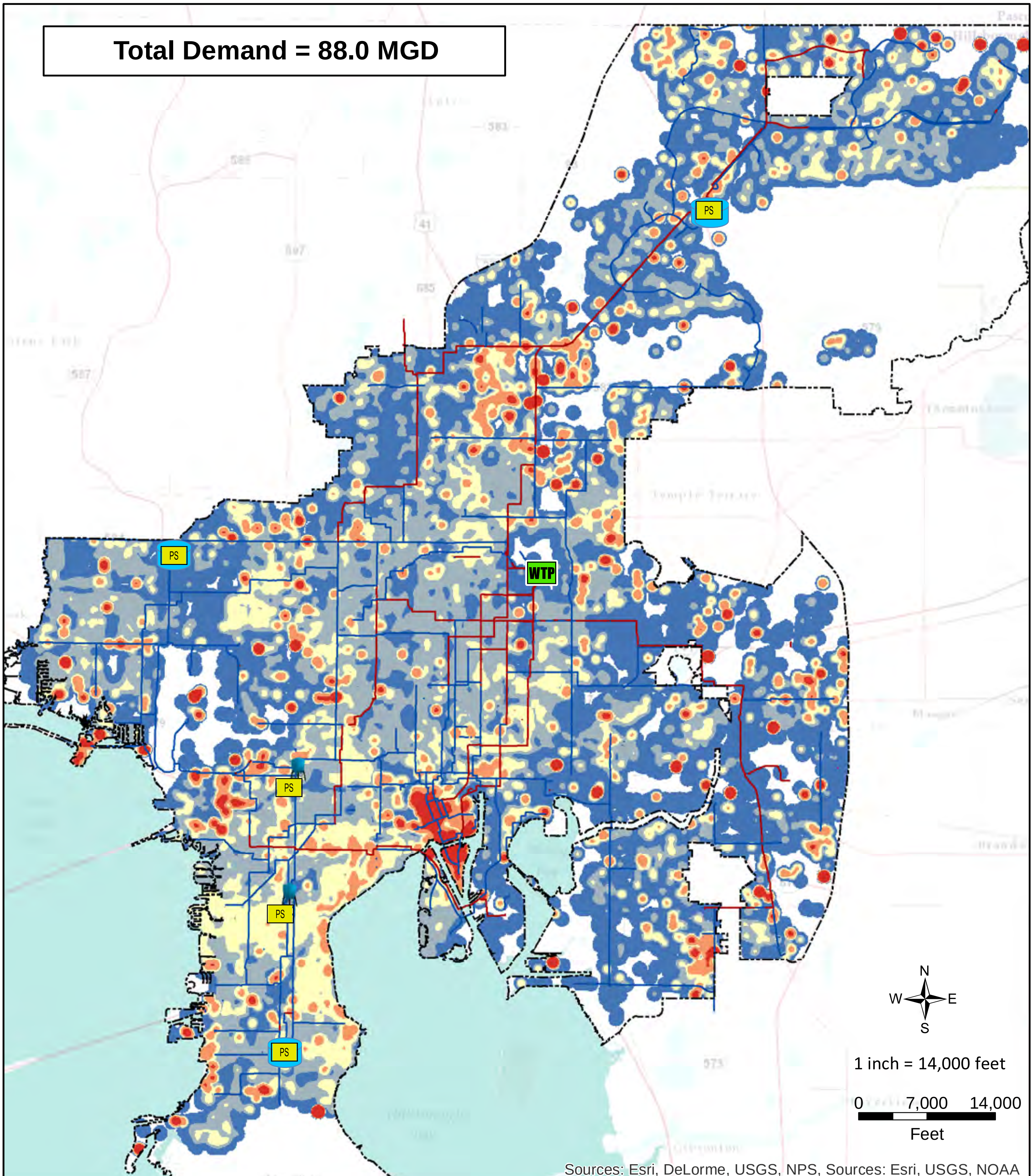
- Low Density
- Med-Low Density
- Medium Density
- Med-High Density
- High Density

CITY OF TAMPA

Potable Water Master Plan

Figure A3

Planning Year 2025 Demand Allocation



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WTP	WTP	Diameter		**2035 Demand Density**	
PS	Pump Stations		16 - 24-inch		Low Density
	Ground Storage Tank		Greater than 24-inch		Med-Low Density
	Elevated Storage Tank		Service Area		Medium Density
					Med-High Density
					High Density

CITY OF TAMPA

Potable Water Master Plan

Figure A4

Planning Year 2035 Demand Allocation

Appendix B

Distribution System Improvements Technical Memorandum

FINAL

DISTRIBUTION SYSTEM IMPROVEMENTS

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

8 MARCH 2018

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ABBREVIATIONS

ADD	Average Day Demand
AFB	Air Force Base
AWWA	American Water Works Association
BEP	Best Efficiency Point
DLTWTF	David L. Tippin Water Treatment Facility
EPS	Extended Period Simulation
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FF	Fire Flow
FY	Fiscal Year
gpm	Gallon per minute
HGL	Hydraulic grade line
HSPS	High Service Pump Station
ISO	Insurance Service Office
MDD	Maximum Day Demand
MGD	Million Gallons per Day
PHD	Peak Hour Demand
PF	Peaking Factor
psi	Pounds per square inch
R&R	Repair and Rehabilitation
RPS	Repump Station
SCADA	Supervisory Control and Data Acquisition
TBW	Tampa Bay Water
TIA	Tampa International Airport
TM	Technical Memorandum
TPA	Tampa Port Authority
TWD	Tampa Water Department
VFD	Variable Frequency Drive

1. Introduction

As part of the City's 2015 Potable Water Master Plan Update, Black & Veatch has calculated the City's demand projections, as documented in the Population & Demand Projections Technical Memorandum (November 2016), and updated the City's hydraulic model, as described in the Hydraulic Calibration Report (November 2016 and January 2018). Using the demand projections and calibrated hydraulic model, Black & Veatch performed a distribution system analysis of the base year (2015) and three future planning years (2020, 2025 and 2035) based on the existing system infrastructure and operating strategies. The system analysis evaluated the hydraulic capacity of the existing distribution system and highlights areas requiring improvements to meet the system performance criteria established by the Tampa Water Department (TWD), as previously documented in the Distribution System Assessment Technical Memorandum (December 2016).

Shortly after the submission of the December 2016 Distribution System Assessment Technical Memorandum, TWD identified an unintentionally closed 36-inch valve in the distribution system that was impacting delivery pressures in the North Tampa area. The calibration of the model completed in 2016 was influenced by this previously unknown valve closure condition; therefore, it was necessary to re-calibrate the model (in January 2018) with field data collected after the valve was opened. Additionally, during the period between the original memorandum and the re-calibration, the City had completed significant operational changes, migrating from operating one pressure zone to three Using the recalibrated model, Black & Veatch reassessed the hydraulic performance of the distribution system, identified improvements to enable the system to meet the performance criteria, and worked with the TWD during a series of three workshops to validate the improvements and select options that best met the City needs. This Distribution System Improvements Technical Memorandum (TM) presents a summary of the system analysis and recommended improvements stemming from the evaluations completed.

2. Revised System Conditions and Assessment

Since the system assessment and identification of the closed valve in 2016, the TWD opened the valve and has been operating the distribution system with the desired three pressure zones. This change in operating conditions allowed for additional data collection and definition throughout the system. This section identifies changes in the system conditions that were previously documented in the December 2016 TM. Conditions not specifically mentioned in this section are assumed to have remained the same no changes (e.g. pump curves, etc.)

2.1 UPDATED DIURNAL PATTERNS

Using the same calculations identified in the Recalibration TM (January 2018), three unique diurnal patterns were created for each pressure zone. The maximum day demand (MDD) diurnal pattern analysis was based off of the 2017 MDD. One week of SCADA data was collected before and after the 2017 MDD (August 15, 2017), and a diurnal pattern was calculated for each day during this 15-day period. Then a "typical" system diurnal pattern was fit to match the average of the 15 patterns for each pressure zone. The peaks and troughs were adjusted to match the PHD:MDD peaking factor (PF) but still follows the typical pattern of the system. **Figure 1** through **Figure 3** illustrate the selected MDD analysis pattern for each pressure zone, David L. Tippin Water Treatment Facility (DLTWTF), North Tampa, and South Tampa, respectively. **Figure 4** illustrates the assumed MacDill AFB diurnal pattern.

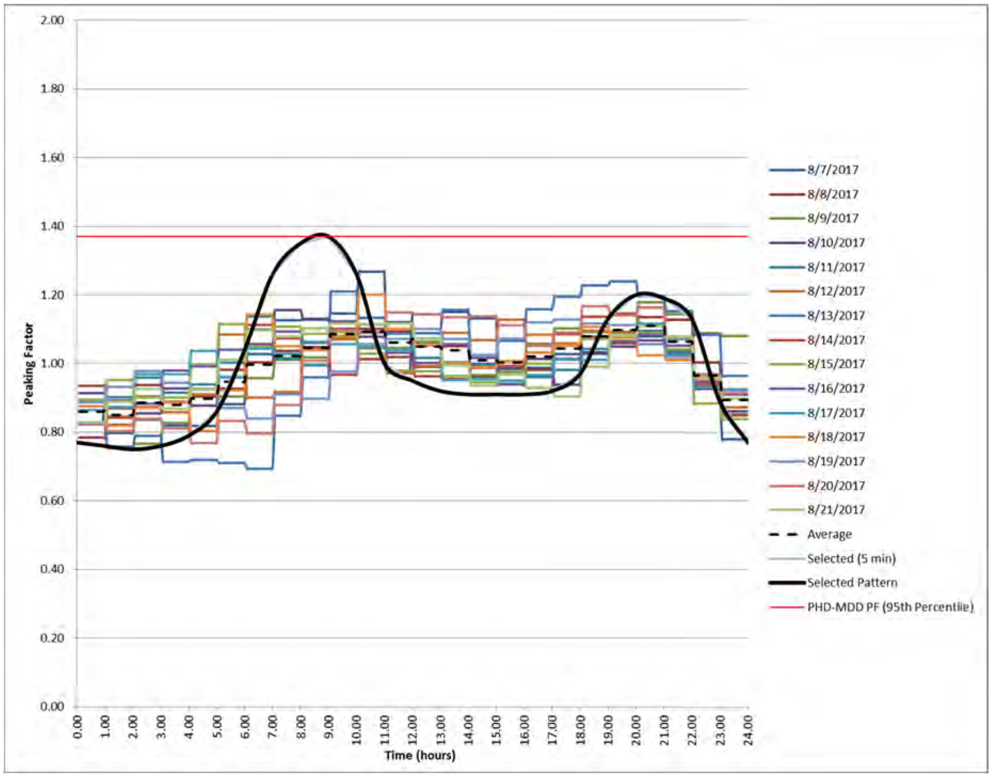

Figure 1 DLTWTF Zone MDD Diurnal Pattern

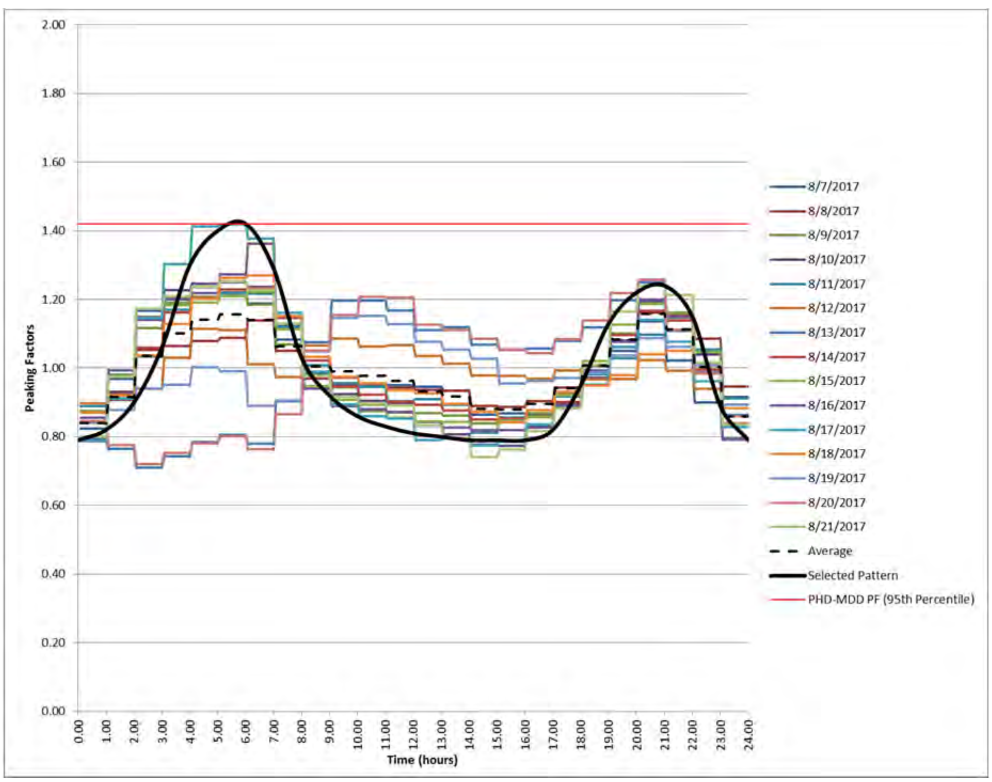

Figure 2 North Tampa MDD Diurnal Pattern

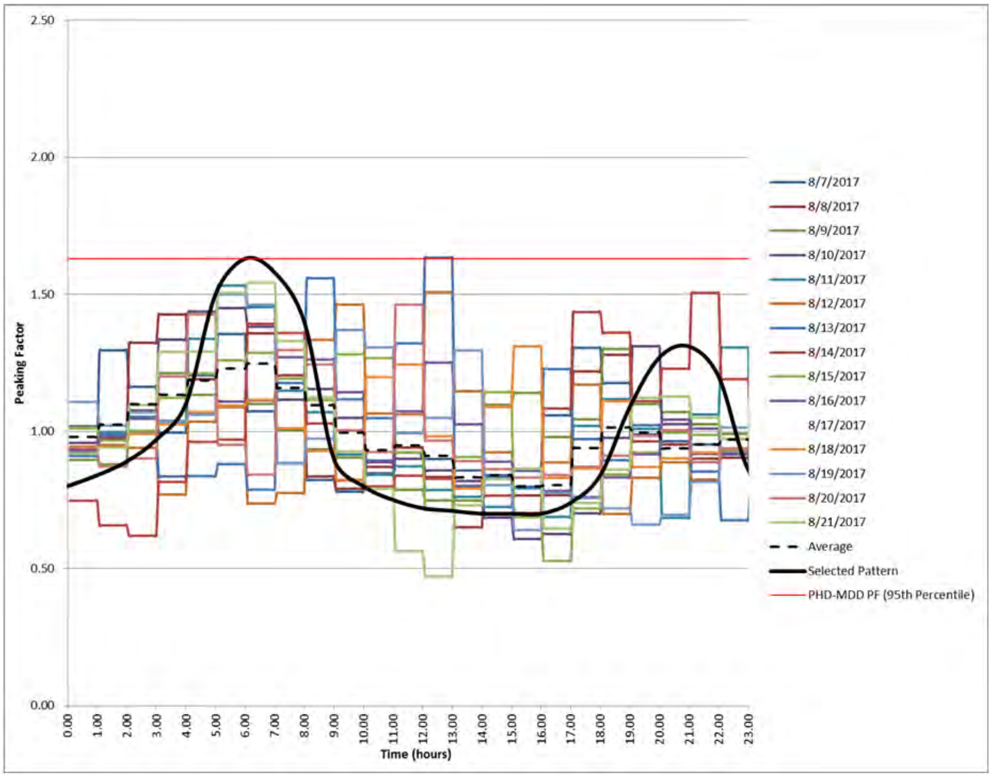

Figure 3 South Tampa MDD Diurnal Pattern

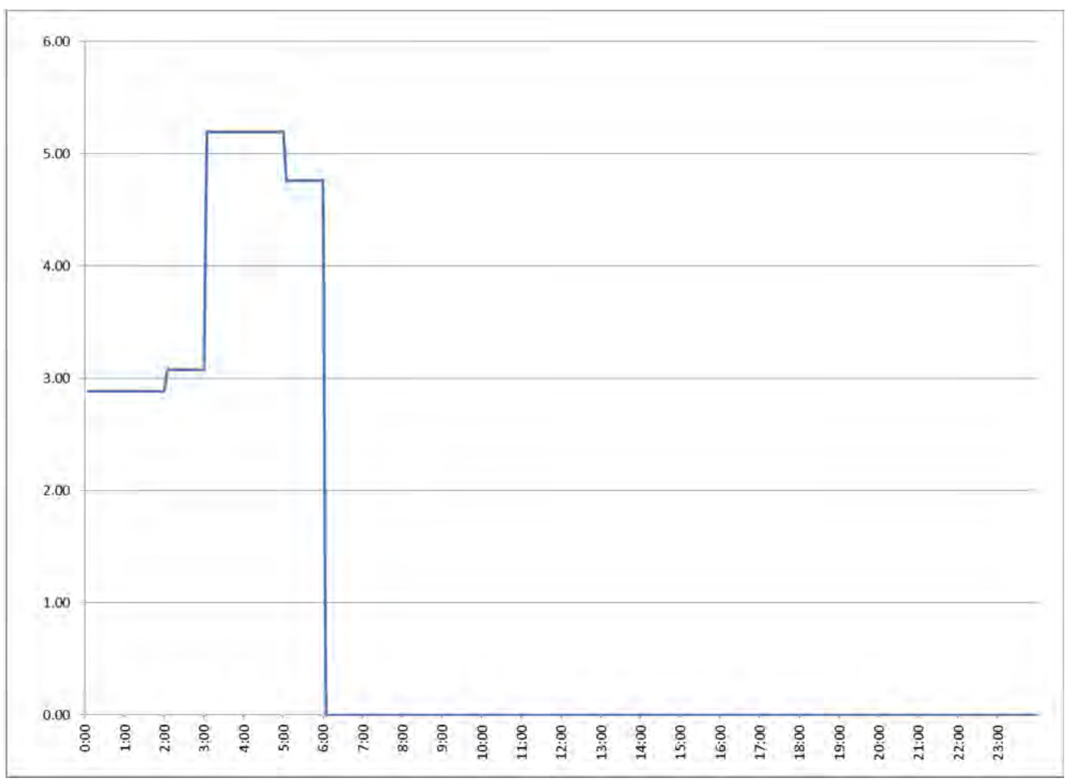

Figure 4 MacDill AFB Diurnal Pattern

2.2 UPDATED SYSTEM DEMANDS

None of the average day demands (ADD) or MDDs were affected by the updated data, however, the additional information provided more insights around the peak hour demand (PHD) for each pressure zone as reflected in the diurnal patterns above. **Table 1** summarizes the updated demand peaking factors and **Table 2** summarizes the updated demands used for the system analysis and improvement identification.

Table 1 Updated Demand Peaking Factors

PRESSURE ZONE	MDD:ADD	PHD:MDD	PHD:ADD
North Tampa	1.56	1.42	2.22
South Tampa	1.56	1.63	2.54
DLTWTF	1.56	1.37	2.14

Table 2 Updated Demand Projections

PRESSURE ZONE	DEMAND BY PLANNING YEAR (MGD)											
	2015			2020			2025			2035		
	ADD	MDD	PHD	ADD	MDD	PHD	ADD	MDD	PHD	ADD	MDD	PHD
North Tampa	4.8	7.4	10.5	6.1	9.5	13.5	7.0	10.8	15.4	8.3	13.0	18.5
South Tampa	4.6	7.2	11.7	5.1	7.9	12.9	5.2	8.1	13.2	5.4	8.4	13.6
DLTWTF	59.6	93.0	127.4	66.1	103.2	141.3	68.8	107.3	147.0	74.3	115.9	158.8
Total	69.0	107.6	-	77.3	120.6	-	80.9	126.2	-	88.0	137.3	-

NOTEs:
- It is unlikely that the MDD for all three pressure zones would occur at the same time, but it is possible and the system modeling assumes this worst case scenario. It is important to track the demands for improvement triggers.
- However, none of the PHDs occur at the same time, thus there is no total PHD calculated

2.3 UPDATED SYSTEM CONTROLS

The system controls focused around the facilities within the DLTWTF pressure zone remained the same in the model. However, the controls for the Interbay RPS and Morris Bridge RPS were changed to accommodate the three pressure zone configuration.

2.3.1 Updated Pump Controls

Both the Interbay RPS and Morris Bridge RPS are equipped with variable frequency drives (VFD) and as such can operate on a set discharge flow, pressure, or speed. The TWD has updated the controls such that both RPSs are using set discharge pressures as summarized in Table 3. Note that Pump 7 at the Morris Bridge RPS is proposed for the future as part of the Morris Bridge RPS upgrades. Also, the two jockey pumps at the Interbay RPS (#5 & 6) cannot operate in conjunction with pumps 1-4 as they were designed for recirculation when there was no South Tampa Pressure Zone. The pump controls for the remaining three RPSs remained the same and the discharge pressure from the DLTWTF HSPS remained 65 psi.

Table 3 Pump Operation Average Day Demands

PUMP STATION	OPERATION	# OF PUMPS	CONTROL TYPE	CONTROL LOCATION	CONTROL SETTING
Morris Bridge	>8,000 gpm	1-4 VFD	Discharge Pressure	Morris Bridge RPS	70 psi
	8,000 – 3,500 gpm	5-6 VFD			
	<3,500 gpm	7 VFD			
Interbay	ON	1-4 VFD	Discharge Pressure	Interbay RPS	65 psi
	OFF	5-6 VFD	Discharge Pressure for recirculation	Interbay RPS	65 psi

2.3.2 Tank Fill Valve Controls

Historically the tanks within the system were filled at night during the minimum demand periods and were staggered to allow each to fill quickly. However, the creation of the pressure zones required a change in filling operation for the Interbay and Morris Bridge Tanks. The tanks are now constantly filled based on a remote operator valve position command. For the system assessment, a constant flow was assumed and set to match the MDD of the pressure zone. This allows the tanks to drain and fill during a 24-hour period. Black & Veatch recommends the installation of sleeve valves with flow control functions at the inlet to all of the ground storage tanks (Interbay, Morris Bridge and Northwest Tanks) for more control and optimization of the flows into the tanks. The tank fill valve controls for the remaining three tanks remained the same.

2.4 UPDATED SYSTEM ASSESSMENT

Black & Veatch analyzed the existing distribution system for the purpose of identifying system capacity need, operational changes, and resiliency and reliability needs. Twenty-five scenarios were selected to analyze the distribution system as summarized in **Table 4**. The results of the system analysis are included in **Appendix A** as a series of system maps and tank level figures showing the minimum pressures, maximum pressures, maximum velocities, available fire flow, and water age for the various system conditions analyzed. The 2035 System Analysis results are also included in this Technical Memorandum as **Figure 5** and **Figure 6**.

Prior to identifying capital improvements, the system assessment included investigation of potential operational changes that could minimize or defer the need for some piping improvements, while also reducing concerns with water age/quality issues. As part of the investigations, Black & Veatch evaluated the elevations throughout the distribution system compared to the elevation and discharge pressure at the DLTWTF HSPS. **Figure 7** illustrates the theoretical maximum static pressures throughout the distribution system based on maintaining the current discharge pressure setting of 65 psi from the DLTWTF HSPS as if there was no headloss in the system. This assessment showed that there are a few areas in the system that are at higher elevations than the majority of the rest of the system, which makes it more challenging to maintain a minimum pressure of 40 psi. The ability to address these higher elevation areas with distribution system piping improvements alone is anticipated to be challenging, therefore, potential modifications to the current operating protocol for the system were considered in the assessment, as further described in Section 3.2.

Table 4 Distribution System Assessment Summary

#	SCENARIO NAME	DEMAND	SIMULATION TYPE	PURPOSE
1	Base MDD Analysis	2015 MDD	EPS - 24 hrs	Analyze the capacity and operation of the distribution system including tank cycling.
1.1	Base MDD Analysis + ASR Recharge	2015 MDD	EPS - 24 hrs	
2	2020 MDD Analysis	2020 MDD	EPS -	
3	2025 MDD Analysis	2025 MDD	EPS - 24 hrs	
4	2035 MDD Analysis	2035 MDD	EPS - 24 hrs	
4.1	2035 MDD Analysis + ASR Recharge	2035 MDD	EPS - 24 hrs	
5	Base MDD+FF Analysis	2015 MDD	EPS - 24 hrs	Analyze the ability of the system to meet fire flow demands.
6	2020 MDD+FF Analysis	2020 MDD	EPS - 24 hrs	
7	2025 MDD+FF Analysis	2025 MDD	EPS - 24 hrs	
8	2035 MDD+FF Analysis	2035 MDD	EPS - 24 hrs	
9	Base Water Quality Analysis	2015 ADD	EPS - Min 72 hrs	Create a baseline for water age to compare to future years
10	Base PHD Analysis	2015 PHF	NA (Steady State)	Document conditions
11	Base ADD Analysis	2015 ADF	NA (Steady State)	Document conditions
12	DLTWTF Failure	2015 MDD	EPS - 24 hrs	Analyze the criticality of pumping/storage facilities.
13	DLTWTF Failure	2035 MDD	EPS - 24 hrs	
14	Morris Bridge WTP Failure	2015 MDD	EPS - 24 hrs	
15	Morris Bridge WTP Failure	2035 MDD	EPS - 24 hrs	
16	Interbay Repump Station Failure	2015 MDD	EPS - 24 hrs	
17	Interbay Repump Station Failure	2035 MDD	EPS - 24 hrs	
18	Northwest Repump Station Failure	2015 MDD	EPS - 24 hrs	
19	Northwest Repump Station Failure	2035 MDD	EPS - 24 hrs	
20	Palma Ceia Elevated Tank Failure	2015 MDD	EPS - 24 hrs	
21	Palma Ceia Elevated Tank Failure	2035 MDD	EPS - 24 hrs	
22	West Elevated Tank Failure	2015 MDD	EPS - 24 hrs	
23	West Elevated Tank Failure	2035 MDD	EPS - 24 hrs	
24	Failure of top 10 most critical pipe/valve	2015 MDD	EPS - 24 hrs	
25	Failure of top 10 most critical pipe/valve	2035 MDD	EPS - 24 hrs	

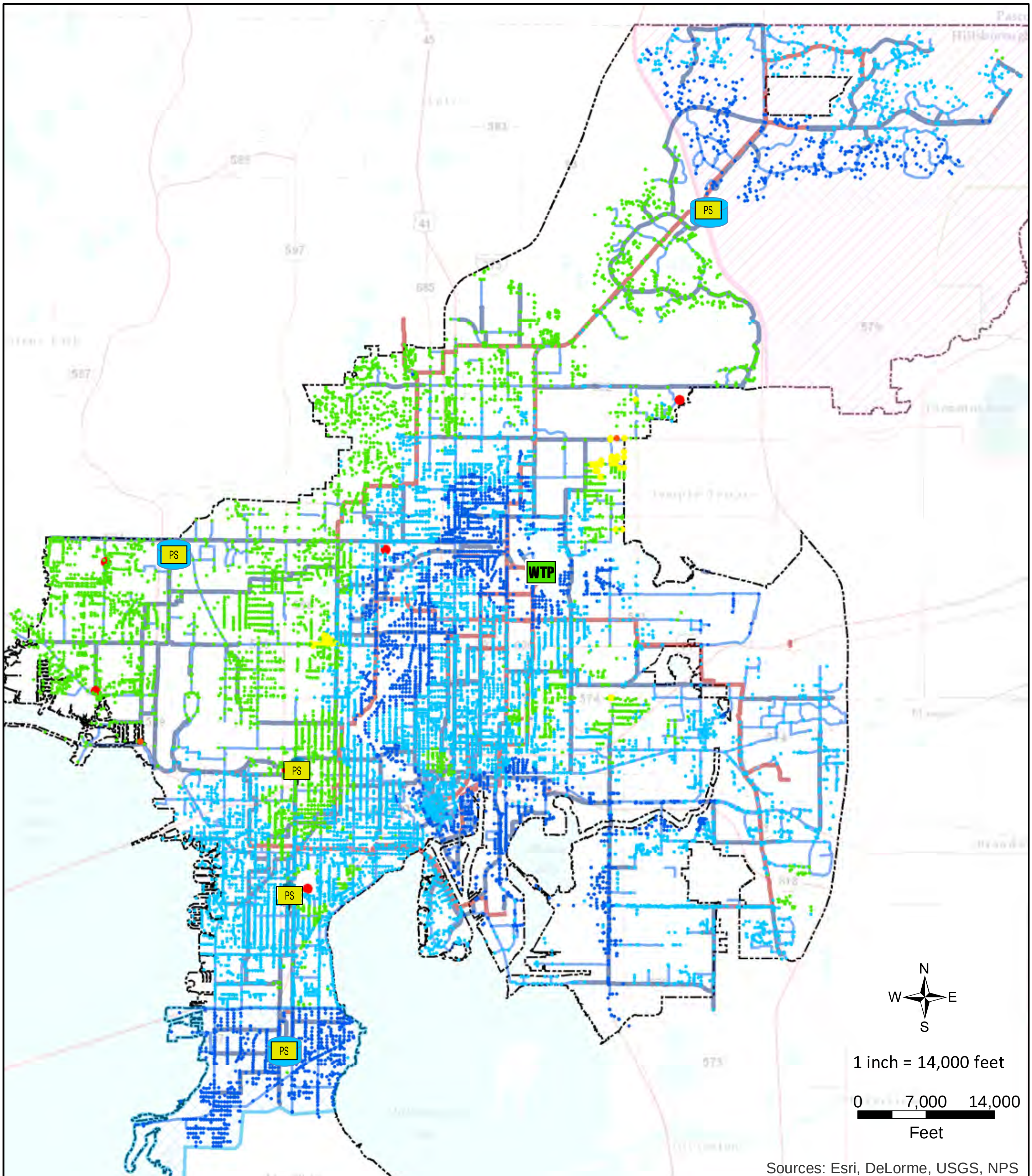

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Figure 5

Planning Year 2035
Existing System Assessment
Minimum Pressures

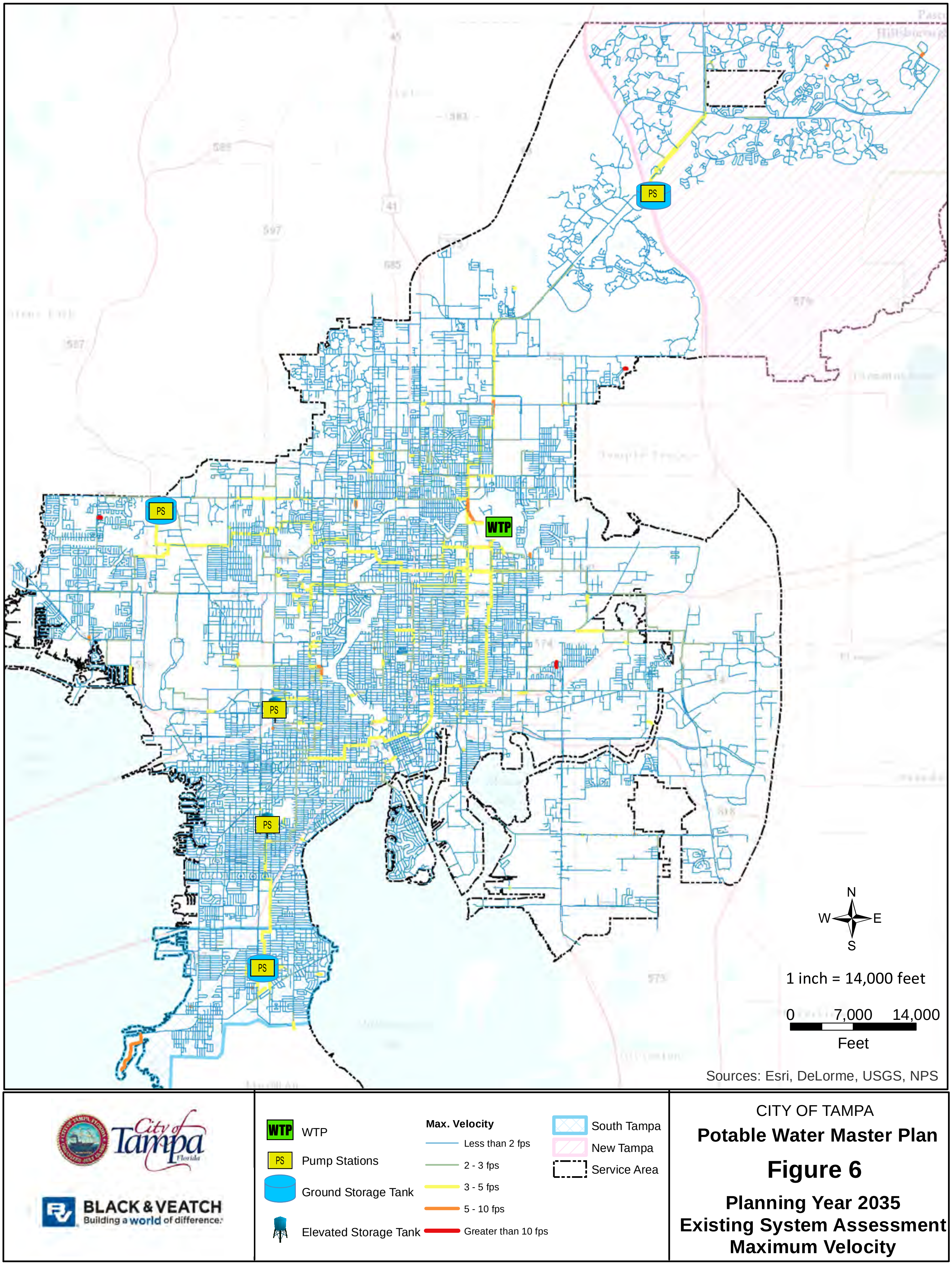

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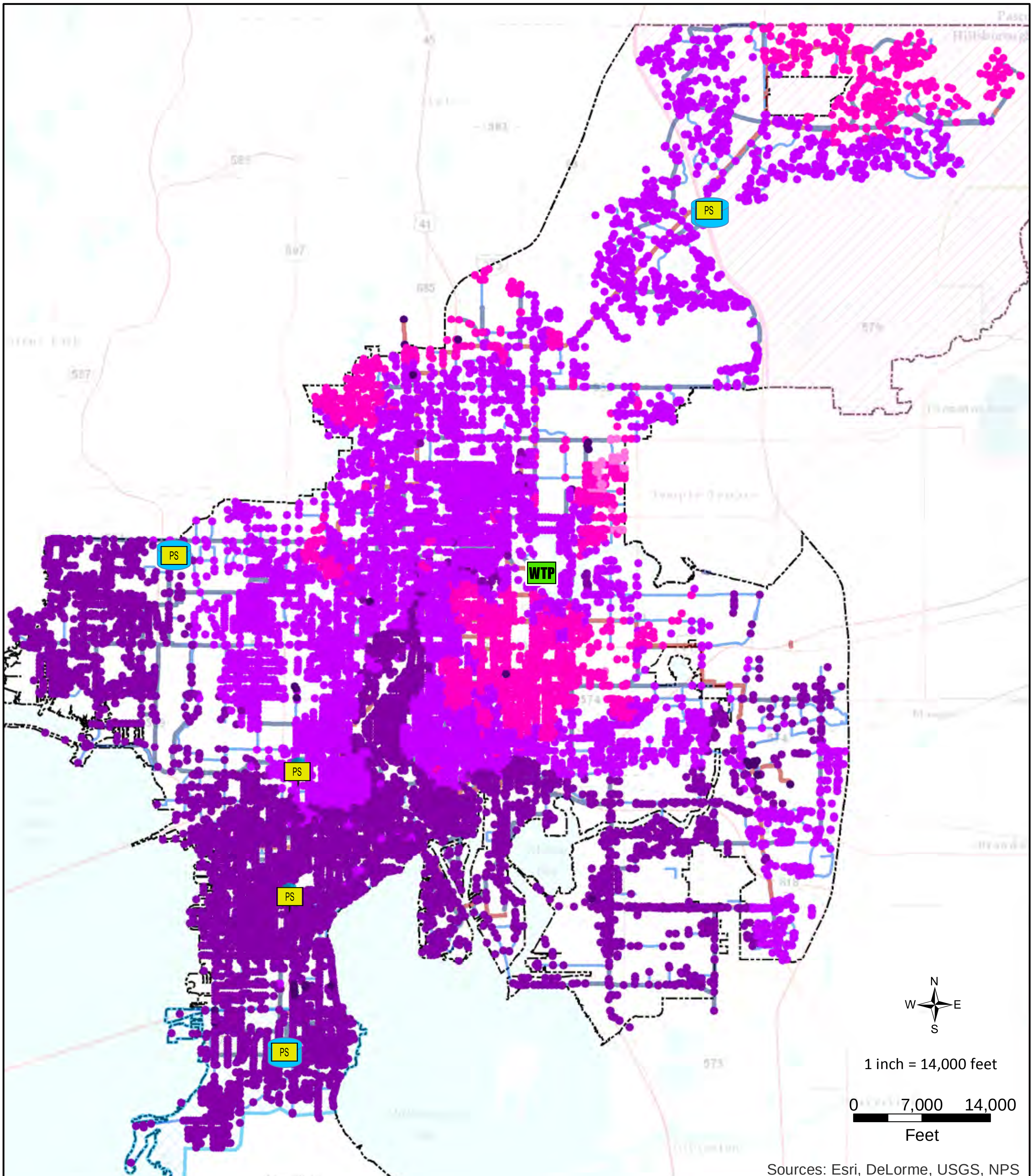
Figure 6

Planning Year 2035
Existing System Assessment
Maximum Velocity



WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank

MaxT_Press
- Less than 50 psi
- 50 - 60 psi
- 60 - 70 psi
- 70 - 80 psi
- Greater than 80 psi

Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

City of Tampa Florida

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Figure 7

Theoretical Max Pressure
DLTWTF HSPS
65 psi

3. Distribution System Improvements

The following section documents the recommended system improvements based on the system assessment results, the system performance criteria, and an approach that prioritized lower cost operational improvements before capital improvements. The hydraulic assessment of the distribution system revealed that the hydraulic capacity of the existing distribution system piping is predominantly satisfactory based on the demands projected through the planning period. Transmission and distribution mains appear to be properly sized and well distributed throughout the system. However, the system does contain a significant quantity of 2-inch pipe within residential neighborhoods in the DLTWTF pressure zone, which has left some areas without fire flow protection. It is recommended that the City continue to execute the smaller diameter replacement program in order to be able to provide adequate fire flow to all areas of the system.

3.1 PERFORMANCE CRITERIA

Black & Veatch met with the TWD to develop the desired system performance criteria which was used to determine what improvements are needed in the distribution system. Collectively, the group established the basic assumptions and system performance goals that were used to identify system performance deficiencies that require improvement. The criteria are based on various water system design guidelines and consider references such as existing and proposed regulations (i.e. FDEP). **Table 5** summarizes the performance criteria selected for the system analysis and subsequent recommended improvements.

3.2 OPERATIONAL IMPROVEMENTS

3.2.1 DLTWTF HSPS Discharge Pressure

As discussed previously, the DLTWTF HSPS currently operates with a discharge pressure of 65 psi, which results in multiple areas within the DLTWTF zone with a static pressure below or just above the minimum pressure criteria of 40 psi. Increasing the HSPS discharge pressure would increase static pressures throughout the zone and result in a much larger percentage of the zone staying within the defined pressure criteria. **Figure 8** illustrates the theoretical maximum static pressures throughout the distribution system should the HSPS discharge pressure be increased to 70 psi and **Figure 9** illustrates the system assessment minimum pressures with the increased HSPS discharge pressure and no other improvements. In comparison to **Figure 7**, increasing the HSPS discharge pressure by 5 psi does bring the vast majority of the system pressures into compliance with the system pressure criteria without requiring the installation of capital improvement projects. These capital projects would otherwise be needed to reduce headloss in the system, which could also result in additional water/age/quality concerns. It is recommended that the TWD consider the potential for a small increase in the discharge pressure at the DLTWTF HSPS from 65 psi to 70 psi.

A review of the existing pumps at the DLTWTF indicates that the existing pumps are already sized to be able to operate at the proposed slightly higher pressure. Increasing the system pressures is not without risks. The City's system is aging, and increases in the system pressures could result in an increased frequency of pipe breaks. To minimize this impact, Black & Veatch recommends that any potential increases in system pressures are done gradually over time, so that TWD can observe how the distribution system reacts to the small incremental increases in pressure.

Table 5 Distribution System Performance Criteria Table.

Parameter	Criteria / Description	Performance Goal	Comments
1. Demand Peaking Factor	MDD : ADD	**95th confidence interval (only exceeded 1 year out of 20 years)** [B&V]	- Ratio to be calculated based on actual system data from 2004 - 2015. - PHD:MDD data is not available for the period and will be based on 95th Percentile of 5 years (2011-2015)
	# Years of Historic Data	**12**	- 12 years were selected to include the last drought conditions in 2007.
2. Pump Station Capacity	Supply + Remote Pump Stations (w/out elevated storage)	**Firm Capacity > PHD + Fire Flow (per service area)** **[F.A.C 62-555.320(15)(a)]**	- Firm Capacity > PHD + Fire Demand, unless elevated finished drinking water storage is provided [F.A.C. 62-555.320 (15)(a)] - Firm Capacity + useful elevated storage capacity > greater of PHD for 4 hours or MDD+FF [F.A.C 62-555.320(15)(b)] - Firm capacity per pressure zone is the capacity with the largest pump out of service per pressure zone. • North Tampa Zone, South Tampa (Interbay) and DLT Zone - Existing Elevated tanks cannot be counted for F.A.C 62-555.320(15)(a) as they do not float on the system. - If elevated tank improvements are made to allow the tanks to float on the system, the criterion may be reduced to meet F.A.C. 62-555.320(15)(b).
	Supply + Remote Pump Stations (w/elevated storage)	**Firm Capacity > MDD + Fire Flow or PHD for 4 hours (per service area)** **[F.A.C 62-555.320(16)(b)]**	
3. Storage Volume	Total Storage (per pressure zone)	**> 25% of the System's MDD + Fire Flow (Reserve)** **[F.A.C. 62-555.320 (19)(a)]**	- Unless a demonstration showing that the useful finished water storage capacity (minus fire protection) is sufficient for operational equalization [F.A.C. 62-555.320(19)(b)1] - Unless a demonstration showing that the water system's total useful finished water storage capacity (minus fire protection) is sufficient to meet the water systems PHD for 4 consecutive hours [F.A.C. 62-555.320(19)(b)2] - Equalization storage should be 15-20% of max daily use. [Lindeburg] - Per discussion with the City, total storage does not include additional emergency storage due to existing WQ concerns.
	Fire Reserve	**3,500 gpm for 3 hours (per service area)**	- Minimum fire flow = 1,000 gpm for 1 hour [Florida Fire Code, Table 18.4.5.1.2] - Fire Flow between 1,500 gpm & 2,750 gpm = a duration of 2 hours; 3,000 & 3,750 gpm = a duration of 3 hours [Florida Fire Code]
4. Pressure	Minimum Pressure – Peak hour demand conditions. (Non-Fire, Non-Emergency)	**> 50 psi Transmission** **> 40 psi Distribution** **> 25 psi Metered Discharge** **[TWD Tech Manual, 3.2.A.2]**	- > 20 psi [F.A.C. 62-555.320 (15)(b)] - Minimum pressure at the tap should be 25 psi. Minimum pressures at fire hydrants should be 60 psi, possibly higher in commercial and industrial districts [Lindeburg] - Metered discharge pressure is on the private side of the customer meter and is not represented in the model
	Maximum Pressure	**< 75 psi**	- Florida 2010 Plumbing Code requires a service line PRV if the pressures within the building exceeds 80 psi.
5. Fire Flow	System Demand/Supply	**MDD**	- If fire protection is being provided the design capacity should be fire flow plus maximum day demand. MDD+FF[F.A.C. 62-555.320(15)(a)] - PHD+FF was not selected due to existing WQ concerns which would increase with oversized water mains.
	Minimum Flow	**1,000 gpm (residential)** **3,500 gpm for 3 hours (commercial & Industrial)** **[exceeds TWD Tech Manual, 3.2.A.3.c]**	- Residential fire flow can be reduced to 500 gpm if building has automatic sprinkler systems and greater than 30 ft separation between buildings [18.4.5.1.23, Florida Fire Code] - 1,000 gpm for 1 hour (residential) & 3,000 gpm for 3 hours (commercial & industrial)[TWD Tech Manual, 3.2.A.3.c]
	Maximum Flow	**3,500 gpm for 3 hours** **[ISO & AWWA M31]**	The maximum flow is the maximum fire flow required from the TWD system. For system customers with fire flow requirements greater than what can be provided by the TWD system, it is assumed that those customers will construct private fire protection systems as needed to meet their own fire service needs.
	Minimum Residual Pressure	**> 25 psi [TWD Tech Manual, 3.2]**	- Minimum residual pressures = 20 psi. [F.A.C. 62-555.320 (15)(a)]
6. Pipe Capacity	Maximum Velocity	**< 5 ft./sec at peak hour demands (normal, non-fire conditions)** **< 10 ft./sec at MDD+FF demands** **[TWD Tech Manual, 3.2]**	- This parameter is used to identify pipes that may be contributing to pressure and/or flow deficiencies. - Considered a secondary criteria to trigger consideration for improvement, but not automatically triggering an improvement
	Maximum Head loss (HL) per 1,000 Feet	**< 3ft (Mains >=16-inch diameter)** **< 5ft (Mains <16-inch diameter)**	- This parameter is used to identify pipes that may be contributing to pressure and/or flow deficiencies. - Considered a secondary criteria to trigger consideration for improvement, but not automatically triggering an improvement

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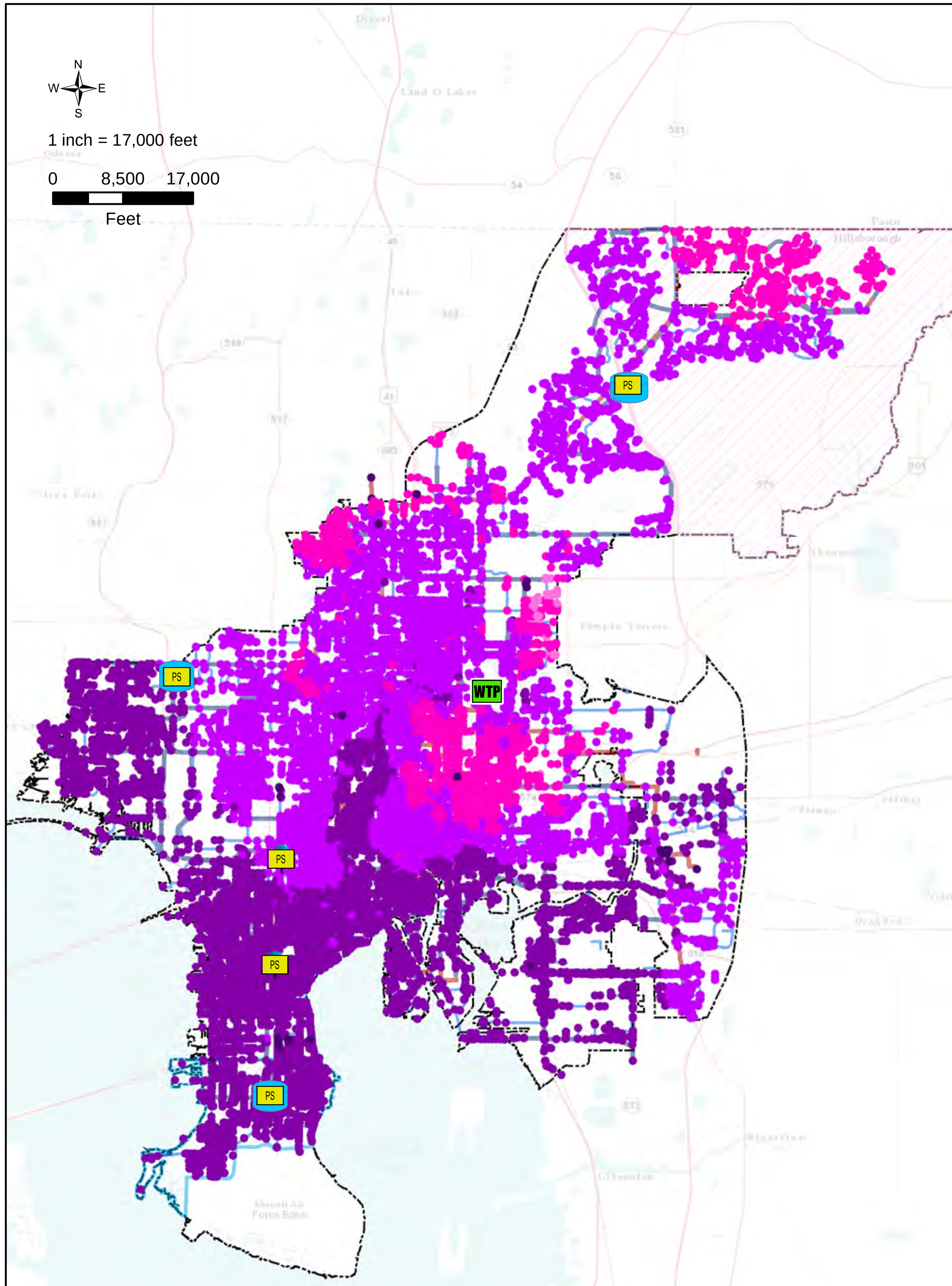
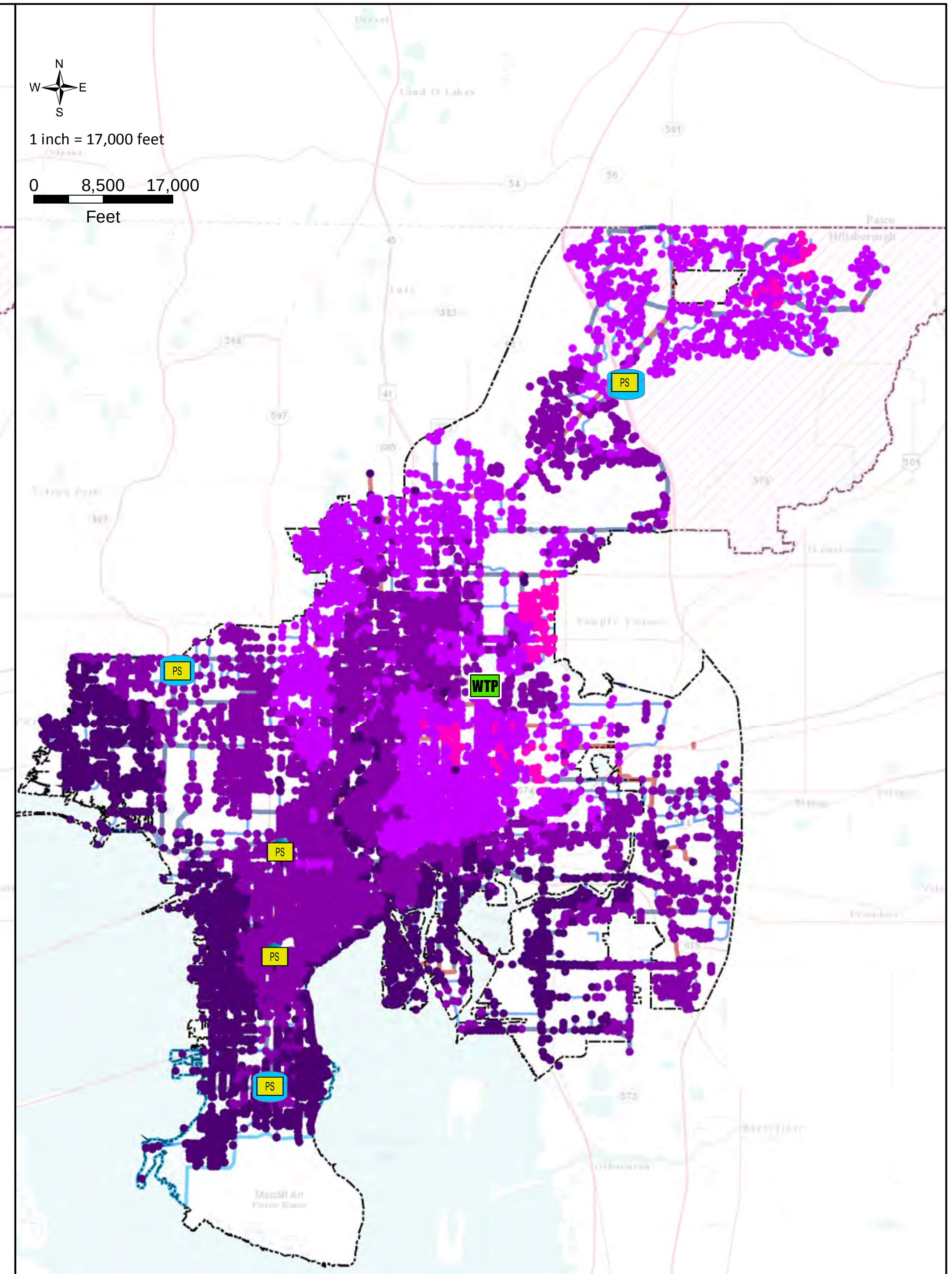
Potable Water Master Plan

Figure 8

Theoretical Max Pressure
DLTWTF HSPS
65 psi versus 70 psi



Theoretical Max Pressure
DLTWTF HSPS
65 psi



Theoretical Max Pressure
DLTWTF HSPS
70 psi

WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Max Pressure

- Less than 50 psi
- 50 - 60 psi
- 60 - 70 psi
- 70 - 80 psi
- Greater than 80 psi

Diameter

- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch

South Tampa

New Tampa

Service Area

City of Tampa Florida

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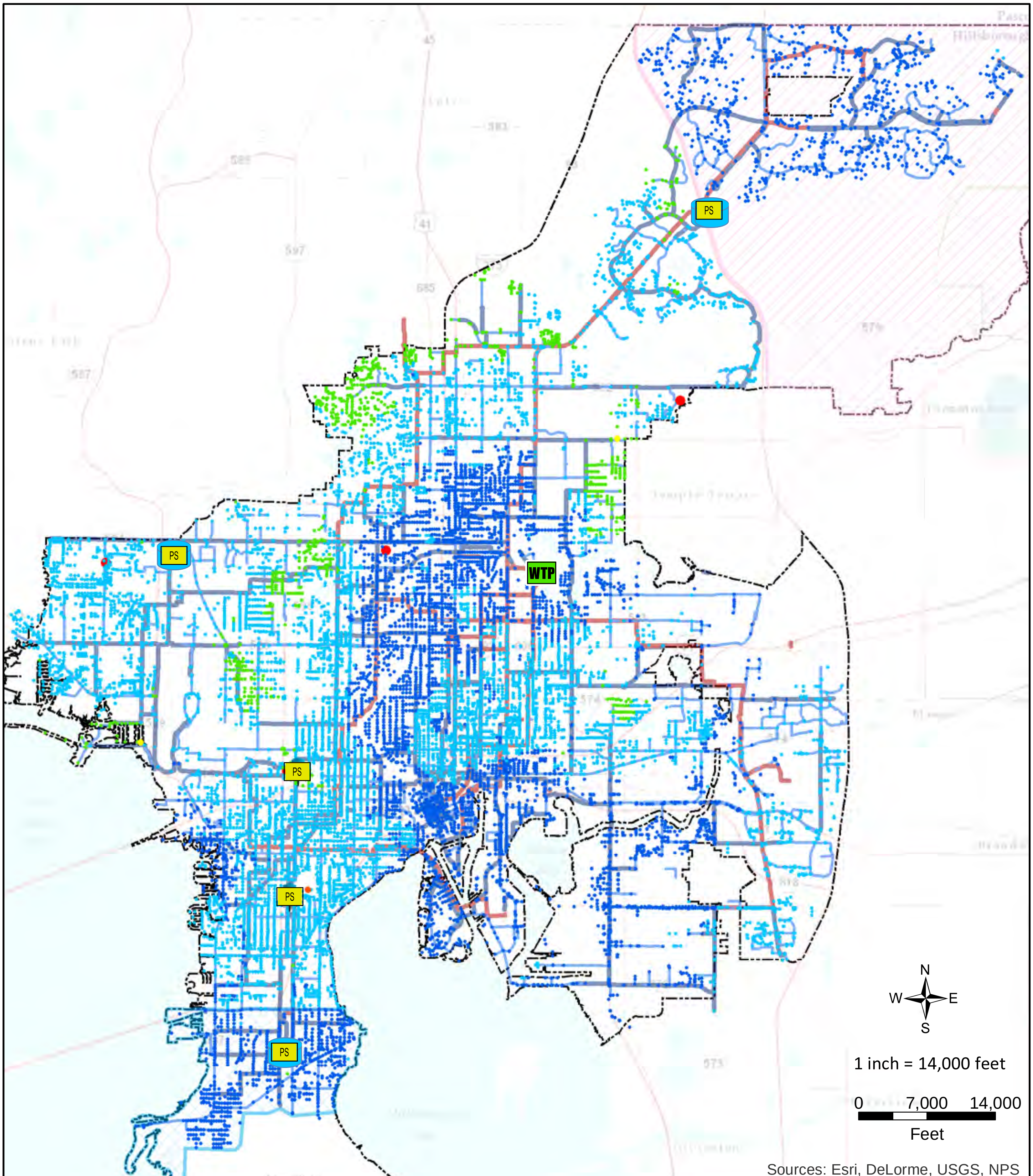

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WTP — WTP
PS — Pump Stations
Ground Storage Tank
Elevated Storage Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

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Potable Water Master Plan

Figure 9

Planning Year 2035
HSPS 70 psi Discharge
Minimum Pressures

3.2.2 Additional Operational Improvements

The TWD can more efficiently utilize the Northwest, Palma Ceia and West Tampa RPS's and decreases the reliance on the DTWLTF HSPS by updating the operating and control strategies for these RPS facilities. Currently the pumps are remotely turned on and off by operations staff to manage tank levels / tank turnover and to maintain system pressures. Typically, each operator shift will turn on pumps to drawdown the tanks by 5 to 6 feet to force at least a third of the tank volume to turn over each day. However, if these controls were modified to allow the pumps to operate during the morning and afternoon peak demand times, they would be more beneficial to the system as a whole and decrease the peak demand supplied by the DLTWTF HSPS. In the planning year 2035, modifying the RPS pump controls will reduce the required additional capacity of the DLTWTF HSPS by 13 MGD.

It is recommended that the TWD implement a monitoring and controls system that will activate the RPS's based on the output flow of the DLTWTF HSPS and/or a local pressure setting. The recommended system would be automated and would activate the RPS's in order to minimize the peak flow at the HSPS, as well as rotate which RPS's are being used to ensure even wear on pumps and cycling of each of the tanks. Should the City not wish to install an automated system, a system which monitors the HSPS flow and provides operators with pre-set indicators and a defined control strategy for operators to follow could be similarly effective.

It is also recommended that the City install flow meters at the Palma Ceia and West Tampa RPS's in order to collect flow data into their historian to better understand conditions at those RPS's. Alternatively, the City could perform a pump test and a survey of the pump bowl shapes to generate accurate pump curves, observe pump efficiency and have an understanding of pump flows at different tank levels at the current point in time.

It is also recommended that power monitors be installed at all RPS's to begin data collection on the power consumption of each facility.

3.3 PUMP STATION CAPACITY IMPROVEMENTS

The capacities of the pumping facilities were analyzed using an Excel-based desktop model for each planning year to evaluate the adequacy of the existing facilities and to identify any deficiencies in capacity based on the performance criteria. Note that hydraulic limitations were assessed using the hydraulic model and summarized later in the technical memorandum.

3.3.1 FDEP Pump Station Capacity Regulations

F.A.C 62-555.320(15) requires the firm capacity of a system or pressure zone to provide MDD plus Fire Flow (FF) if elevated storage is provided and PHD+FF if elevated storage is not provided.

62-555.320 Design and Construction of Public Water Systems

> (15) High-Service or Booster Pumps. For purposes of this subsection, well pump installations shall be considered high-service pumping stations if the well pumps serve as high-service pumps.
>
> (a) Unless elevated finished-drinking-water storage is provided, the total capacity of all high-service pumping stations connected to a water system, or the capacity of a booster pumping station, shall be sufficient to:
>
> > 1. Meet at least the water system's, or the booster station service area's, peak-hour water demand (and if

fire protection is being provided, meet at least the water system's, or the booster station service area's, design fire-flow rate plus a background water demand equivalent to the maximum-day demand other than fire-flow demand); and

2. Maintain a minimum gauge pressure of 20 pounds per square inch throughout the water system's, or the booster station service area's, distribution system up to each customer's point of connection to the distribution system.

(b) Where elevated finished-drinking-water storage is provided, the total capacity of all high-service pumping stations connected to a water system, or the capacity of a booster pumping station, shall be sufficient to at least meet the water system's, or the booster station service area's, maximum-day water demand (including design fire-flow demand if fire protection is being provided) and to maintain distribution system pressure as specified in subparagraph 62-555.320(15)(a)2., F.A.C. In addition, the total capacity of the high-service pumping stations, or the capacity of the booster pumping station, combined with the useful elevated finished-water storage capacity shall be sufficient to meet the water system's, or the booster station service area's, peak-hour water demand for at least four consecutive hours (and if fire protection is being provided, shall be sufficient to meet the water system's, or the booster station service area's, design fire-flow rate plus a background water demand equivalent to the maximum-day demand other than fire-flow demand for the design fire-flow duration).

Since the TWD's elevated storage tanks are below the systems HGL and require pumping to drain the tanks, the system is not considered to have elevated storage and must meet the PHD+FF. **Table 6** summarizes the system demands and pump station criteria per planning year.

Interbay Repump Station

The results indicate that the South Tampa pressure zone pumping capacity is currently deficient and additional pumping capacity, about 4 MGD, is required. The additional pump capacity will be required to address fire flow demands throughout the planning horizon. The RPS capacity is sufficient to meet peak hour demands alone. There are two options available to remedy the deficient pumping capacity; 1) install an additional pump at the IB RPS with a capacity of 4 MGD. 2) Install check valves along the pressure zone boundary (Gandy Blvd.) to allow flow from the neighboring DLTWTF zone to supply the South Tampa pressure zone and supplement the pump capacity in the event of reduced pressures from fire demands during a peak demand period. Black & Veatch recommends the second option of installing check valves along the pressure zone boundary to address fire flow and resilience concerns. The resilience impacts are discussed further in subsequent sections of this tech memo.

NOTE: Were elevated storage to be added to the South Tampa zone the station would not be considered deficient because it would be evaluated for its ability to supply MDD+FF rather than PHD+FF.

High Service Pump Station

Similarly, additional pumping capacity will be needed to the DLTWTF pressure zone by 2020. By 2035, the desktop analysis shows a 45 MGD pumping capacity deficit. This deficit can be mitigated through the installation of additional elevated storage or additional RPS capacity.

Table 6 Pump Station Capacity Compared to PHD+FF

PRESSURE ZONE	PUMPING FACILITY	MAX CAPACITY	M. FIRM CAPACITY	PERFORMANCE CRITERIA (MGD) PHD + Fire Flow(4)(5)				MEETS CRITERIA (Y/N)				DEFICIENT CAPACITY	YEAR IMPROVEMENT REQUIRED
		(MGD)	(MGD)	2015	2020	2025	2035	2015	2020	2025	2035	(MGD)	
New Tampa(1)	Morris Bridge RPS Pumps #1-4	102	66.0	15.6	18.6	20.4	23.5	Y	Y	Y	Y	N/A	N/A
South Tampa	Interbay RPS(2)	28	15.0	16.8	17.9	18.2	18.7	**N**	**N**	**N**	**N**	3.7	2015
DLTWTF(3)	DLTWTF Total	198.5	140.2	137.8	163.8	170.9	185.2	Y	**N**	**N**	**N**	45.0	2020
	High Service	*164*	*114*										
	Northwest	*15*	*12*										
	West Tampa	*10*	*7*										
	Palma Ceia	*9*	*7*										

1. Total Firm Capacity = 62 MGD; Pumps #1-4 and Pumps #5&6 cannot operate at the same time and the firm capacity of Pumps #1-4 = 48 MGD. Pumps #1-4 are required to meet regulations
2. Interbay firm capacity exclude the two small jockey pumps due to pump station configuration
3. DLTWTF firm capacity is based upon the largest pump at the DLTWTF being out of service. The remainder of the pumps within this pressure zone ar operational.
4. The demand on the DLTWTF inlcudes the MDD of North Tampa and South Tampa due to the constant filling of the tanks
5. PHD + Fire Flow for each Plan Year is the PHD in MGD plus the Fire Flow of 3,500 gpm converted to MGD or 5.0 MGD

Table 7 Pump Station Capacity Compared to MDD+FF

PRESSURE ZONE	PUMPING FACILITY	MAX CAPACITY	M. FIRM CAPACITY	PERFORMANCE CRITERIA (MGD) MDD + Fire Flow(4)(5)				MEETS CRITERIA (Y/N)				DEFICIENT CAPACITY	YEAR IMPROVEMENT REQUIRED
		(MGD)	(MGD)	2015	2020	2025	2035	2015	2020	2025	2035	(MGD)	
New Tampa(1)	Morris Bridge RPS Pumps #1-4	102	66.0	12.5	14.6	15.9	18.1	Y	Y	Y	Y	N/A	N/A
South Tampa	Interbay RPS(2)	28	15.0	12.2	12.9	13.1	13.4	Y	Y	Y	Y	N/A	N/A
DLTWTF(3)	DLTWTF Total	198.5	140.2	112.7	125.6	131.2	142.3	Y	Y	Y	**N**	2.1	2035
	High Service	*164*	*114*										
	Northwest	*15*	*12*										
	West Tampa	*10*	*7*										
	Palma Ceia	*9*	*7*										

3.3.2 Hydraulic MDD Pump Capacity Requirements

Throughout the system assessment, various combinations of improvements were evaluated to address identified deficiencies. The required pumping capacity for each set of conditions varied greatly. **Table 8** summarizes the various DLTWTF HSPS capacity requirements for some of the major improvement combinations of improvements. NOTE: the peak flows described in the table below are pump discharge flows not customer demands.

Table 8 Maximum DLTWTF Flows throughout System Assessment

ALT #	SYSTEM CONDITIONS	DLTWTF DISCHARGE PRESSURE (PSI)	DLTWTF PEAK DISCHARGE FLOW (MGD)	FIRE FLOW (MGD)	ADDT'L REQUIRED DLTWTF FIRM PUMPING CAPACITY (MGD)	ESTIMATED COST ($1,000)
1	2035 MDD Existing System	65	175	5	66	
2	2035 MDD Existing System	70	175	5	66	
3	2035 MDD Existing System + Modified RPS Controls	70	162	5	53	
4	2035 MDD Ex. System + Broadway EST (3.5 MG)	70	159	5	50	
5	2035 MDD Ex. System + Nebraska EST (2.0 MG)	70	159	5	50	
6	2035 MDD Ex. System + Broadway (3.5 MG) & Nebraska EST (2.0 MG) - West Tampa and Palma Ceia removed from service	70	154	5	45	
7	2035 MDD Proposed System Improvements + Broadway (3.5 MG) & Nebraska EST (2.0 MG) + Modified RPS Controls	70	148	5	39	
NOTE: All proposals for the Broadway Tank are 2.0 MG and all proposals for the Nebraska Tank are 3.5 MG						

3.3.2.1 DLTWTF Clearwell to Support the HSPS Expansion

The DLTWTF was initially constructed in the 1920s and has been expanded over the years to accommodate the City's growth. As such, there are currently five separate clearwell structures connected with piping, which supply eight pumps at three various locations that discharge into the distribution system. The changes in design, system demands, and configuration have resulted in a clearwell and pump combination that only allow for 12.5 MG of the 20.0 MG storage capacity to be available without causing cavitation in a few of the pumps and potential buoyancy problems with the tanks. In addition, the blending chamber which feeds the clearwell was designed for lower flows and at high flows the chamber pressurizes and starts to leak into the filter gallery.

These issues, combined with the projected HSPS flows described above (140 – 167 MGD), have led to a recommendation in the 2017 David L. Tippin Water Treatment Facility Master Plan to abandon the two oldest clearwell structures (2.0 and 0.5 MG tanks), the existing blending chamber, and pumps 1-6; repurpose the existing 7.5 MG clearwell to be a blending chamber; construct a new 5.0 MG clearwell; and add pumping capacity to reach 140 MGD total capacity to be completed before 2025. This provides an excellent opportunity to increase the storage capacity onsite at the DLTWTF. More discussion on sizing of the additional clearwell storage is included in the Storage Capacity Improvements section of this technical memorandum.

Accounting for the proposed modifications to the existing clearwell structures, a new 13 MG tank would increase the total storage capacity of the DLTWTF pressure zone to 31.5 MG exceeding the FAC requirements in 62-555.320(19)(a) and allowing for 4.5 to 5 hours of supply capacity should the treatment system be out of service. NOTE: this accounts for the reduction in volume from the 2 and 0.5 MG clearwell demolition. Black & Veatch recommends increasing the proposed additional storage at the DLTWTF site from 5.0 MG to 13.0 MG. **Figure 13** illustrates the potential location for the additional clearwell storage. Black & Veatch also recommends beginning collection of data related to the groundwater level on the site in anticipation of the design of a new clearwell structure.

3.3.3 Pump Capacity Recommendations

Without the addition of two elevated storage tanks, which will be describe further in the TM, Black & Veatch recommends increasing the firm capacity of the DLTWTF HSPS to 167 MGD. With the addition of the Broadway and Nebraska elevated tanks and a modification of the Northwest, West Tampa and Palma Ceia RPS controls/operating strategy, the proposed capacity could be reduced by 14 MGD to 153 MGD. Both of these conditions are higher than the 140 MGD proposed HSPS in the 2017 David L. Tippin Water Treatment Facility Master Plan. Black & Veatch recommends increasing the capacity of the HSPS in two stages; 140 MGD then the additional capacity when triggered.

3.4 STORAGE CAPACITY IMPROVEMENTS

The capacities of the storage facilities were analyzed using an Excel-based desktop model for each planning year to evaluate the adequacy of the existing facilities and to identify any deficiencies in capacity based on the performance criteria. Note that hydraulic limitations were assessed using the hydraulic model and summarized later in the technical memorandum.

3.4.1 FDEP Storage Regulations

The Florida Administrative Code (F.A.C.), which sets the requirements for water systems within the State, addresses the required storage volumes in Chapter 62-555.320(19). The F.A.C. chapter set the required volume in paragraph (a) as 25% of the system's MDD plus the a fire reserve but also provides two methods of proving that less storage is sufficient for the specific systems purposes.

62-555.320 Design and Construction of Public Water Systems

> (19) Finished Drinking Water Storage Capacity. This subsection addresses finished-water storage capacity necessary for operational equalization to meet peak water demand. (If fire protection is being provided, additional finished-water storage capacity shall be provided as necessary to meet the design fire-flow rate for the design fire-flow duration.) The finished-water storage capacity necessary to meet the peak water demand for a consecutive system may be provided by the consecutive system or by a wholesale system delivering water to the consecutive system.
>
> (a) Except as noted in paragraph (b) below, the total useful finished-water storage capacity (excluding any storage capacity for fire protection) connected to a water system shall at least equal 25 percent of the system's maximum-day water demand, excluding any design fire-flow demand.
>
> (b) A total useful finished-water storage capacity less than that specified in paragraph (a) above is acceptable if the supplier of water or construction permit applicant makes one of the following demonstrations:

1. A demonstration consistent with Section 10.6.3 in Water Distribution Systems Handbook as incorporated into Rule 62-555.330, F.A.C., showing that the water system's total useful finished-water storage capacity (excluding any storage capacity for fire protection) is sufficient for operational equalization.

2. A demonstration showing that, in conjunction with the capacity of the water system's source treatment, and finished-water pumping facilities, the water system's total useful finished-water storage capacity (excluding any storage capacity for fire protection) is sufficient to meet the water system's peak-hour water demand for at least four consecutive hours. For small water systems with hydropneumatic tanks that are installed under a construction permit for which the Department receives a complete application on or after August 28, 2003, the supplier of water or construction permit applicant also shall demonstrate that, in conjunction with the capacity of the water system's source, treatment, and finished-water pumping facilities, the water system's total useful finished-water storage capacity (i.e., the water system's total effective hydropneumatic tank volume) is sufficient to meet the water system's peak instantaneous water demand for at least 20 consecutive minutes.

3.4.1.1 FAC 62-55.320(19)(a) – Greater than 25% MDD + Fire Reserve

The required storage based on the requirements of F.A.C. 62-555.320(19) (a) and the system's ability to meet those requirements are summarized in **Table 9** below. This calculation assumes a fire reserve accounting for 3,500 gpm for 3 hours. There is sufficient storage for the South and North Tampa pressure zones but insufficient storage for the DLTWTF zone. With the future construction project at Morris Bridge RPS, the Morris Bridge pumps 1-4 will be able to pump into the DLTWTF zone while pumps 5-7 will still be able to pump to the North Tampa zone. This will allow the excess storage in the Morris Bridge tanks to be allocated to the DLTWTF zone and reduce, but not eliminate, the required additional storage.

Table 9 FAC 62-555.320(19)(a) Storage Requirements

PRESSURE ZONE	STORAGE FACILITY	TOTAL VOLUME	EFFECTIVE VOLUME	Minimum Storage Volume (MG) 25% of MDD + Fire Reserve[1]				MEETS CRITERIA (Y/N)				DEFICIENT VOLUME	YEAR IMPROVEMENT REQUIRED
		(MG)	(MG)	2015	2020	2025	2035	2015	2020	2025	2035	(MG)	
New Tampa	Morris Bridge RPS	10.0	7.5	2.5	3.0	3.3	3.9	Y	Y	Y	Y	N/A	N/A
South Tampa	Interbay RPS	5.0	5.0	2.4	2.6	2.7	2.7	Y	Y	Y	Y	N/A	N/A
DLTWTF	DLTWTF Total	26.0	18.5	23.9	26.4	27.4	29.6	N	N	N	N	11.1	2016
	Clearwell	*20.0*	*12.5*										
	Northwest	*3.0*	*3.0*										
	West Tampa	*1.5*	*1.5*										
	Palma Ceia	*1.5*	*1.5*										
	Deficient Storage without considering the Morris Bridge excess volume (MG)							5.4	7.9	8.9	11.1		
	Deficient Storage considering the Morris Bridge excess volume (MG)							0.4	3.4	4.8	7.5		

1. Fire Reserve storage required is 3500 gpm for 3 hours or 0.63 MG

3.4.1.2 FAC 62-55.320(19)(b)2 – PHD for 4 Consecutive Hours

There are some water quality concerns with adding increased storage into the existing distribution system. Therefore the system was analyzed under the requirements of FAC 62-555.320(19)(b)2 to evaluate whether the additional storage identified in FAC 62-555.320(19)(a) was really needed for system operations. The allowance identified requires that a demonstration showing that the water system's total storage capacity was sufficient to meet the water system's peak-hour water demand for at least four consecutive hours. It is important to note that the volume of storage required by FAC 62-555.320(19)(b) is total useful storage, rather than firm storage, and does allow for tanks to be out of service.

The hydraulic model was set up for a 4-hour simulation with the settings presented in **Table 10**.

Table 10 4 PHD Hydraulic Model Simulation Settings

PUMP STATION	PUMPS ACTIVE	MODELED DISCHARGE PRESSURE
DLTWTF HSPS	Yes	65 psi
Morris Bridge RPS	Yes	70 psi
Interbay RPS	Yes	65 psi
Northwest RPS	2 of 3	65-70 psi
Palma Ceia RPS	Yes	58-62 psi
West Tampa RPS	Yes	52-56 psi
OTHER CONDITIONS		
Interbay and Morris Bridge Tank Fill Valves = Closed		
THIC Interconnect active		
No ASR Recharge		
No emergency water supply interconnects active		

The model results illustrated in **Figure 10** and **Figure 11** indicated that the existing system storage can meet the minimum pressure criteria under the 2035 PHD conditions for four consecutive hours with the DLTWTF HSPS peak flow at 140 MGD. A minimum of 69 MGD of source treatment capacity is required to replenish the DLTWTF clearwells during the 4-hour period, which is below the existing rated capacity of 120 MGD. This analysis meets the requirements of the FAC regulations and the TWD does not have to install additional storage unless operational conditions dictate otherwise. NOTE: This analysis does assume that all the tanks are full and none are out of service during this event.

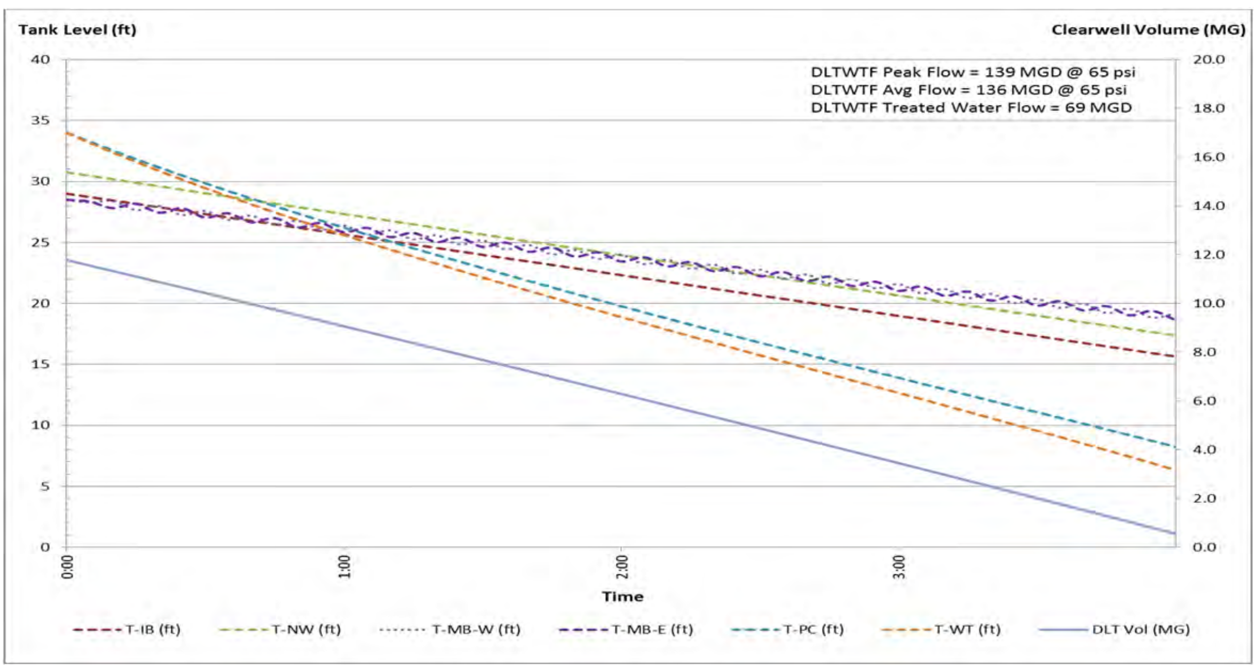
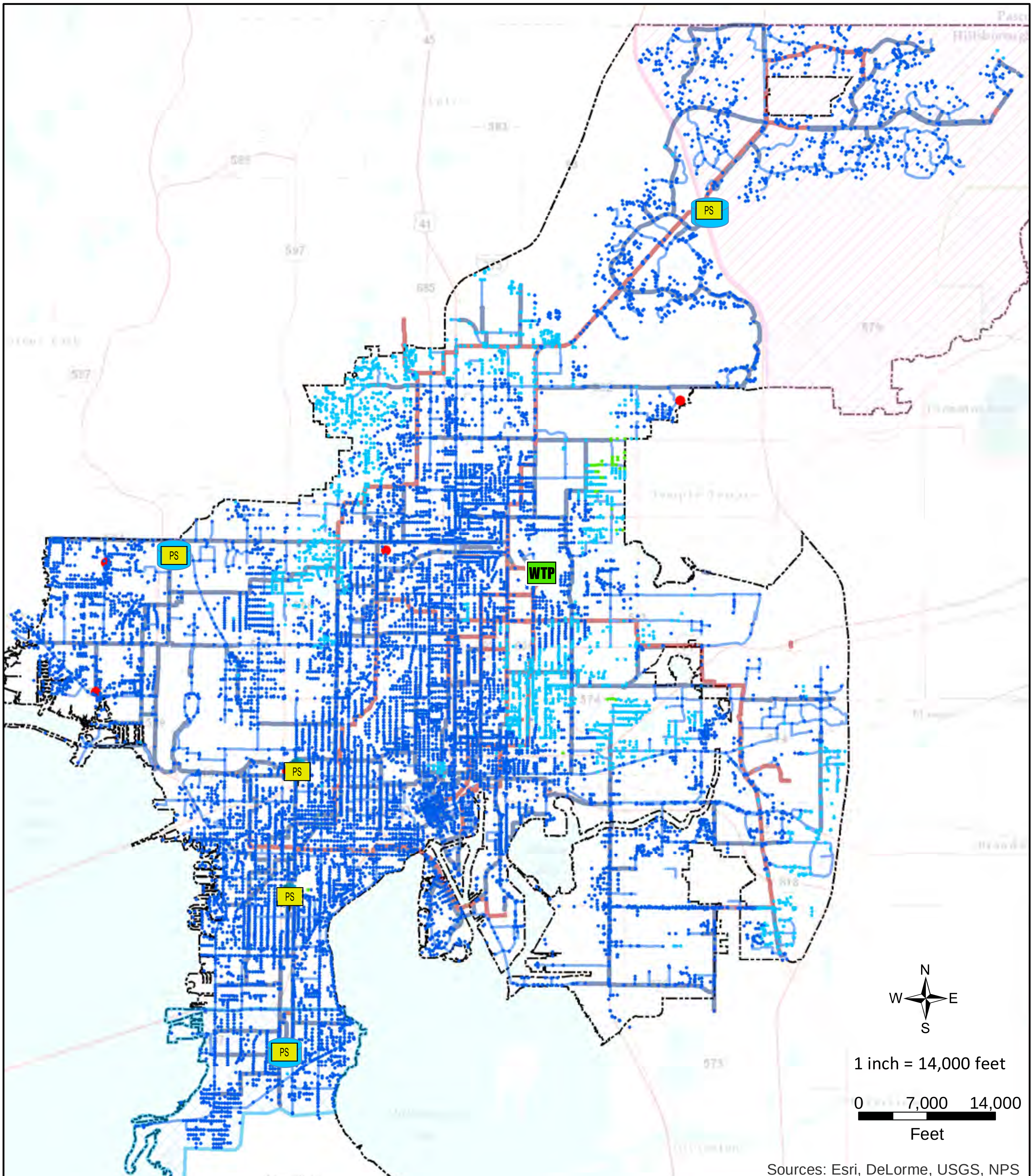


Figure 10 2035 Four Consecutive Peak Hour Demands – Tank Levels



CITY OF TAMPA

Potable Water Master Plan

Figure 11

Planning Year 2035
Consecutive 4-hr PHD
Minimum Pressures

WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

City of Tampa Florida

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3.4.2 Existing System Recovery from Consecutive Max Demands

In addition to meeting the FAC regulations, the TWD requested a consecutive 3-day MDD EPS analysis to ensure that the system could recover storage capacity. **Figure 12** illustrates the tank levels during a 3-day consecutive 2035 MDD scenario and shows the tank levels recovering daily.

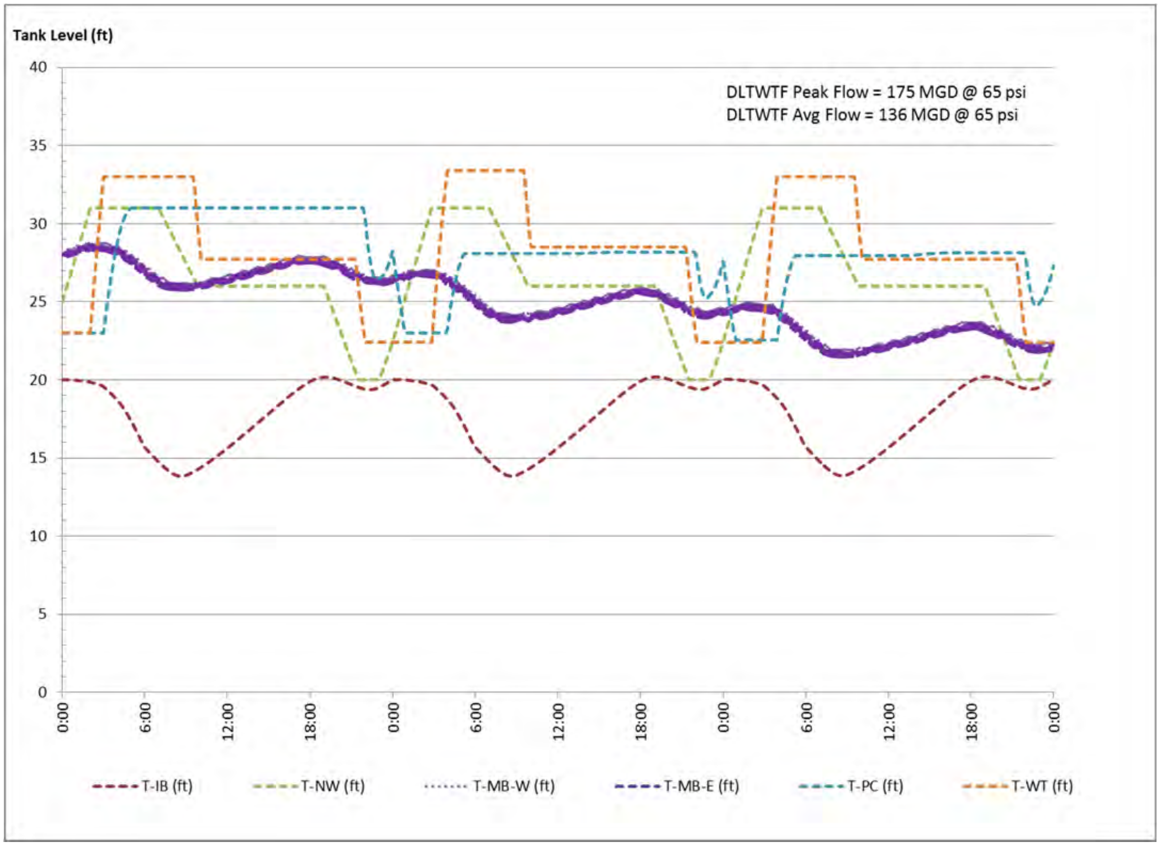


Figure 12 Three Consecutive Max Day Demands

3.4.3 Additional Storage Investigations

Additional storage options were considered as part of the system analysis to determine if and what type of additional storage was needed to improve the system operations. The types of additional investigated were clearwell, elevated, and ground. The locations varied based on transmission main and neighboring utility water main locations.

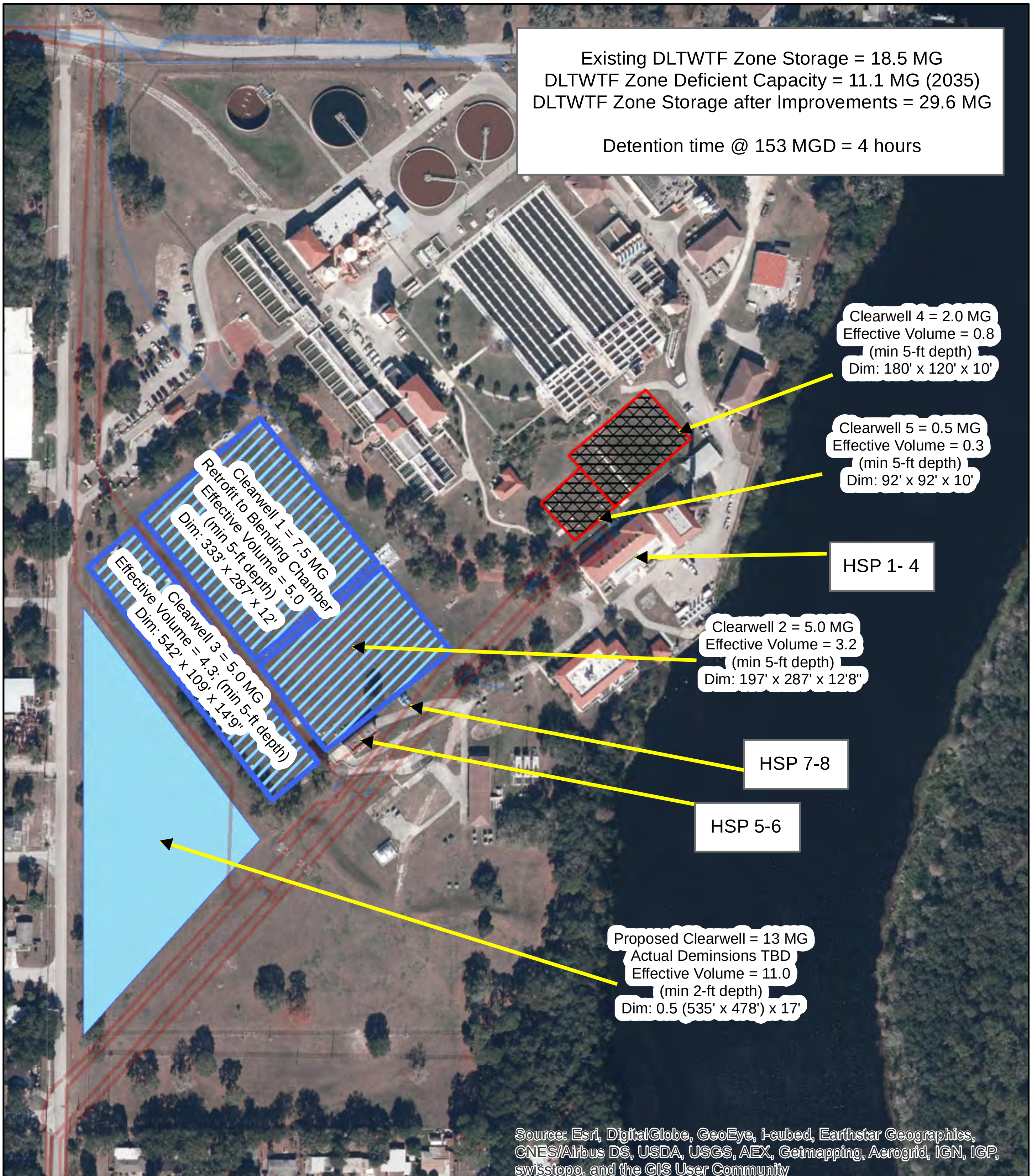
3.4.3.1 DLTWTF Clearwell

As discussed in the Pump Station Capacity Improvements section above, changes to the HSPS and clearwell configurations are required to meet the projected HSPS flows (140 – 167 MGD). This provides an excellent opportunity to increase the storage capacity onsite at the DLTWTF. Accounting for the proposed modifications to the existing clearwell structures, which includes abandoning the two oldest clearwell structures (2.0 and 0.5 MG tanks) and the existing blending chamber; repurposing the existing 7.5 MG clearwell to be a blending chamber; and constructing a new 5.0 MG clearwell, replacing the proposed 5 MG tank with a new 13 MG tank would increase the total storage capacity of the DLTWTF pressure zone to 31.5 MG exceeding the FAC requirements in 62-555.320(19)(a) and allowing for 4.5 to 5 hours of supply capacity should the treatment system be out of service. Black & Veatch recommends increasing the proposed additional storage at the DLTWTF site from 5.0 MG to 13.0 MG. NOTE: if it is feasible to keep the 2.0 and 0.5 MG clearwells in operation, that would reduce the new storage capacity from 13 MG to 12 MG based on effective volumes of the existing clearwells. **Figure 13** illustrates the potential location for the additional clearwell storage. Black & Veatch also recommends collecting data related to the groundwater level on the site in anticipation of the design of a new clearwell structure.

3.4.3.2 Other Storage Options

Black & Veatch also investigated options for installing additional storage within the DLTWTF pressure zones in various forms; elevated, ground, and interconnect. Locations of the additional storage were selected based on existing infrastructure such as large transmission capacity and the locations of the existing RPSs. **Table 11** summarizes the pros and cons of the various storage options. The following briefly summarizes the information considered for each type of storage option. More details on the analysis including relative costs comparisons are located in **Appendix B** – Recommended Storage Improvements Workshop Presentation.

1. Clearwell Storage: Opportunistic based on the needs of the HSPS.
2. Elevated Storage Tanks (EST):
    - The addition of one 3.5-MG (Nebraska) composite elevated tank and one 2.0-MG (Broadway) composite tank to float on the updated HGL
    - Raise the elevation of the West Tampa and Palma Ceia tanks to float on the updated HGL
    - Replace the West Tampa and Palma Ceia tanks with larger and taller tanks to float on the updated HGL
3. Ground Storage Tanks (GST):
    - Add 3.0 MG tank to the Northwest RPS
    - Replace the West Tampa Elevated tank with two 4.0 MG GSTs
    - Abandon the Palma Ceia RPS and EST
4. Interconnections:
    - Connect Tampa Bay Water (TBW) US301 interconnect to a new GST and pump station
    - Install a new interconnect with Hillsborough County from either Northwest WTP or Lake Park WTP in the northwestern portion of the system.



City of Tampa Florida

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wMain Diameter

- Less than 12-inch
- 12 - 24-inch
- Greater than 24-inch

Clearwell Status

- Demolish
- Existing
- Proposed

CITY OF TAMPA

Potable Water Master Plan

Figure 13

DLTWTF Clearwell Storage Improvements

Table 11 Additional DLTWTF Zone Storage Pro/Con Summary

STORAGE OPTIONS	BENEFITS (PROS)			DETRIMENTS (CONS)				COMMENTS
	REDUCE TRANSIENT / PRESSURE SURGES	POTENTIAL TO LOWER ENERGY COSTS	RESILIENT TO POWER LOSS	LIMITS OPERATIONAL FLEXIBILITY	INCREASES WATER AGE AND NITRIFICATION CONCERNS	SIZE LIMITATIONS	INCREASED / SAFETY MAINTENANCE CONCERNS	
2. Elevated Storage	Y	Y	Y	LIMITS HGL RANGE	Y	Y MAX 4 MG	Y NEED CONTRACTOR	Small revenue opportunity with wireless utilities; Potential for additional site due to size limitations; possible to add a pump with the tank to enable operators to force a tank turn over
3. Ground Storage	N	N	N GENERATOR REQUIRED	N	Y	N	N	More easily expanded than EST or clearwell options. Increases operational complexity
4. Interconnect w/ GSTs	N	N	N GENERATOR REQUIRED	N	Y POTENTIAL POINT OF CONNECTION NOT IN HIGH DEMAND AREAS	N	N	Increases water supply availability / reliability with neighboring utilities Increases operational complexity Requires cooperation of neighboring utility

3.4.4 Long-Term Plan for West Tampa and Palma Ceia Tanks

As part of the DLTWTF zone storage evaluation, Black & Veatch investigated the need and long-term plan for the Palma Ceia and West Tampa Tanks as they are aging and below the HGL of the distribution system. In addition, the Palma Ceia Tank is due for significant repairs and rehabilitation (R&R). The following observations are from that investigation.

The West Tampa and Palma Ceia tank locations are ideally suited from a demand perspective. They are located in high demand centers of the distribution system and in areas of projected increased demands from redevelopment. The locations combined with the modified RPS controls described above allow these RPSs to protect the system from low pressures due to high demands.

Although the tanks are not critical to the system from existing demands, the storage and pumping capacity from each RPS is critical to meet FAC regulations and operational needs for the future planning years. Removal of these tanks would require the replacement of the storage and pumping capacity elsewhere within the distribution system. However, it is unlikely that available locations exist within or adjacent to the high demand areas and would have less of an impact on the potential low pressures in the areas of high demands.

Aerials of the tank sites show ample room at the West Tampa location for replacing the existing tank with a larger and taller tank or to just raise the existing tank to float on the HGL of the distribution system. However, there is limited space available at the more congested Palma Ceia tank location. It would be more difficult to replace or raise the existing tank.

Black & Veatch recommends maintaining the West Tampa and Palma Ceia Tanks due to their relationship with the high demand areas. These tanks are in ideal locations and removal of them would have to be accompanied by replacement of their capacity at the same or other, likely less effective, locations. Replacement tank cost estimates are approximately $7.2M each. When annual maintenance costs are 50% or more of the replacement costs, the City should consider replacing the tanks.

3.4.5 Effect of Elevated Storage on High Service Pumping Capacity

Increased storage within the DLTWTF zone allows for more of the peak hour demand to be supplied from the tanks and the RPSs rather than from the DLTWTF HSPS, thus reducing the criticality of the HSPS. Without additional storage within the pressure zone, the projected demands will need to be supplied instantaneously from the HSPS, requiring the capacity to be approximately 167 MGD by 2035. However, the installation of two additional elevated storage tanks, Broadway in the southeastern portion of the system and Nebraska in the northern portion of the system, would decrease the HSPS capacity by 14 MG to 153 MG. A rough cost comparison included in **Appendix B** indicates the additional storage option would likely cost about double the additional pumping capacity.

3.4.6 Storage Improvement Recommendations

Black & Veatch recommends increasing the proposed new clearwell capacity identified in the 2017 David L. Tippin Water Treatment Facility Master Plan from 5.0 MG to 13.0 MG. Additionally, Black & Veatch recommends installing two new elevated storages tanks (Broadway and Nebraska) to provide system resilience. The basis of the recommendation for additional elevated storage is discussed later in this technical memorandum. These tanks are not required based on State regulations, but they would provide the additional benefits of protecting the system from transient pressures, reducing the size of the DLTWTF HSPS, and allowing the Northwest, West Tampa and

Palma Ceia RPSs to be taken out of service for maintenance as demands increase. The exact location of the tanks should be investigated further.

3.5 WATER MAIN CAPACITY IMPROVEMENTS

3.5.1 Planned Improvements

The existing system has several distribution system improvements already planned for completion prior to 2020. Those improvements include two new pipeline projects; the CIAC and KBar pipelines. The CIAC pipeline is a 36-inch water main from the DLTWTF HSPS to just south of the Palma Ceia RPS. The CIAC pipeline supplies additional flow to the portion of the distribution south of W. Kennedy Blvd. and increases pressures to above the selected performance criteria of 40psi. The KBar pipeline is located in the North Tampa pressure zone and connects two dead-ends increasing looping and available fire flow while decreasing water age.

In addition to the two water main planned improvements, the TWD also has significant planned improvements at the Morris Bridge RPS. The improvements include: 1) The addition of a low flow pump (Pump 7) which will be able to pull directly from the DLTWTF pressure zone rather than from the tanks; 2) the addition of new control valves which will allow Pumps 1-4 to pump south to the DLTWTF pressure zone while Pumps 5-7 pump into the North Tampa pressure zone; and 3) a bypass for the TBW interconnect around the two GSTs directly into the distribution system. These improvements will be completed prior to 2020.

3.5.2 TPA and TIA Master Meters

Black & Veatch completed an investigation of the potential to install master meters at the Tampa Port Authority (TPA) and the Tampa International Airport (TIA) to isolate the onsite water mains and transfer ownership of those mains to the respective customers. The tech memo has not yet been finalized. This is an effort to simplify maintenance of the water mains, which is complicated due to access restrictions at these locations. The investigation showed that the water mains in the TPA and TIA sites could be isolated from the system without significant impacts to the surrounding distribution system. Therefore, installation of the master meters is assumed to be installed as part of the system analysis and improvement identification.

3.5.3 System Assessment Summary

The updated system capacity analysis showed that much of the distribution system maintains adequate minimum pressures throughout the entirety of a MDD and does not exceed the maximum pressure criteria. The results of the system analysis are included in **Appendix A** as a series of system maps and tank level figures showing the minimum pressures, maximum pressures, and maximum velocities for the various system conditions analyzed. Quantification of compliance with the minimum and maximum pressure criteria is presented in **Table 12**. The lowest pressures in the system across the planning years are located in the western portion of the DLT WTF zone surrounding the Northwest RPS and in the northern part of the DLTWTF zone near the boundary of the New Tampa zone. High elevations at Busch Gardens and Lake Carroll result in low minimum pressures as the result of low static pressure. Areas with high elevations and low static pressures can be seen in **Figure 7**. Additionally, the southern portion of the DLTWTF zone between Kennedy Blvd. and Gandy Blvd. also exhibit low pressures, however, these issues will be addressed by the CIAC pipeline improvements.

Table 12 Percent of the existing 2035 System Meeting Pressure Criteria

#	SCENARIO NAME	MINIMUM PRESSURES			MAX. PRESSURES	
		> 30 psi	> 40 psi	> 50 psi	> 75 psi	> 85 psi
1	Base MDD Analysis	99.84%	89.56%	47.63%	0.01%	0.00%
2	2020 MDD Analysis	99.83%	95.98%	42.82%	0.04%	0.03%
3	2025 MDD Analysis	99.81%	92.08%	35.58%	0.04%	0.03%
4	2035 MDD Analysis	99.68%	71.01%	22.76%	0.02%	0.01%

The updated system capacity analysis also reviewed pipe velocity and headloss criteria in an effort to identify potential causes of any pressure issues throughout the system. The results of this assessment showed that most of the distribution system operates well within the criteria range. Quantification of compliance with the maximum velocity and headloss criteria for water mains with a diameter equal to or great than 4-icnhes is presented in **Table 13**.

Table 13 Percent of the Existing 2035 System Meeting Pipe Criteria

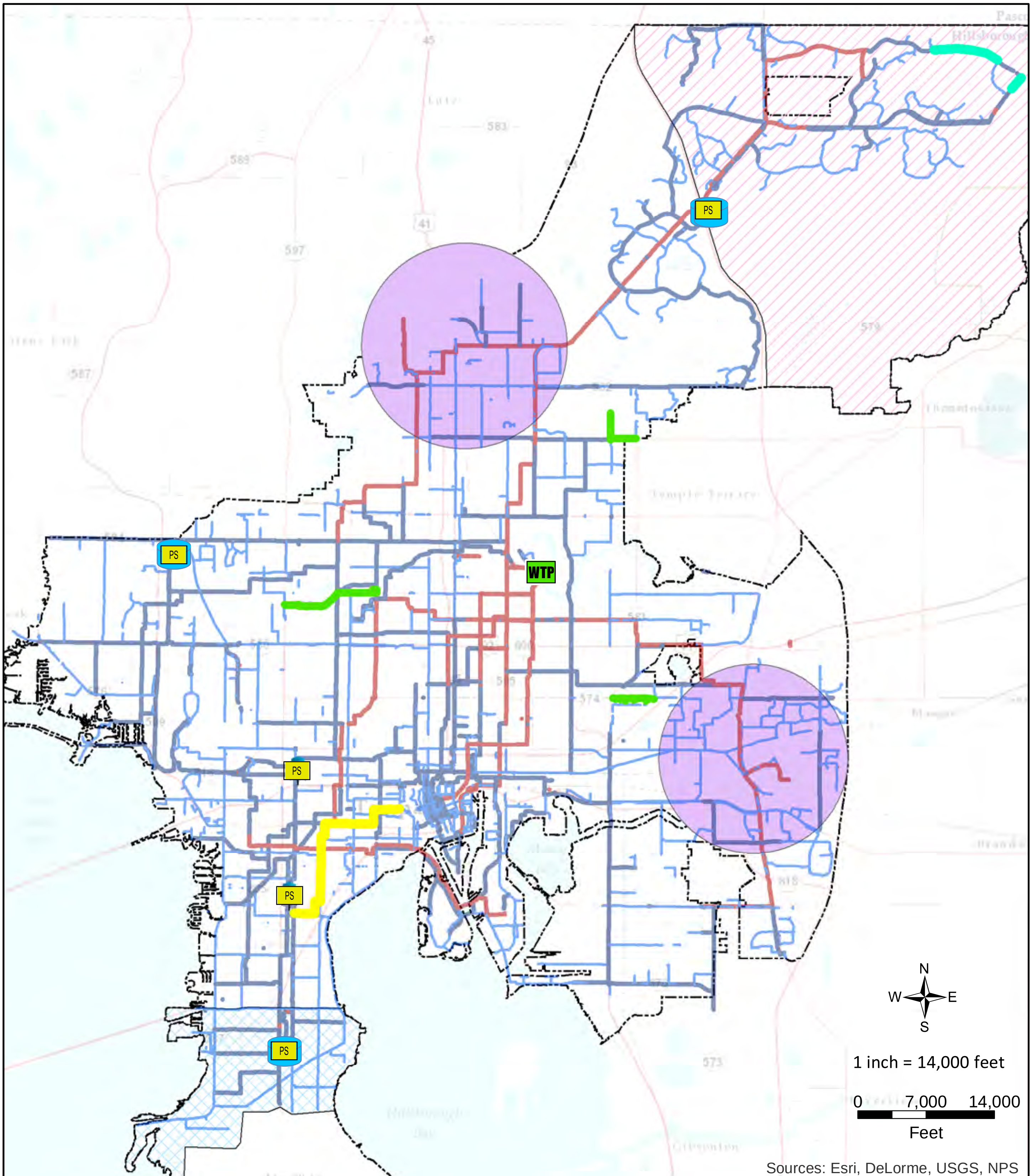
#	SCENARIO NAME	MAXIMUM VELOCITY			MAXIMUM HEADLOSS/1000’	
		> 3 fps	> 5 fps	> 10 fps	> 3 ft/k-ft	> 5 ft/k-ft
1	Base MDD Analysis	1.74%	0.18%	0.04%	3.08%	1.12%
2	2020 MDD Analysis	1.49%	0.23%	0.04%	2.31%	0.85%
3	2025 MDD Analysis	1.60%	0.20%	0.05%	2.60%	0.85%
4	2035 MDD Analysis	1.95%	0.28%	0.05%	3.45%	0.89%

3.5.4 Water Main Capacity Improvement Recommendations

Due to the overall performance of the distribution system after the operational changes described above, the system assessment only resulted in the identification of a limited number of improvements to address areas within the system exhibiting high headloss, as well as some areas of low pressure which could be improved by the installation of new infrastructure. **Figure 14** illustrates the location of the recommended improvements and **Table 14** summarizes the extent of the improvements. Note that these improvements are recommended regardless of the installation of additional storage within the DLTWTF zone. **Appendix C** contains a more detailed description of each project.

Table 14 Water Main Capacity Improvement Summary

PROJECT ID	REPLACE / NEW	PROPSOED DIAMETER	LENGTH	DESIGN PLAN YEAR PROPOSED	COMMENTS
A	New	As shown on Figure 19		2018	Already Planned
B	New	As shown on Figure 19		2018	Already Planned
CP003	Replacement	12-inch 16-inch	1 mile 200 feet	2020	Reduces 2020 peak hour headloss gradient (headloss/1,000 ft) in the pipelines from 5.4 to 1.3
CP004	New	12-inch	1 mile	2025	>2.5 psi pressure increase
CP005	New	8-inch 12-inch	800 feet 2 miles	2035	Reduces 2035 peak hour headloss gradient from 15.1 to 4.9 in 2035



WTP
Pump_Stations
Ground Storage Tank
Elevated Storage Tank
Proposed_Tank_Areas

KBar Improvements
CIAC Improvements
Capacity Improvements

Diameter
Less than 12-inch
12 - 16-inch
16 - 24-inch
Greater than 24-inch
South Tampa
New Tampa
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 14

Proposed Water Main Capacity Improvements Through 2035

4. Fire Flow Capacity Improvements

In addition to meeting the MDD demands and pressures, the water distribution system must also provide water during a fire event, known as fire flow (FF), and maintain minimum pressures throughout the distribution system. The amount of fire flow required varies based on the Florida Fire Code guidelines, which consider the structure's size, use, and building materials. Typical residential fire flow requirements range from a minimum of 500 to 1,500 gallon per minute (gpm), typical commercial fire flow ranges from 2,000 to 2,500 gpm and industrial fire flow can exceed 3,500 gpm. Both the ISO and the American Water Works Association (AWWA) recommend the maximum fire flow capacity provided by a distribution system to be 3,500 gpm. Providing more than 3,500 gpm can require excessively large transmission systems and can results in poor water quality in storage facilities. Water utilities should carefully consider and balance the fire flow provided by the distribution system with water quality requirements.

4.1 AVAILABLE FIRE FLOW ASSESSMENT

The TWD Technical Manual recommends a residential fire flow of 1,000 gpm and a commercial/industrial fire flow of 3,000 gpm with a minimum pressure of 25 psi. **Table 15** summarizes the system assessment for available fire flow. Improvements were identified to address the residential fire flow deficiencies as discussed further in this section. To be sensitive to oversizing the transmission system and avoiding increasing water age within the system, Black & Veatch recommends an analysis of the required commercial fire flow needs be conducted and commercial fire flow corridors be identified before commercial fire flow improvements are planned. The results of the system analysis are included in **Appendix A.**

Table 15 Percent of the System Meeting Fire Flow Goals

#	SCENARIO NAME	RESIDENTIAL[1] (1,000 GPM)	COMMERCIAL / INDUSTRIAL[1] (3,500 GPM)
1	Base MDD+FF Analysis	95%	61%
2	2020 MDD+FF Analysis	97%	62%
3	2025 MDD+FF Analysis	91%	51%
4	2035 MDD+FF Analysis	87%	50%

NOTE: increased coverage is due to the addition of the planned CIAC & KBar pipelines.
[1] Percentages of the system meeting goals is calculated from junctions located on pipelines 6-inches in diameter and larger

4.2 RECOMMENDED FIRE FLOW IMPROVEMENTS

Thirty-three fire flow improvements were identified to ensure that 100% of the system served by 6-inch and larger pipeline, which is the minimum pipe size capable of serving residential fire flow, met requirements through the planning year 2035. An additional six fire flow improvements were identified to improve available fire flow conditions in commercial zones through the planning year 2035. Additionally, a previous study analyzed risk factors throughout the system, one of which being adequacy of fire hydrant spacing. None of these areas corresponded with the fire flow improvements referenced in this tech memo. Increased fire protection throughout the distribution system will occurs as the City continues the small diameter water main replacement program and R&R program.

The fire flow improvement projects were generally identified and categorized into one of three categories and are labeled as such in **Figure 15, Table 16** and in **Appendix C**. The three categories and their label logic (in parenthesis) are:

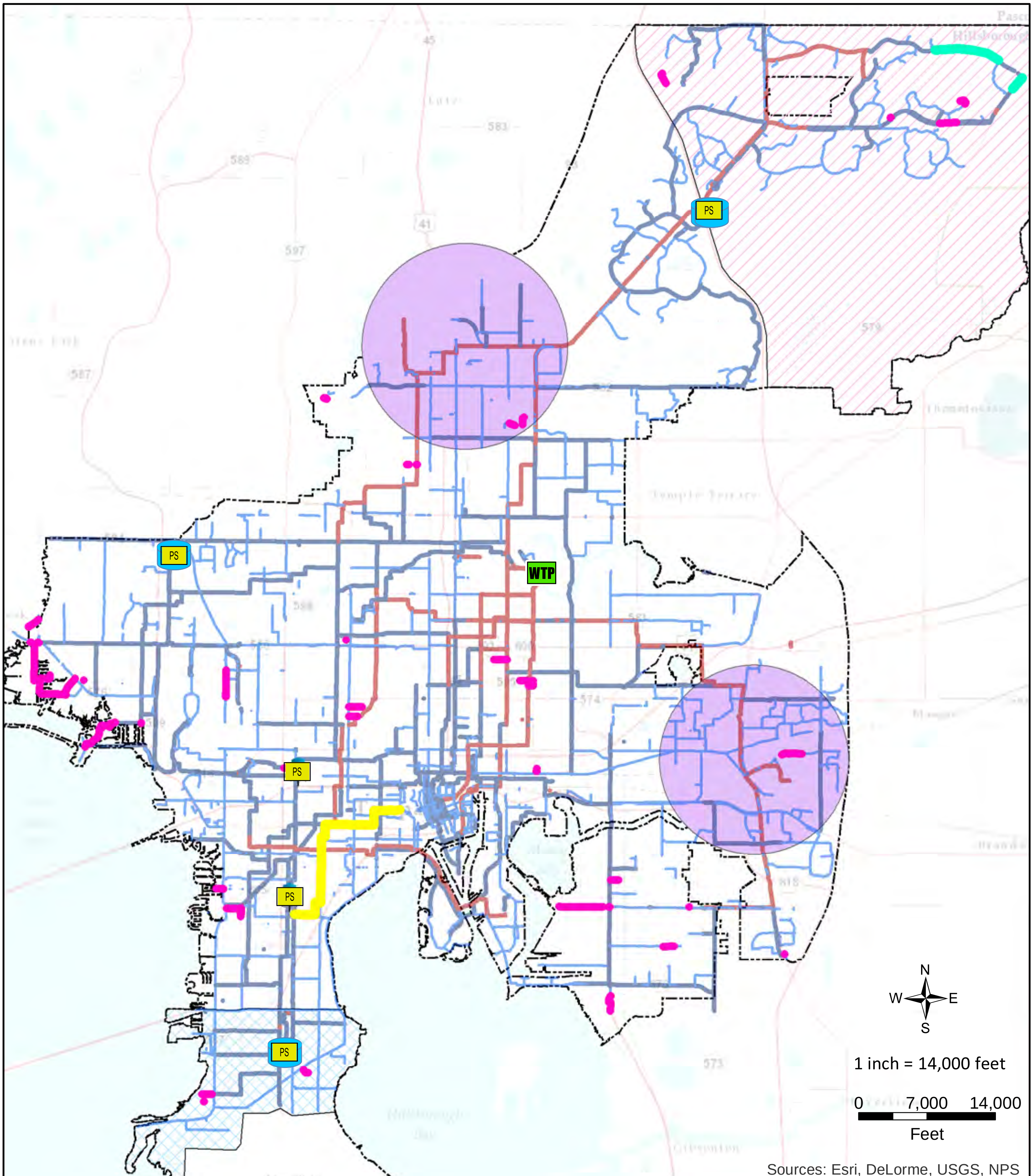
- **General (FF0-##)** – projects to increase available fire flow resulting from long dead ends, under sized or limited transmission capacity, or a long distance from existing transmission capacity
- **Disconnects / New Connections (FF1-##)** – projects to increase available fire flow, primarily on dead-end pipelines, by connecting to nearby pipes, and/or increasing looping in the direct vicinity of the project.
- **Pipe Size Flow Restrictions (FF2-##)** – projects to increase available fire flow caused by connections to or being in the immediate proximity of 2-inch and 3-inch diameter pipe within the distribution network

Table 16 Fire Flow Capacity Improvement Summary

PROJECT ID	REPLACE / NEW	PROPSOED DIAMETER	LENGTH	PLAN YEAR PROPOSED	FF INCREASE (GPM)	COMMENTS
FF0-01	Replacement	12-inch	2,100 feet	2015	2,500	Increases FF from 1,100 to 3,500 gpm
FF0-02	Replacement	12-inch	4,600 feet	2015	1,100	Increases FF from 1,200 to 2,300 gpm
FF0-03	Replacement	8-inch	1,250 feet	2015	640	Increases FF from 600 to 1,240 gpm
FF0-04	Replacement	12-inch	4,600 feet	2015	330	Increases FF from 670 to 1,000 gpm
FF0-05	New	12-inch	1,200 feet	2015	1,140	Increases FF from 1,400 to 2,540 gpm
FF0-06	Replacement	16-inch	1 mile	2015	1,250	Increases FF from 1,900 to 2,750 gpm
FF0-07	Replacement	12-inch	3,300 feet	2015	450	Increases FF from 800 to 1,250 gpm
FF0-08	Replacement	8-inch	800 feet	2015	400	Increases FF from 810 to 1,210 gpm
FF0-09	Replacement	12-inch	1,400 feet	2015	330	Increases FF from 800 to 1,130 gpm
FF0-10	New	12-inch	1,100 feet	2015	830	Increases FF from 860 to 1,690 gpm
FF0-11	Replacement	8-inch	800 feet	2015	480	Increases FF from 870 to 1,350 gpm
FF0-12	Replacement	8-inch	800 feet	2015	580	Increases FF from 910 to

PROJECT ID	REPLACE / NEW	PROPSOED DIAMETER	LENGTH	PLAN YEAR PROPOSED	FF INCREASE (GPM)	COMMENTS
						1,490 gpm
FF0-13	Replacement	12-inch	900 feet	2015	220	Increases FF from 780 to 1,000 gpm
FF0-14	Replacement	8-inch	1,900 feet	2015	890	Increases FF from 920 to 1,810 gpm
FF0-15	Replacement	12-inch	2,800 feet	2015	630	Increases FF from 920 to 1,550 gpm
FF0-16	Replacement	12-inch	600 feet	2015	270	Increases FF from 980 to 1,150 gpm
FF1-00	New	8-inch	50 feet	2015	2,070	Increases FF from 380 to 2,450 gpm
FF1-01	New	16-inch	120 feet	2015	510	Increases FF from 690 to 1,200 gpm
FF1-02	New	12-inch	10 feet	2015	4,170	Increases FF from 1,030 to 5,200 gpm
FF1-03	New	16-inch	10 feet	2015	1,430	Increases FF from 1,100 to 2,530 gpm
FF1-04	New	6-inch	10 feet	2015	2,900	Connect 6-inch dead ends for improvement of neighborhood FF
FF1-05	New	8-inch	20 feet	2015	590	Increases FF from 930 to 1,510 gpm
FF1-06	New	20-inch	60 feet	2025	250	Connect 20-inch and 16-inch dead ends for improvement of neighborhood FF
FF1-07	New	6-inch	10 feet	2025	1,600	Connect 6-inch dead ends for improvement of neighborhood FF
FF2-00	Replacement	12-inch	600 feet	2015	3,780	Increases FF from 90 to 3,870 gpm
FF2-01	Replacement	8-inch	2,500 feet	2015	2,360	Increases FF from 120 to 2,480 gpm
FF2-02	Replacement	8-inch	1,000 feet	2015	1,510	Increases FF from 380 to 1,890 gpm
FF2-03	Replacement	8-inch	300 feet	2015	4,190	Increases FF from 430 to 4,620 gpm
FF2-04	Replacement	8-inch	50 feet	2015	2,280	Increases FF from 420 to 2,700 gpm
FF2-05	Replacement	6-inch	2,200 feet	2015	1,750	Increases FF from 410 to 2,160 gpm
FF2-06	Replacement	12-inch	20 feet	2015	3,110	Increases FF from 500 to

PROJECT ID	REPLACE / NEW	PROPSOED DIAMETER	LENGTH	PLAN YEAR PROPOSED	FF INCREASE (GPM)	COMMENTS
						3,610 gpm
FF2-07	Replacement	8-inch	20 feet	2015	1,450	Increases FF from 480 to 1,930 gpm
FF2-08	Replacement	8-inch	2,300 feet	2015	3,940	Increases FF from 640 to 4,580 gpm
FF2-09	Replacement	8-inch	1,100 feet	2015	4,350	Increases FF from 550 to 4,900 gpm
FF2-91	Replacement	6-inch	700 feet	2015	770	Increases FF from 980 to 1,750 gpm



WTP WTP

PS Pump_Stations

Ground Storage Tank

Elevated Storage Tank

Proposed_Tank_Areas

KBar Improvements

CIAC Improvements

Fire Flow Improvements

Diameter

Less than 12-inch

12 - 16-inch

16 - 24-inch

Greater than 24-inch

South Tampa

New Tampa

Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 15

Proposed
Fire Flow Improvements
Through 2035

5. Resilience and Reliability Improvements

Resilience is the capacity to recover quickly from a negative event. In the case of water utilities, a negative event can come in many forms due to both acute shocks and chronic stresses from anything from security threats to storm surges from hurricanes to power outages.

5.1 RESILIENCE AND RELIABILITY GOALS

For this Potable Water Master Plan, resilience and reliability needs were assessed from the acute shock perspective of losing one of the TWDs major facilities. Several scenarios were analyzed to determine if the distribution system has sufficient redundancy to be resilient to single asset failures at the DLTWTF and each of the RPSs in both the existing system and in 2035 under MDD. Improvements were identified with the goal of creating complete redundancy for each facility. The results of the system analysis are included in **Appendix A.**

5.2 RECOMMENDED RESILIENCE IMPROVEMENTS

5.2.1 Interbay RPS

The Interbay RPS is the sole source of water for the South Tampa pressure zone, however, that is a recent development due to the closing of several valves along the Gandy Blvd. that created a pressure boundary. Should the Interbay RPS fail, those same valves could be opened and the zone could be absorbed into the DLTWTF zone and supplied by the DLTWTF and other RPSs. To make that process more seamless and less manually intensive, Black & Veatch recommends installing check valves along the pressure zone boundary, which would automatically open if the pressures within the South Tampa pressure zone were less than the pressures within the DLTWTF zone. These valves should be equipped with sensors to alert the operations staff should they be active and opened.

5.2.2 Morris Bridge RPS and 54-inch Transmission Main

With the addition of the planned improvements at the Morris Bridge RPS and the TBW interconnect, the RPS is now completely redundant, and no new improvements are recommended. If the RPS fails, the bypass for the TBW interconnect can then supply the North Tampa pressure zone with up to 40 MGD directly or the valves isolating the North Tampa zone can be opened and supplied by the DLTWTF zone.

Similarly, if the 48-inch/54-inch transmission main, which normally supplies flow the Morris Bridge RPS, fails, the TBW interconnect can be activated and used to supply the pressure zone. Depending on where the break occurs, Pumps 1-4 can also discharge south to absorb the portion of the DLTWTF zone isolated from supply.

However, should the TBW interconnect be used on a regular basis as a water supply source, the built-in redundancy would be lost. Should this become the base Black & Veatch would recommend installing a water main parallel to the 48-inch/54-inch water main that supplies the Morris Bridge RPS. This project has been included in the CIP and should be implemented if the TBW interconnect becomes a normal supply of water to meet the system demands.

5.2.3 Northwest, West Tampa and Palma Ceia RPSs

The Northwest, West Tampa, and Palma Ceia RPSs have complete redundancy under the existing system demands. However with the increased demands in 2035, the RPSs become more critical. Losing any of the three RPSs during a MDD means the distribution system may not meet the City's minimum system pressure criteria; however, the system remains in compliance with minimum regulatory pressures. Additional elevated storage or a new RPS would allow for complete redundancy for 24-hours for the West Tampa and Palma Ceia RPSs and would increase the resilience of the distribution system. A discussion of the benefits of elevated storage versus a new RPS with ground storage is included in the DTLWTF storage options section above.

One additional water main improvement project is needed in addition to the new storage to increase east-west transmission capacity for complete redundancy of the Northwest RPS as shown in **Figure 16**. The water main improvement project consists of a combined 7,900-ft of 16-inch and 20-inch pipe along Hillsborough Ave.

5.2.4 DLTWTF High Service Pump Station

An event that resulted in the inability to operate the DLTWTF and associated HSPS would have the greatest negative impacts to the operation of the system. It is assumed that TWD would communicate with customers to request reduced water consumption during this type of scenario to keep demands to ADD conditions or less, rather than MDD. Based on this assumption and a 24-hour DLTWTF failure scenario, the TWD could make the following system configuration changes:

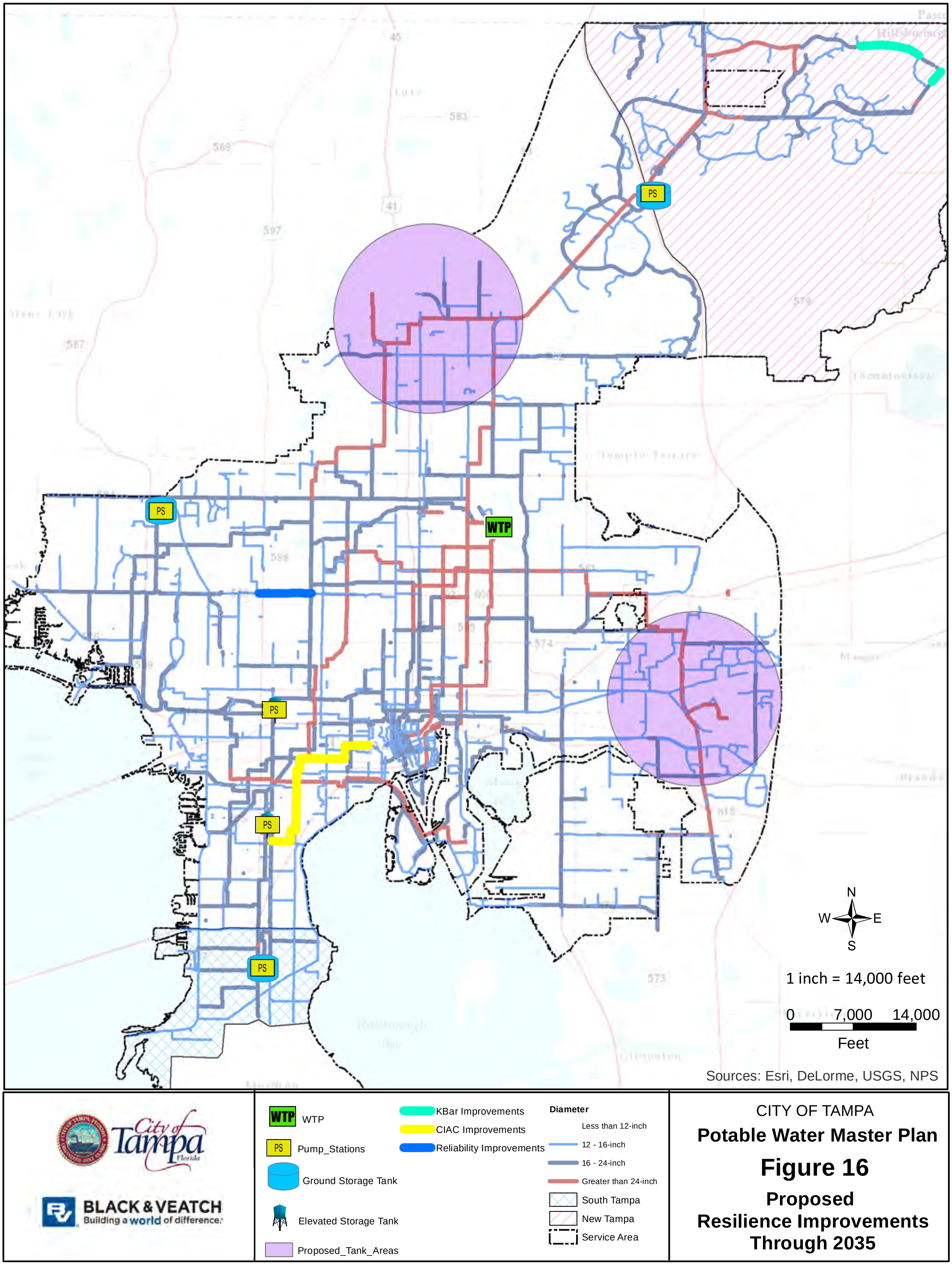
- The TWD would activate all of the interconnections with neighboring utilities allowing for a supply of 70 MGD from Tampa Bay Water (40 MGD at Morris Bridge and 30 MGD at US301).
- Pumps 1-4 at Morris Bridge would be activated to pump south into the DLTWTF pressure zone. This would provide around 40 MGD to the DLTWTF zone while the North Tampa zone relies on the storage volume of the two tanks.
- The supply to Interbay and Morris Bridge RPSs would stop or be reduced to about 0.5 MGD based on 2035 ADD.

Under these conditions and without additional supply and/or storage in the DLTWTF zone, the system could meet the existing ADD for 24 hours, but would still need an additional 5.5 MGD by 2035. The additional supply can come in the form of additional storage or additional interconnections with neighboring utilities. Black & Veatch recommends a combination of additional storage, which will also increase redundancy of the RPSs, and an additional 6 MGD interconnect with Hillsborough County or Tampa Bay Water.

Figure 17 illustrates the location of the Hillsborough County and Tampa Bay Water transmission mains which are the preferred interconnect locations. One such location could be with Hillsborough County just north of the Northwest RPS. The interconnection flow could discharge directly into the distribution system, if feasible based on the County's operational pressures, or into the Northwest tank. Note that this option requires negotiations and cooperation with each utility.

5.2.5 Recommended Resilience Improvement Summary

To achieve full redundancy of each RPS and tank within the distribution system Black & Veatch recommends: 1) 6,000-ft of 20-inch and 1,900-ft of 16-inch water main along Hillsborough Ave; 2) One 3.5-MG and one 2.0-MG elevated storage tanks; and 3)An additional 6 MG interconnection, likely with Hillsborough County.



City of Tampa Florida

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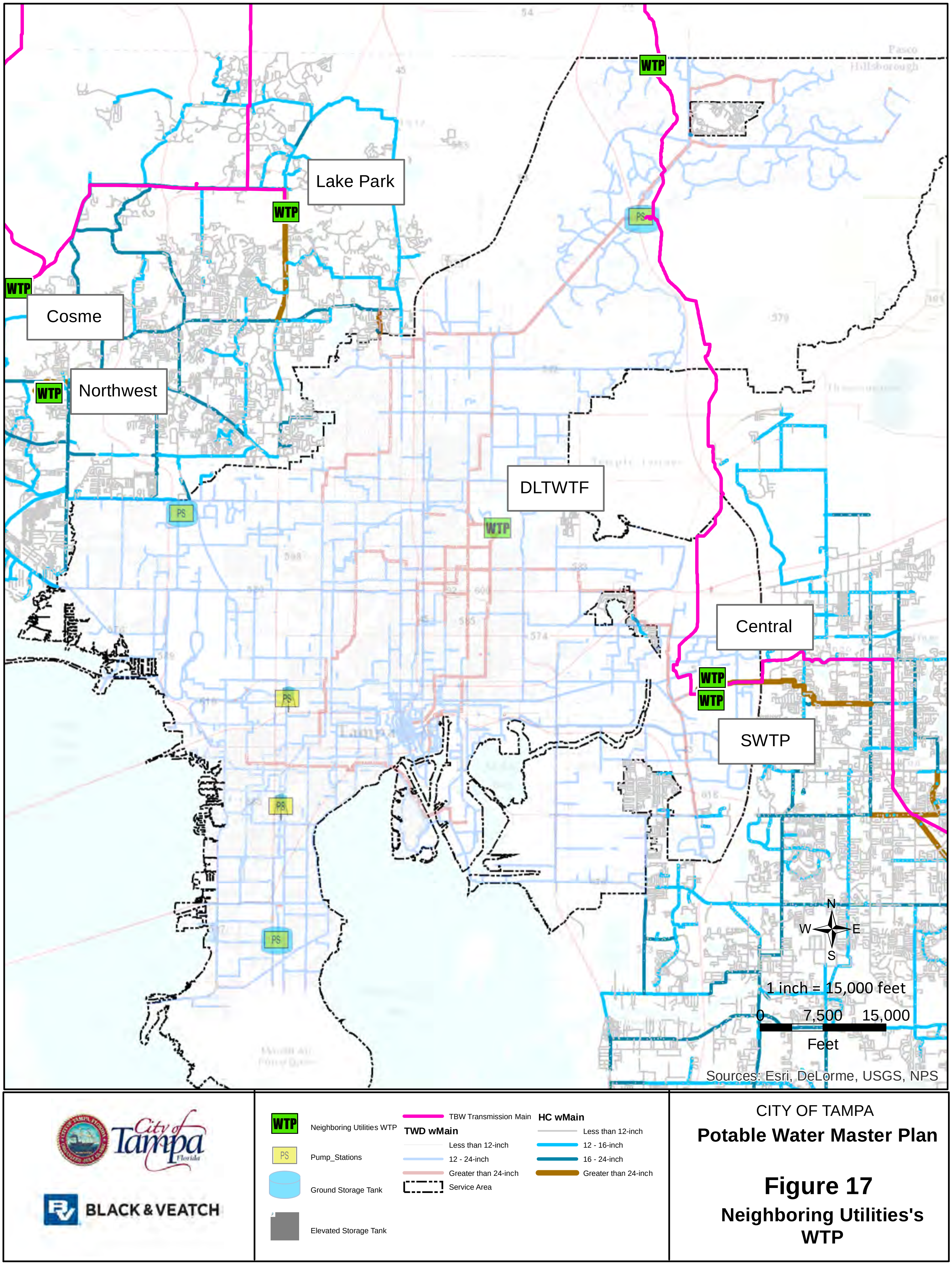
CITY OF TAMPA

Potable Water Master Plan

Figure 16

Proposed Resilience Improvements Through 2035



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Potable Water Master Plan

Figure 17

Neighboring Utilities's WTP

6. Water Quality Analysis

The water quality analysis consists of a hydraulic water age analysis to iteratively refine the proposed capacity, fire flow, and resilience improvements to ensure that the improvements do not detrimentally affect the water age and thus the potential water quality of the distribution system.

6.1 EXISTING SYSTEM WATER AGE

A water age analysis for the base year (2015) was performed as part of the distribution system analyses to set a baseline for comparing to water ages in future planning year analyses. As part of the water age analysis, tank mixing model parameters were assumed based on tank volume and inlet/outlet configuration and assigned to storage tanks as summarized in **Table 17**.

Table 17 Tank Mixing Models

#	TANK	MIXING MODEL	COMMENTS
1	Morris Bridge	First in / First Out	This models the flow through the tank similar to "plug flow" with no mixing and where the first water to enter the tank is the first to leave the tank. This was selected because each of the ground storage tanks have separated inlet and outlet pipes.
2	Interbay	First in / First Out	
3	Northwest	First in / First Out	
4	West Tampa	Complete Mix	This models a completely mixed tank where all water that enters the tank is subsequently and completely mixed with the water already in the tank. This option was selected due to the relatively small size of these tanks and the high flowrate at which these tanks typically fill.
5	Palma Ceia	Complete Mix	

Generally, the model results show that the water age of the existing system is less than 5 days with small pockets around the tanks with ages up to 10 days. Additionally, the water age in each of the small pressure zones is in the 5 to 10 day range. This is attributed to all of the supply to these small zones going through the ground storage tanks. The results of the system analysis are included in **Appendix A.** It is important to note that though water age is commonly used to water quality analysis, it has limitations and should be used to check the impacts of new improvements. It is not uncommon to have poor correlations between water age and chlorine residuals due to the numerous factors affecting chlorine consumption. Black & Veatch would recommend a full water quality calibration with chlorine residual or a surrogate sampling to truly understand the water quality of the distribution system.

6.2 IMPACTS OF PROPOSED IMPROVEMENTS ON WATER AGE

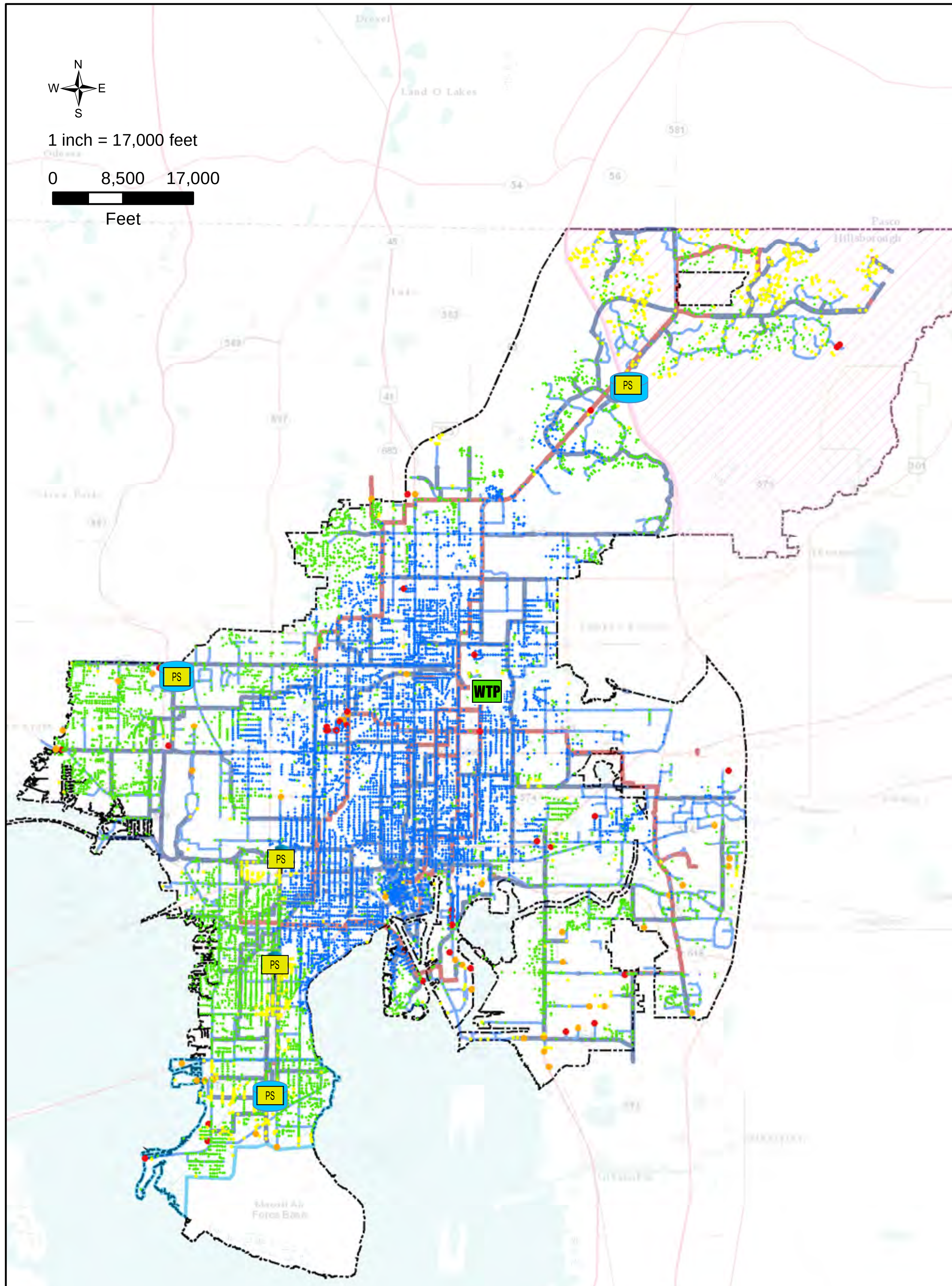
Most of the proposed improvements have negligible impacts on water age with the exception of the proposed Broadway EST. This improvement increases the water age in the southeast portion of the system to approximately 10 days, which is an increase of 5 days. Additionally if determined appropriate during design, the tank could be designed with a motorized isolation valve and pump to force turnover during low demand periods. The phasing of the tank should also coincide with increased demands throughout the DLTWTF zone and not be constructed before the system conditions warrant it to avoid potential water age/water quality impacts.

CITY OF TAMPA

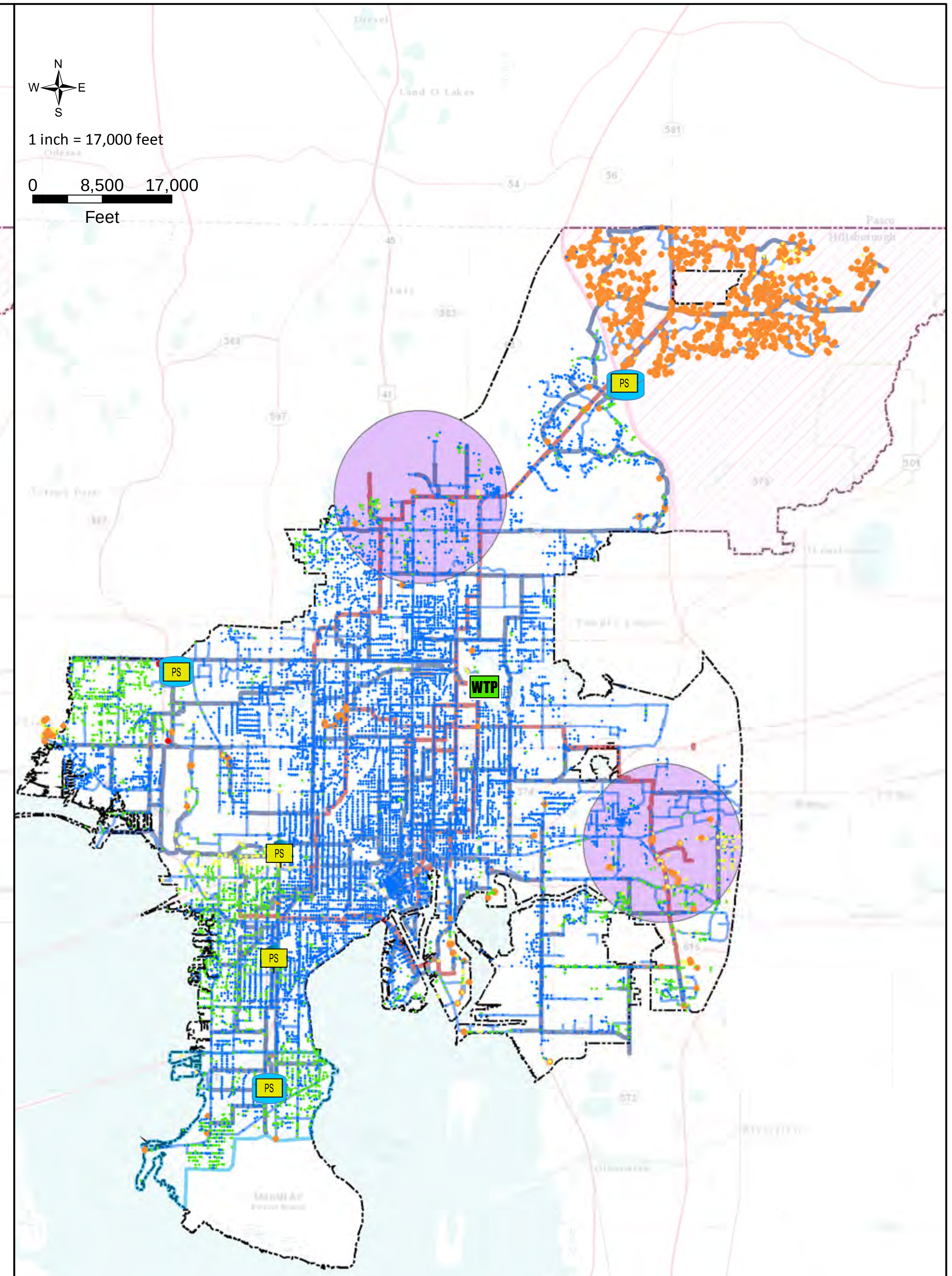
Potable Water Master Plan

Figure 18

Proposed Planning Year 2035
ADD
Water Age



Planning Year 2015
Existing System Assessment
Water Age



Proposed Planning Year 2035
Proposed System
Water Age Increase

WTP
Pump Stations
Ground Storage Tank
Elevated Storage Tank

Water Age Increase

Water Age Increase

Less than 1 day
1 - 5 days
5 - 10 days
10 - 20 days
Greater than 20 days

wMain

Diameter

< 12-inch
12 - 16-inch
16 - 24-inch
> 24-inch
Proposed_Tank_Areas
South Tampa
New Tampa
Service Area

City of Tampa Florida

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7. Summary of Recommended Improvements

Black & Veatch has identified a number of recommended improvement projects to not only address the regulatory and traditional performance criteria such as storage and pumping capacity, pressures, and fire flow, but also to increase the resilience of the distribution system due to potential asset failures. These recommended improvements will be combined with the R&R improvements identified in Phase 700 of the Potable Water Master Plan to create a comprehensive capital improvement plan (CIP). **Figure 19** shows the compilation of recommended improvement projects, and **Figure 20** and **Figure 21** show the proposed 2035 system conditions once projects have been implemented.

7.1 PRIORITIZATION AND IMPLEMENTATION OF IMPROVEMENTS

Improvements were identified through planning year 2035 based on the available population projection information, and then a phased implementation schedule was created based on the intermediate planning year demands. However, demand projections are constantly changing and can cause a project to be needed before or after the initially identified planning year. Therefore, a trigger based on demands, operational conditions, etc. was identified for each recommended improvement. The prioritization summarized in **Table 18** will be further refined with the TWD during a CIP prioritization workshop prior to finalizing the improvements for the City's CIP.

7.2 SUMMARY OF RECOMMENDED IMPROVEMENTS

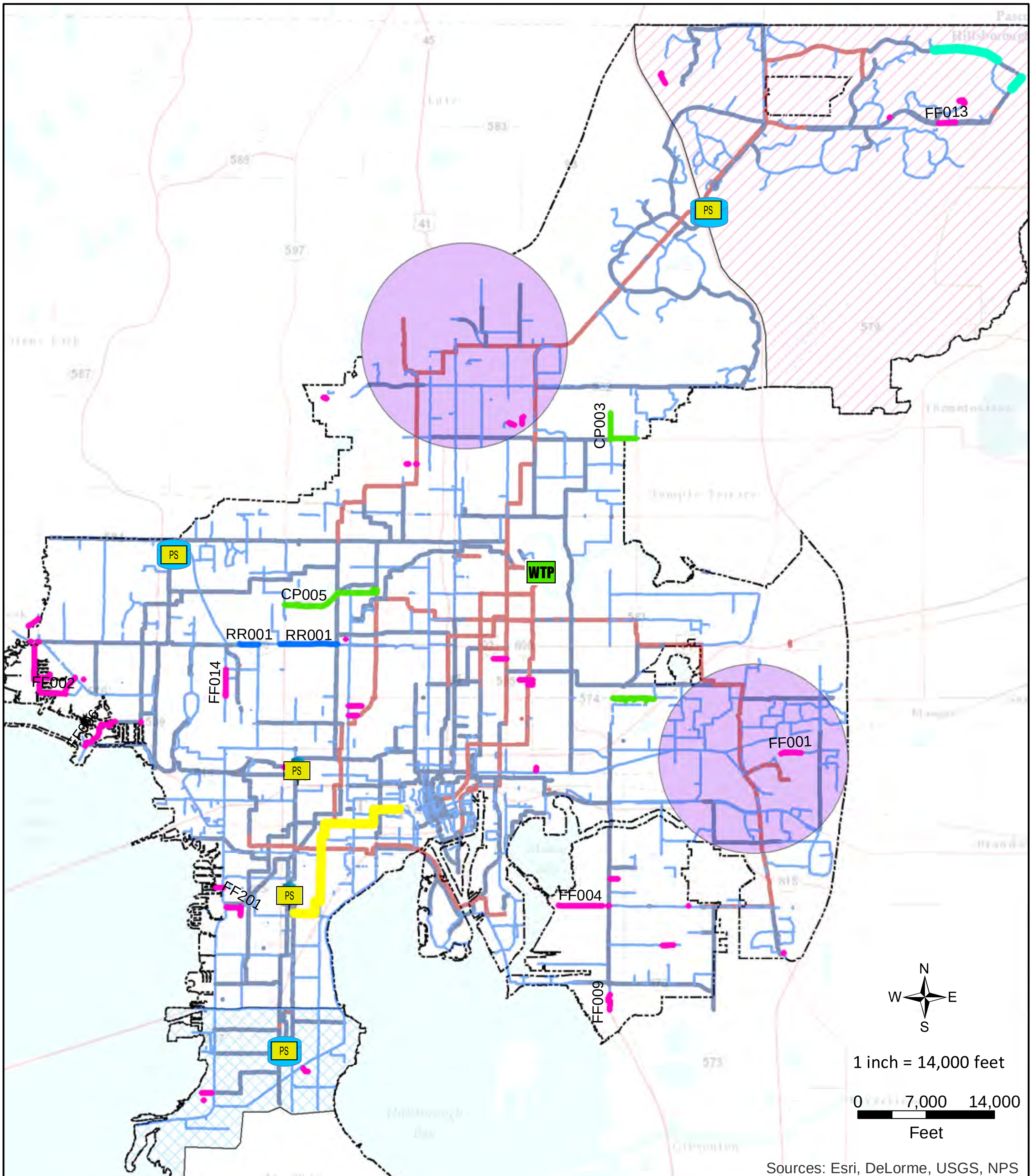
Table 18 Facility Criticality Assessment with Improvements

#	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR
A	CIAC Water Main	As shown on Figure 19	Planned	Capital	2017
B	KBar Water Main	As shown on Figure 19	Planned	Capital	2017
C	Morris Bridge RPS Upgrade	Piping and pump upgrades	Planned	Capital	2017
1	IB, NW and MB Tank Inlet Sleeve Valves	Installation of sleeve valves with flow control functions at the inlet to the Interbay, Northwest and Morris Bridge Tanks	Tank turnover / DLTWTF Flows	Capital: Operational flexibility	2019
2	DLTWTF Discharge Pressure	Increase DLTWTF HSPS discharge pressure to 70 psi; slowly / incrementally	Min pressures	Operational / Controls	2018
3	RPS controls modifications	Modify the NWRPS, WTRPS and PCRPS to operate during peak demand periods rather than time of day	Increased reliance on DLTWTF HSPS	Operational / Controls	2018
4	DLTWTF Blending Chamber, Clearwell and HSPS Upgrades	Demo 2.0 MG and 0.5 MG clearwells, convert 7.5 MG clearwell to blending chamber, install new 13.0 MG clearwell, demo pumps 1-6 and install new 140 MGD HSPS	Condition of the existing clearwells	R&R and Expansion	2020
5	HSPS Expansion	Install additional pumping capacity at the new HSPS building total new capacity = 153 MGD	DLTWTF Pressure Zone Demands	Performance Criteria: Pump Capacity	2030

#	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR
			greater than 135 MGD	Expansion	
6	Northeast (Nebraska) EST	Installation of a new EST in the north portion of the DLTWTF	DLTWTF Pressure Zone Demands greater than 130 MGD	Resilience	2025
7	Southeast (Broadway) EST	Installation of a new EST in the north portion of the DLTWTF	DLTWTF Pressure Zone Demands greater than 135 MGD	Resilience	2030
8	Commercial Fire Flow Study	Perform an analysis of the required commercial fire flow needs be conducted and commercial fire flow corridors be identified	Fire Flow Demands	Study	2018
9	South Tampa Check Valves	Install check valves along South Tampa Pressure Zone (along Gandy Blvd)	Opportunistic	Resilience	TBD
10	Hillsborough County Interconnect	Interconnect with Hillsborough County in the northwest portion of the system either directly into the distribution system or the Northwest Tank	DLTWTF Pressure Zone Demands greater than 140 MGD	Resilience	2030
11	West Tampa and Palma Ceia Flow Meters	Install flow monitors on the effluent side of the West Tampa and Palma Ceia RPS's and connect to the data historian	Data Collection	Operational / Controls	2018
12	RPS Power Monitors	Install power monitors on all RPS equipment and connect to the data historian	Data Collection	Operational / Controls	2018
13	DLTWTF Clearwell Groundwater Level Study	Collection of data related to the groundwater level on the site in anticipation of the design of a new clearwell structure	DLTWTF Blending Chamber, Clearwell and HSPS Upgrade Project	Capacity	2018
14	Water Quality Model Calibration Study	Collect water quality data throughout the system in order to conduct a calibration of the existing water quality model	Water Quality	Study	2018
15	R-01 Hillsborough Ave WM	6,000-ft of 12-inch pipe along Hillsborough Ave.	DLTWTF Pressure Zone Demands greater than 125 MGD	Resilience	2025

#	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR
16	CP003	12-inch; 1 Mile 16-inch; 200 feet	System Pressures	Capacity	2020
17	CP004	12-inch; 1 mile	System Pressures	Capacity	2025
18	CP005	8-inch; 800 feet 12-inch; 2 miles	System Pressures	Capacity	2035
19	FF0-01	12-inch; 4,600 feet	Opportunistic	Fire Flow	2018
20	FF0-02	8-inch; 1,250 feet	Opportunistic	Fire Flow	2018
21	FF0-03	12-inch; 4,600 feet	Opportunistic	Fire Flow	2018
22	FF0-04	12-inch; 1,200 feet	Opportunistic	Fire Flow	2018
23	FF0-05	16-inch; 1 mile	Opportunistic	Fire Flow	2018
24	FF0-06	12-inch; 3,300 feet	Opportunistic	Fire Flow	2018
25	FF0-07	8-inch; 800 feet	Opportunistic	Fire Flow	2018
26	FF0-08	12-inch; 1,400 feet	Opportunistic	Fire Flow	2018
27	FF0-09	12-inch; 1,100 feet	Opportunistic	Fire Flow	2018
28	FF0-10	8-inch; 800 feet	Opportunistic	Fire Flow	2018
29	FF0-11	8-inch; 800 feet	Opportunistic	Fire Flow	2018
30	FF0-12	12-inch; 900 feet	Opportunistic	Fire Flow	2018
31	FF0-13	8-inch; 1,900 feet	Opportunistic	Fire Flow	2018
32	FF0-14	12-inch; 2,800 feet	Opportunistic	Fire Flow	2018
33	FF0-15	12-inch; 600 feet	Opportunistic	Fire Flow	2018
34	FF0-16	8-inch; 50 feet	Opportunistic	Fire Flow	2018
35	FF1-00	16-inch; 120 feet	Opportunistic	Fire Flow	2018
36	FF1-01	12-inch; 10 feet	Opportunistic	Fire Flow	2018
37	FF1-02	16-inch; 10 feet	Opportunistic	Fire Flow	2018
38	FF1-03	6-inch; 10 feet	Opportunistic	Fire Flow	2018
39	FF1-04	8-inch; 20 feet	Opportunistic	Fire Flow	2018
40	FF1-05	20-inch; 60 feet	Opportunistic	Fire Flow	2018
41	FF1-06	6-inch; 10 feet	Opportunistic	Fire Flow	2025
42	FF1-07	12-inch; 600 feet	Opportunistic	Fire Flow	2025
43	FF2-00	8-inch; 2,500 feet	Opportunistic	Fire Flow	2018
44	FF2-01	8-inch; 1,000 feet	Opportunistic	Fire Flow	2018
45	FF2-02	8-inch; 300 feet	Opportunistic	Fire Flow	2018
46	FF2-03	8-inch; 50 feet	Opportunistic	Fire Flow	2018
47	FF2-04	6-inch; 2,200 feet	Opportunistic	Fire Flow	2018
48	FF2-05	12-inch; 20 feet	Opportunistic	Fire Flow	2018

#	PROJECT NAME	PROJECT DESCRIPTION	PROJECT TRIGGER	PROJECT TYPE	ANTICIPATED DESIGN YEAR
49	FF2-06	8-inch; 20 feet	Opportunistic	Fire Flow	2018
50	FF2-07	8-inch; 2,300 feet	Opportunistic	Fire Flow	2018
51	FF2-08	8-inch; 1,100 feet	Opportunistic	Fire Flow	2018
52	FF2-09	6-inch; 700 feet	Opportunistic	Fire Flow	2018
53	FF2-91	12-inch; 4,600 feet	Opportunistic	Fire Flow	2018



WTP
PS Pump_Stations
Ground Storage Tank
Elevated Storage Tank
Proposed_Tank_Areas
KBar Improvements
CIAC Improvements
Capacity Improvements
Fire Flow Improvements
Resilience Improvements

Diameter
Less than 12-inch
12 - 16-inch
16 - 24-inch
Greater than 24-inch
South Tampa
New Tampa
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 19

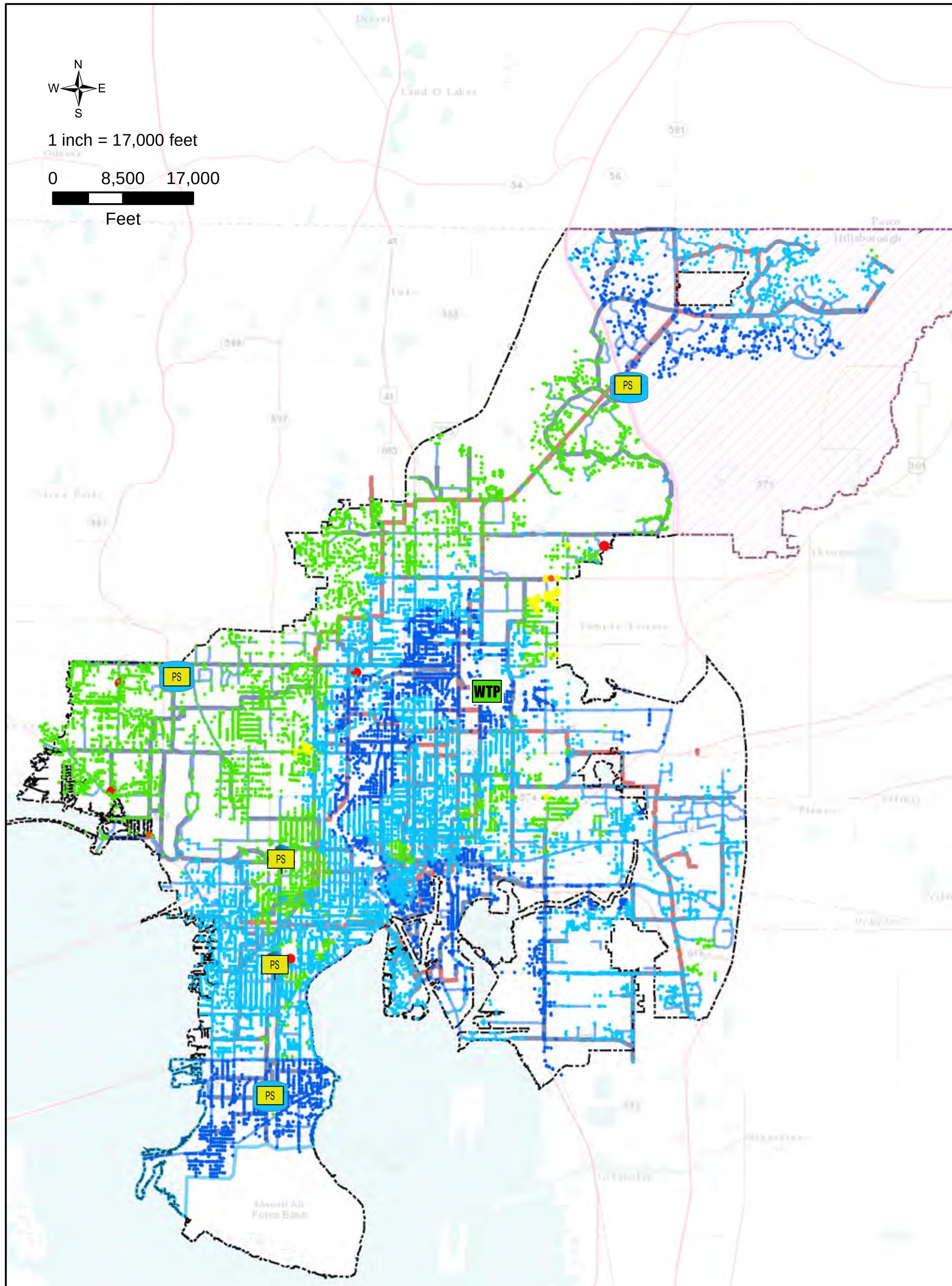
Proposed Improvements Through 2035

CITY OF TAMPA

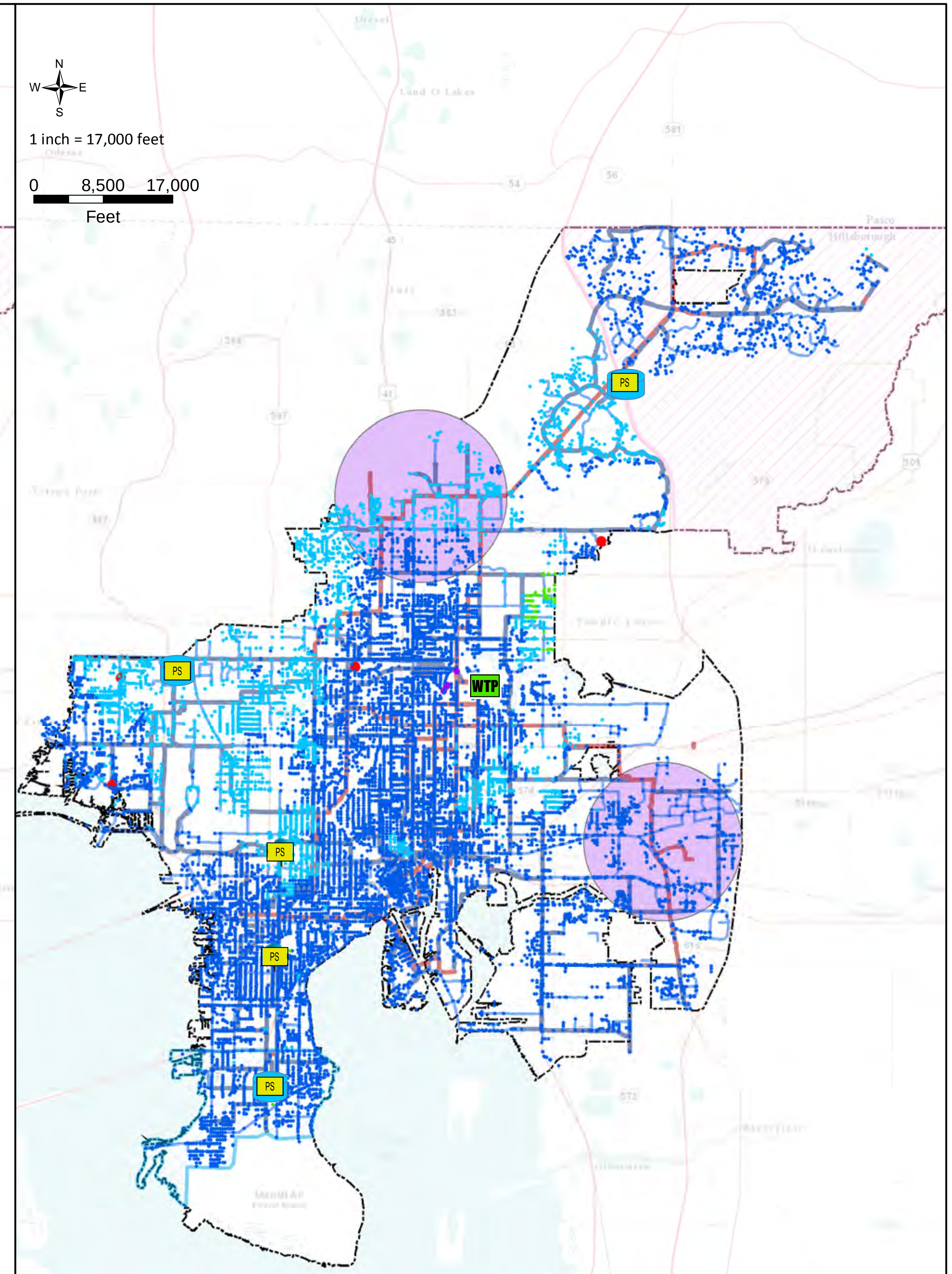
Potable Water Master Plan

Figure 20

Proposed Planning Year 2035
MDD with 24Hr EPS
Minimum Pressures



Planning Year 2035
Existing System Assessment
Minimum Pressures



Proposed Planning Year 2035
MDD with 24Hr EPS
Minimum Pressures

WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Minimum Pressures

MIN_PRESSURE

- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

wMain

Diameter

- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch

Proposed_Tank_Areas

South Tampa

New Tampa

Service Area

City of Tampa Florida

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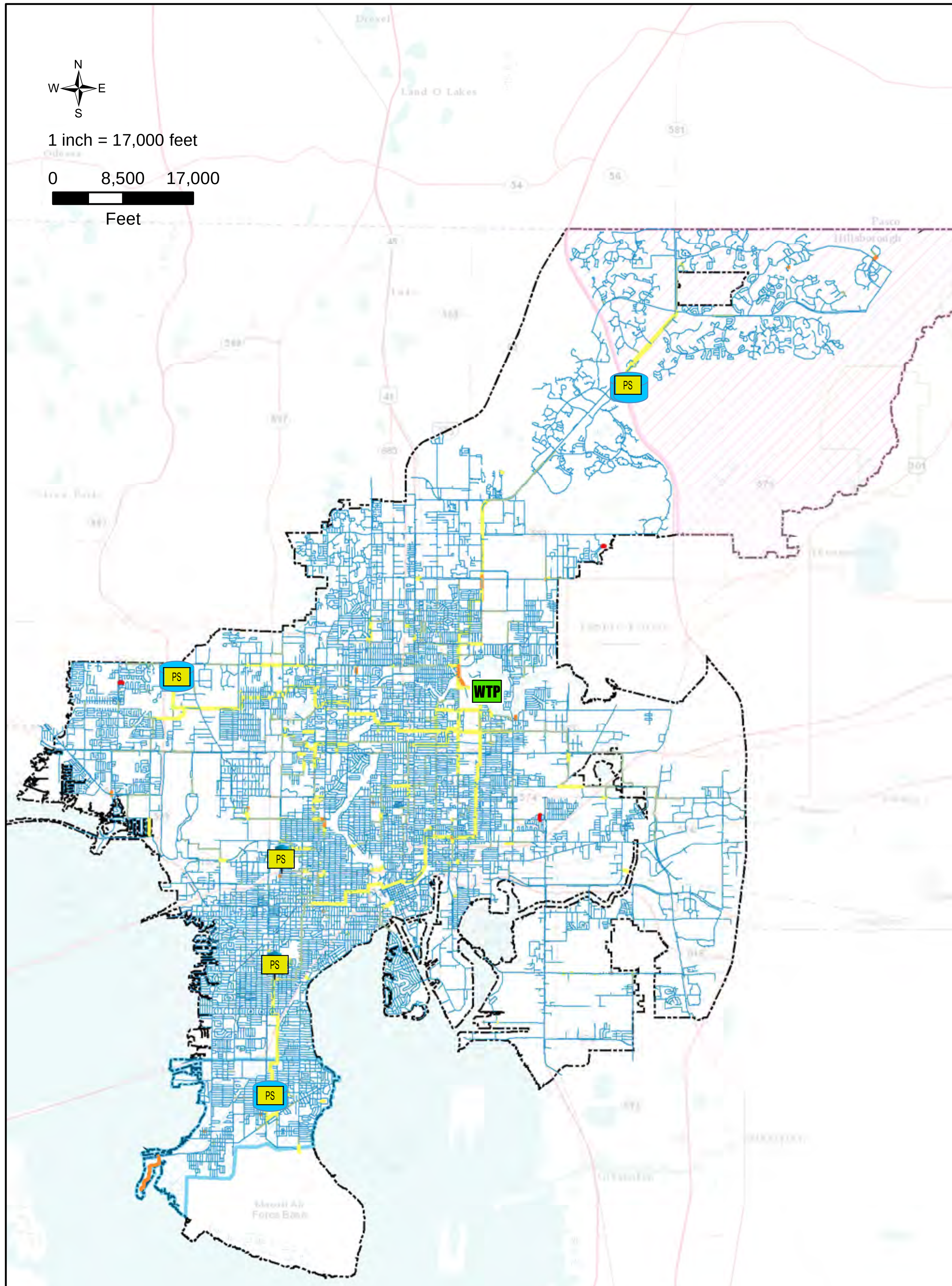
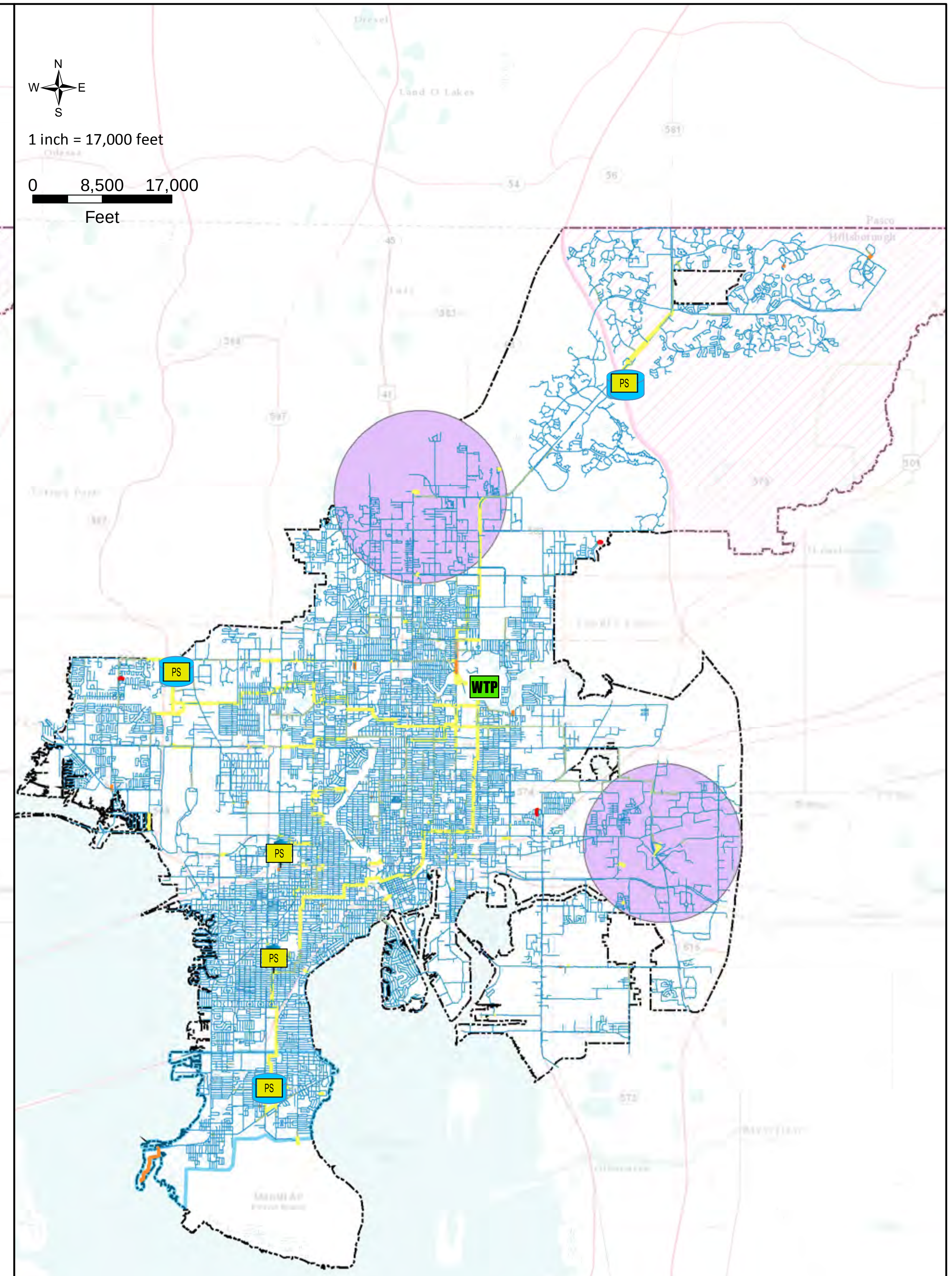
Potable Water Master Plan

Figure 21

Proposed Planning Year 2035 MDD with 24Hr EPS Maximum Velocity



Planning Year 2035
Existing System Assessment
Maximum Velocity



Proposed Planning Year 2035
MDD with 24Hr EPS
Maximum Velocity

WTP
Pump Stations
Ground Storage Tank
Elevated Storage Tank

Max Velocity

Max. Velocity

Less than 2 fps
2 - 3 fps
3 - 5 fps
5 - 10 fps
Greater than 10 fps
Proposed_Tank_Areas
South Tampa
New Tampa
Service Area

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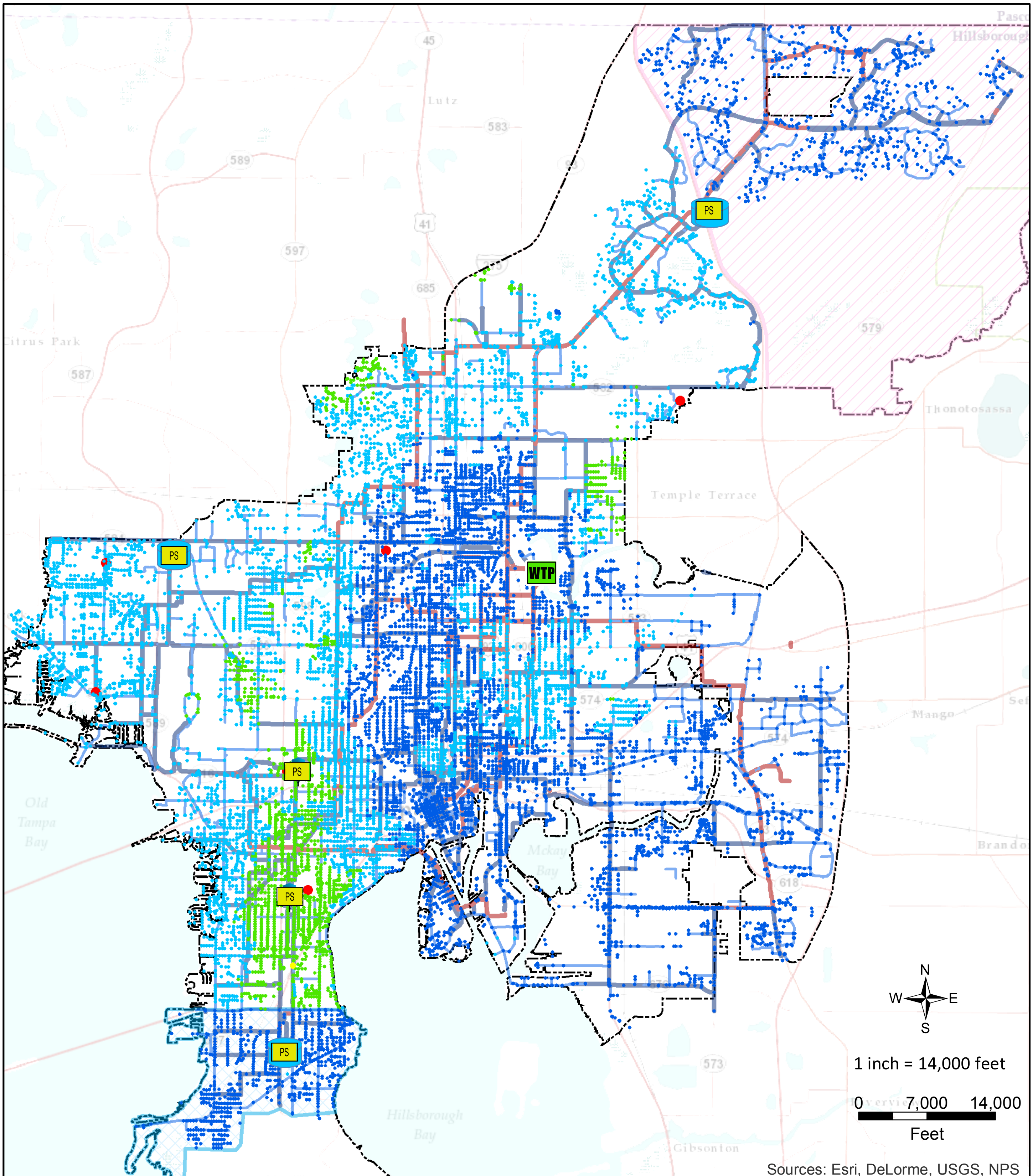
Appendix A

Hydraulic Model Results

Table of Contents



City of Tampa Florida

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WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

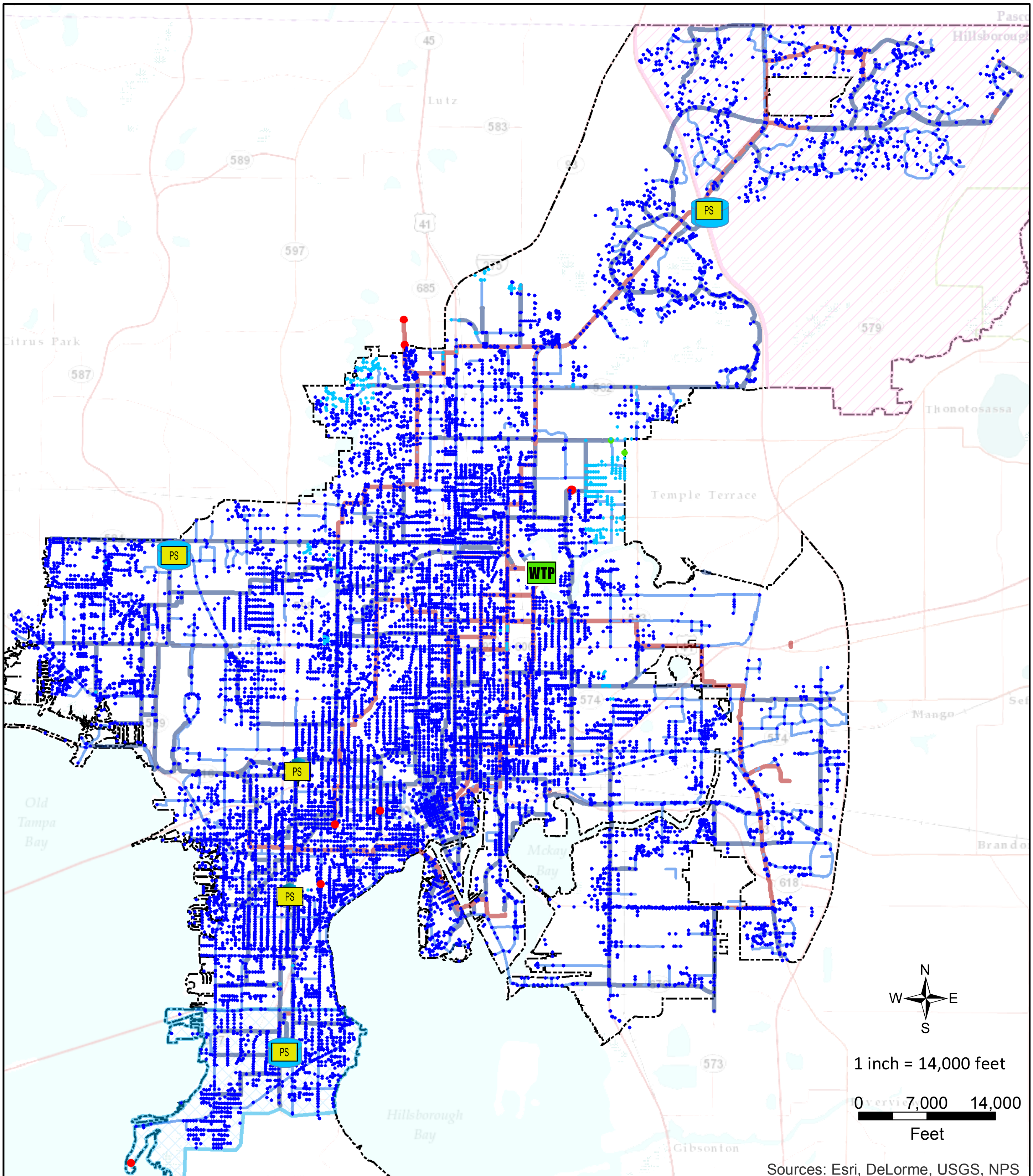
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 1.01

Base Year 2015
MDD with 24Hr EPS
Minimum Pressures



WTP

PS Pump Stations

Ground Storage Tank

Elevated Storage Tank

MAX_PRESSURE
- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

City of Tampa Florida

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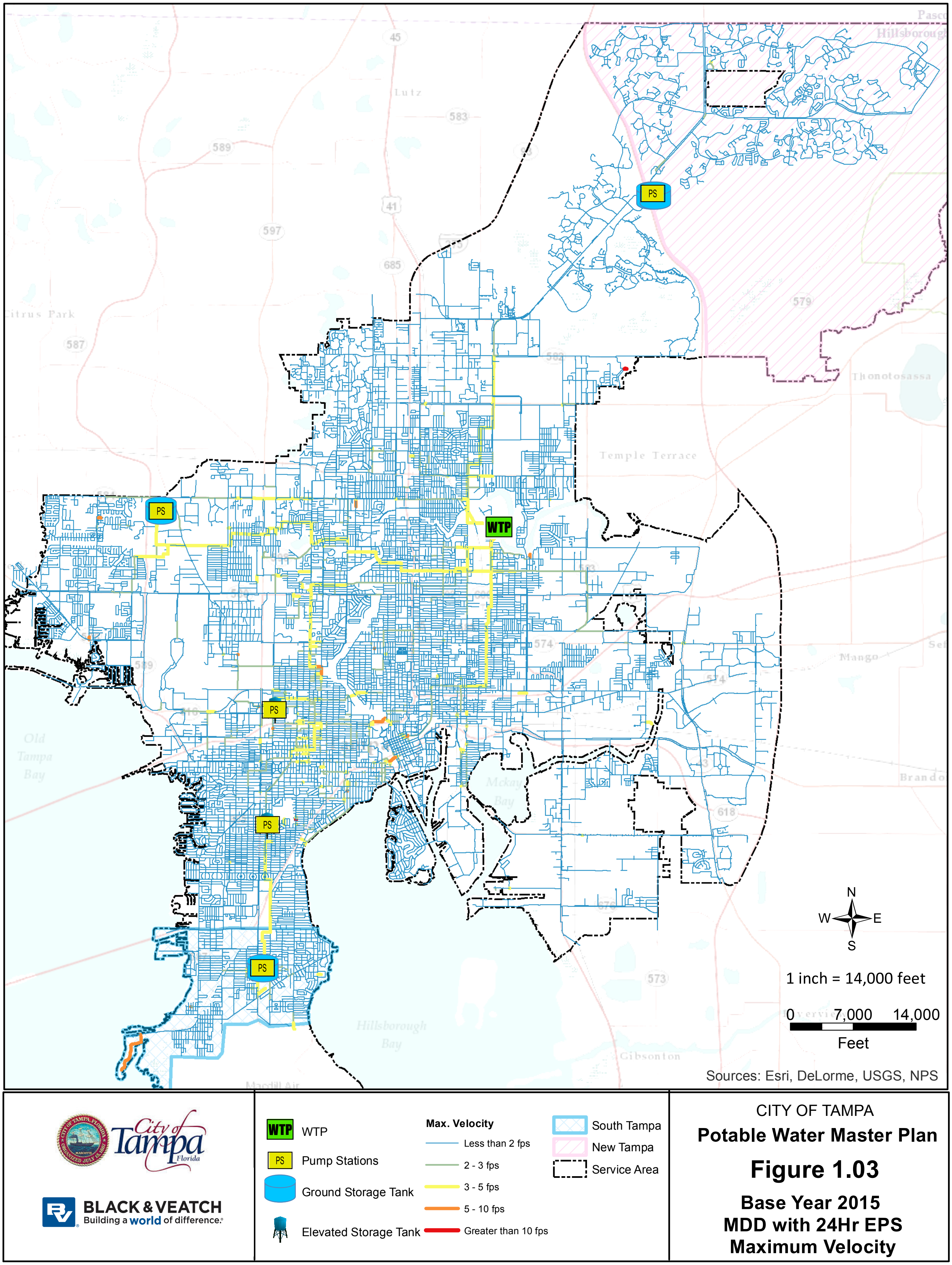
Potable Water Master Plan

Figure 1.02

Base Year 2015
MDD with 24Hr EPS
Maximum Pressures

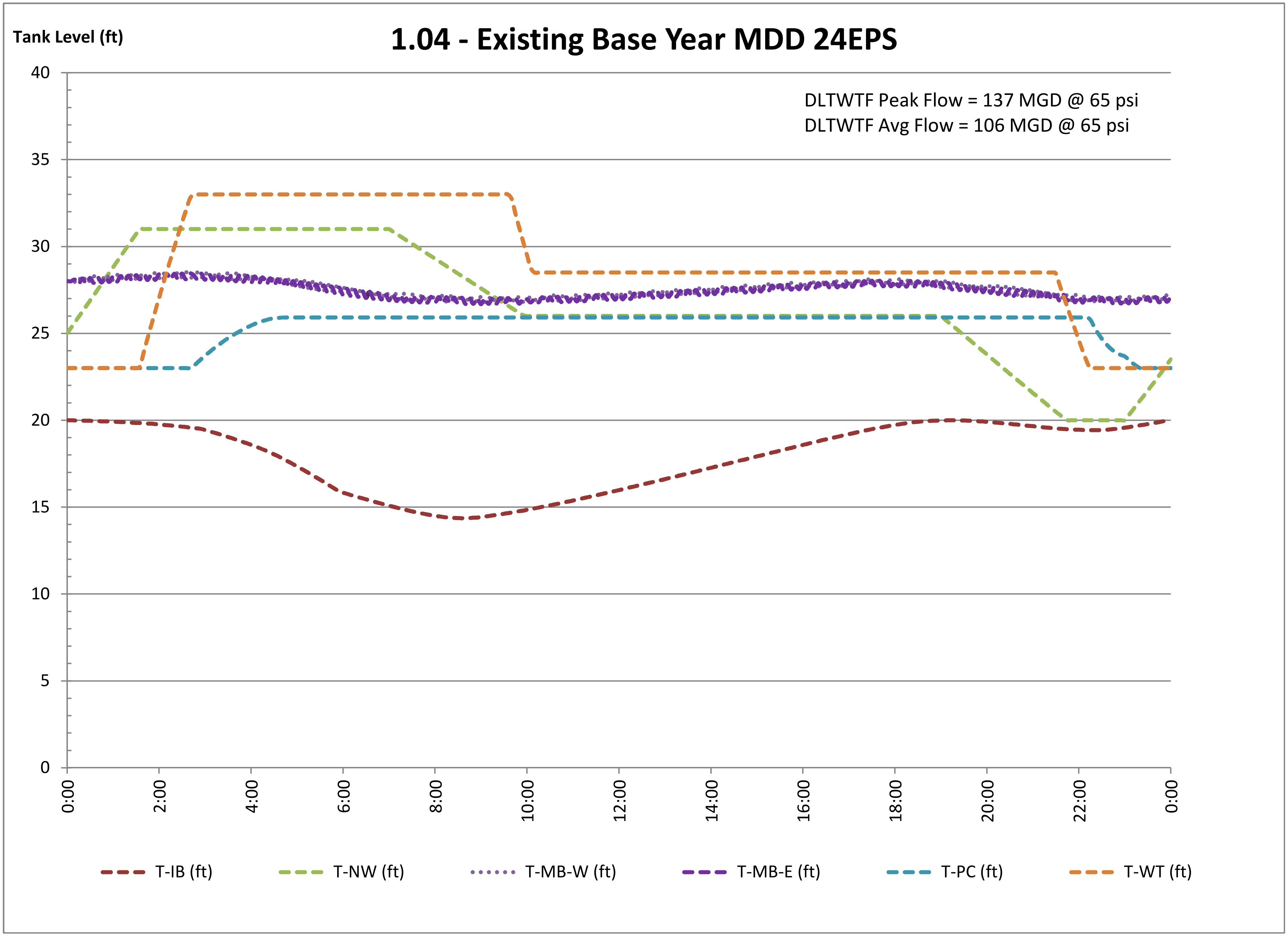


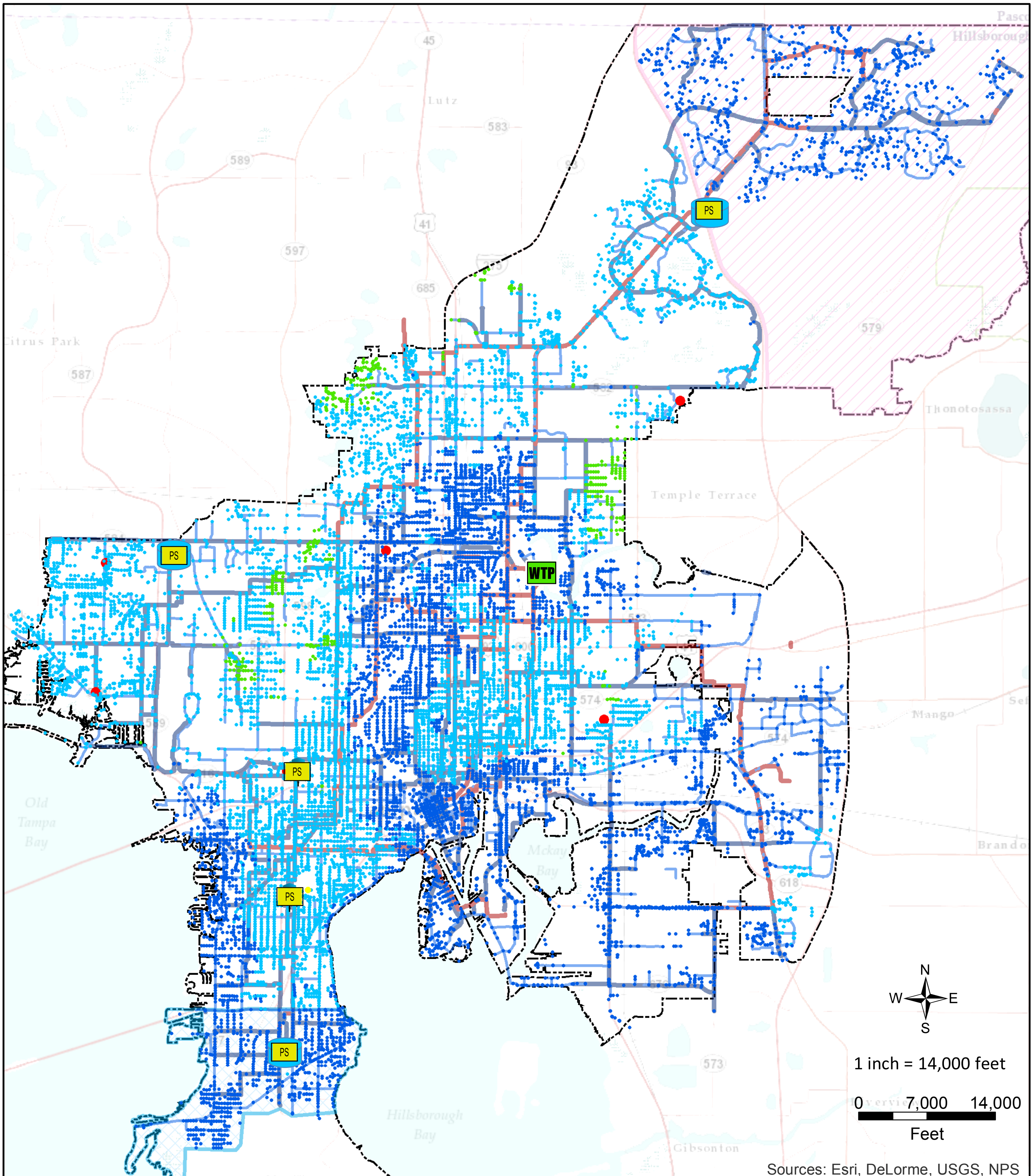
CITY OF TAMPA

Potable Water Master Plan

Figure 1.03

Base Year 2015
MDD with 24Hr EPS
Maximum Velocity


Tank Level (ft)
1.04 - Existing Base Year MDD 24EPS
DLTWTF Peak Flow = 137 MGD @ 65 psi
DLTWTF Avg Flow = 106 MGD @ 65 psi
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
T-IB (ft)
T-NW (ft)
T-MB-W (ft)
T-MB-E (ft)
T-PC (ft)
T-WT (ft)



City of Tampa Florida

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WTP — WTP
PS — Pump Stations
Ground Storage Tank
Elevated Storage Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

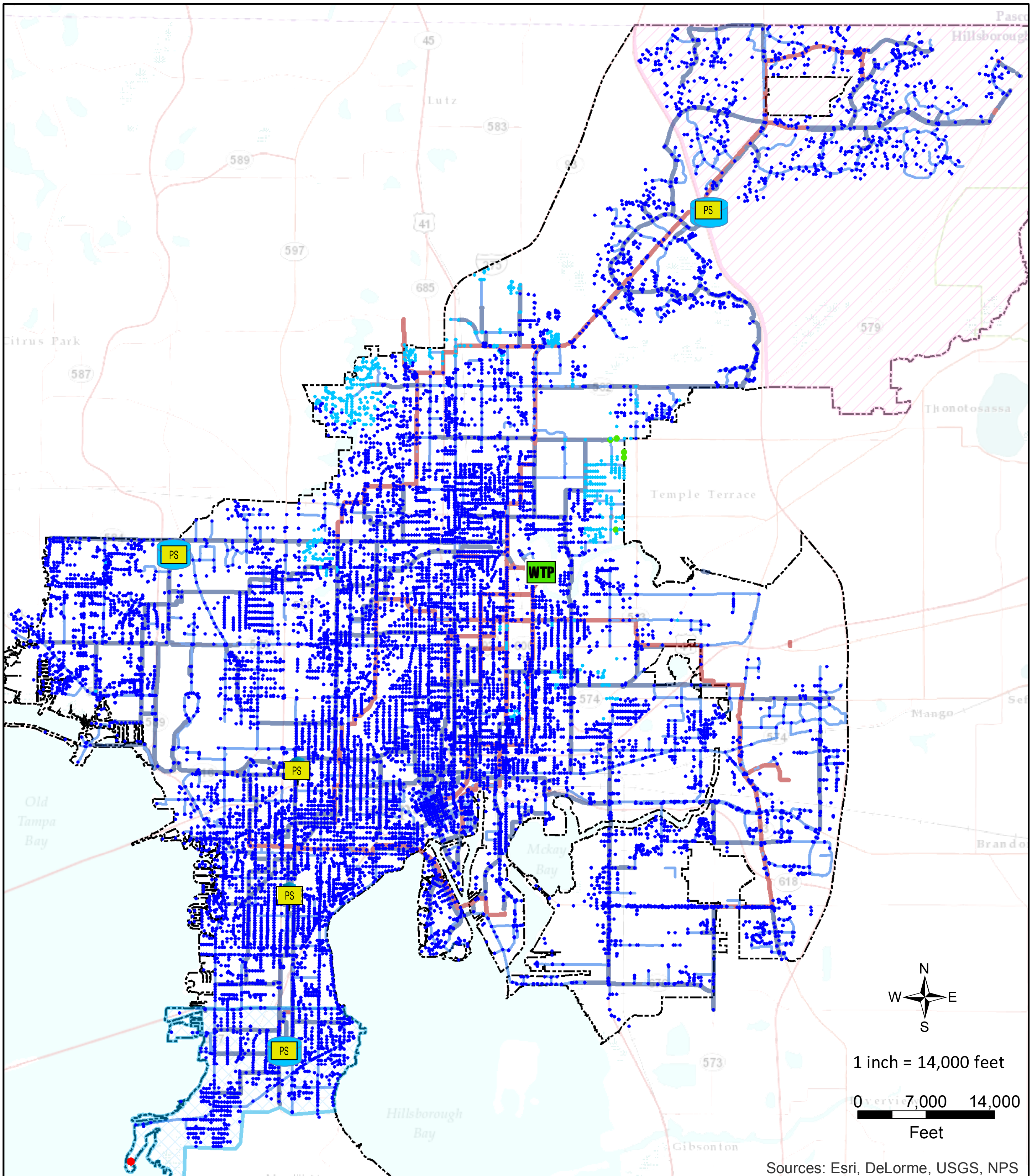
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 1.05

Planning Year 2020
MDD with 24Hr EPS
Minimum Pressures



City of Tampa Florida

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WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Maximum Pressures

MAX_PRESSURE

- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter

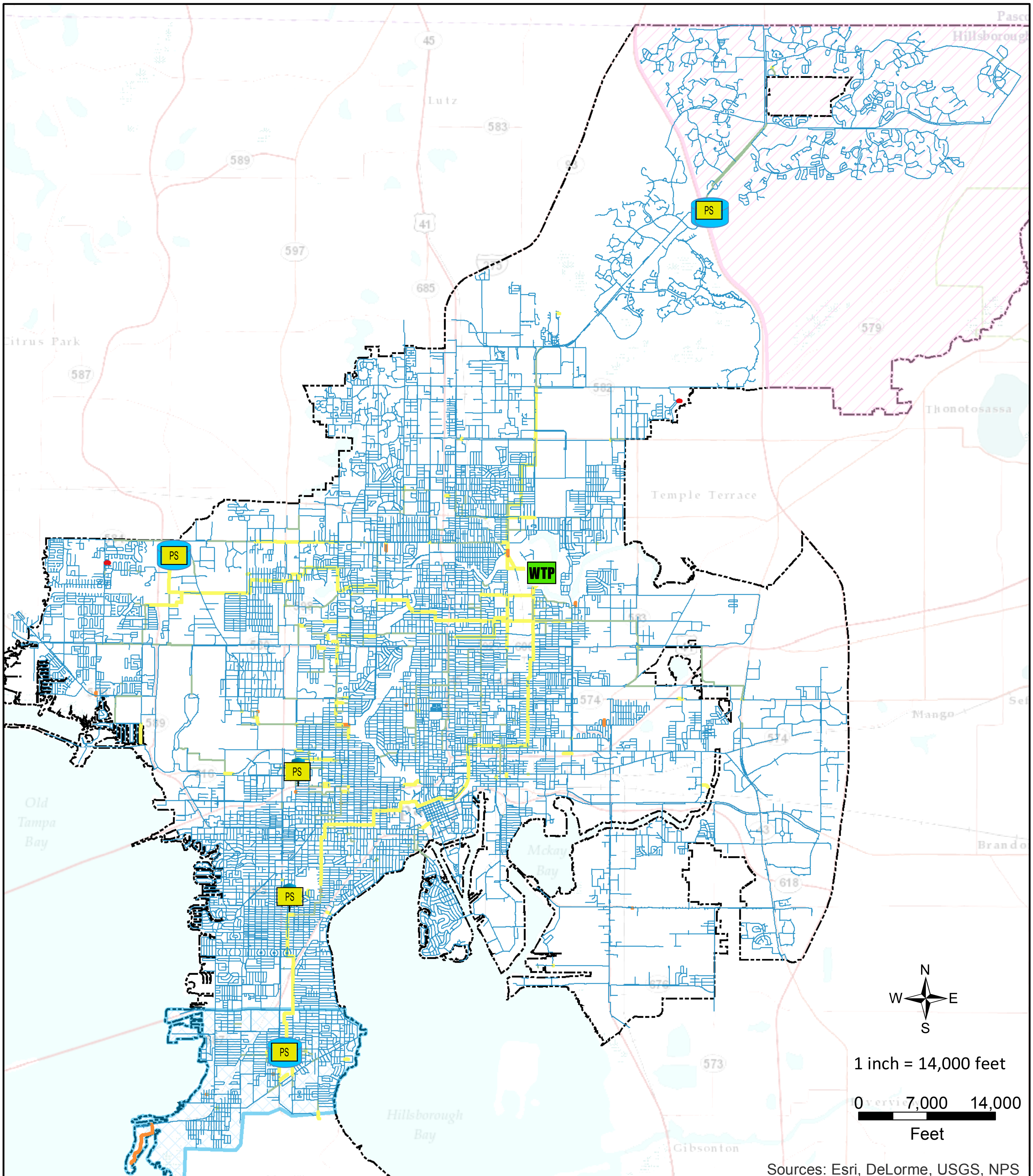
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 1.06

Planning Year 2020
MDD with 24Hr EPS
Maximum Pressures



CITY OF TAMPA

Potable Water Master Plan

Figure 1.07

Planning Year 2020
MDD with 24Hr EPS
Maximum Velocity

Legend		
WTP	**Max. Velocity**	South Tampa
Pump Stations	Less than 2 fps	New Tampa
Ground Storage Tank	2 - 3 fps	Service Area
Elevated Storage Tank	3 - 5 fps	
	5 - 10 fps	
	Greater than 10 fps	

City of Tampa Florida

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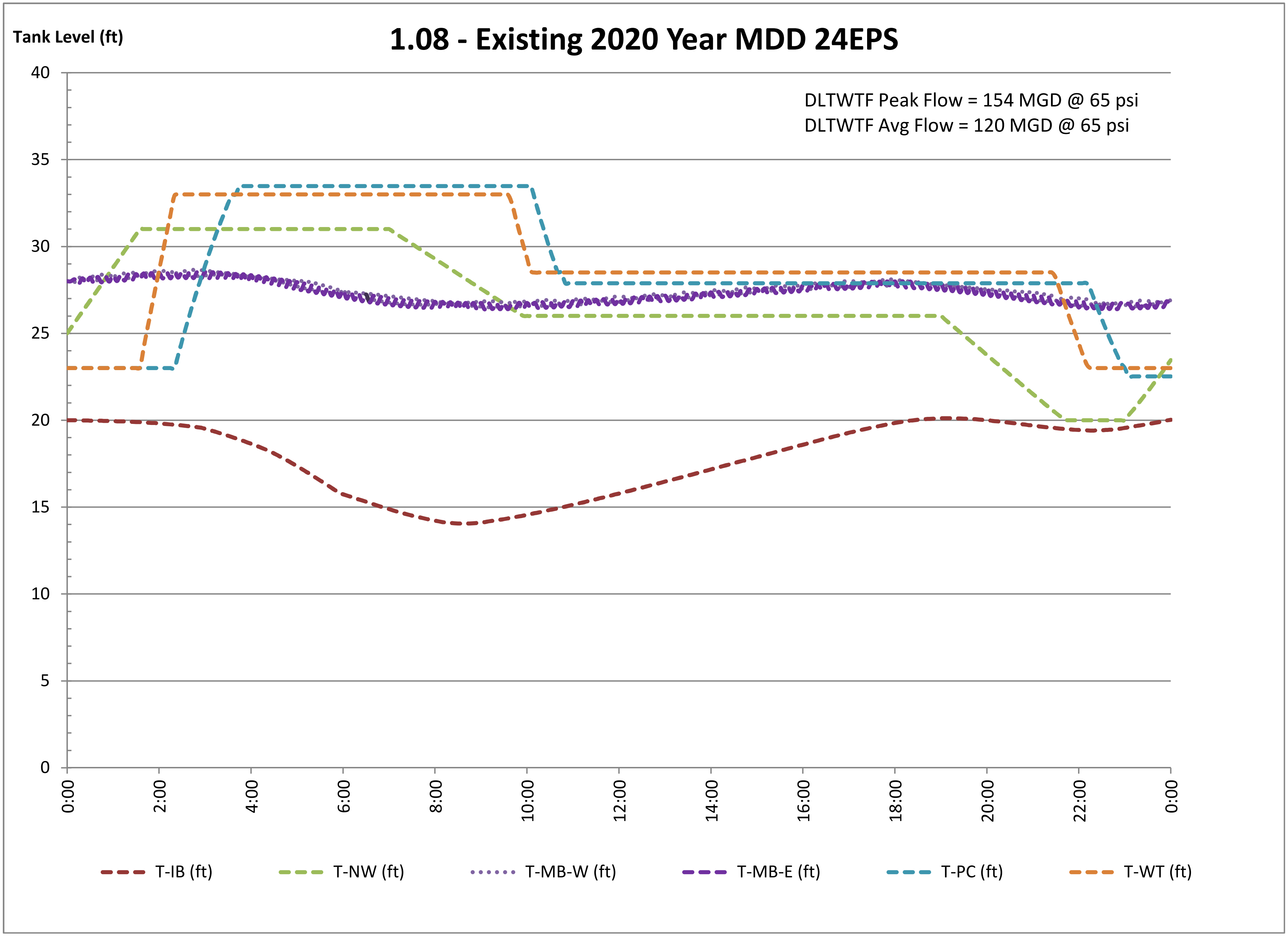
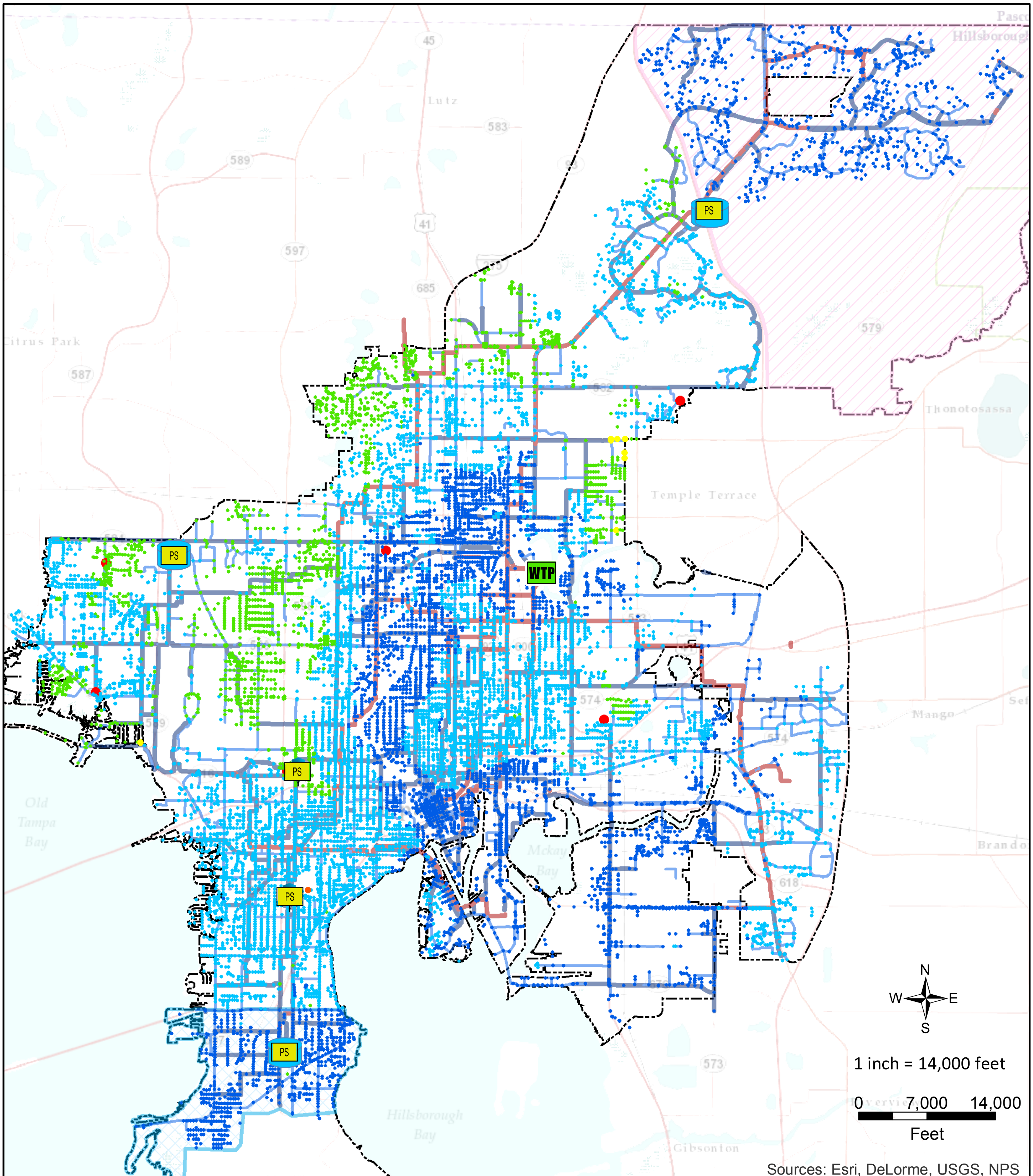


Tank Level (ft)
1.08 - Existing 2020 Year MDD 24EPS
DLTWTF Peak Flow = 154 MGD @ 65 psi
DLTWTF Avg Flow = 120 MGD @ 65 psi
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
T-IB (ft)
T-NW (ft)
T-MB-W (ft)
T-MB-E (ft)
T-PC (ft)
T-WT (ft)



City of Tampa Florida

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WTP
Pump Stations
Ground Storage Tank
Elevated Storage Tank

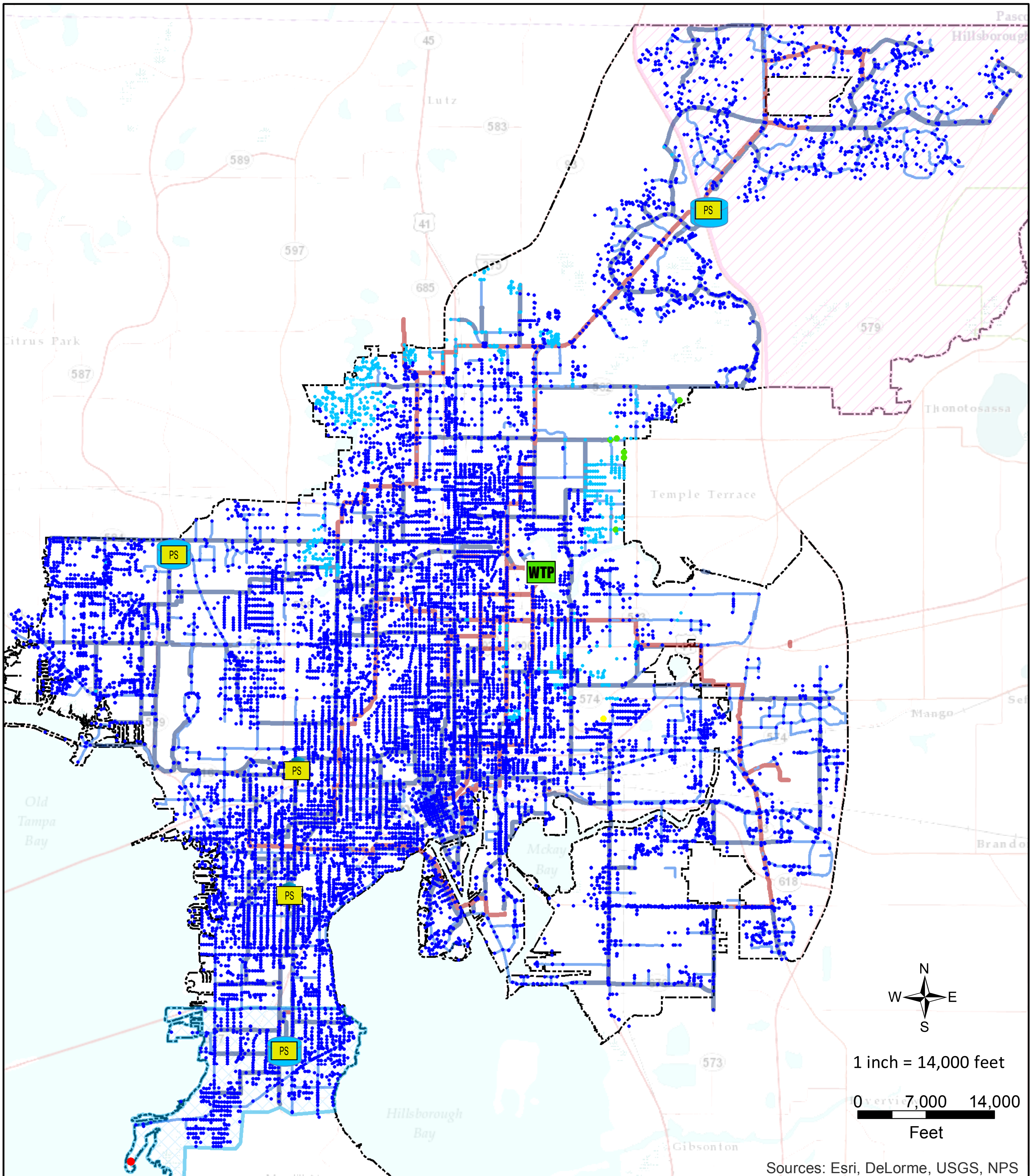
MIN_PRESSURE	Diameter
Below 20 psi	< 12-inch
20 - 25 psi	12 - 16-inch
25 - 30 psi	16 - 24-inch
30 - 40 psi	> 24-inch
40 - 50 psi	South Tampa
50 - 75 psi	New Tampa
75 - 85 psi	Service Area
Greater than 85 psi	

CITY OF TAMPA

Potable Water Master Plan

Figure 1.09

Planning Year 2025
MDD with 24Hr EPS
Minimum Pressures



City of Tampa Florida

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WTP — WTP
PS — Pump Stations
Ground Storage Tank
Elevated Storage Tank

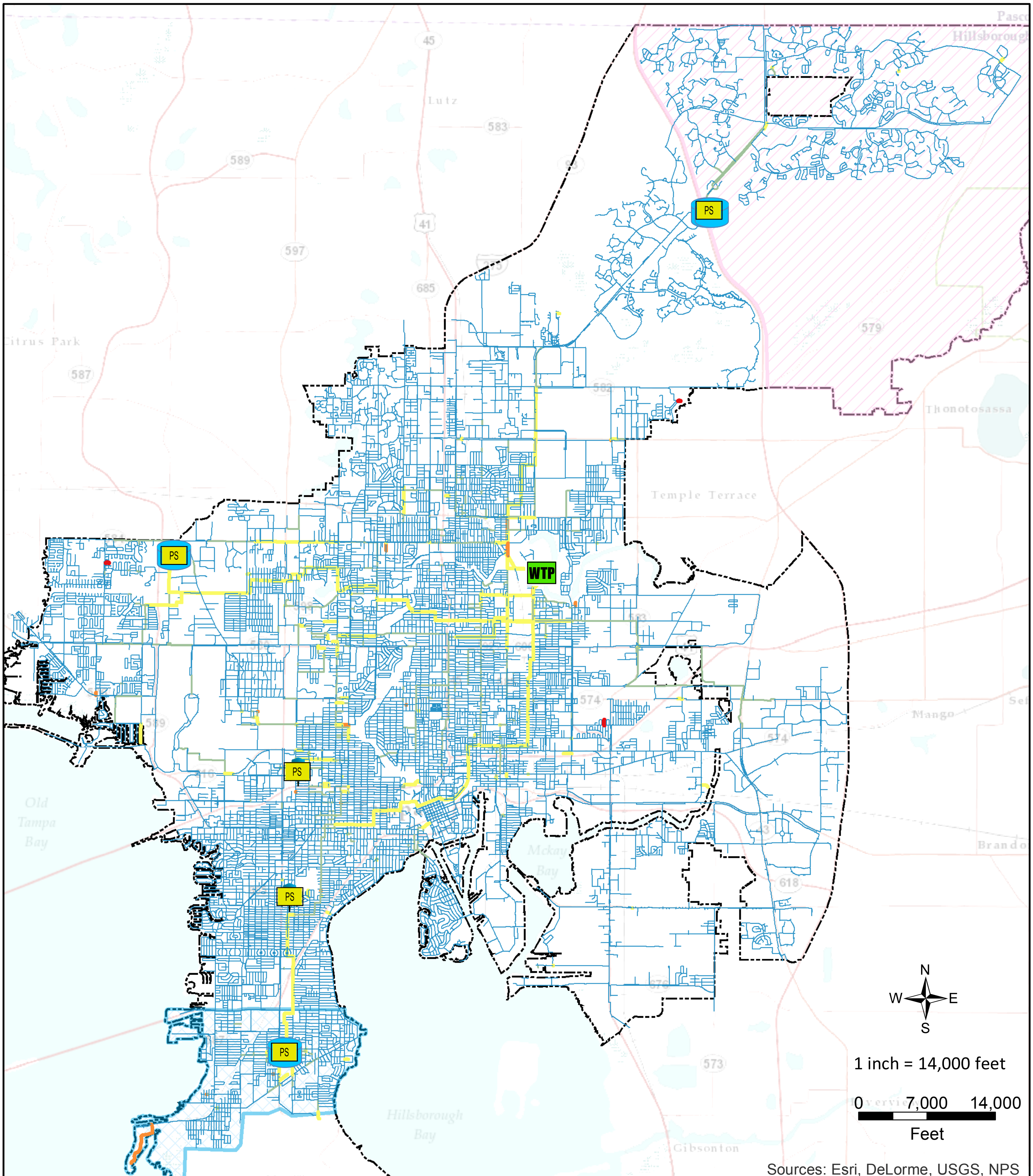
Maximum Pressures
MAX_PRESSURE
- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA
Potable Water Master Plan

Figure 1.10

Planning Year 2025
MDD with 24Hr EPS
Maximum Pressures



WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Max. Velocity

- Less than 2 fps
- 2 - 3 fps
- 3 - 5 fps
- 5 - 10 fps
- Greater than 10 fps

South Tampa

New Tampa

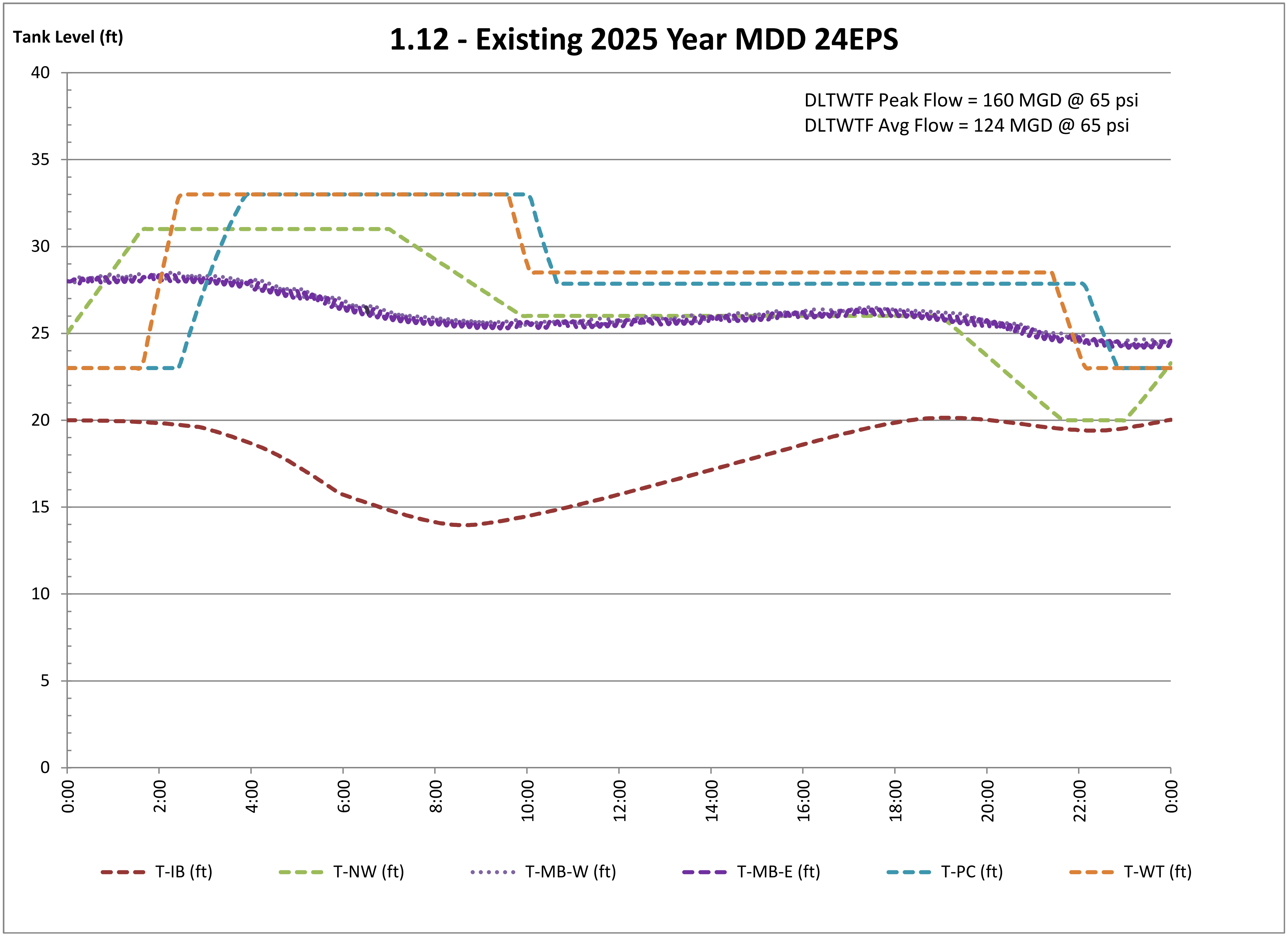
Service Area

CITY OF TAMPA

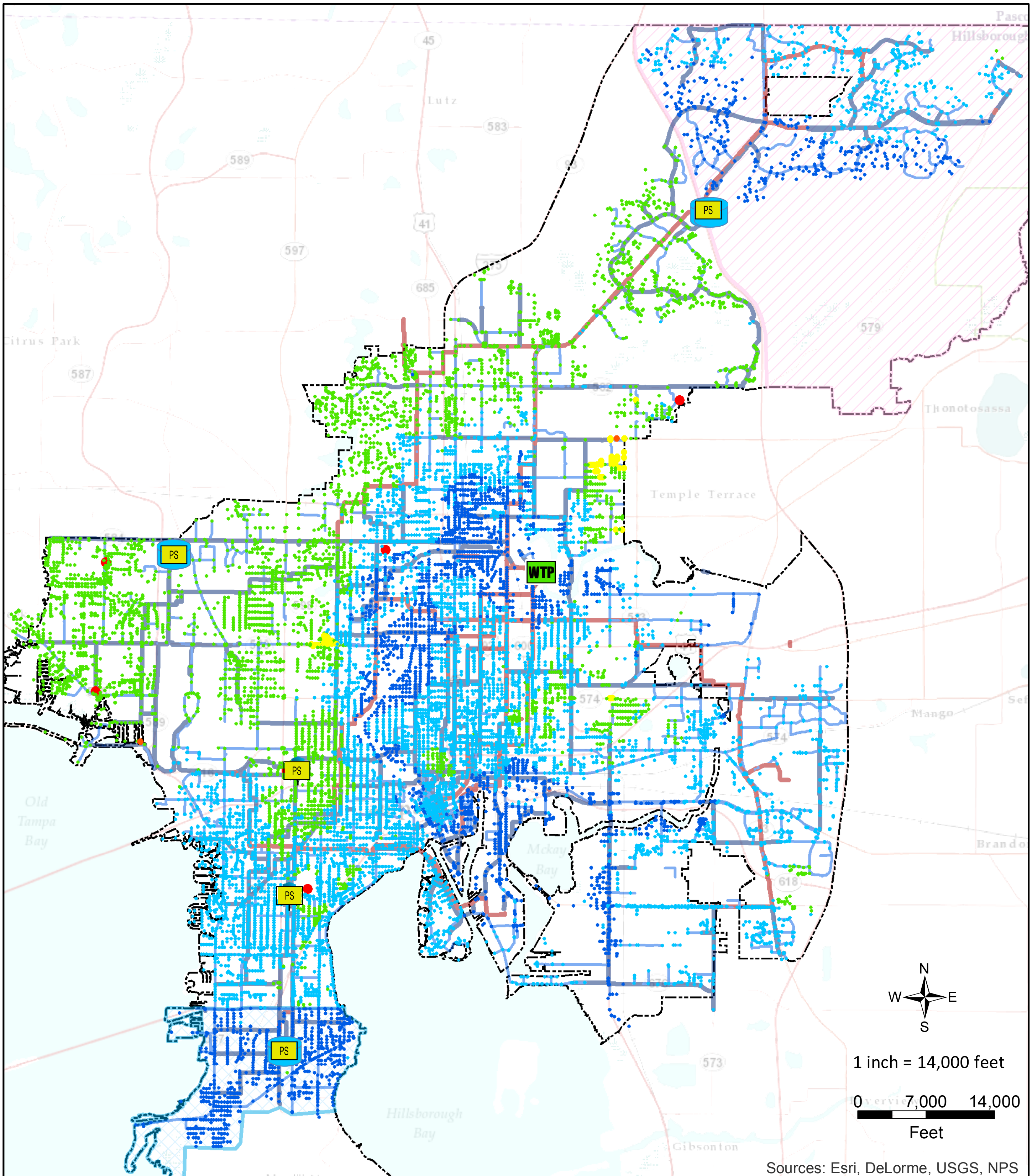
Potable Water Master Plan

Figure 1.11

Planning Year 2025
MDD with 24Hr EPS
Maximum Velocity



1.12 - Existing 2025 Year MDD 24EPS
Tank Level (ft)
DLTWTF Peak Flow = 160 MGD @ 65 psi
DLTWTF Avg Flow = 124 MGD @ 65 psi
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
T-IB (ft)
T-NW (ft)
T-MB-W (ft)
T-MB-E (ft)
T-PC (ft)
T-WT (ft)



City of Tampa Florida

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WTP

PS Pump Stations

Ground Storage Tank

Elevated Storage Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

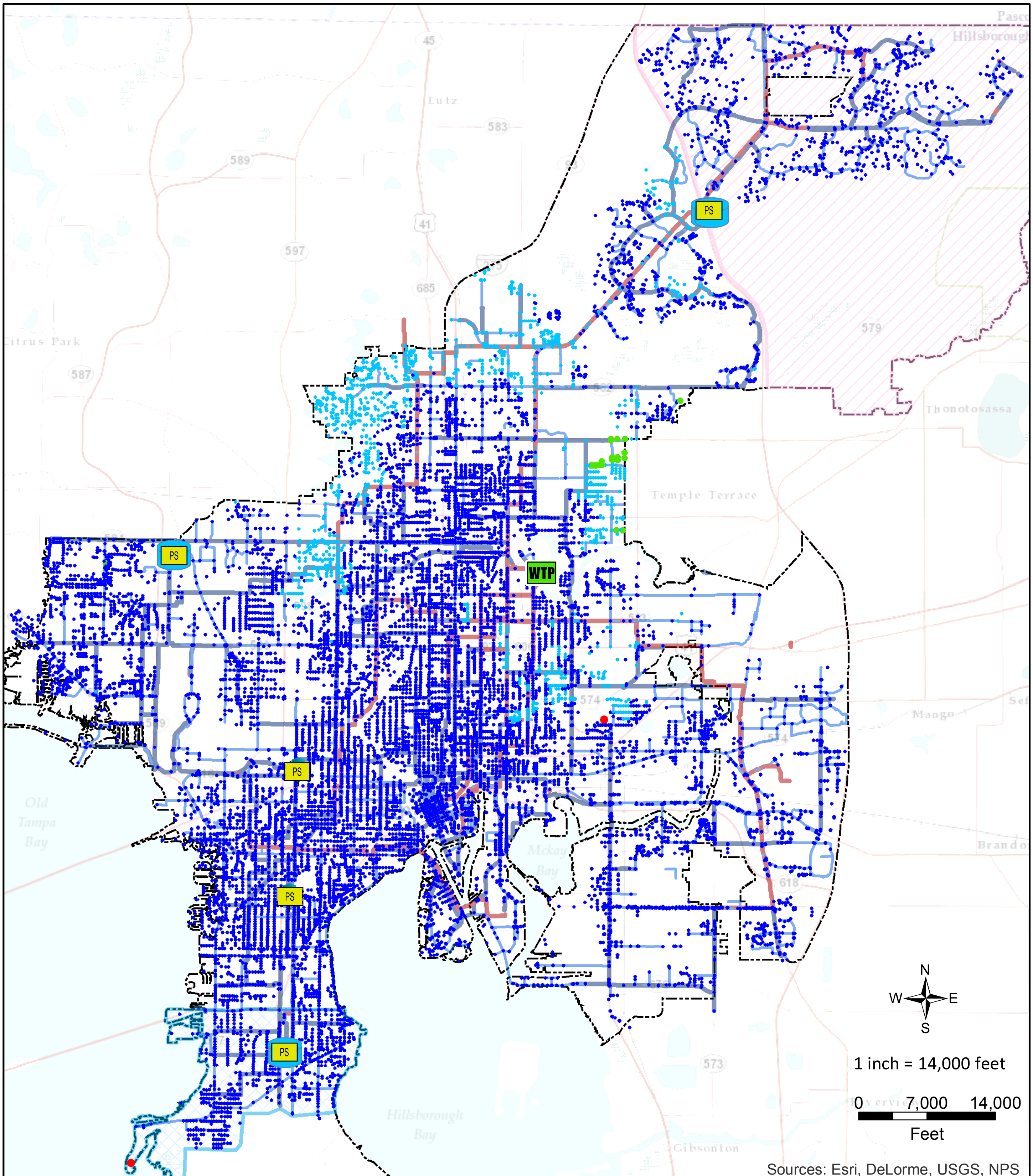
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 1.13

Planning Year 2035
MDD with 24Hr EPS
Minimum Pressures



City of Tampa Florida

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WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank

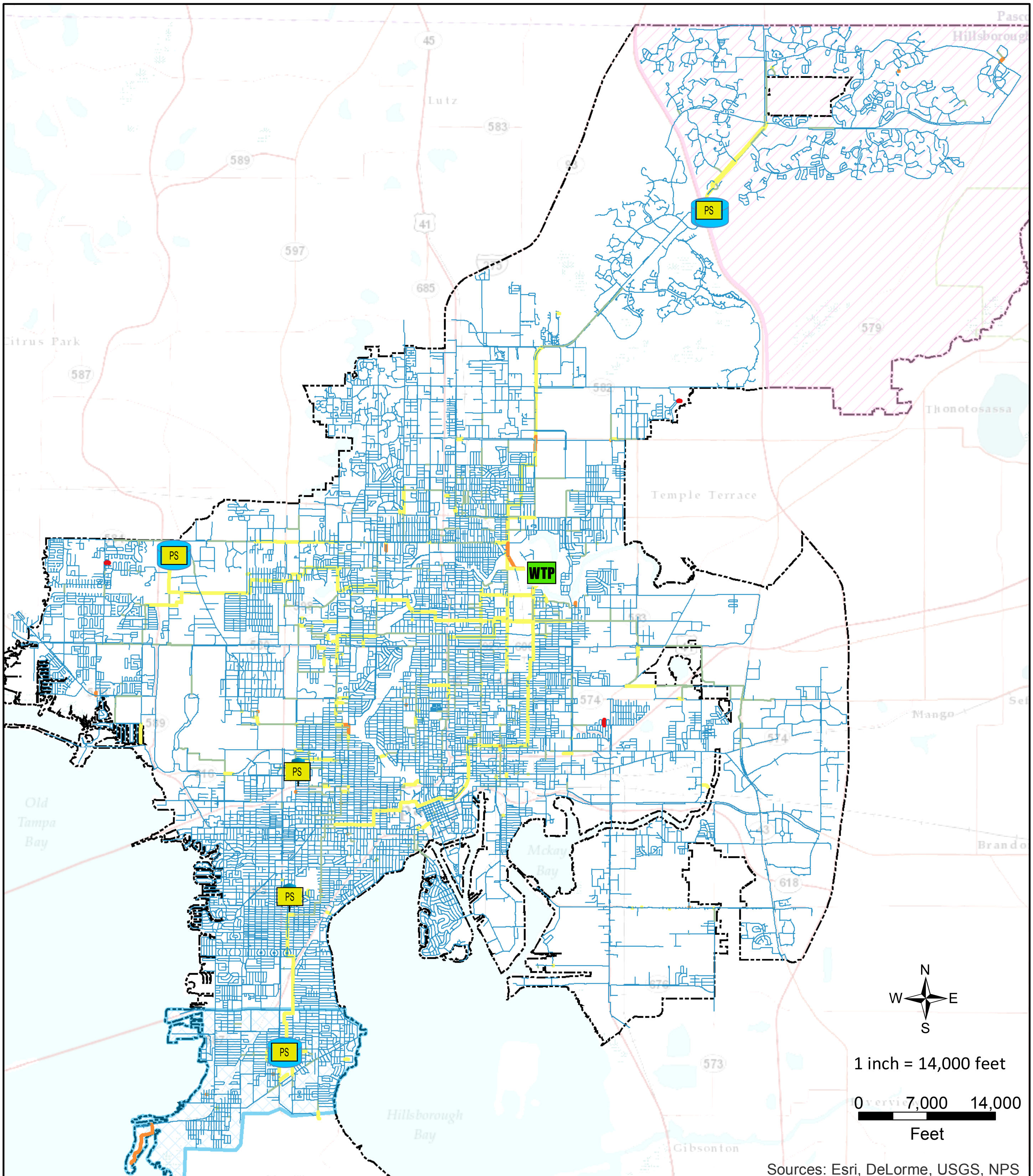
Maximum Pressures
MAX_PRESSURE
- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA
Potable Water Master Plan

Figure 1.14

Planning Year 2035
MDD with 24Hr EPS
Maximum Pressures



WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Max. Velocity

- Less than 2 fps
- 2 - 3 fps
- 3 - 5 fps
- 5 - 10 fps
- Greater than 10 fps

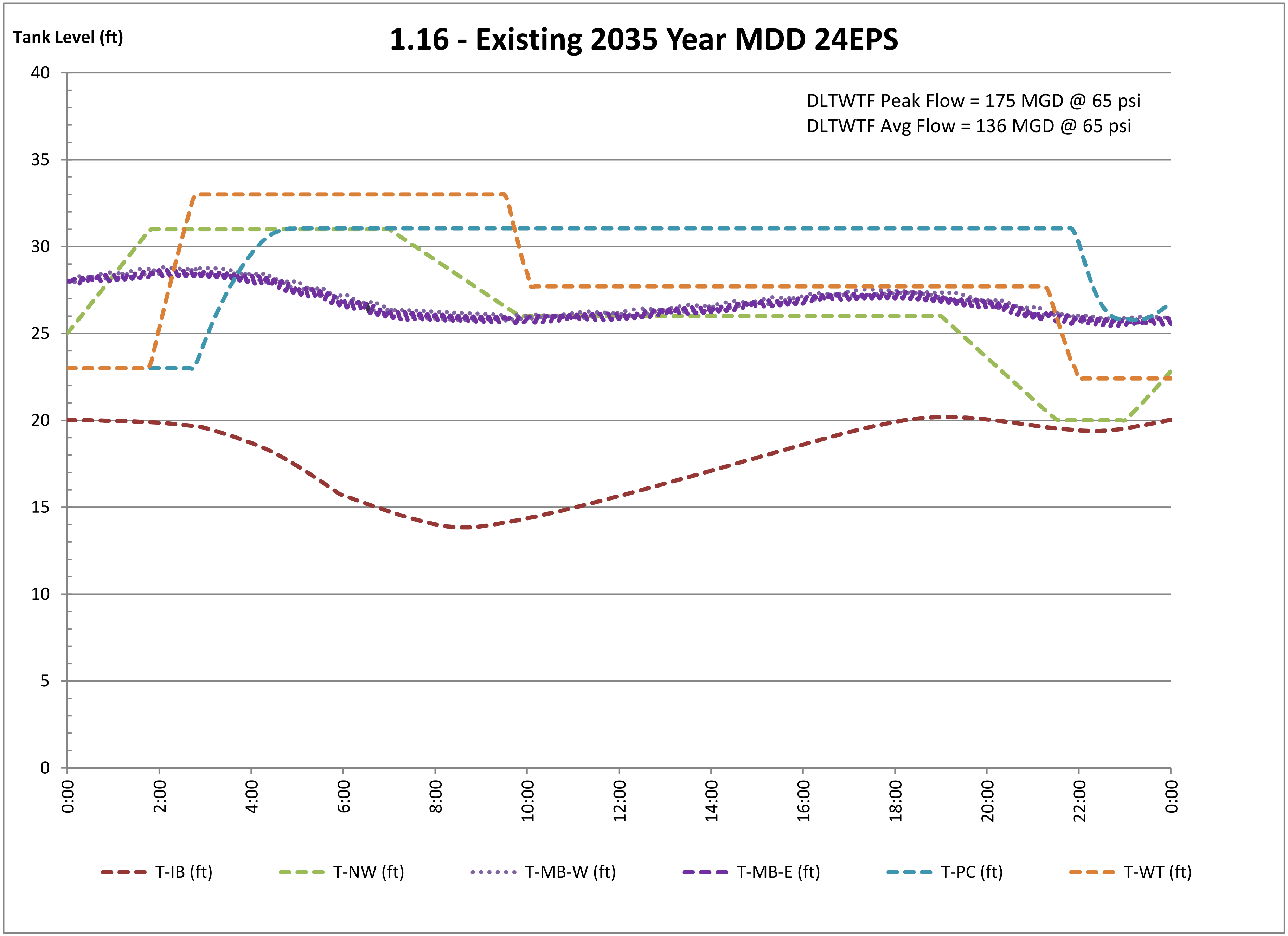
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

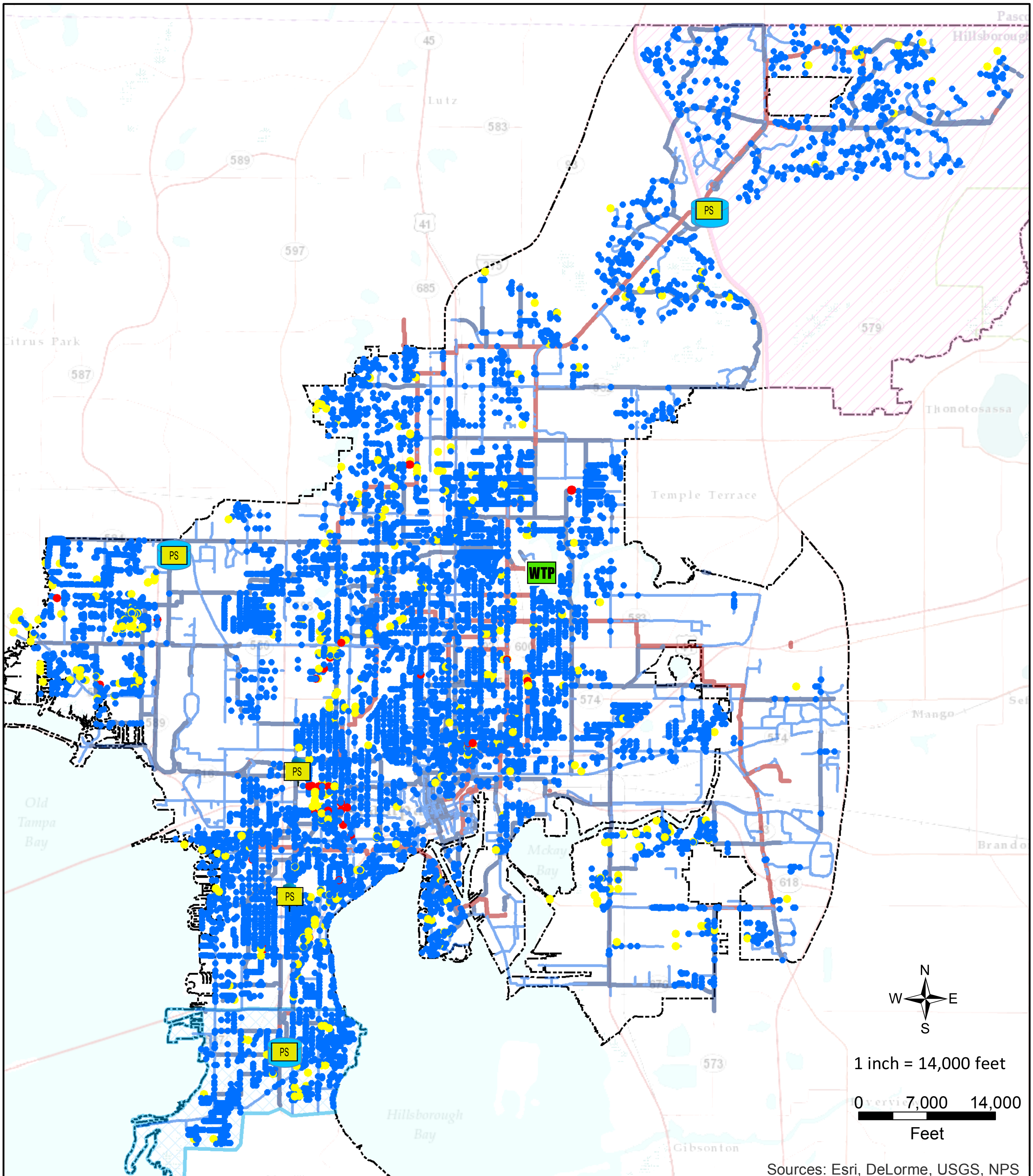
Potable Water Master Plan

Figure 1.15

Planning Year 2035
MDD with 24Hr EPS
Maximum Velocity



1.16 - Existing 2035 Year MDD 24EPS
Tank Level (ft)
DLTWTF Peak Flow = 175 MGD @ 65 psi
DLTWTF Avg Flow = 136 MGD @ 65 psi
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
T-IB (ft)
T-NW (ft)
T-MB-W (ft)
T-MB-E (ft)
T-PC (ft)
T-WT (ft)



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WTP
Pump Stations
Ground Storage Tank
Elevated Storage Tank

Residential Fire Flow

AVAIL_FLOW

- Greater than 1,000 gpm
- 500 to 1,000 gpm
- Less than 500 gpm

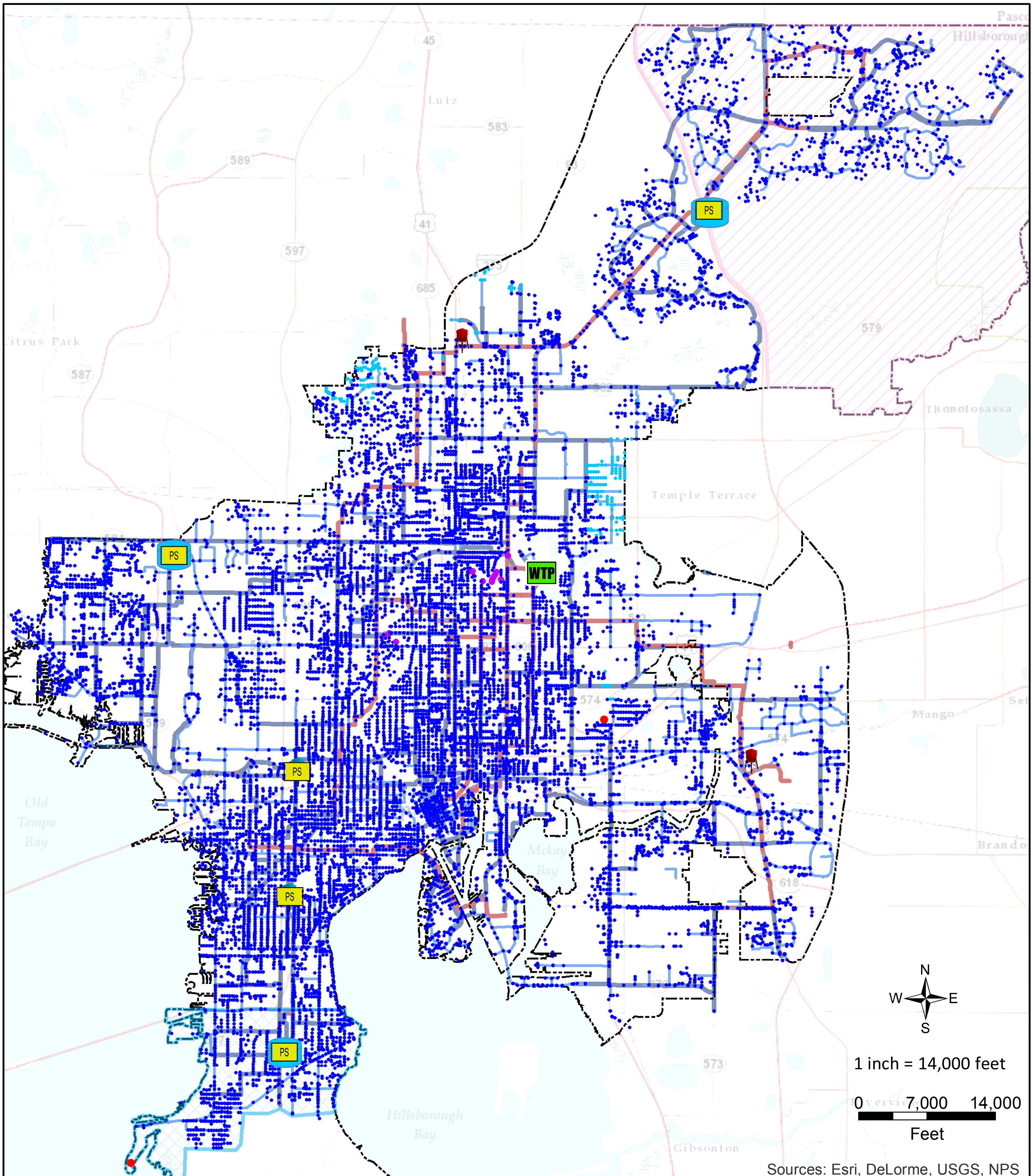
South Tampa
New Tampa
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 2.01

Planning Year 2035
MDD+FF under SS
Available Residential Fire Flow



WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank
Proposed Elevated Tank

Maximum Pressures
MAX_PRESSURE
- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

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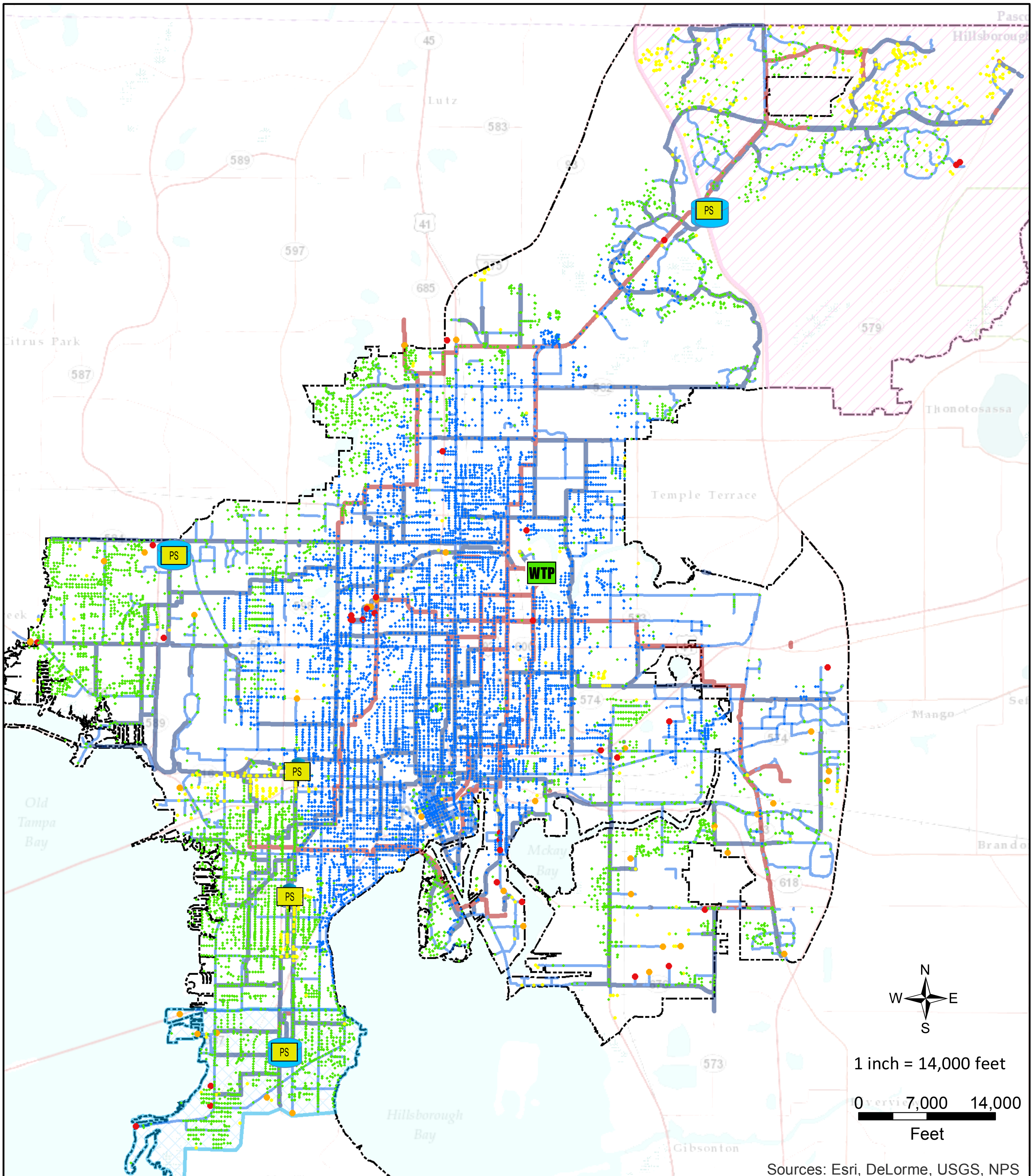
CITY OF TAMPA
Potable Water Master Plan
Figure 4.02
Planning Year 2035
Elevated Storage Options
Maximum Pressures



City of Tampa Florida

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WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Water Age

- Less than 1 day
- 1 to 5 days
- 5 to 10 days
- 10 to 20 days
- Greater than 20 days

South Tampa

New Tampa

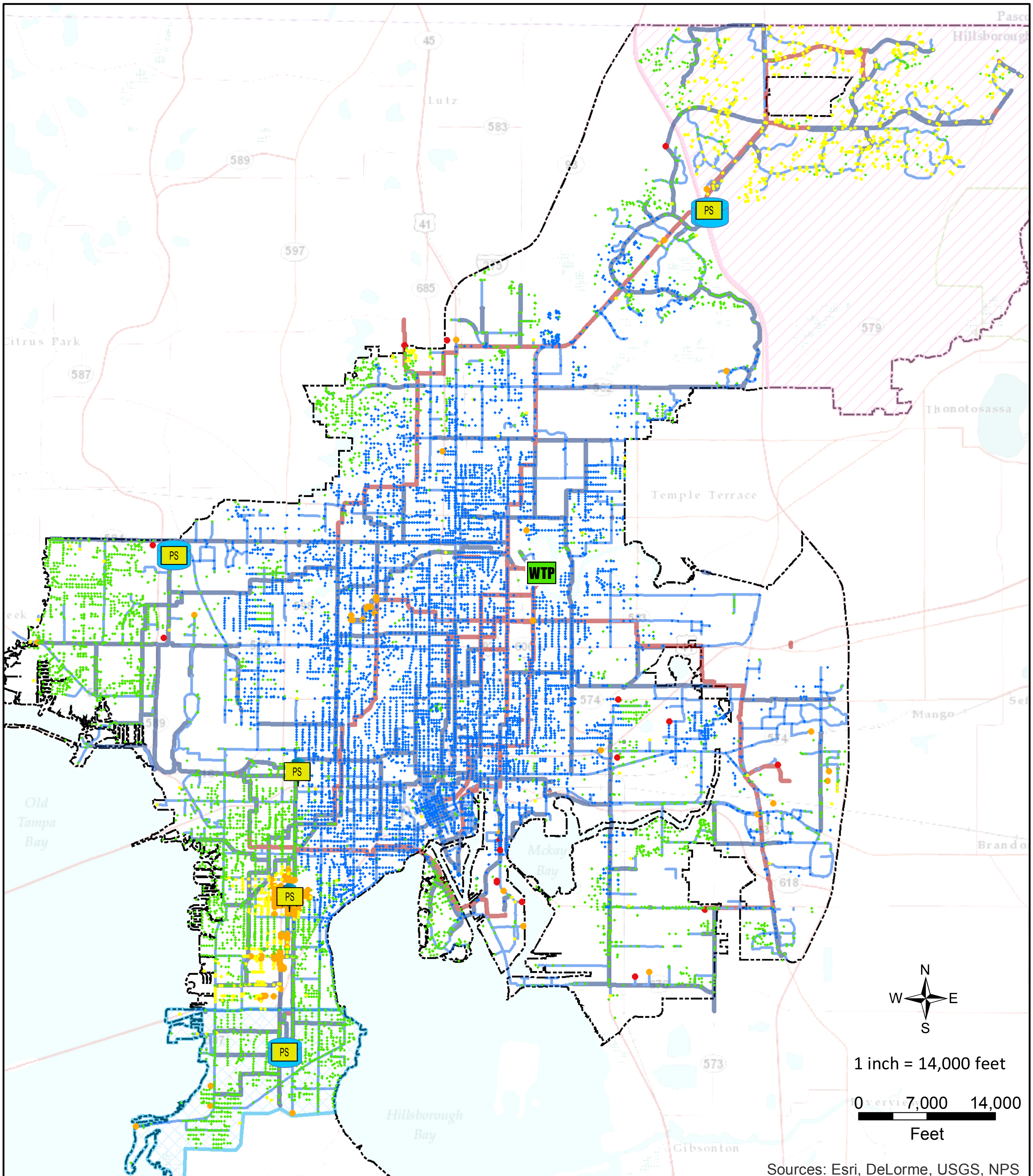
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 3.01

Base Year 2015
ADD under SS
Water Age



City of Tampa Florida

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WTP

PS Pump Stations

Ground Storage Tank

Elevated Storage Tank

Water Age

- Less than 1 day
- 1 to 5 days
- 5 to 10 days
- 10 to 20 days
- Greater than 20 days

South Tampa

New Tampa

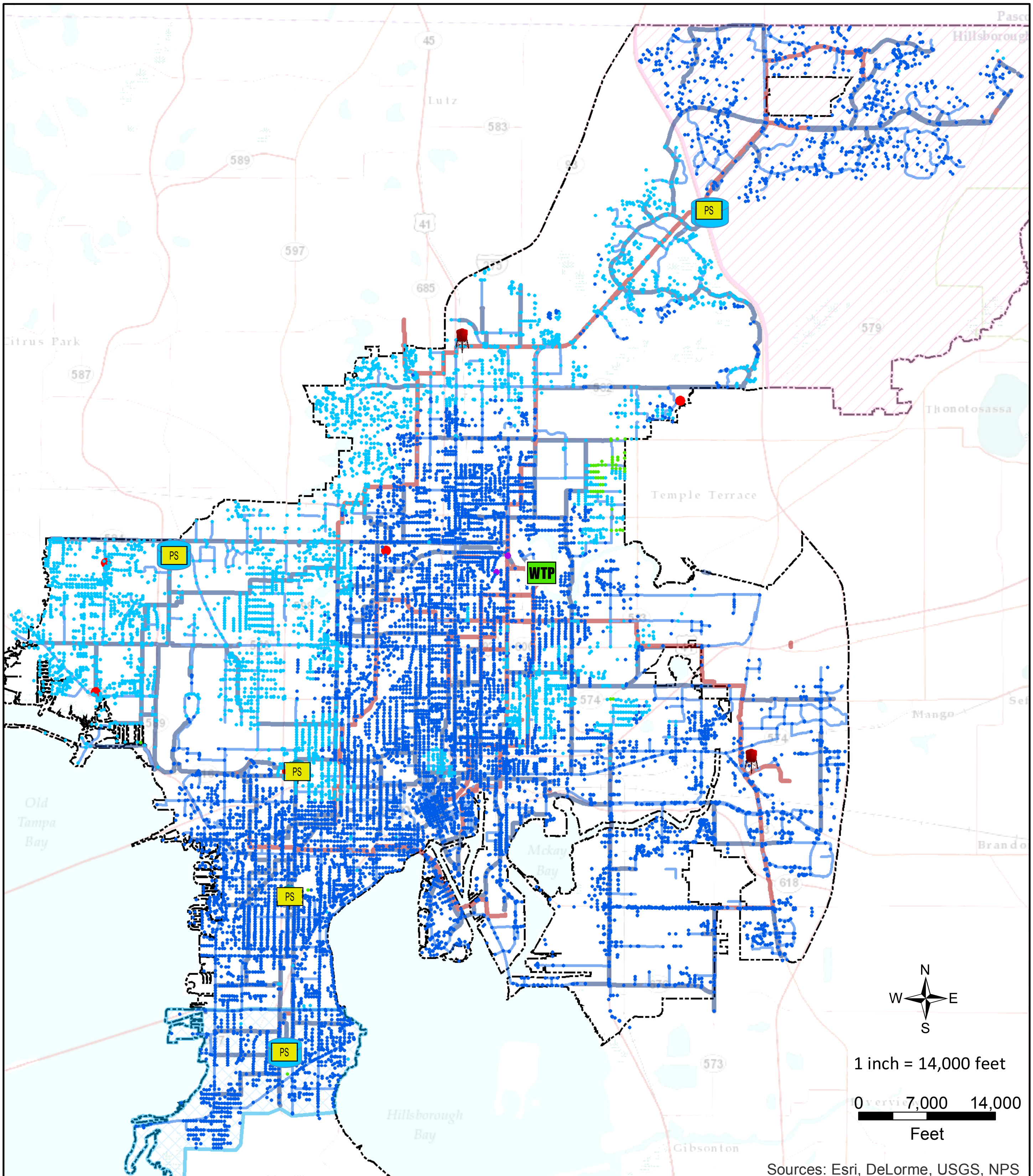
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 3.02

Planning Year 2035
ADD under SS
Water Age



WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Proposed Elevated Tank

MIN_PRESSURE	Diameter
Below 20 psi	< 12-inch
20 - 25 psi	12 - 16-inch
25 - 30 psi	16 - 24-inch
30 - 40 psi	> 24-inch
40 - 50 psi	South Tampa
50 - 75 psi	New Tampa
75 - 85 psi	Service Area
Greater than 85 psi	

City of Tampa Florida

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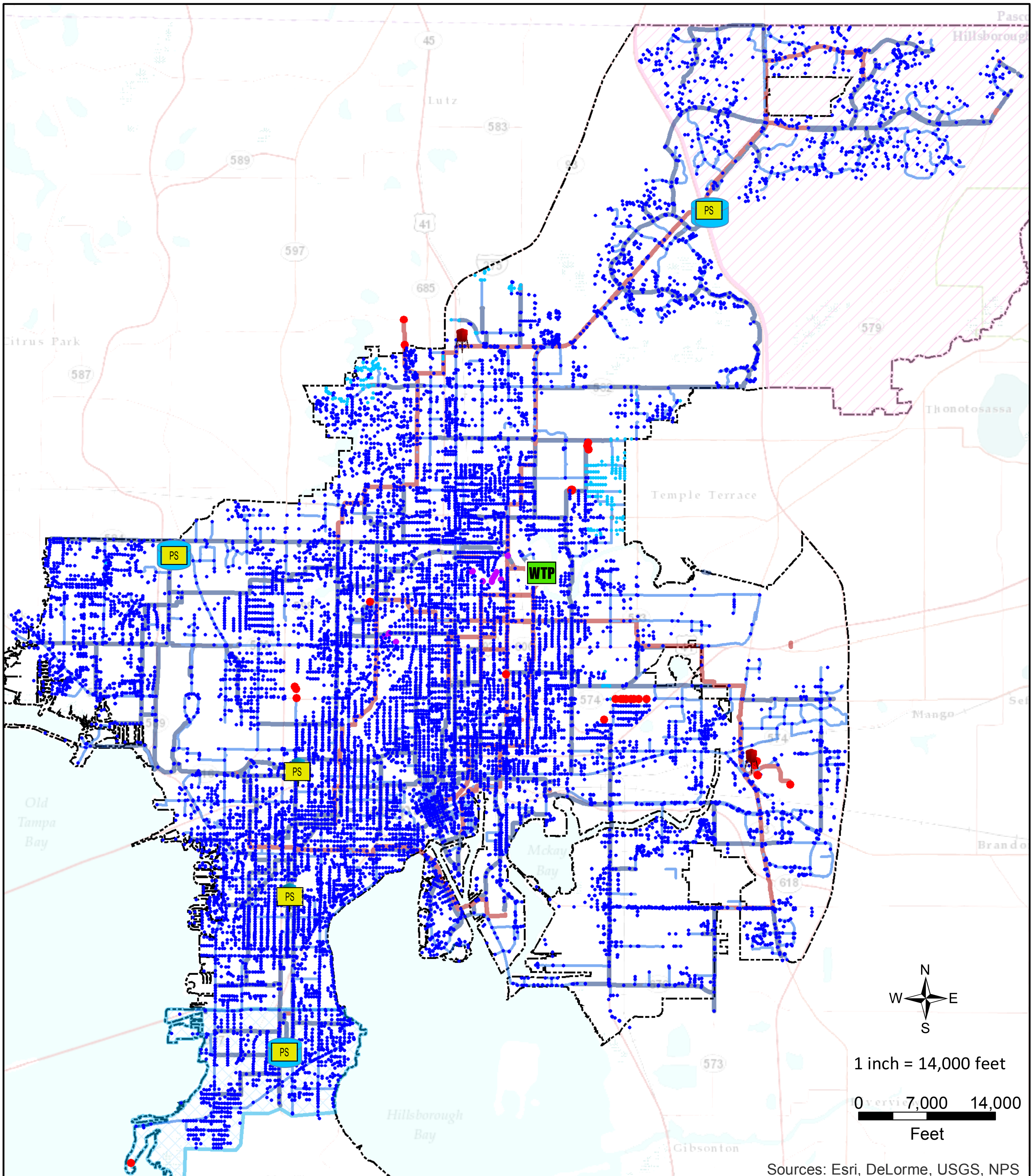
CITY OF TAMPA

Potable Water Master Plan

Figure 4.01

Planning Year 2035
Elevated Storage Options
Minimum Pressures



City of Tampa Florida

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WTP	WTP
PS	Pump Stations
	Ground Storage Tank
	Elevated Storage Tank
	Proposed Elevated Tank

Maximum Pressures

MAX_PRESSURE

- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter

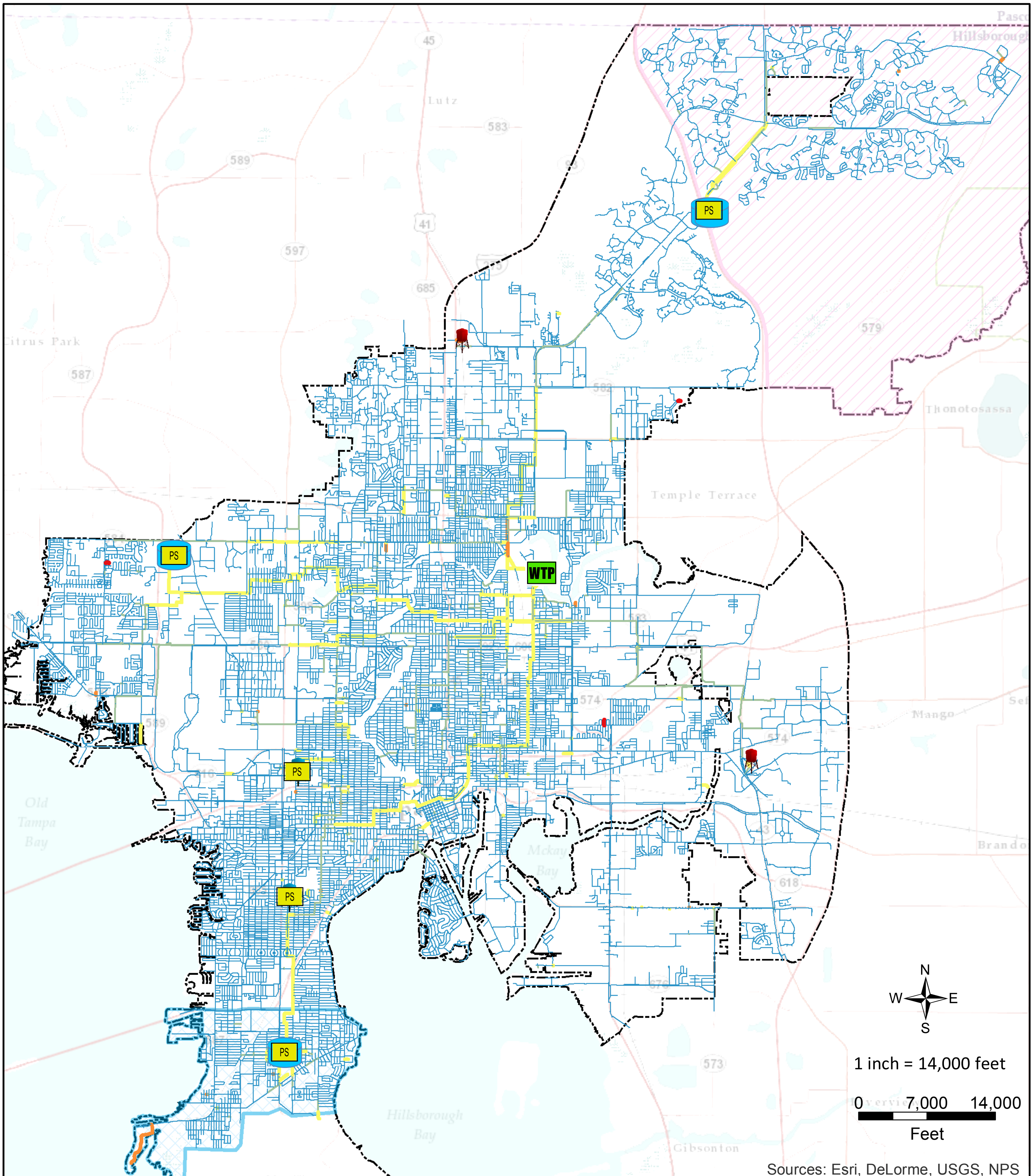
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 4.02

Planning Year 2035
Elevated Storage Options
Maximum Pressures



City of Tampa Florida

BLACK & VEATCH
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WTP WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank
Proposed Elevated Tank

Max Velocity
Max. Velocity
Less than 2 fps
2 - 3 fps
3 - 5 fps
5 - 10 fps
Greater than 10 fps

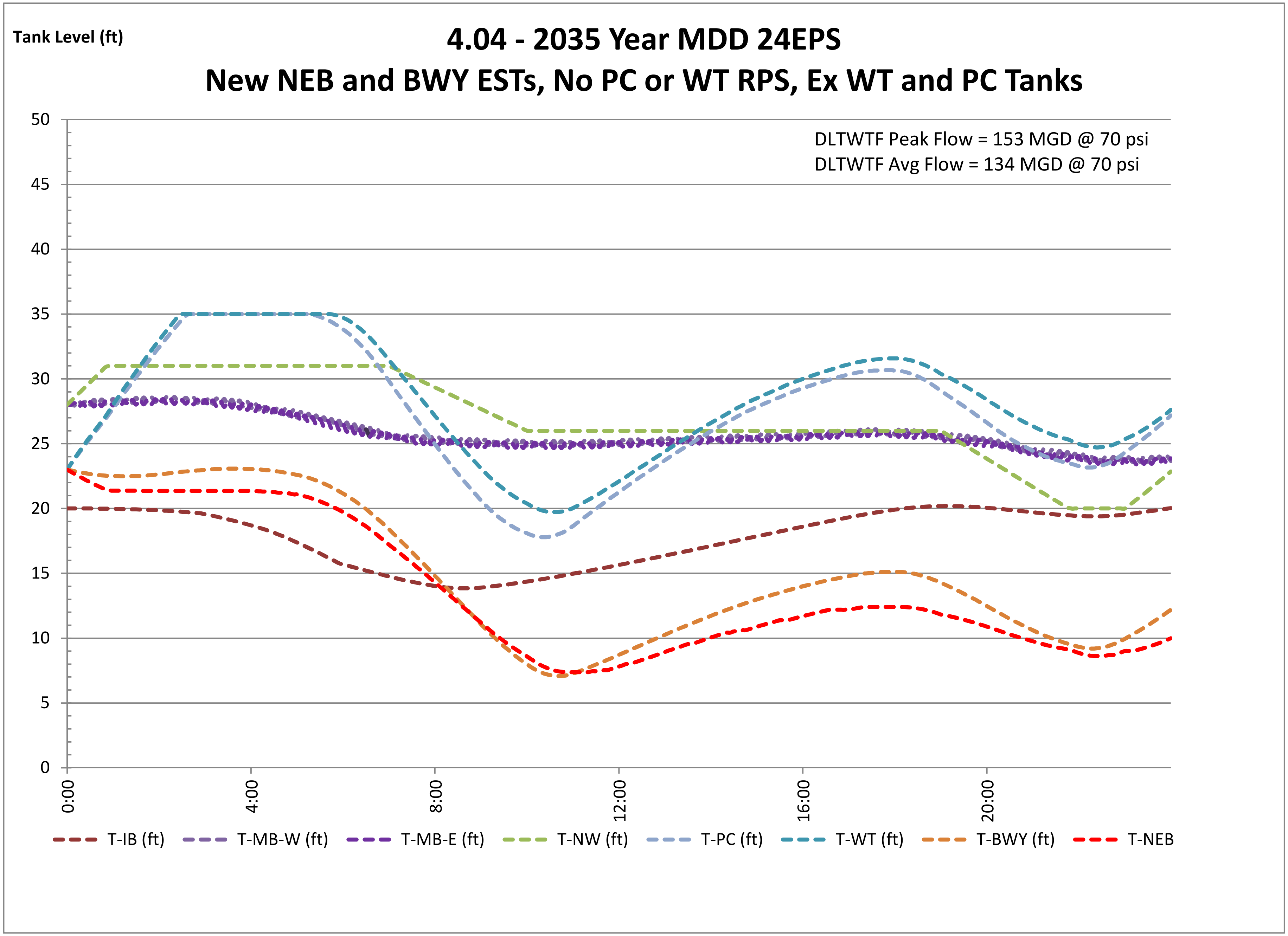
South Tampa
New Tampa
Service Area

CITY OF TAMPA

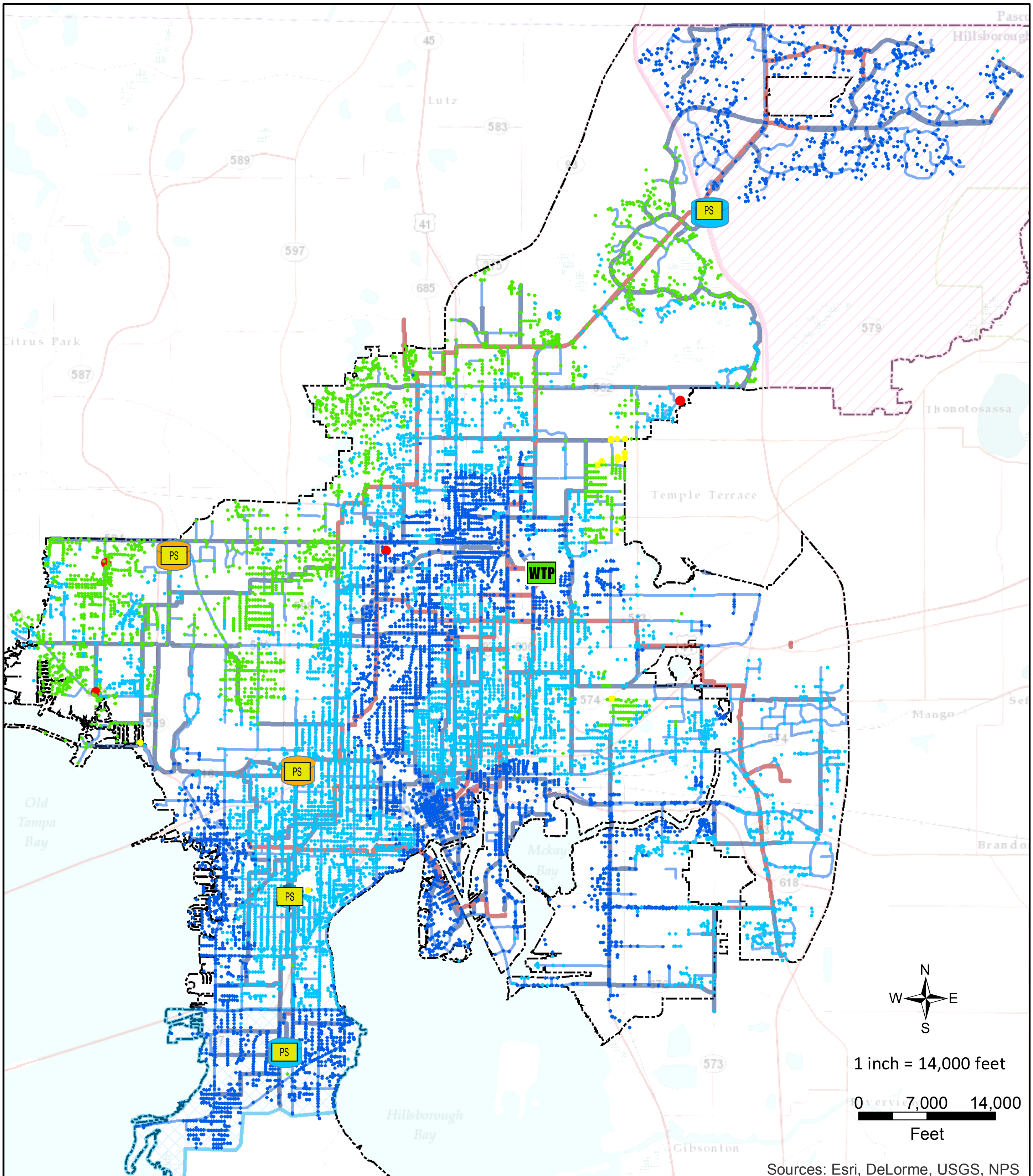
Potable Water Master Plan

Figure 4.03

Planning Year 2035
Elevated Storage Options
Maximum Velocities



Tank Level (ft)
4.04 - 2035 Year MDD 24EPS
New NEB and BWY ESTs, No PC or WT RPS, Ex WT and PC Tanks
DLTWTF Peak Flow = 153 MGD @ 70 psi
DLTWTF Avg Flow = 134 MGD @ 70 psi
50
45
40
35
30
25
20
15
10
5
0
0:00
4:00
8:00
12:00
16:00
20:00
T-IB (ft)
T-MB-W (ft)
T-MB-E (ft)
T-NW (ft)
T-PC (ft)
T-WT (ft)
T-BWY (ft)
T-NEB



City of Tampa Florida

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WTP
Pump Stations
Proposed GST
Ground Storage Tank
Elevated Storage Tank

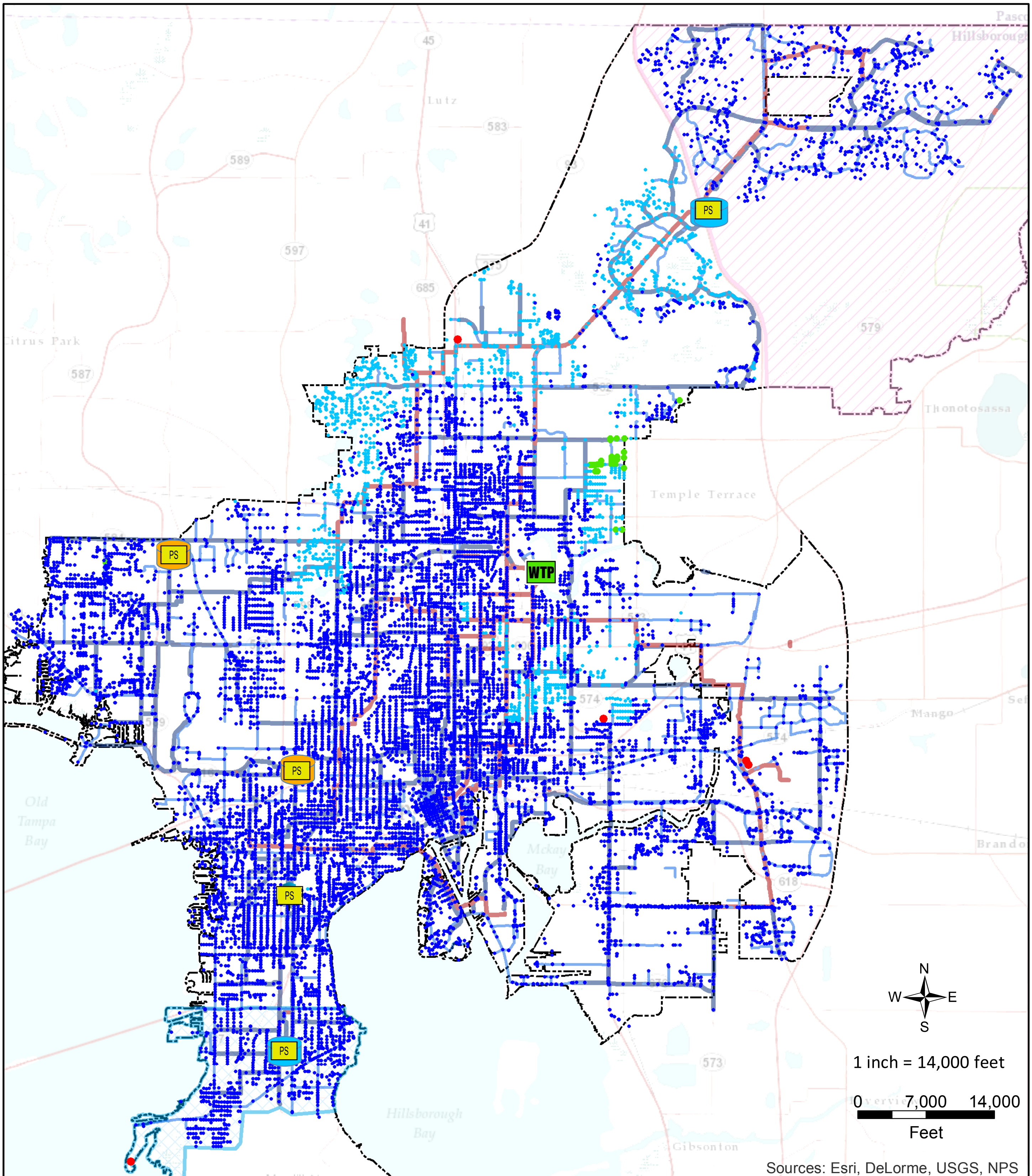
MIN_PRESSURE	Diameter
Below 20 psi	< 12-inch
20 - 25 psi	12 - 16-inch
25 - 30 psi	16 - 24-inch
30 - 40 psi	> 24-inch
40 - 50 psi	South Tampa
50 - 75 psi	New Tampa
75 - 85 psi	Service Area
Greater than 85 psi	

CITY OF TAMPA

Potable Water Master Plan

Figure 4.05

Planning Year 2035
Ground Storage Options
Minimum Pressures



WTP

Pump Stations

Proposed GST

Ground Storage Tank

Elevated Storage Tank

Maximum Pressures

MAX_PRESSURE

- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter

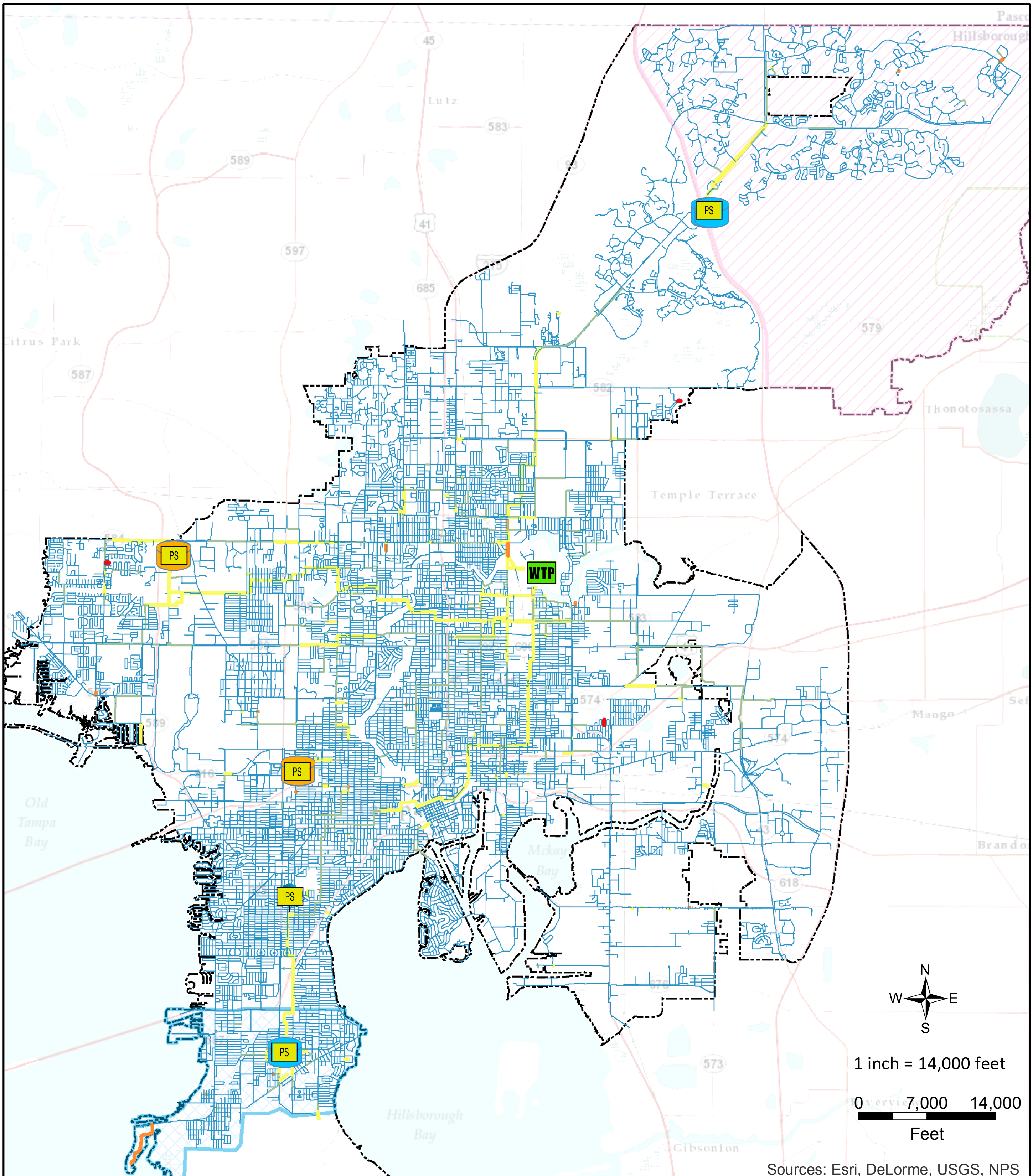
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 4.06

Planning Year 2035
Ground Storage Options
Maximum Pressures



City of Tampa Florida

BLACK & VEATCH
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WTP
PS Pump Stations
Proposed GST
Ground Storage Tank
Elevated Storage Tank

Max Velocity
Max. Velocity
- Less than 2 fps
- 2 - 3 fps
- 3 - 5 fps
- 5 - 10 fps
- Greater than 10 fps

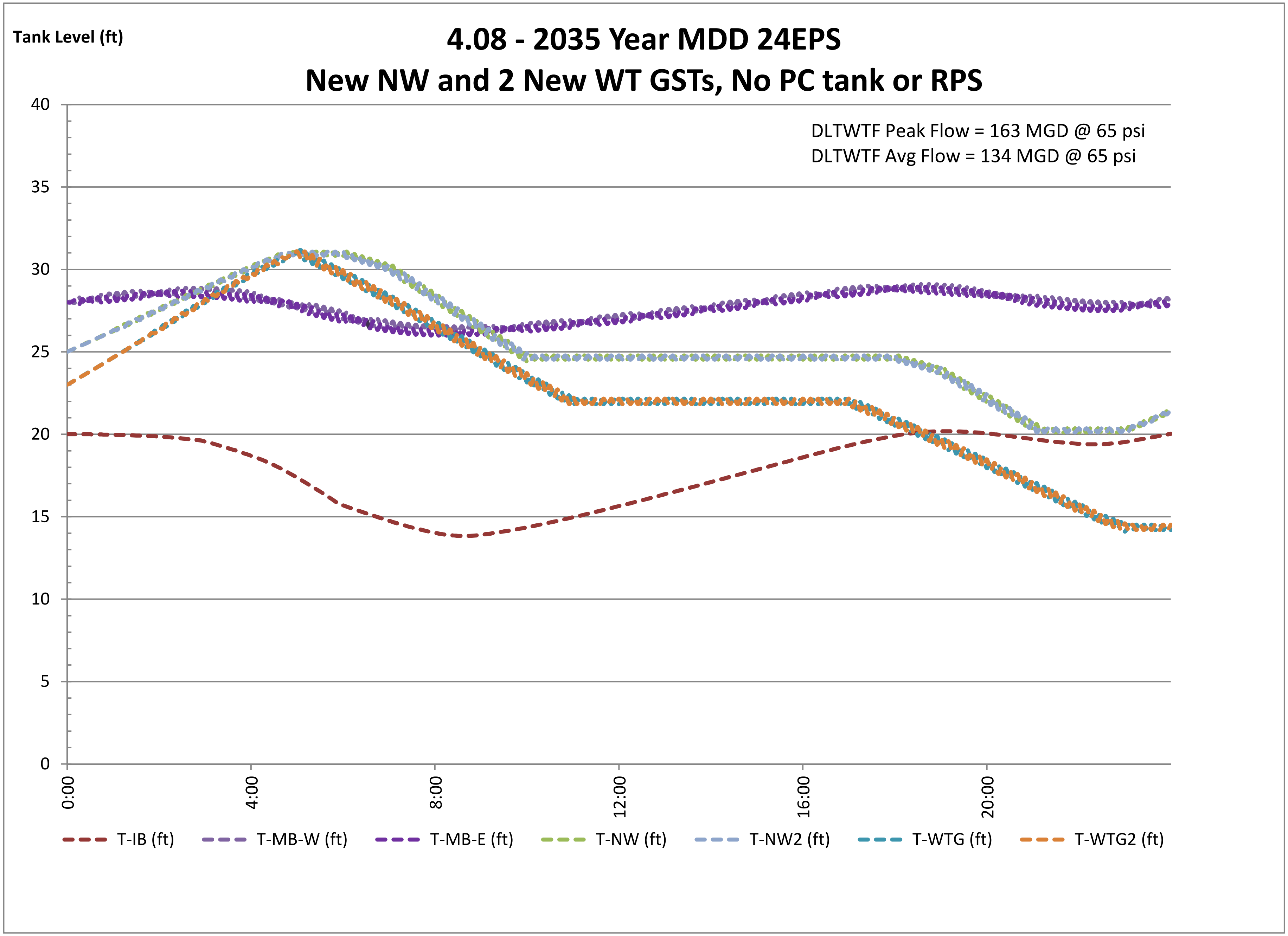
- South Tampa
- New Tampa
- Service Area

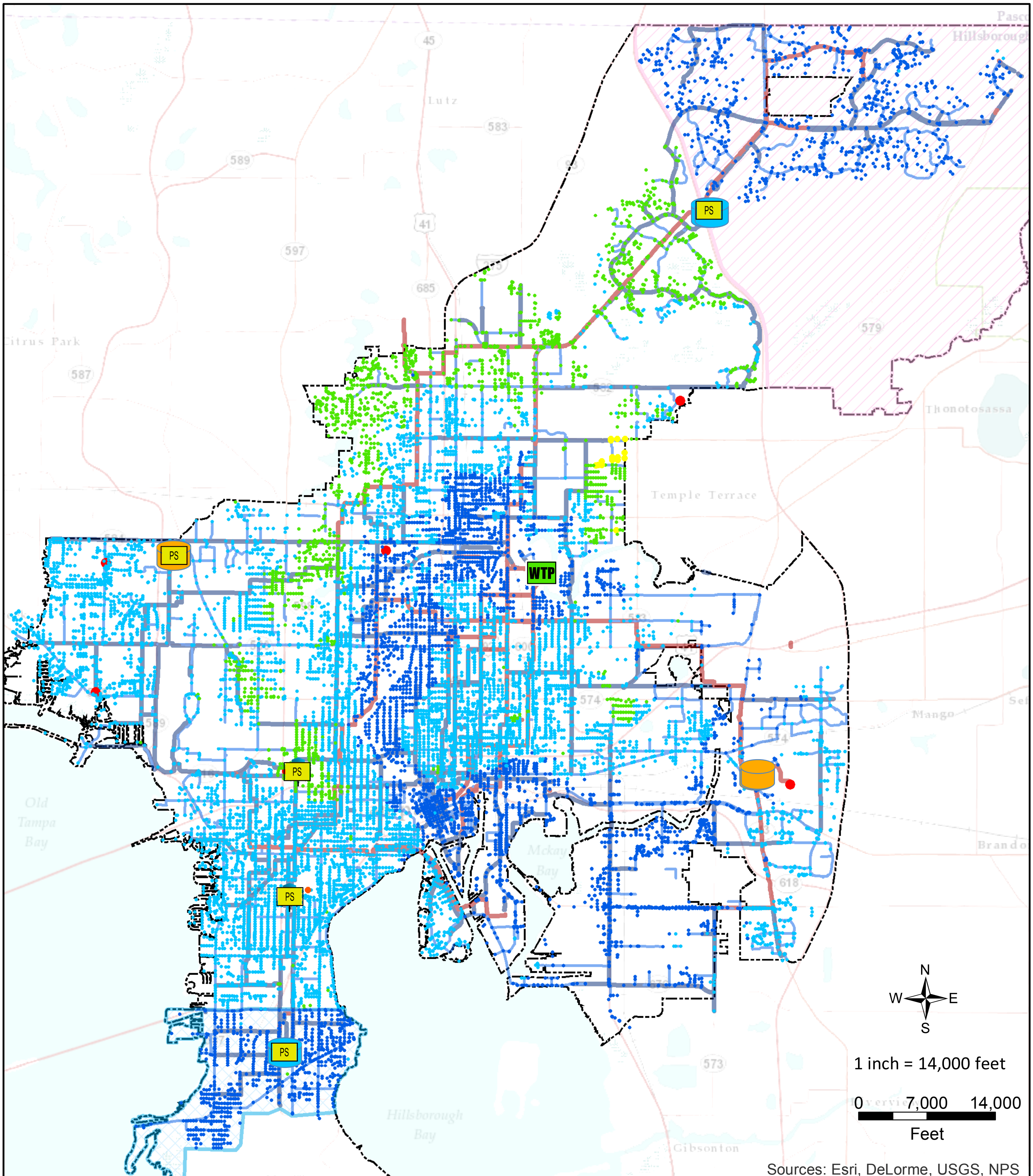
CITY OF TAMPA

Potable Water Master Plan

Figure 4.07

Planning Year 2035
Ground Storage Options
Maximum Velocities


Tank Level (ft)
4.08 - 2035 Year MDD 24EPS
New NW and 2 New WT GSTs, No PC tank or RPS
DLTWTF Peak Flow = 163 MGD @ 65 psi
DLTWTF Avg Flow = 134 MGD @ 65 psi
40
35
30
25
20
15
10
5
0
0:00
4:00
8:00
12:00
16:00
20:00
T-IB (ft)
T-MB-W (ft)
T-MB-E (ft)
T-NW (ft)
T-NW2 (ft)
T-WTG (ft)
T-WTG2 (ft)



City of Tampa Florida

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WTP
Pump Stations
Proposed GST
Ground Storage Tank
Elevated Storage Tank

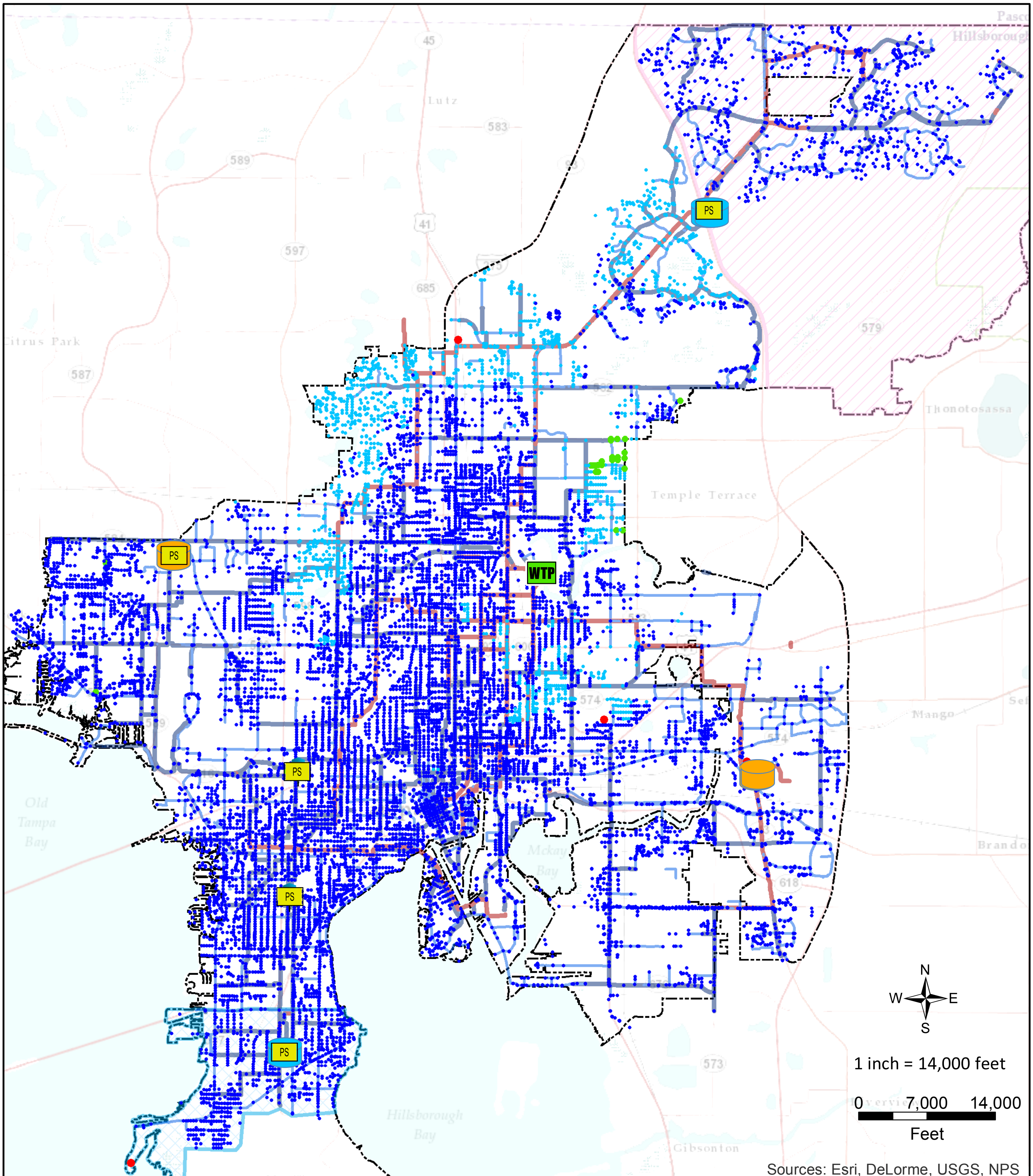
MIN_PRESSURE	Diameter
Below 20 psi	< 12-inch
20 - 25 psi	12 - 16-inch
25 - 30 psi	16 - 24-inch
30 - 40 psi	> 24-inch
40 - 50 psi	South Tampa
50 - 75 psi	New Tampa
75 - 85 psi	Service Area
Greater than 85 psi	

CITY OF TAMPA

Potable Water Master Plan

Figure 4.09

Planning Year 2035
Interconnection Options
Minimum Pressures



WTP

PS Pump Stations

Proposed GST

Ground Storage Tank

Elevated Storage Tank

Maximum Pressures

MAX_PRESSURE

- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter

- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

City of Tampa Florida

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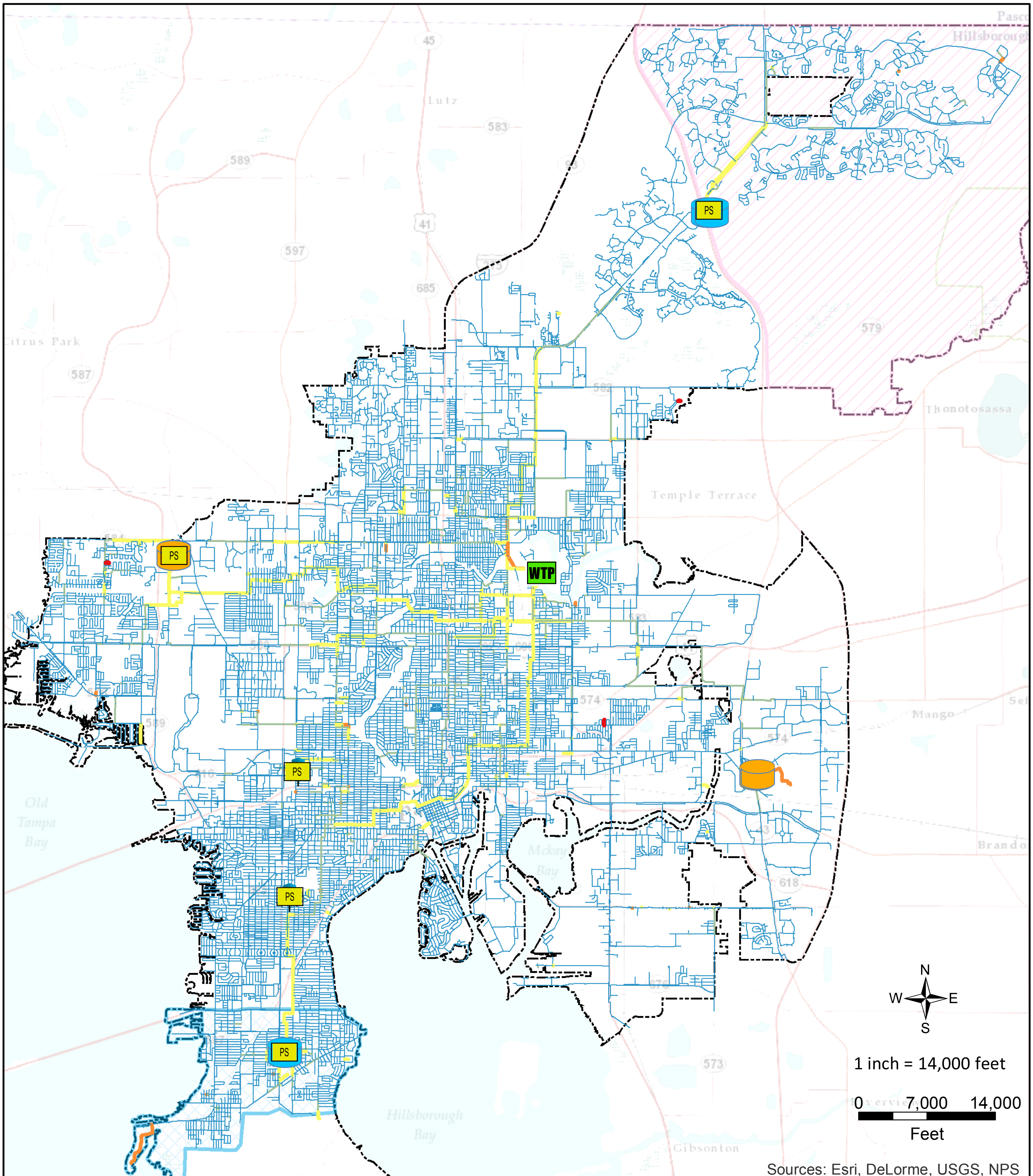
CITY OF TAMPA

Potable Water Master Plan

Figure 4.10

Planning Year 2035
Interconnect Options
Maximum Pressures



City of Tampa Florida

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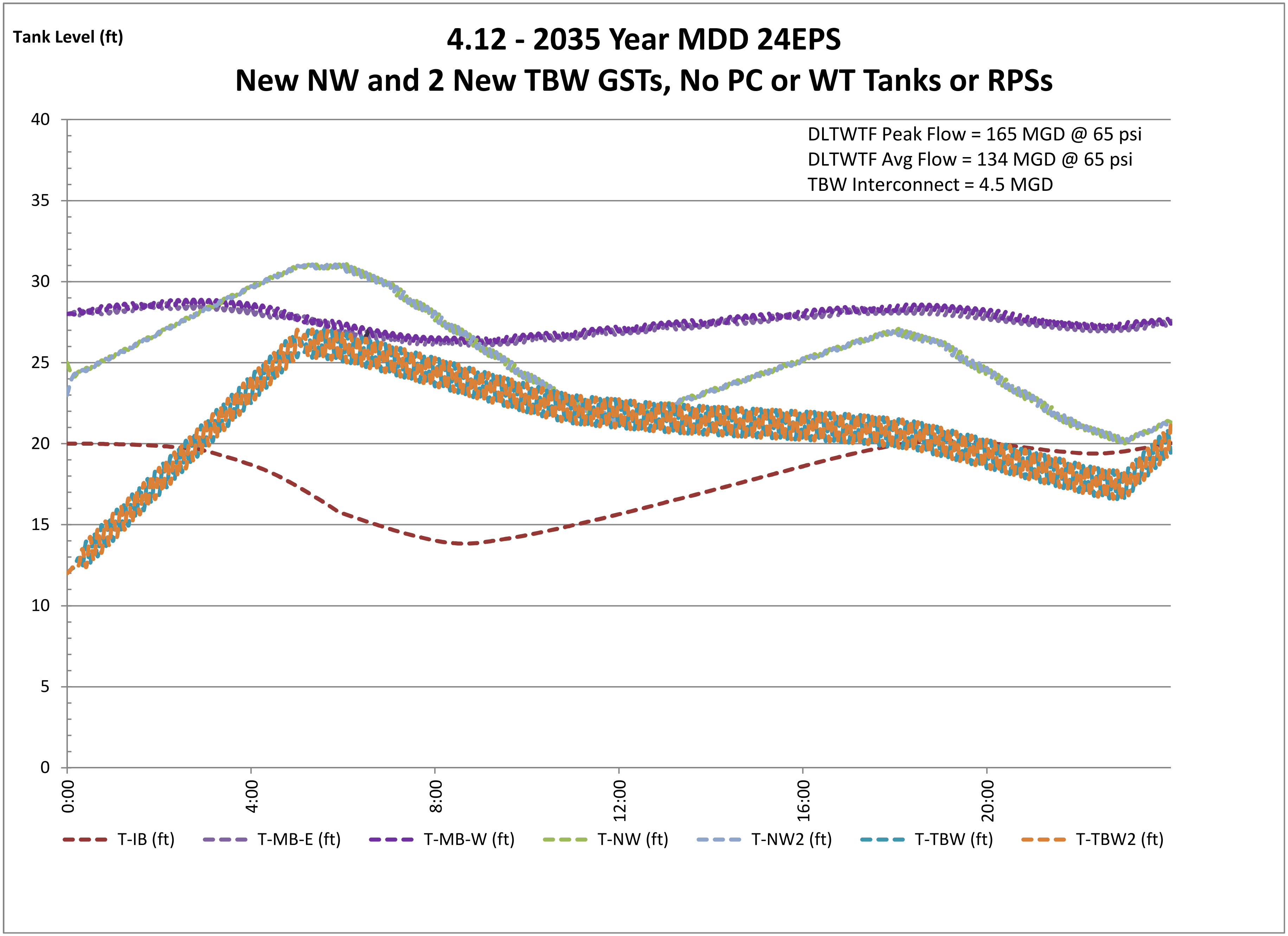
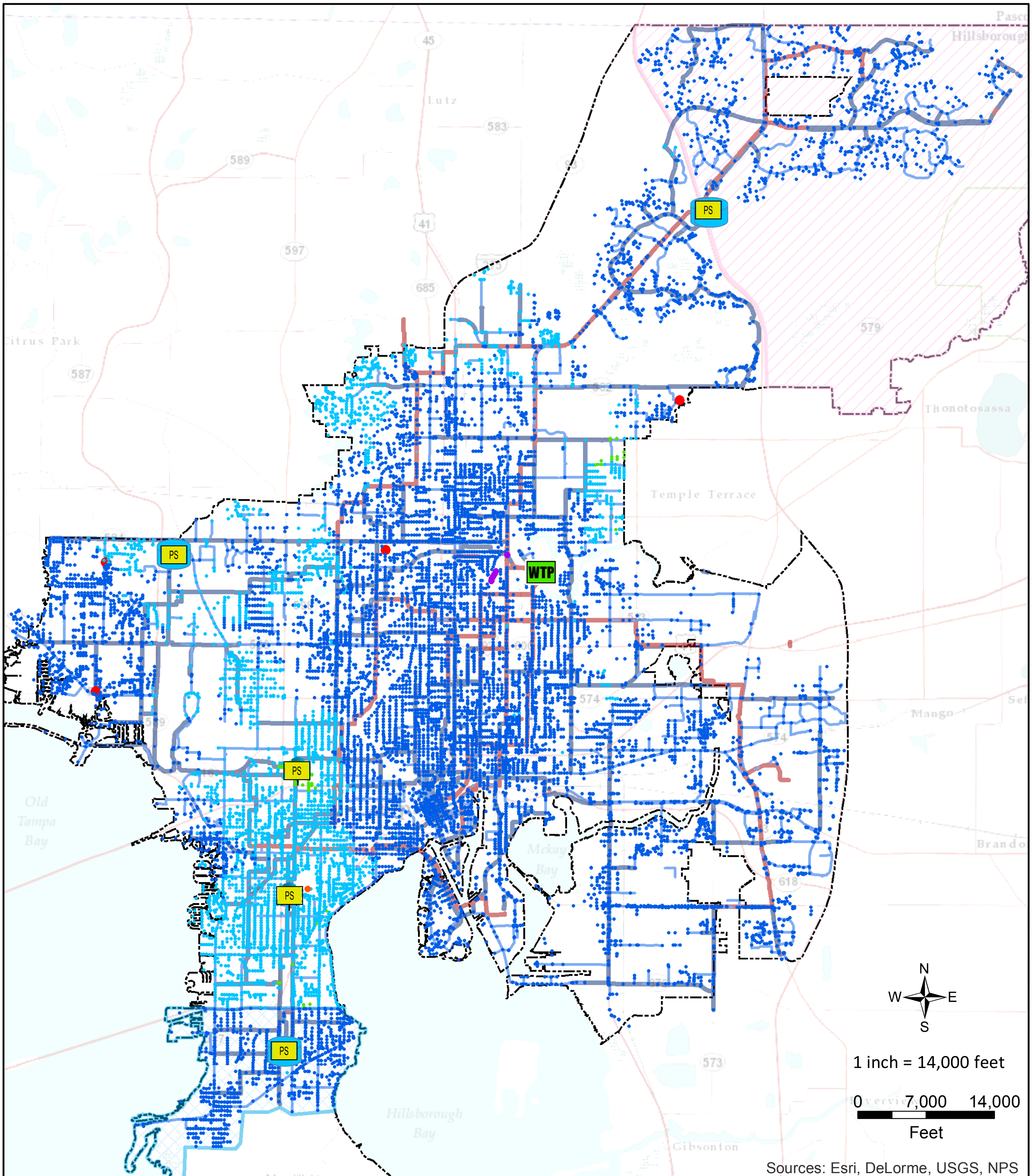
WTP
PS Pump Stations
Proposed GST
Ground Storage Tank
Elevated Storage Tank

Max Velocity
Max. Velocity
Less than 2 fps
2 - 3 fps
3 - 5 fps
5 - 10 fps
Greater than 10 fps

South Tampa
New Tampa
Service Area

CITY OF TAMPA
Potable Water Master Plan
Figure 4.11
Planning Year 2035
Interconnect Options
Maximum Velocities


Tank Level (ft)
4.12 - 2035 Year MDD 24EPS
New NW and 2 New TBW GSTs, No PC or WT Tanks or RPSs
DLTWTF Peak Flow = 165 MGD @ 65 psi
DLTWTF Avg Flow = 134 MGD @ 65 psi
TBW Interconnect = 4.5 MGD
40
35
30
25
20
15
10
5
0
0:00
4:00
8:00
12:00
16:00
20:00
T-IB (ft)
T-MB-E (ft)
T-MB-W (ft)
T-NW (ft)
T-NW2 (ft)
T-TBW (ft)
T-TBW2 (ft)



City of Tampa Florida

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WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

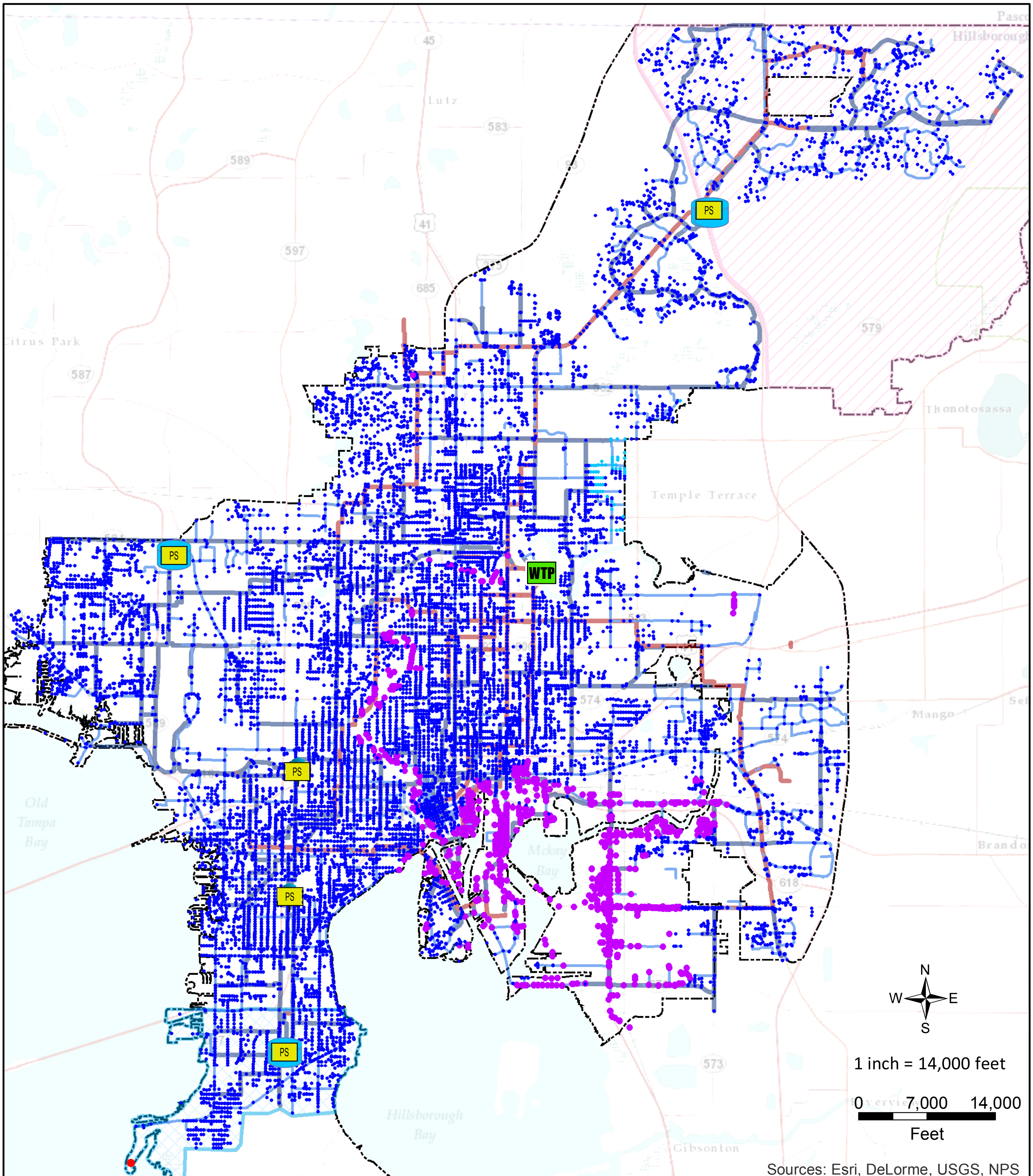
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 5.01

Proposed Base Year 2015 MDD with 24Hr EPS Minimum Pressures



City of Tampa Florida

BLACK & VEATCH
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WTP	WTP
PS	Pump Stations
	Ground Storage Tank
	Elevated Storage Tank

Maximum Pressures

MAX_PRESSURE
- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

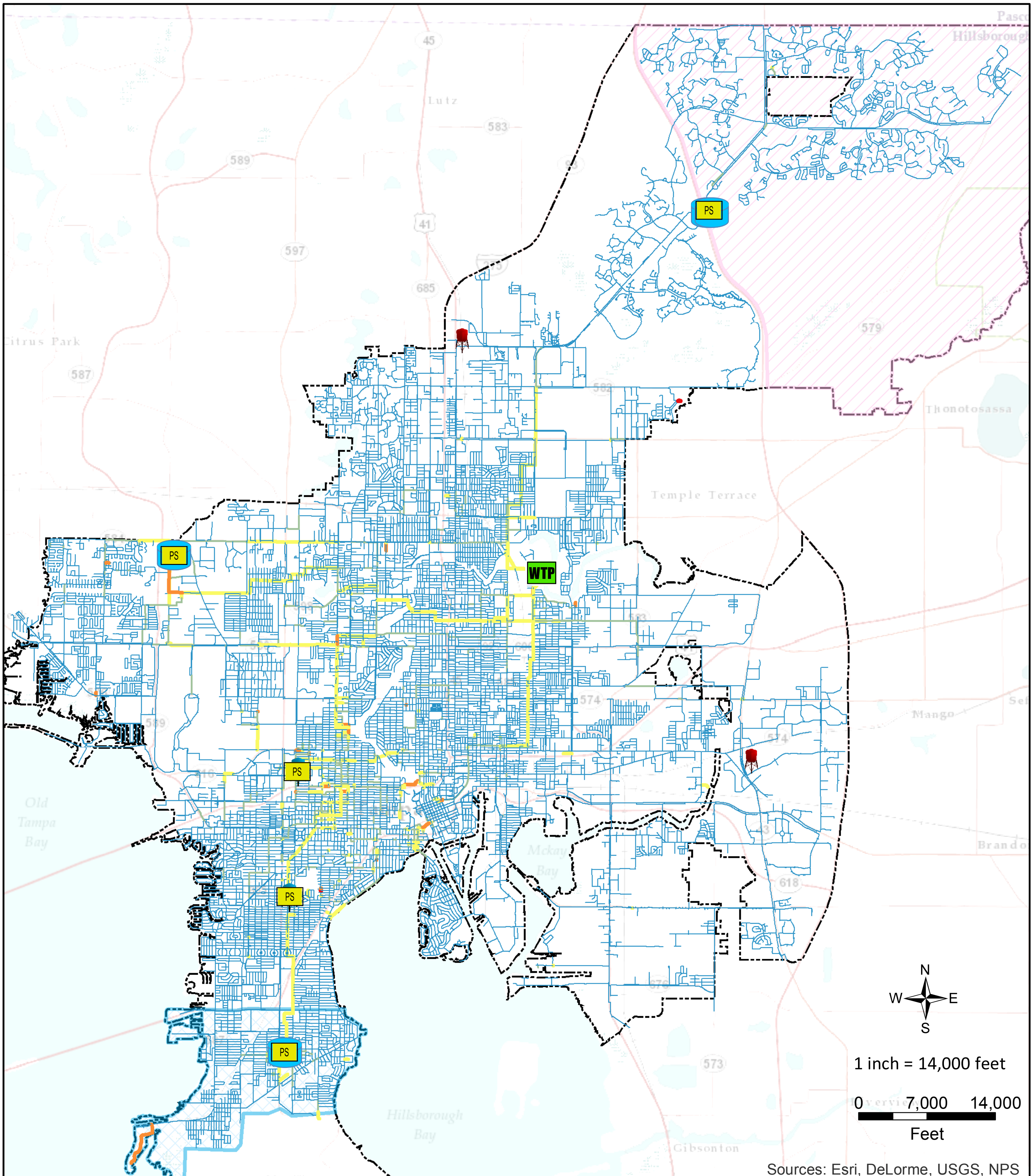
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 5.02

Proposed Base Year 2015 MDD with 24Hr EPS Maximum Pressures



City of Tampa Florida

BLACK & VEATCH
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WTP — WTP

PS — Pump Stations

Ground Storage Tank

Proposed Elevated Tank

Elevated Storage Tank

Max. Velocity

- Less than 2 fps
- 2 - 3 fps
- 3 - 5 fps
- 5 - 10 fps
- Greater than 10 fps

South Tampa

New Tampa

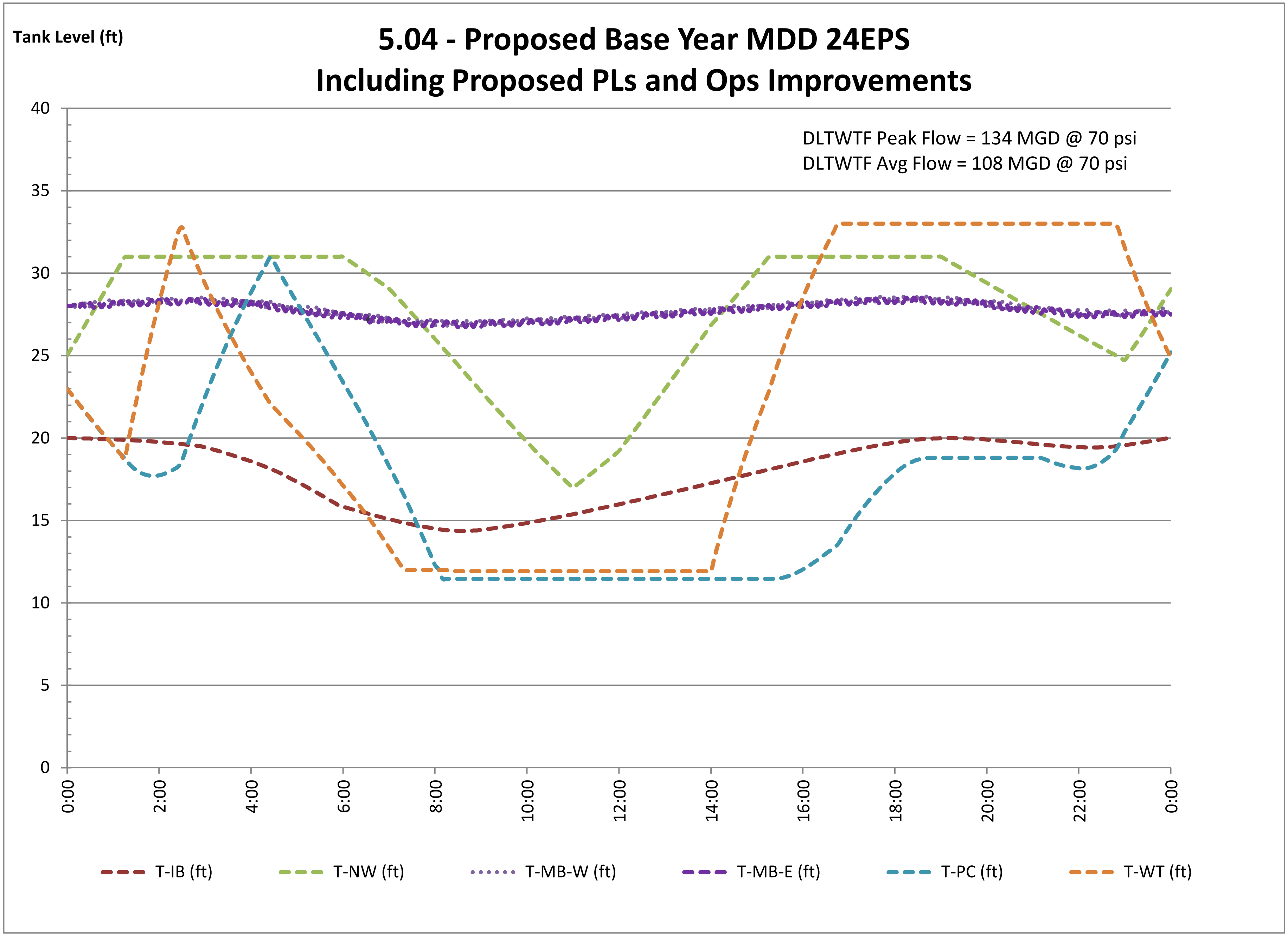
Service Area

CITY OF TAMPA

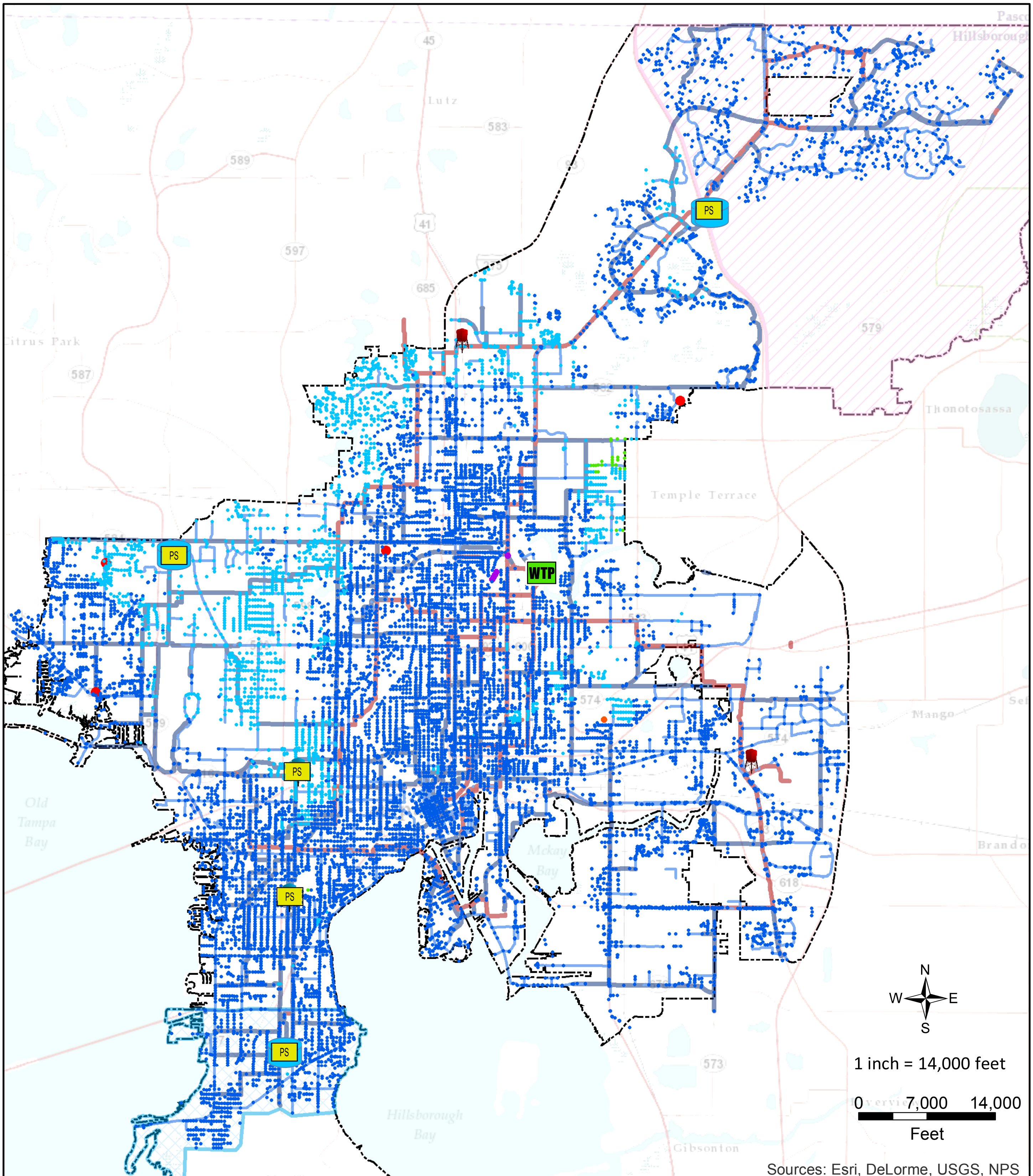
Potable Water Master Plan

Figure 5.03

Proposed Base Year 2015 MDD with 24Hr EPS Maximum Velocity



Tank Level (ft)
5.04 - Proposed Base Year MDD 24EPS
Including Proposed PLs and Ops Improvements
DLTWTF Peak Flow = 134 MGD @ 70 psi
DLTWTF Avg Flow = 108 MGD @ 70 psi
0
5
10
15
20
25
30
35
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
T-IB (ft)
T-NW (ft)
T-MB-W (ft)
T-MB-E (ft)
T-PC (ft)
T-WT (ft)



City of Tampa Florida

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WTP
Pump Stations
Ground Storage Tank
Elevated Storage Tank
Proposed Elevated Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

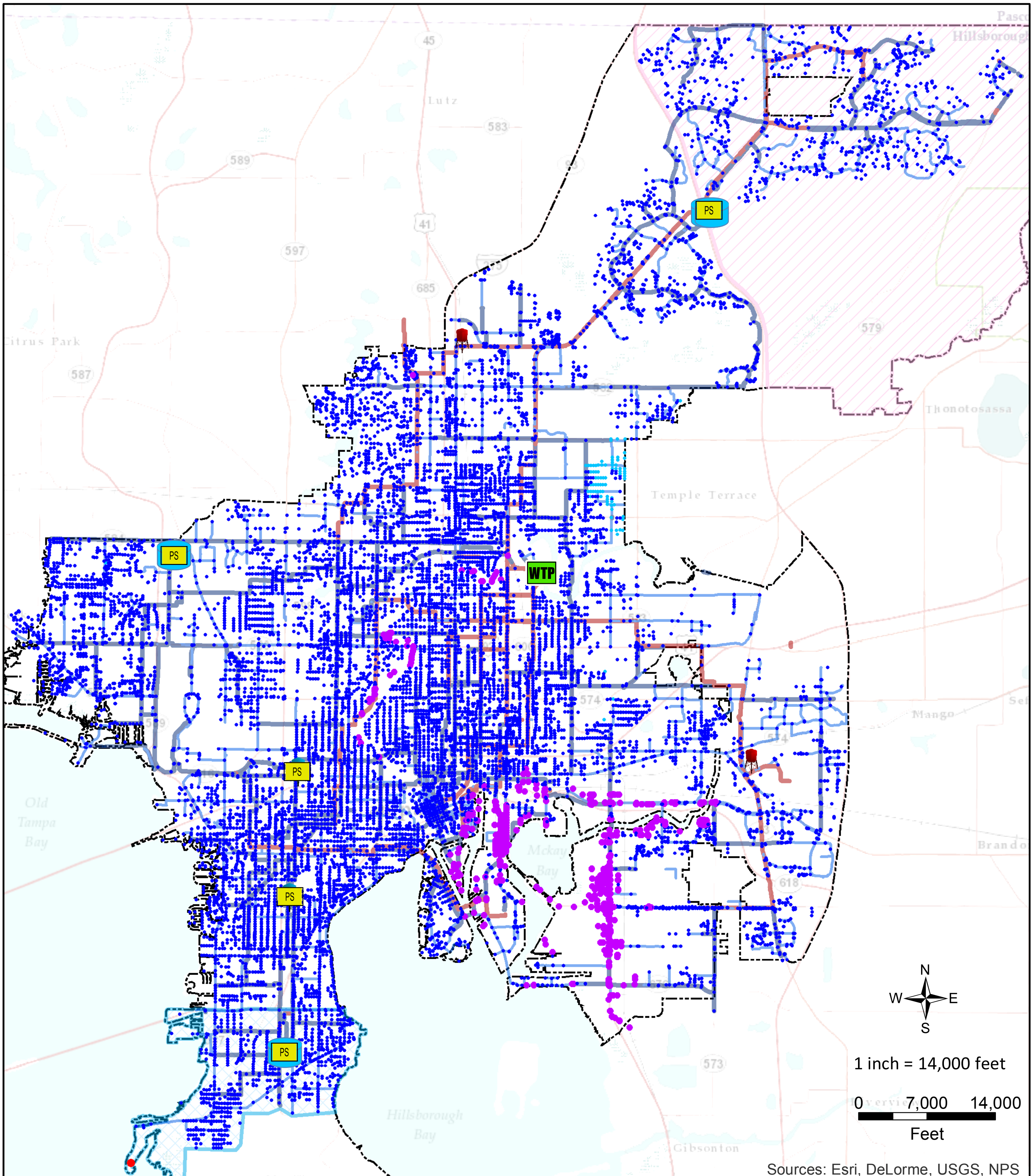
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 5.05

Proposed Planning Year 2020
MDD with 24Hr EPS
Minimum Pressures



City of Tampa Florida

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WTP	WTP
PS	Pump Stations
	Ground Storage Tank
	Elevated Storage Tank
	Proposed Elevated Tank

Maximum Pressures

MAX_PRESSURE

- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter

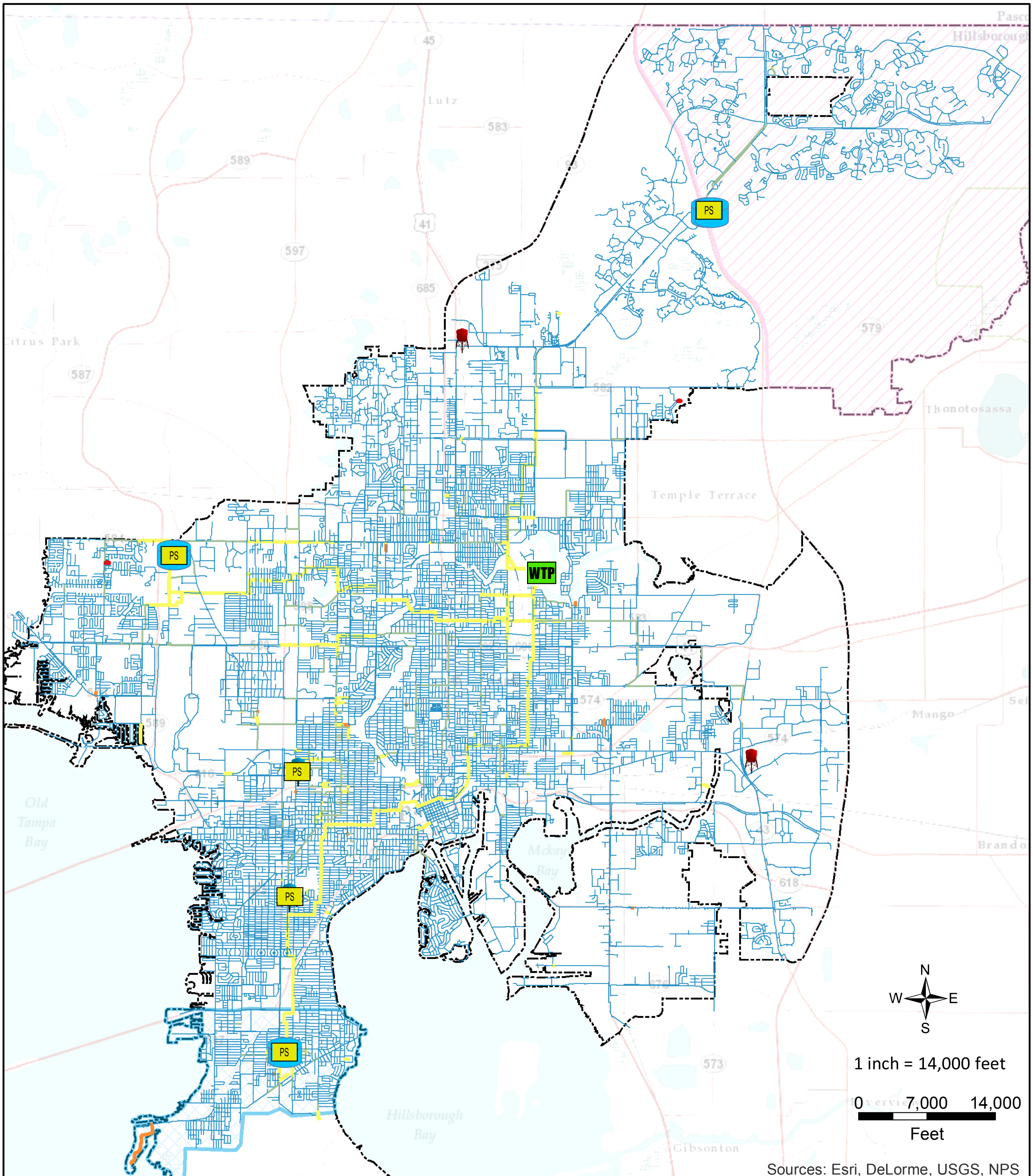
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 5.06

Proposed Planning Year 2020 MDD with 24Hr EPS Maximum Pressures



City of Tampa Florida

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WTP	WTP
PS	Pump Stations
	Ground Storage Tank
	Proposed Elevated Tank
	Elevated Storage Tank

Max. Velocity

- Less than 2 fps
- 2 - 3 fps
- 3 - 5 fps
- 5 - 10 fps
- Greater than 10 fps

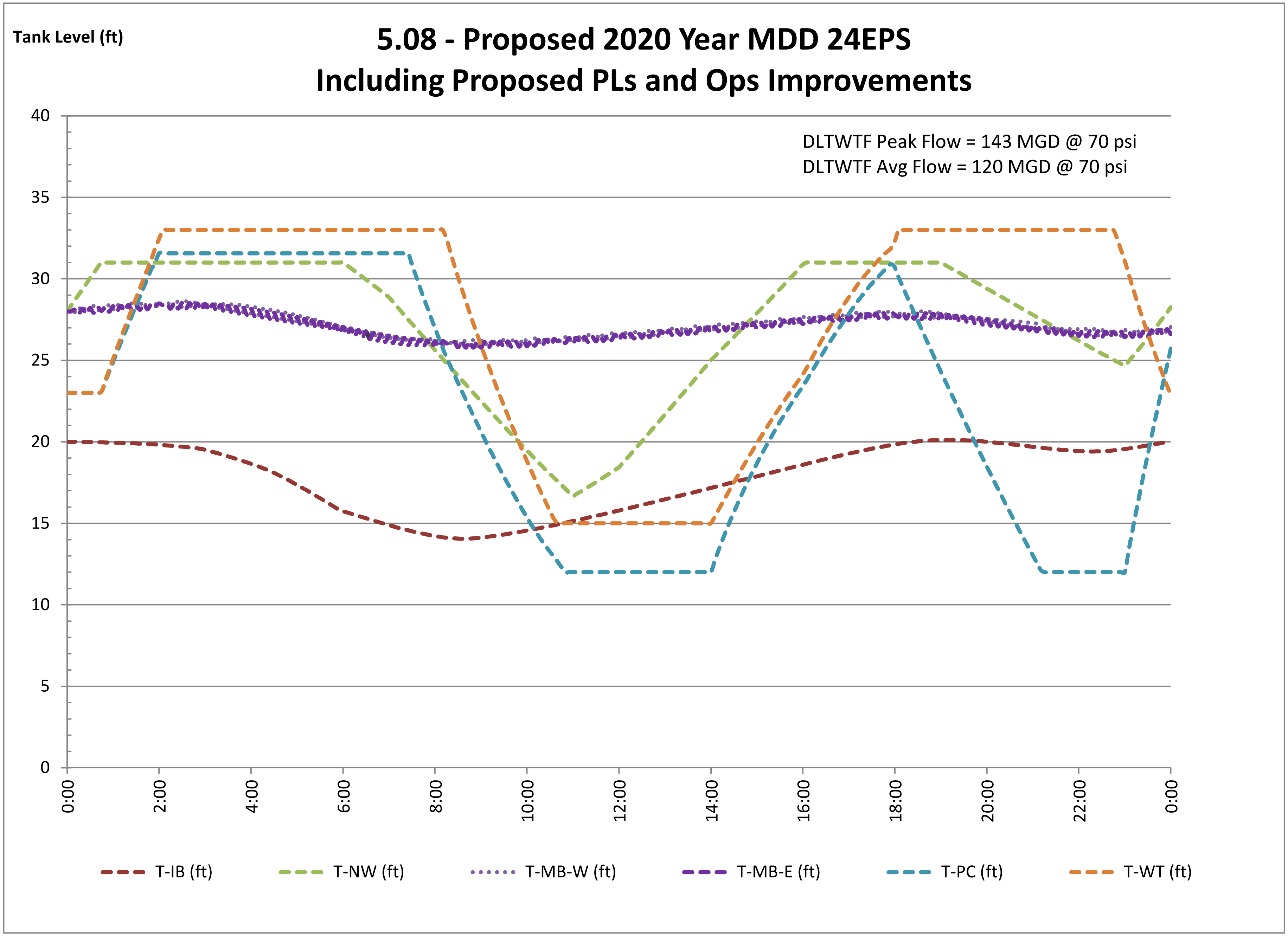
- South Tampa
- New Tampa
- Service Area

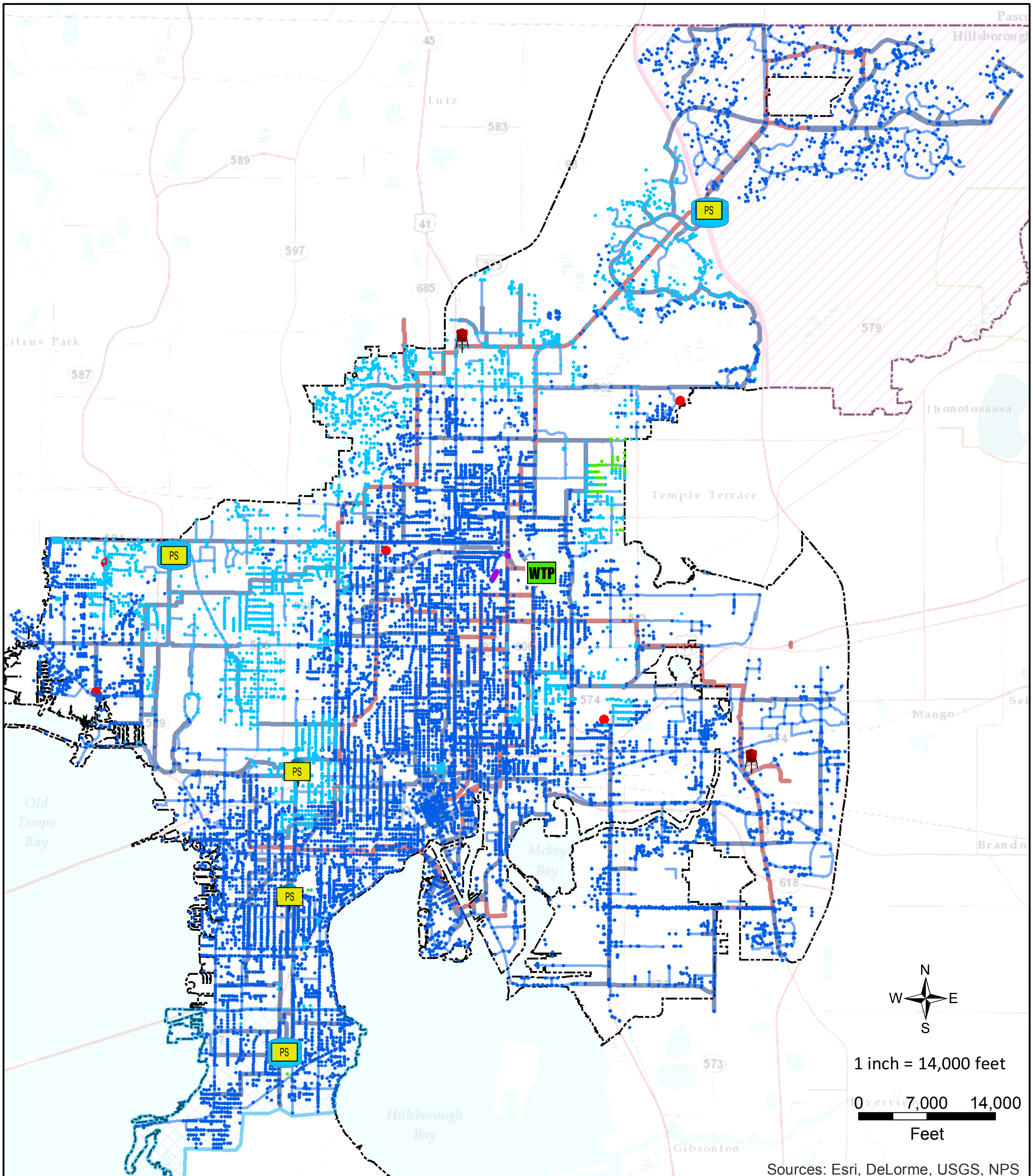
CITY OF TAMPA

Potable Water Master Plan

Figure 5.07

Proposed Planning Year 2020
MDD with 24Hr EPS
Maximum Velocity


Tank Level (ft)
5.08 - Proposed 2020 Year MDD 24EPS
Including Proposed PLs and Ops Improvements
DLTWTF Peak Flow = 143 MGD @ 70 psi
DLTWTF Avg Flow = 120 MGD @ 70 psi
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
T-IB (ft)
T-NW (ft)
T-MB-W (ft)
T-MB-E (ft)
T-PC (ft)
T-WT (ft)



WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Proposed Elevated Tank

MIN_PRESSURE	Diameter
Below 20 psi	< 12-inch
20 - 25 psi	12 - 16-inch
25 - 30 psi	16 - 24-inch
30 - 40 psi	> 24-inch
40 - 50 psi	South Tampa
50 - 75 psi	New Tampa
75 - 85 psi	Service Area
Greater than 85 psi	

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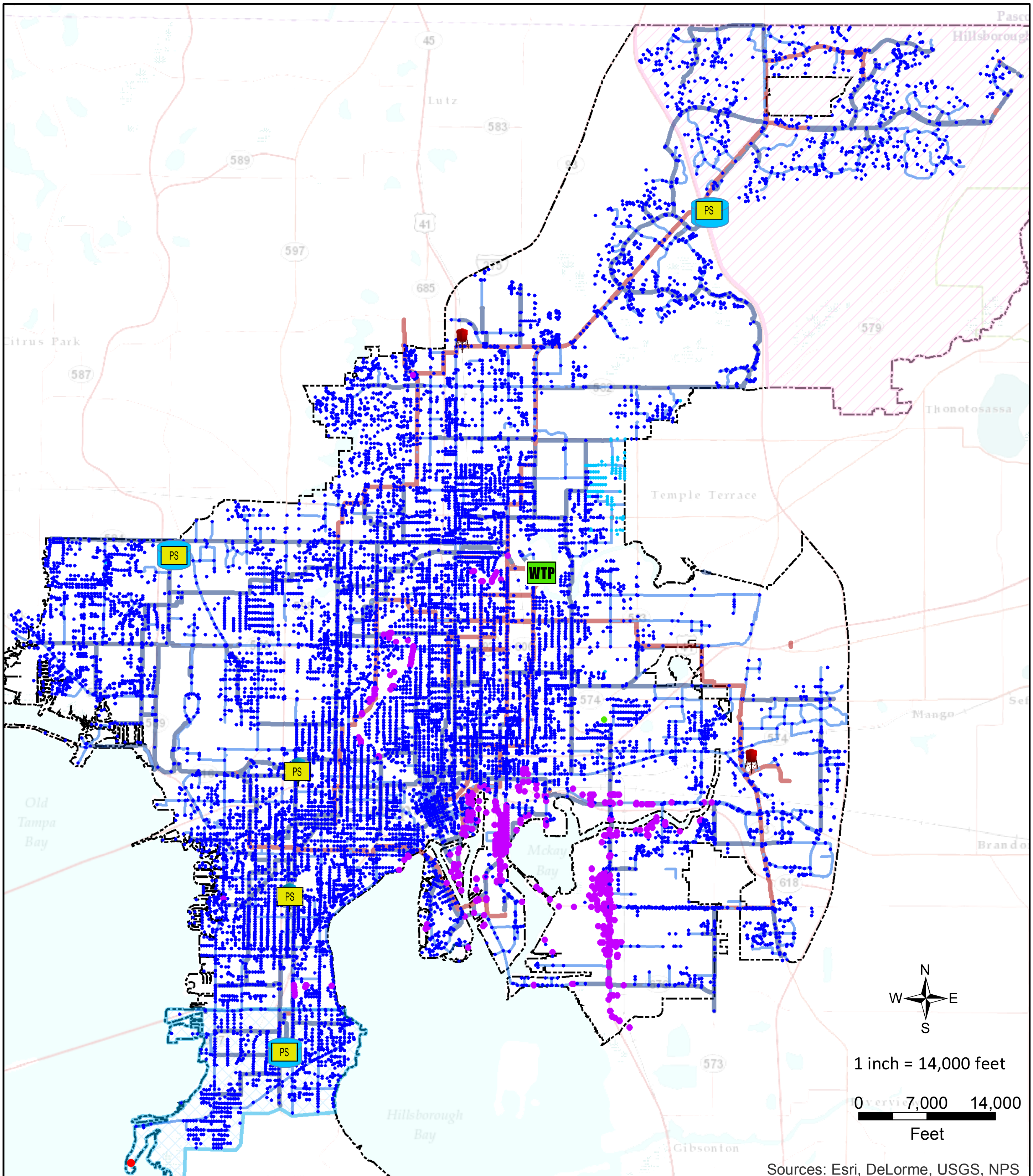
Potable Water Master Plan

Figure 5.09

Proposed Planning Year 2025 MDD with 24Hr EPS Minimum Pressures



City of Tampa Florida

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WTP	WTP
PS	Pump Stations
	Ground Storage Tank
	Elevated Storage Tank
	Proposed Elevated Tank

Maximum Pressures

MAX_PRESSURE
- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

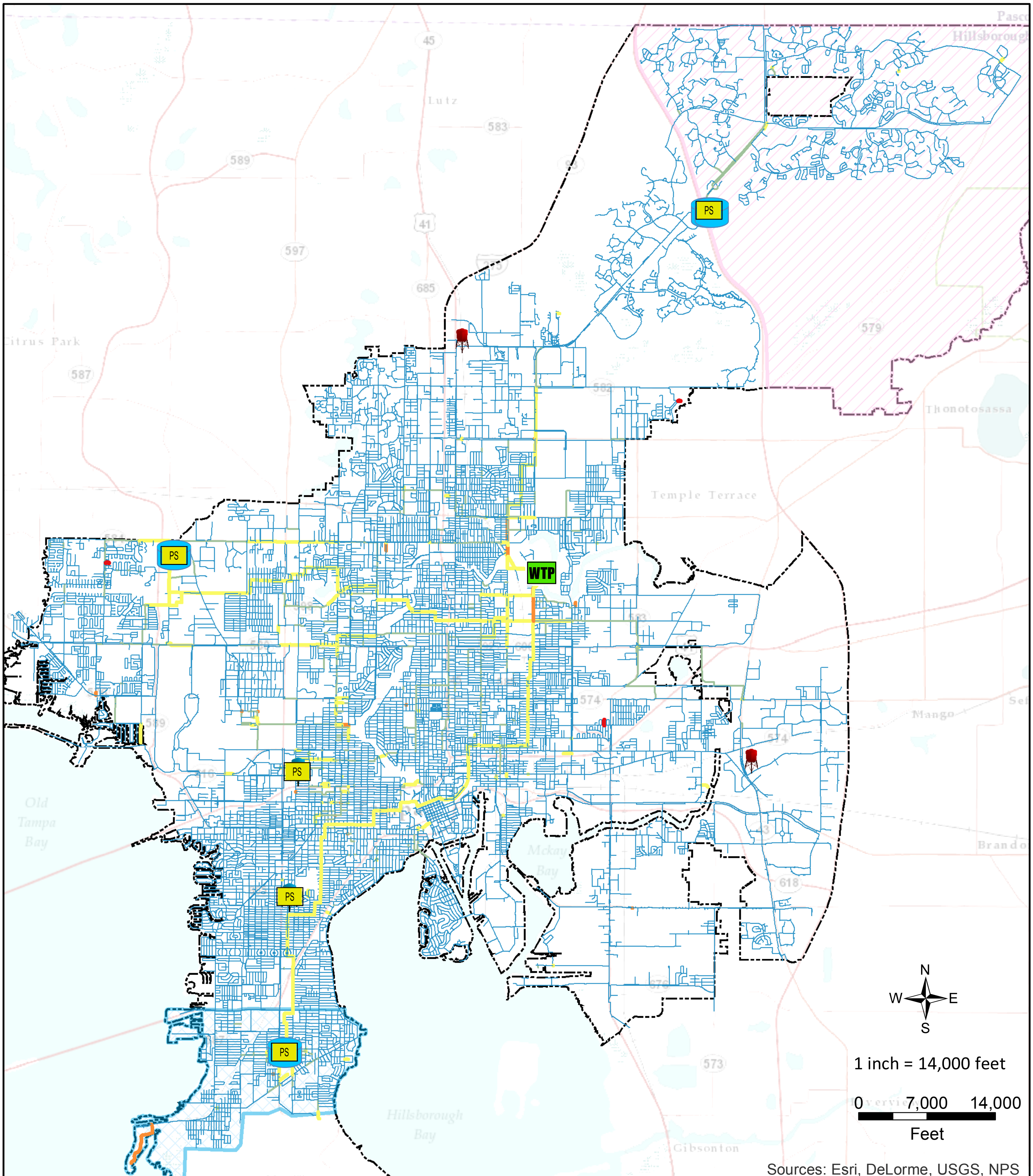
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 5.10

Proposed Planning Year 2025 MDD with 24Hr EPS Maximum Pressures



City of Tampa Florida

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WTP — WTP
PS — Pump Stations
Ground Storage Tank
Proposed Elevated Tank
Elevated Storage Tank

Max. Velocity
- Less than 2 fps
- 2 - 3 fps
- 3 - 5 fps
- 5 - 10 fps
- Greater than 10 fps

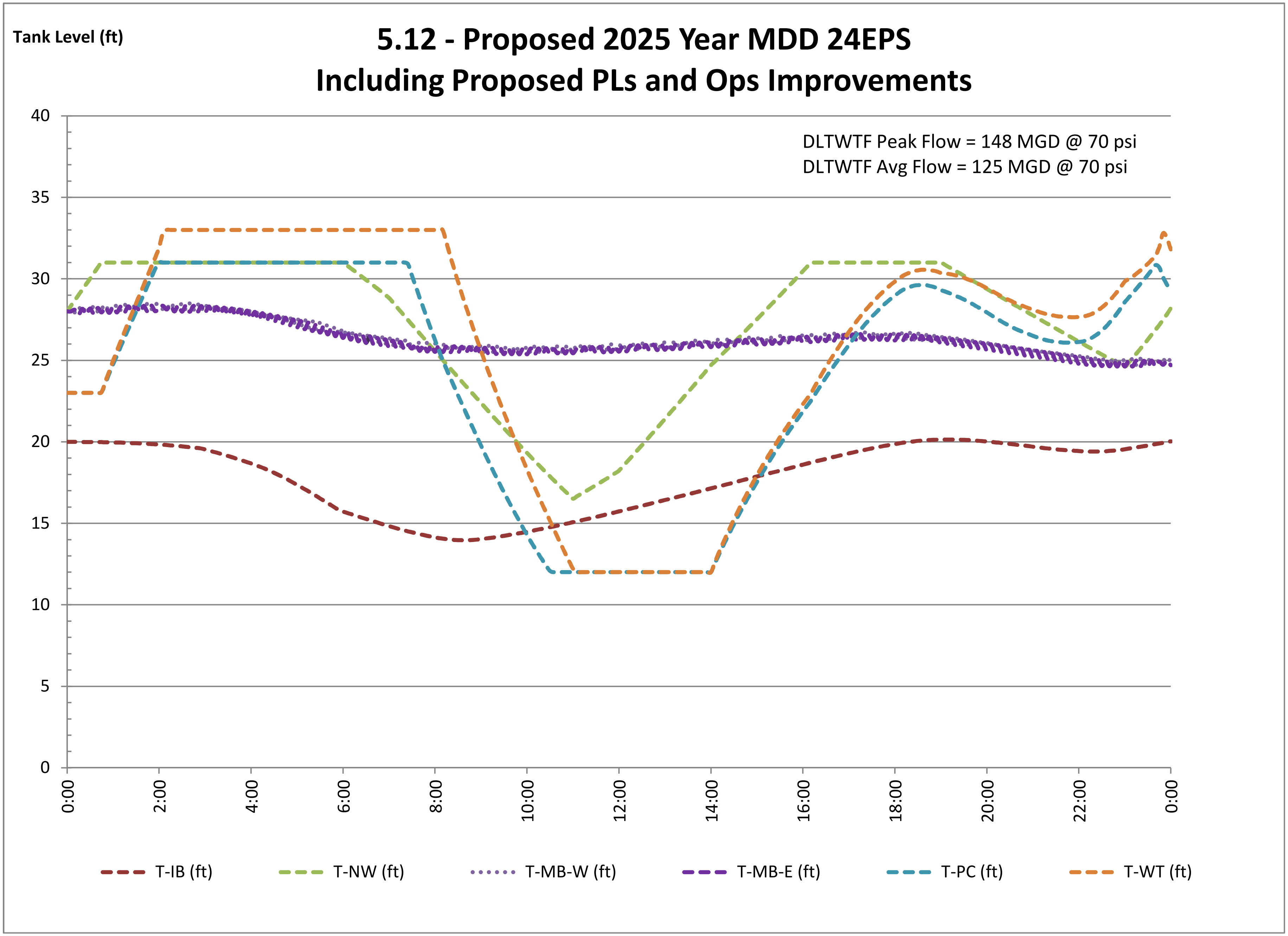
South Tampa
New Tampa
Service Area

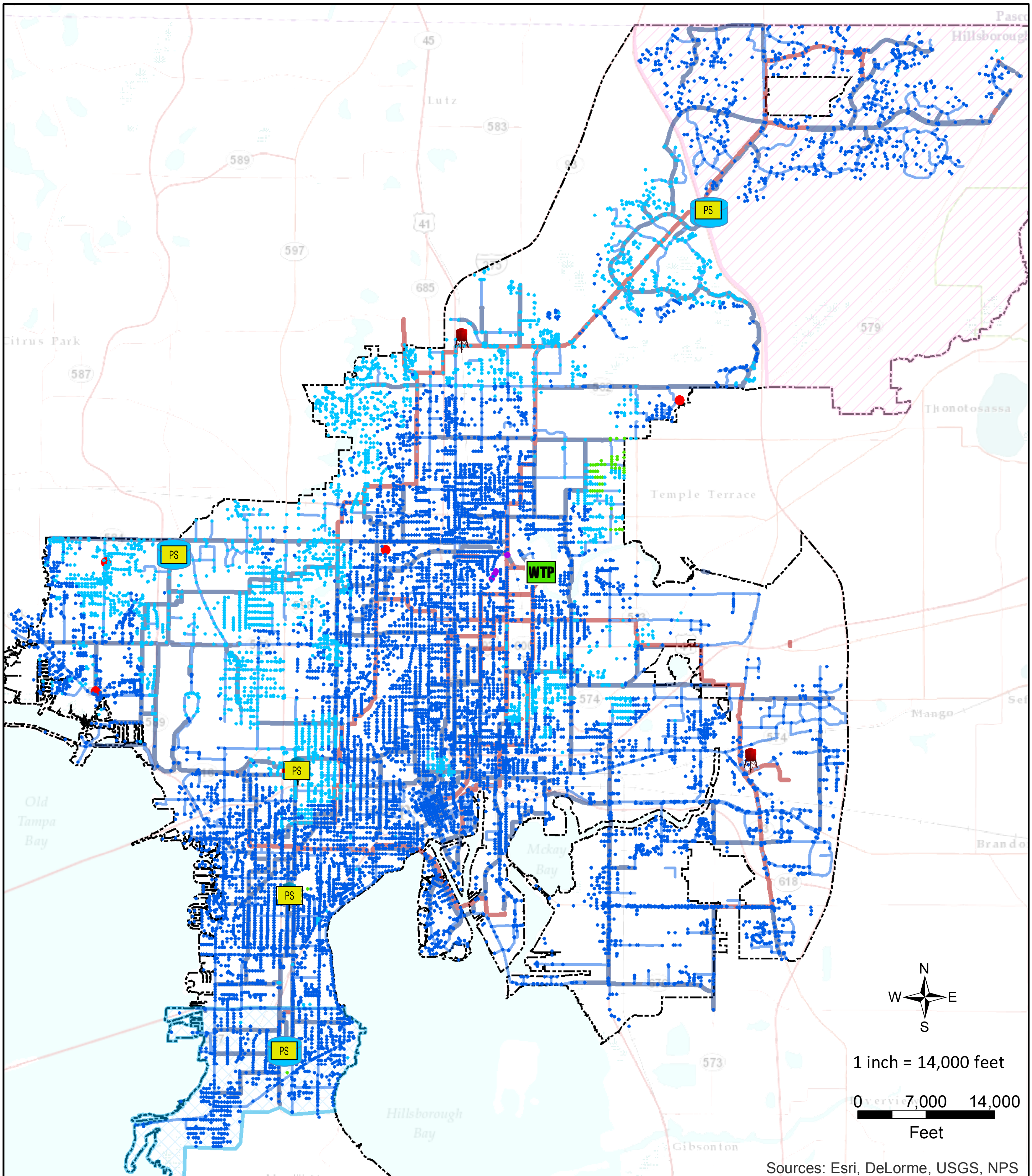
CITY OF TAMPA

Potable Water Master Plan

Figure 5.11

Proposed Planning Year 2025
MDD with 24Hr EPS
Maximum Velocity


Tank Level (ft)
5.12 - Proposed 2025 Year MDD 24EPS
Including Proposed PLs and Ops Improvements
DLTWTF Peak Flow = 148 MGD @ 70 psi
DLTWTF Avg Flow = 125 MGD @ 70 psi
40
35
30
25
20
15
10
5
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
T-IB (ft)
T-NW (ft)
T-MB-W (ft)
T-MB-E (ft)
T-PC (ft)
T-WT (ft)



City of Tampa Florida

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WTP
Pump Stations
Ground Storage Tank
Elevated Storage Tank
Proposed Elevated Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

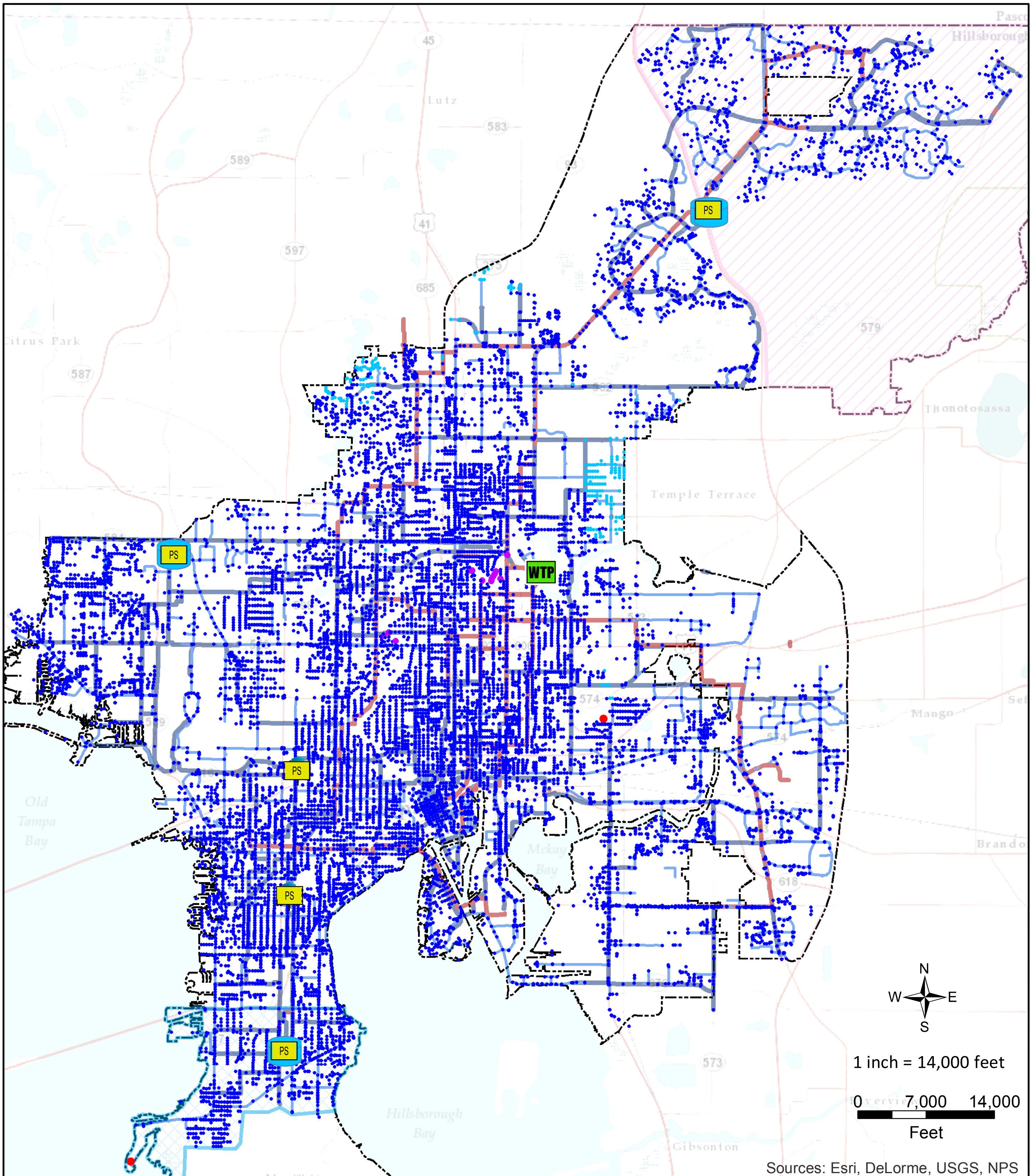
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 5.13

Proposed Planning Year 2035
MDD with 24Hr EPS
Minimum Pressures



City of Tampa Florida

BLACK & VEATCH
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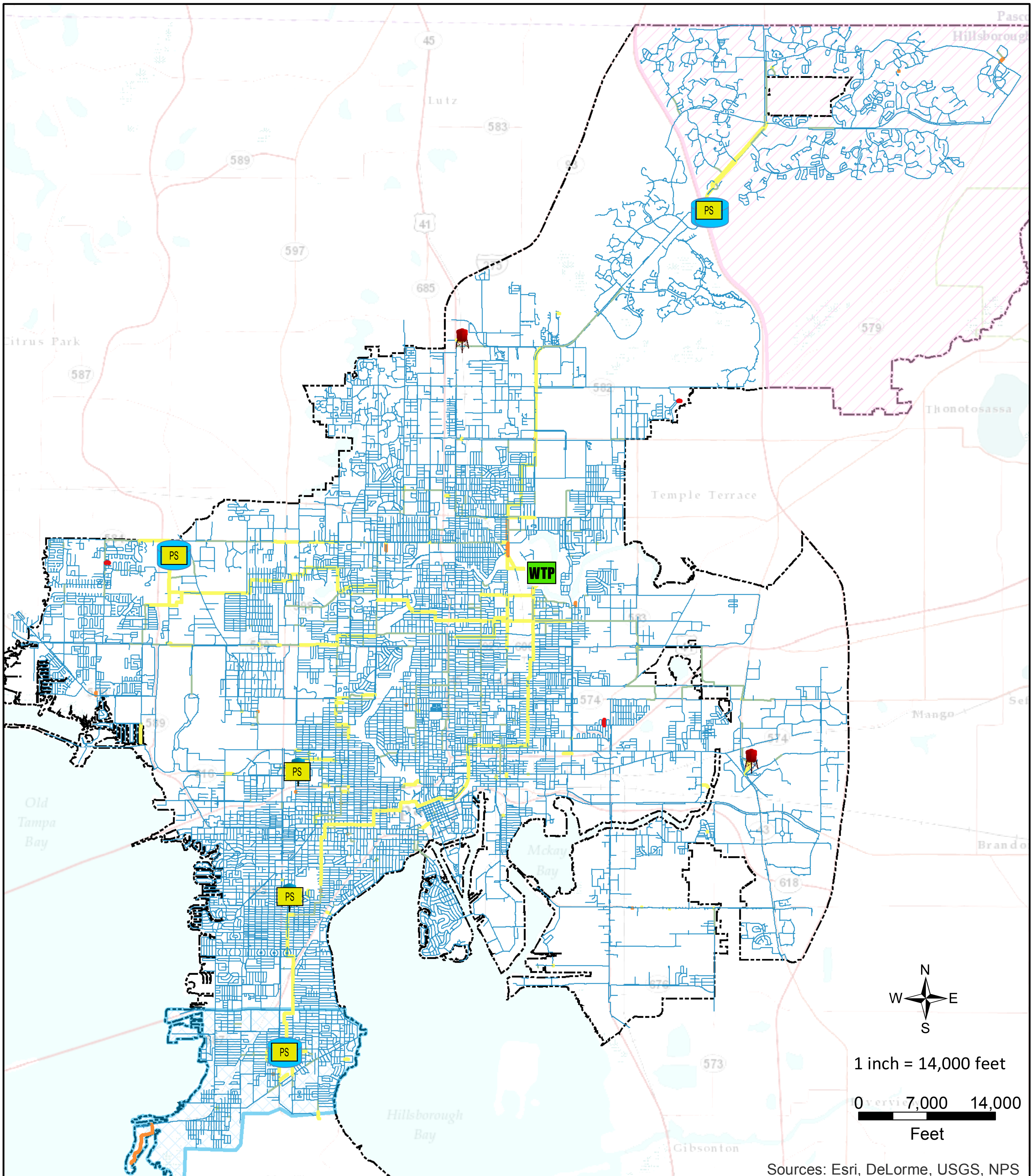
WTP WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank

Maximum Pressures
MAX_PRESSURE
- Less than 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA
Potable Water Master Plan
Figure 5.14
Proposed Planning Year 2035 MDD with 24Hr EPS Maximum Pressures



WTP

Pump Stations

Ground Storage Tank

Proposed Elevated Tank

Elevated Storage Tank

Max. Velocity

- Less than 2 fps
- 2 - 3 fps
- 3 - 5 fps
- 5 - 10 fps
- Greater than 10 fps

South Tampa

New Tampa

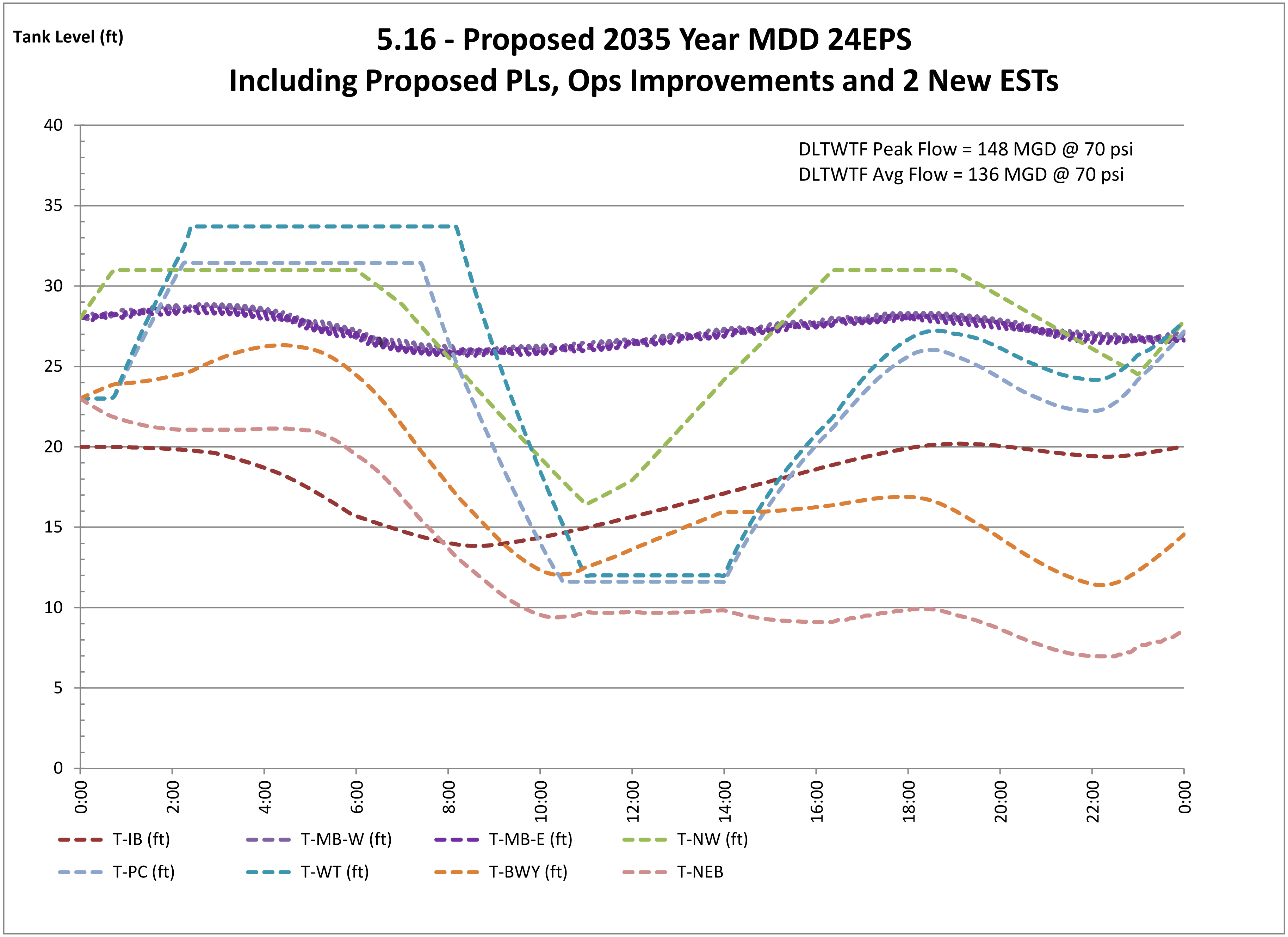
Service Area

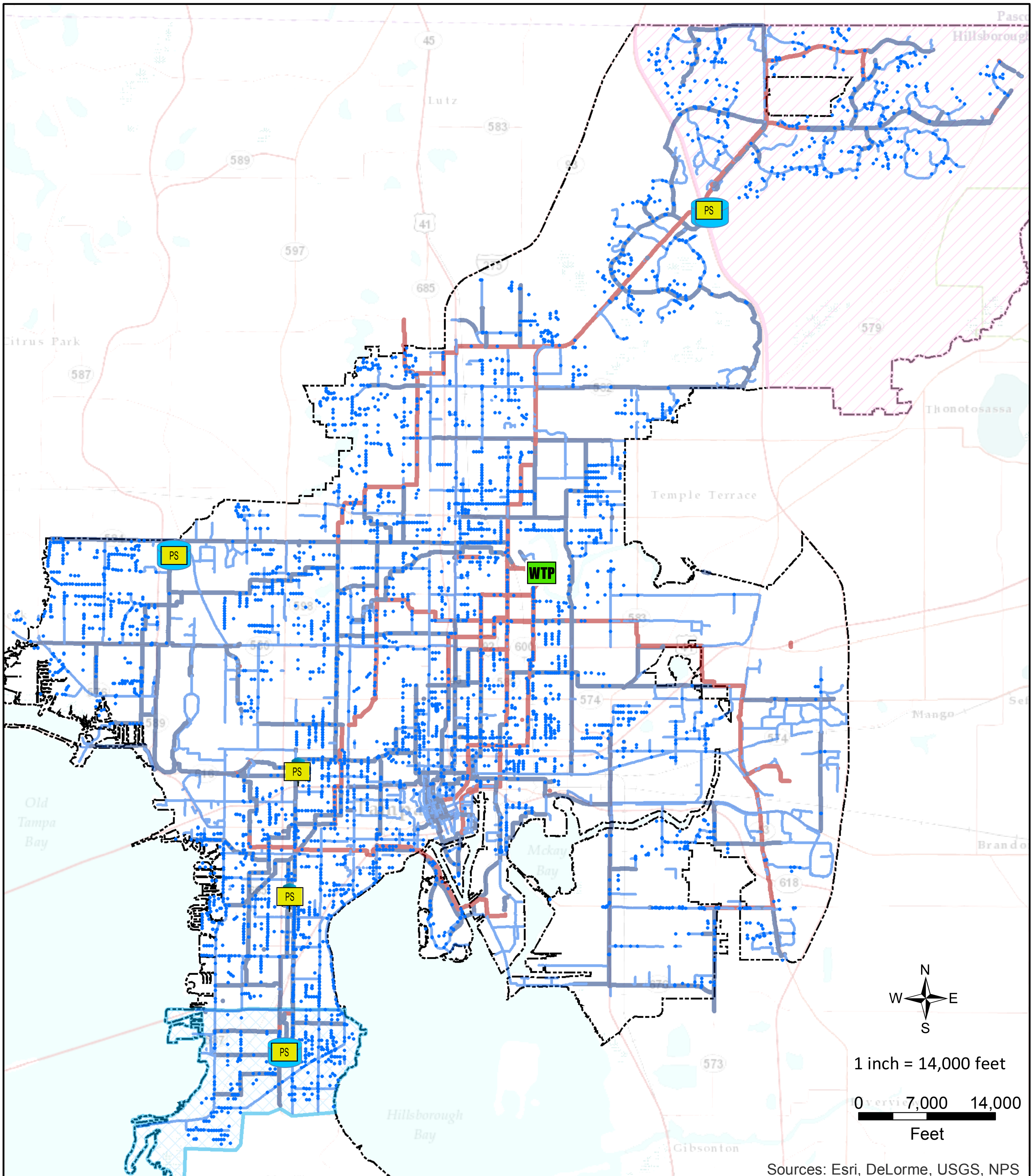
CITY OF TAMPA

Potable Water Master Plan

Figure 5.15

Proposed Planning Year 2035
MDD with 24Hr EPS
Maximum Velocity


Tank Level (ft)
5.16 - Proposed 2035 Year MDD 24EPS
Including Proposed PLs, Ops Improvements and 2 New ESTs
DLTWTF Peak Flow = 148 MGD @ 70 psi
DLTWTF Avg Flow = 136 MGD @ 70 psi
0
5
10
15
20
25
30
35
40
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
T-IB (ft)
T-MB-W (ft)
T-MB-E (ft)
T-NW (ft)
T-PC (ft)
T-WT (ft)
T-BWY (ft)
T-NEB



City of Tampa Florida

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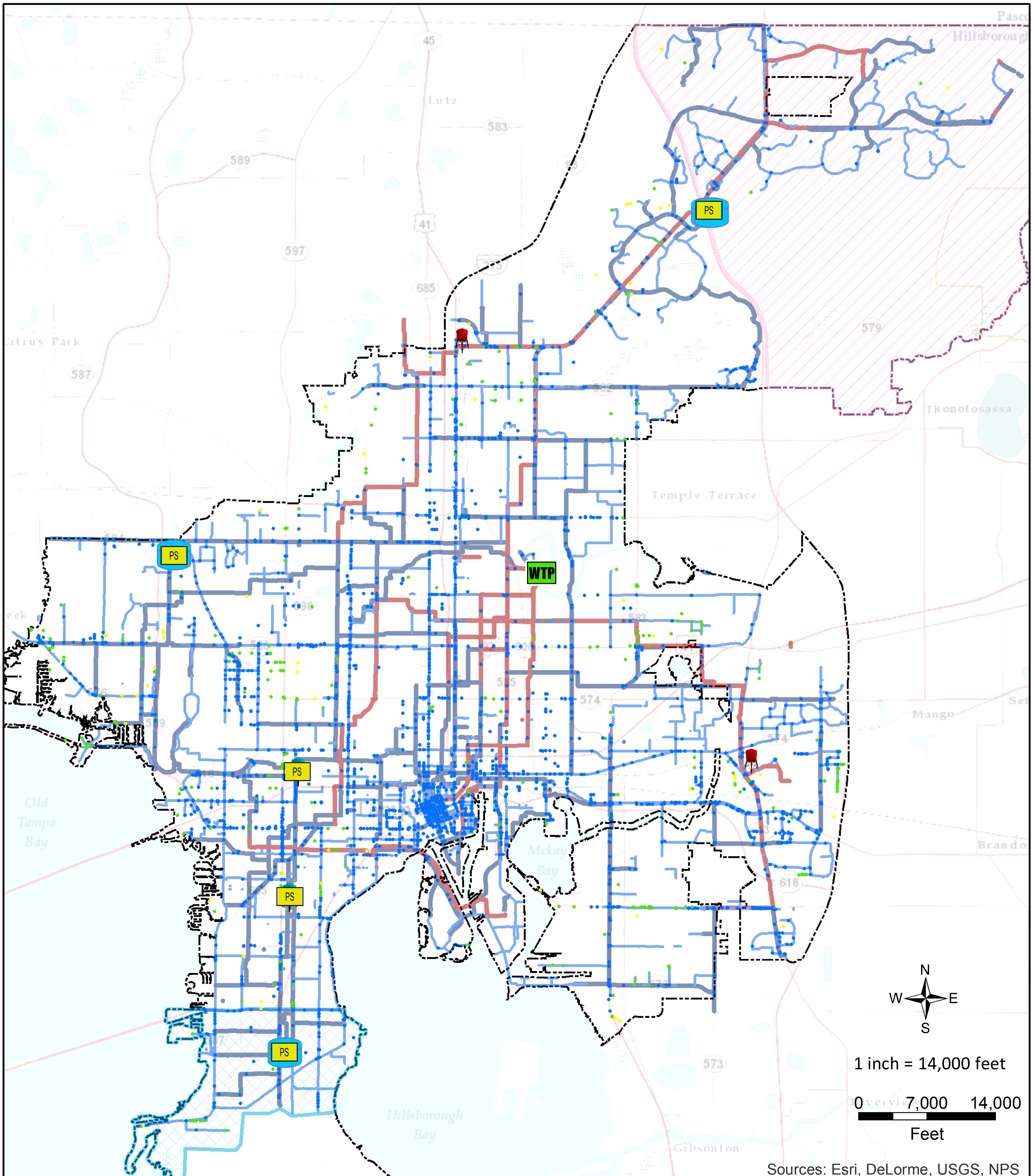
WTP — WTP
PS — Pump Stations
Ground Storage Tank
Elevated Storage Tank

AVAIL_FLOW
Greater than 1,000 gpm
500 to 1,000 gpm
Less than 500 gpm
South Tampa
New Tampa
Service Area

CITY OF TAMPA
Potable Water Master Plan
Figure 6.01
Proposed Base Year 2015
MDD+FF under SS
Available Residential Fire Flow



City of Tampa Florida

BLACK & VEATCH
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WTP WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank
Proposed Elevated Tank

AVAIL_FLOW
- Greater than 3,500 gpm
- 2,000 to 3,500 gpm
- 1,000 to 2,000 gpm
- 500 to 1,000 gpm
- Less than 500 gpm

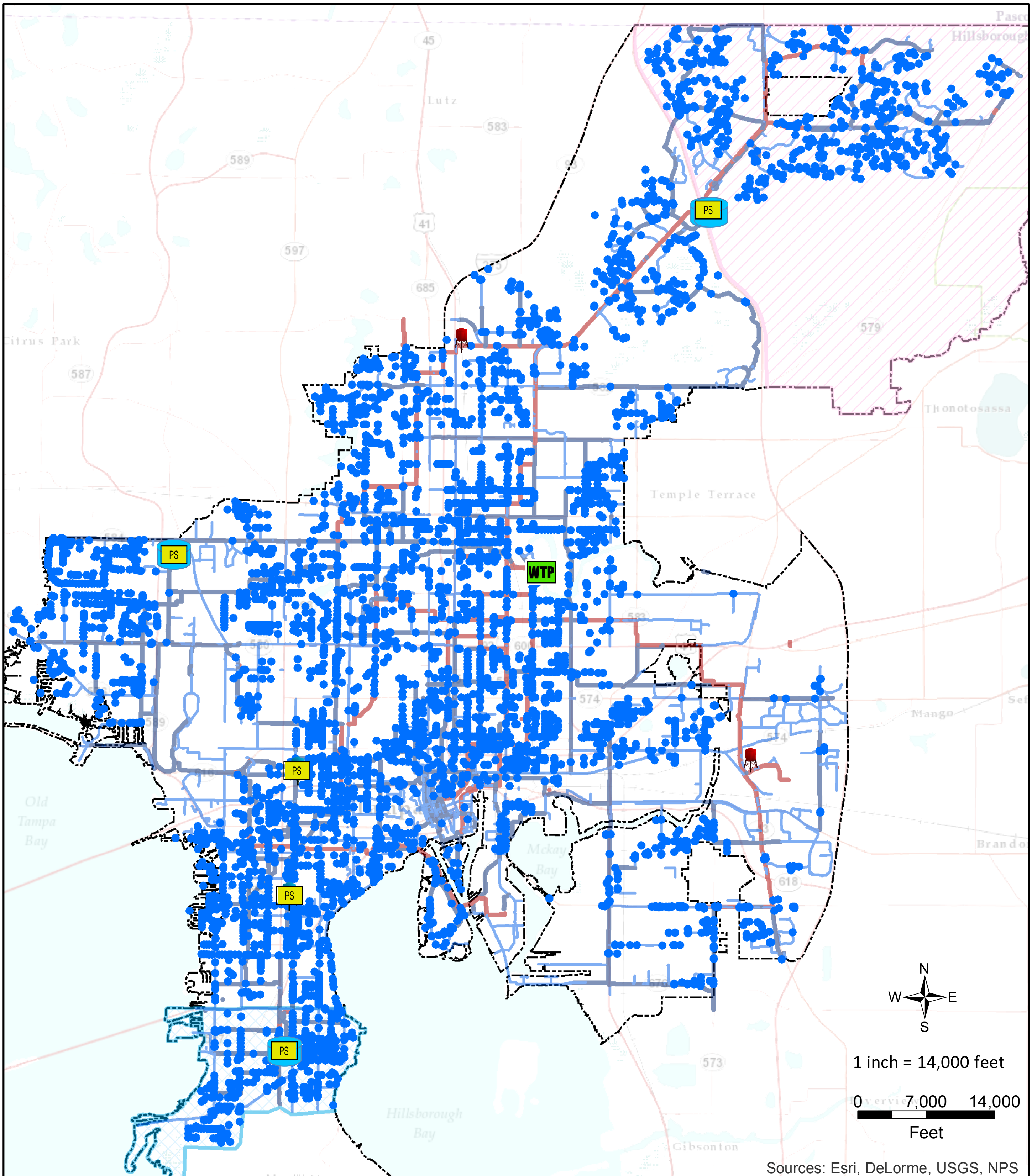
South Tampa
New Tampa
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 6.02

PRoposed Base Year 2015
MDD+FF under SS
Available Commerical Fire Flow



WTP — WTP

PS — Pump Stations

Ground Storage Tank

Elevated Storage Tank

Proposed Elevated Tank

AVAIL_FLOW

- Greater than 1,000 gpm
- 500 to 1,000 gpm
- Less than 500 gpm

South Tampa

New Tampa

Service Area

City of Tampa Florida

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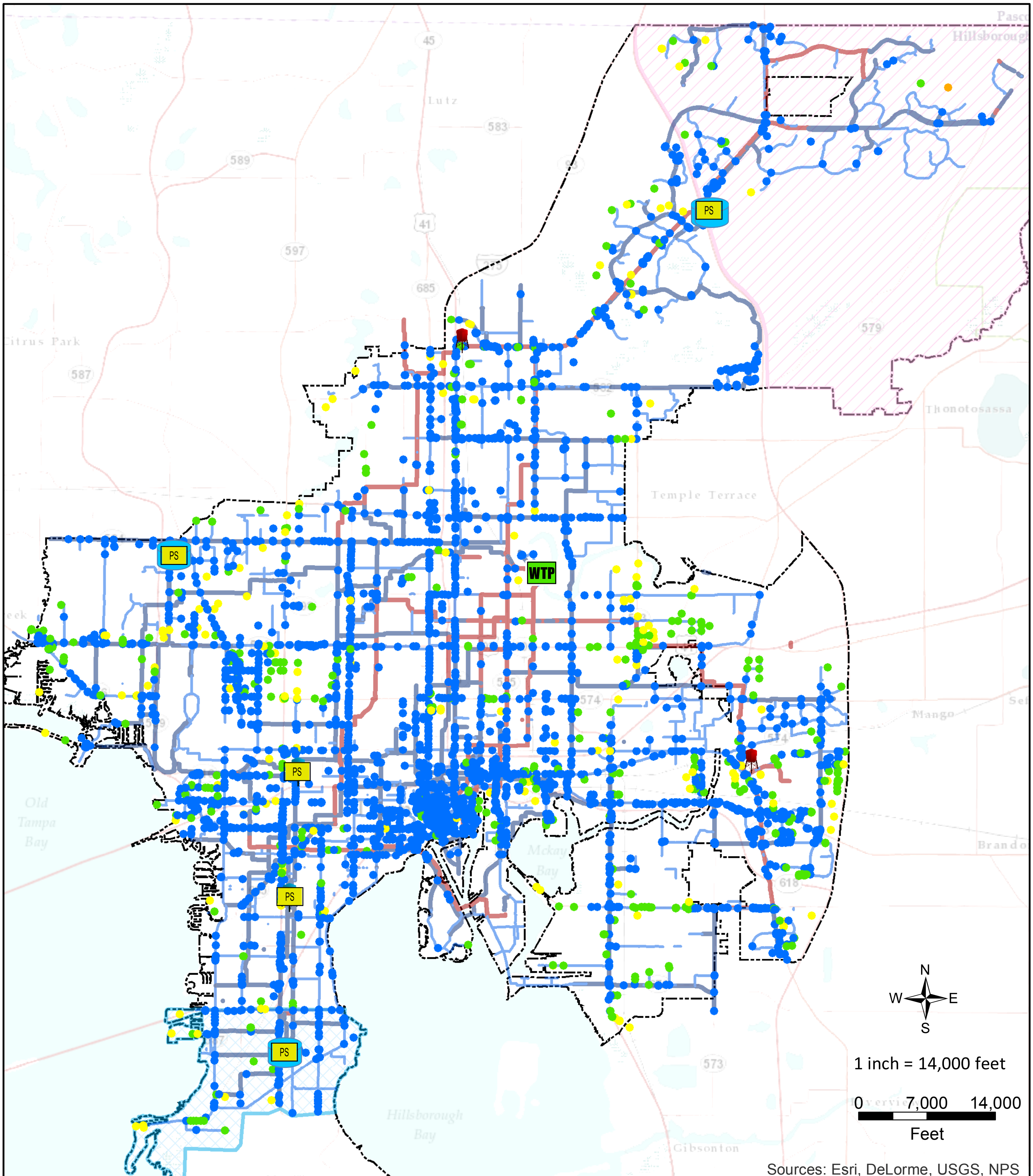
Potable Water Master Plan

Figure 6.03

Proposed Planning Year 2035
MDD+FF under SS
Available Residential Fire Flow



City of Tampa Florida

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WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Proposed Elevated Tank

AVAIL_FLOW

- Greater than 3,500 gpm
- 2,000 to 3,500 gpm
- 1,000 to 2,000 gpm
- 500 to 1,000 gpm
- Less than 500 gpm

South Tampa

New Tampa

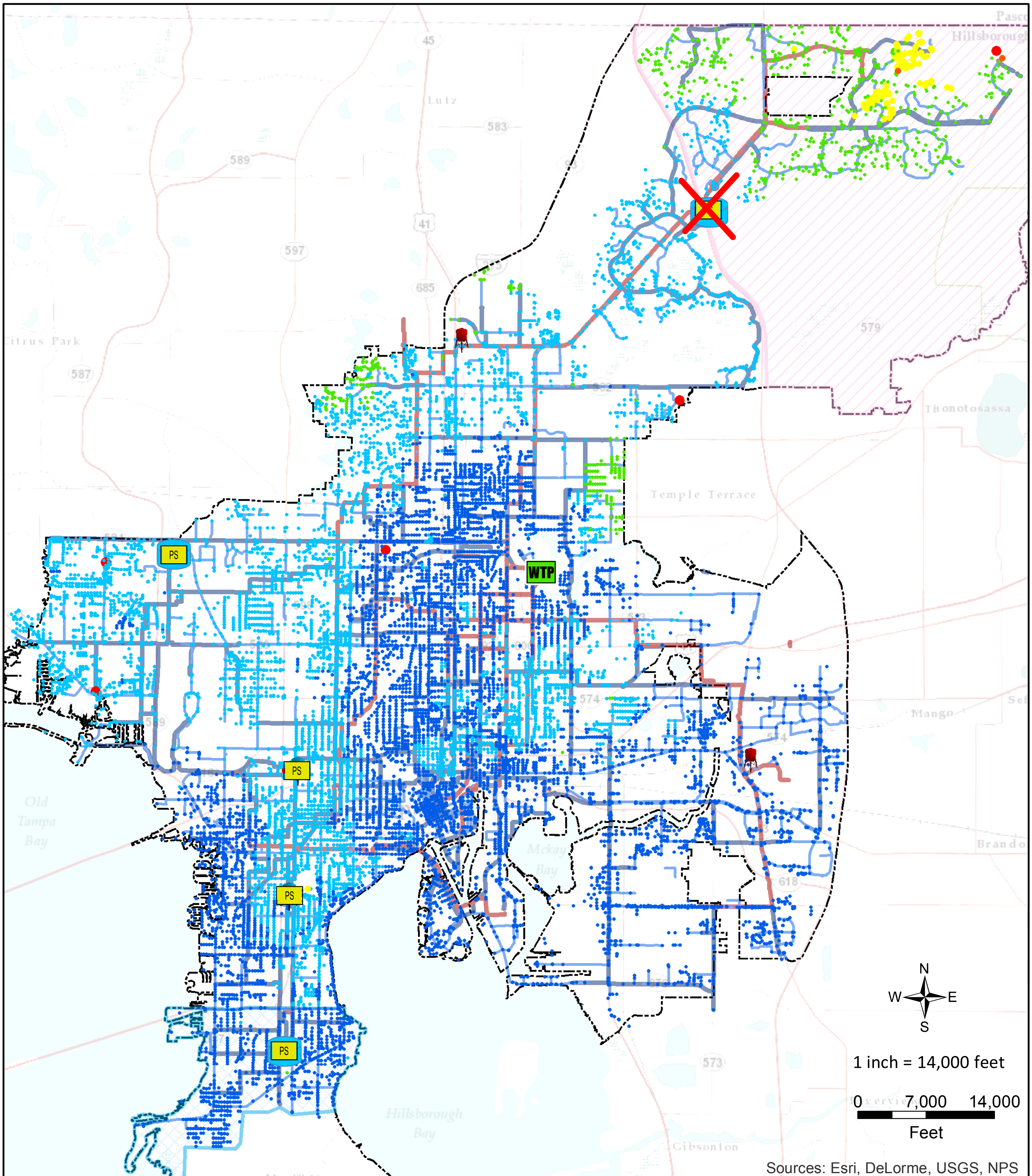
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 6.04

PRoposed Planning Year 2035
MDD+FF under SS
Available Commerical Fire Flow



City of Tampa Florida

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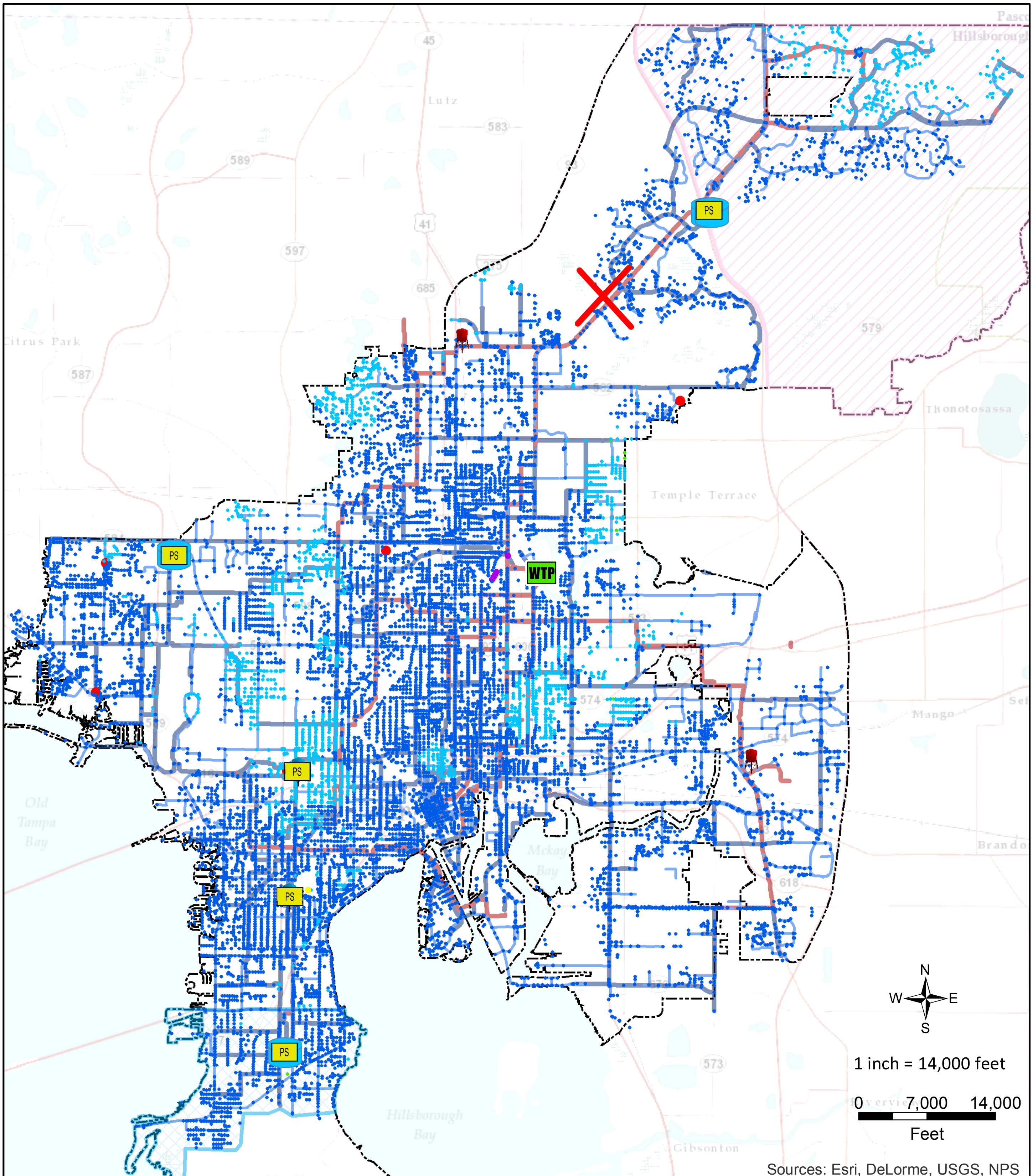
Potable Water Master Plan

Figure 7.01

Proposed Planning Year 2035 MBRPS Failure Minimum Pressures



City of Tampa Florida

BLACK & VEATCH
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WTP	WTP
PS	Pump Stations
	Ground Storage Tank
	Elevated Storage Tank
	Proposed Elevated Tank

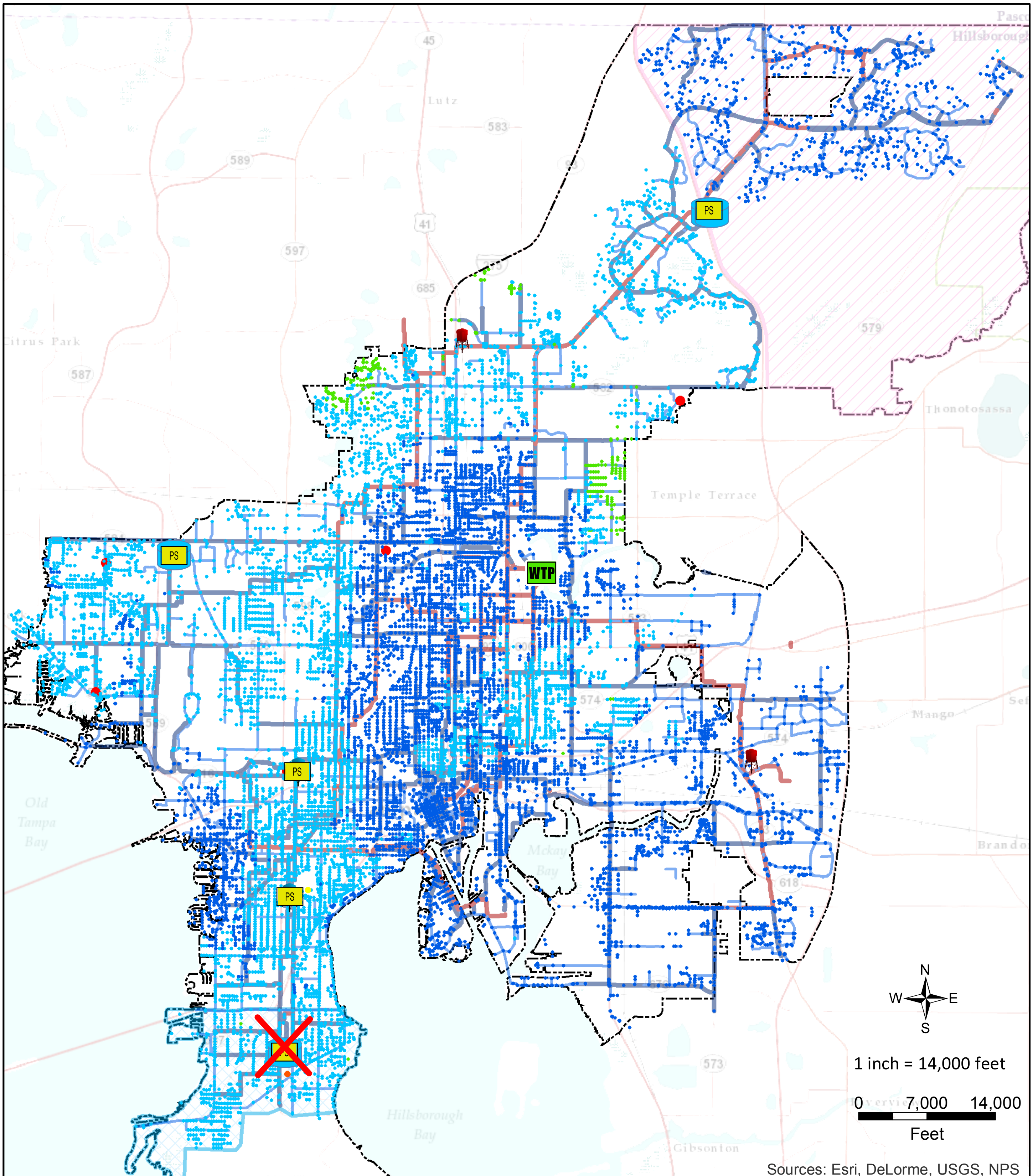
MIN_PRESSURE	Diameter
Below 20 psi	< 12-inch
20 - 25 psi	12 - 16-inch
25 - 30 psi	16 - 24-inch
30 - 40 psi	> 24-inch
40 - 50 psi	South Tampa
50 - 75 psi	New Tampa
75 - 85 psi	Service Area
Greater than 85 psi	

CITY OF TAMPA

Potable Water Master Plan

Figure 7.02

Proposed Planning Year 2035
MB 54-inch Failure
Minimum Pressures



City of Tampa Florida

BLACK & VEATCH
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WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank
Proposed Elevated Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

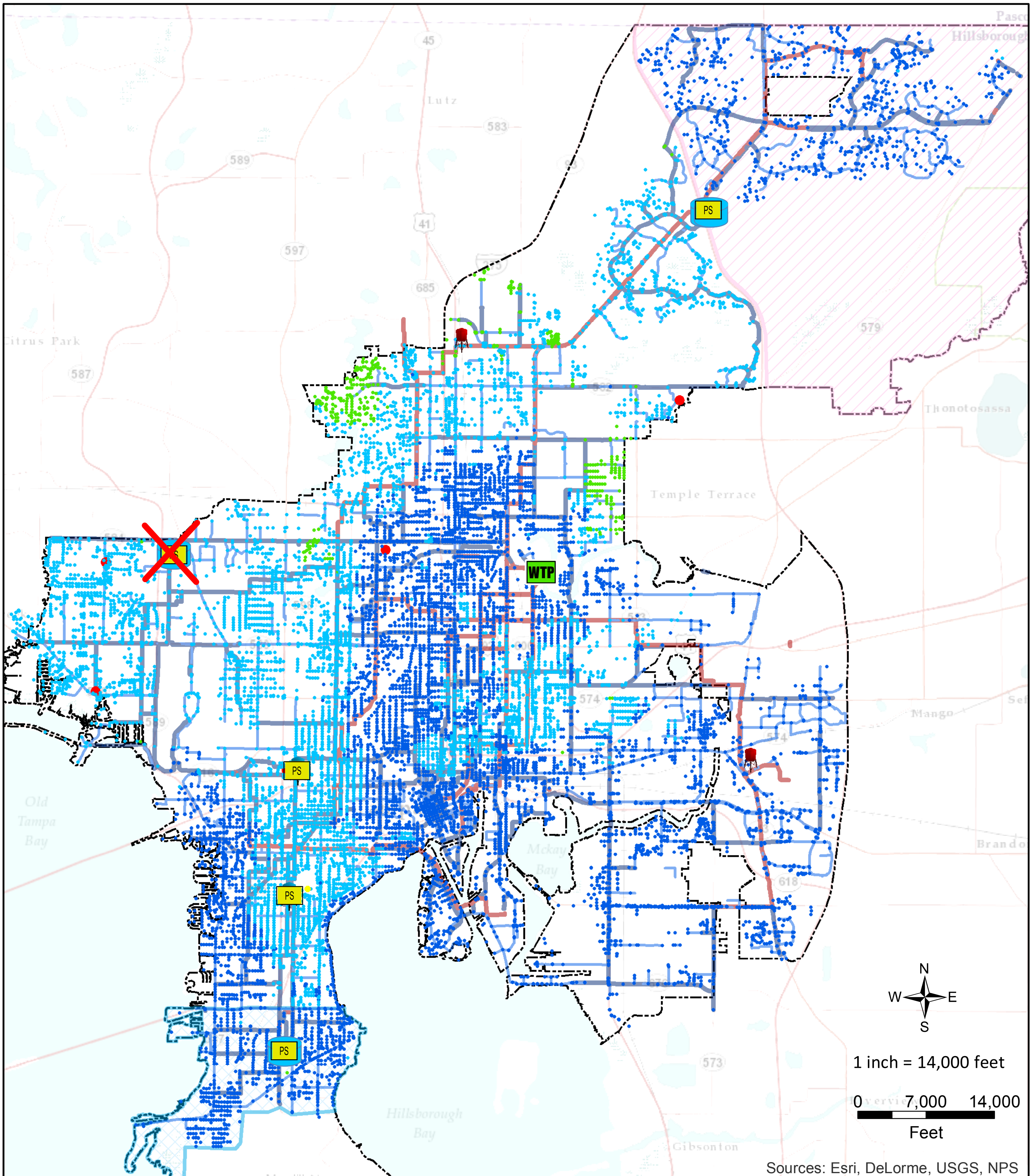
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 7.03

Proposed Planning Year 2035 IBRPS Failure Minimum Pressures



WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Proposed Elevated Tank

MIN_PRESSURE	Diameter
Below 20 psi	< 12-inch
20 - 25 psi	12 - 16-inch
25 - 30 psi	16 - 24-inch
30 - 40 psi	> 24-inch
40 - 50 psi	South Tampa
50 - 75 psi	New Tampa
75 - 85 psi	Service Area
Greater than 85 psi	

City of Tampa Florida

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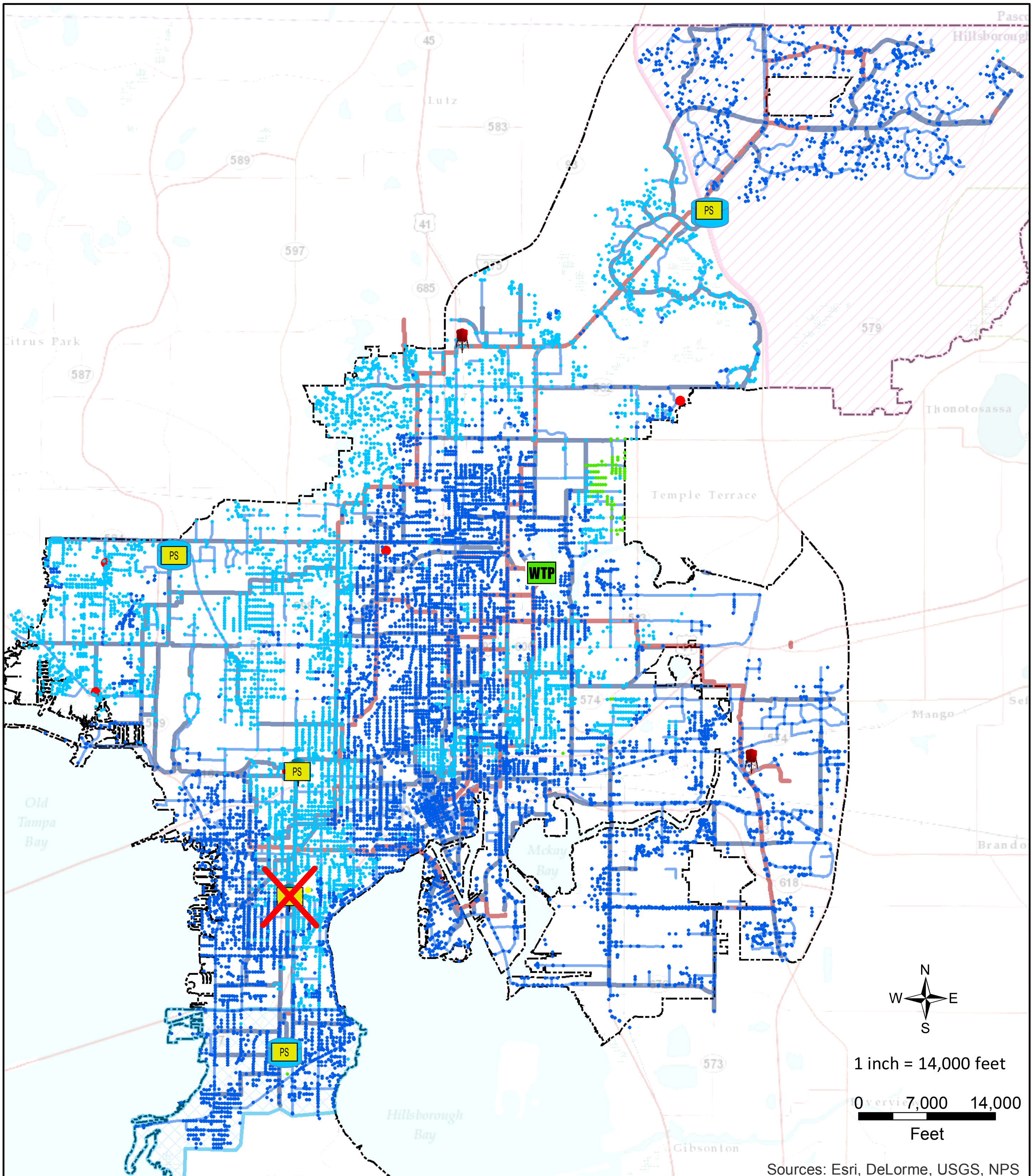
Potable Water Master Plan

Figure 7.04

Proposed Planning Year 2035
NWRPS Failure
Minimum Pressures



City of Tampa, Florida

BLACK & VEATCH
Building a world of difference.

WTP
PS Pump Stations
Ground Storage Tank
Elevated Storage Tank
Proposed Elevated Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

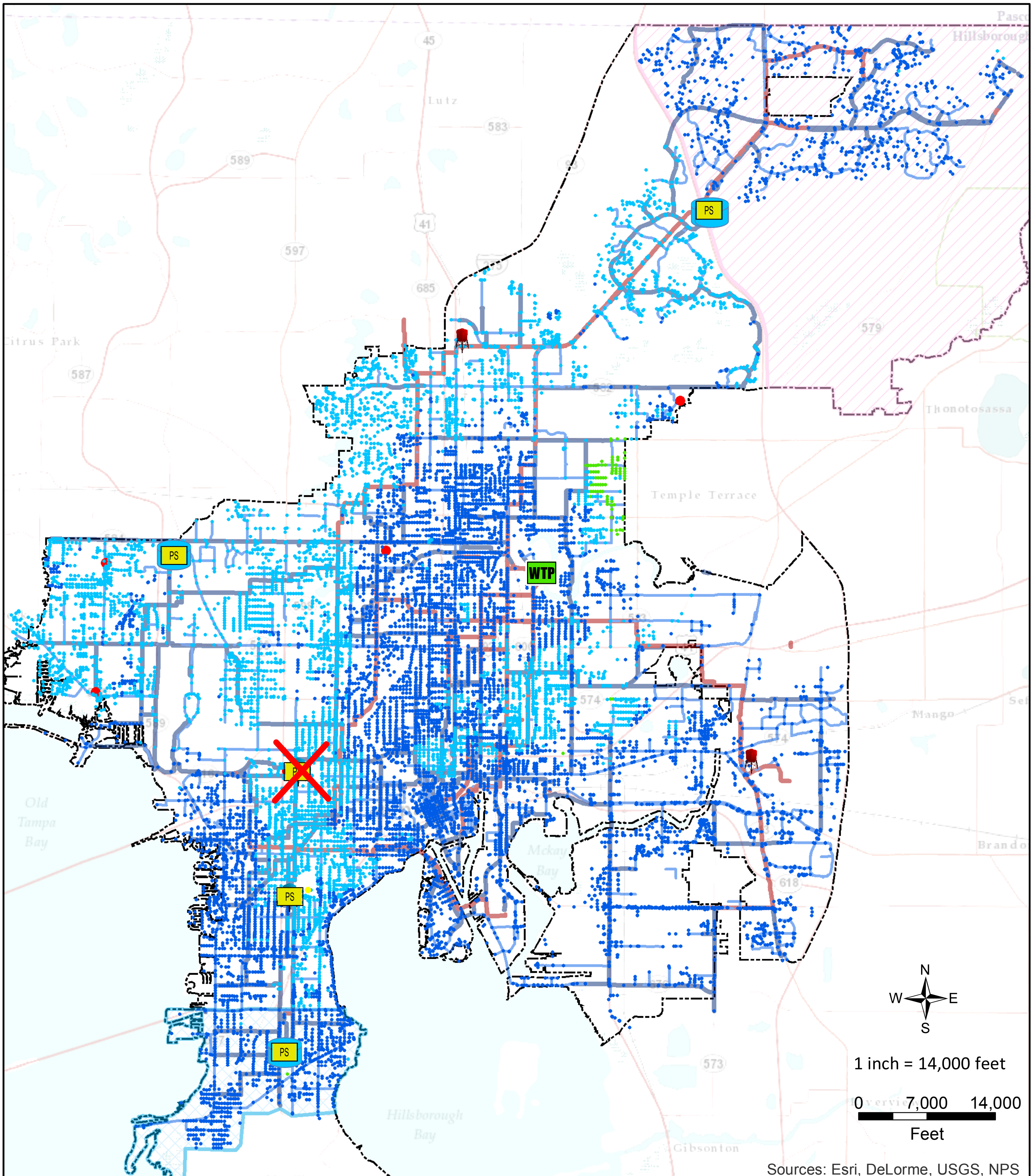
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 7.05

Proposed Planning Year 2035 PCRPS Failure Minimum Pressures



City of Tampa Florida

BLACK & VEATCH
Building a world of difference.

WTP
Pump Stations
Ground Storage Tank
Elevated Storage Tank
Proposed Elevated Tank

MIN_PRESSURE
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

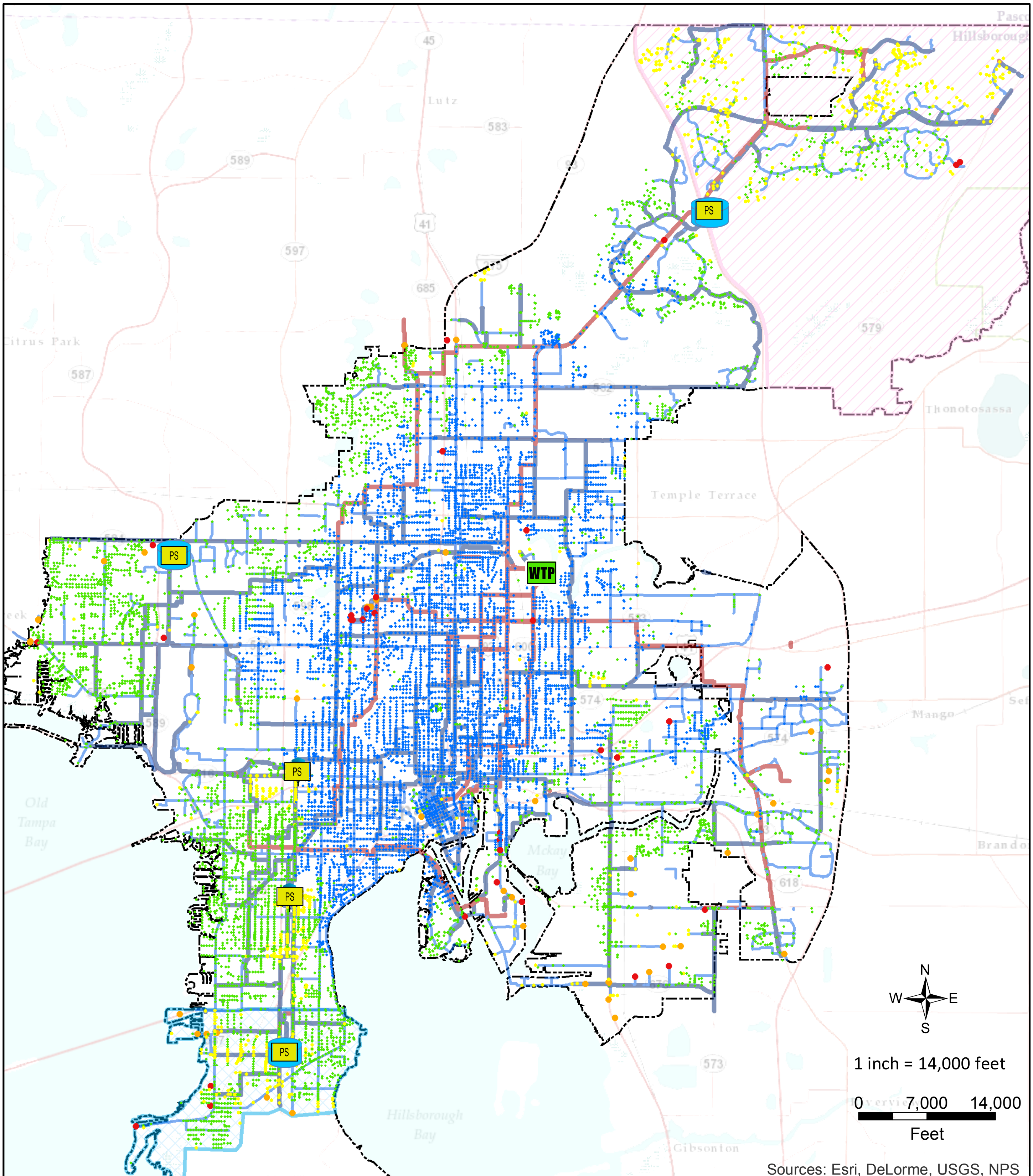
Diameter
- < 12-inch
- 12 - 16-inch
- 16 - 24-inch
- > 24-inch
- South Tampa
- New Tampa
- Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 7.06

Proposed Planning Year 2035
WTRPS Failure
Minimum Pressures



City of Tampa Florida

BLACK & VEATCH
Building a world of difference.

WTP — WTP
PS — Pump Stations
Ground Storage Tank
Elevated Storage Tank

Water Age
- Less than 1 day
- 1 to 5 days
- 5 to 10 days
- 10 to 20 days
- Greater than 20 days

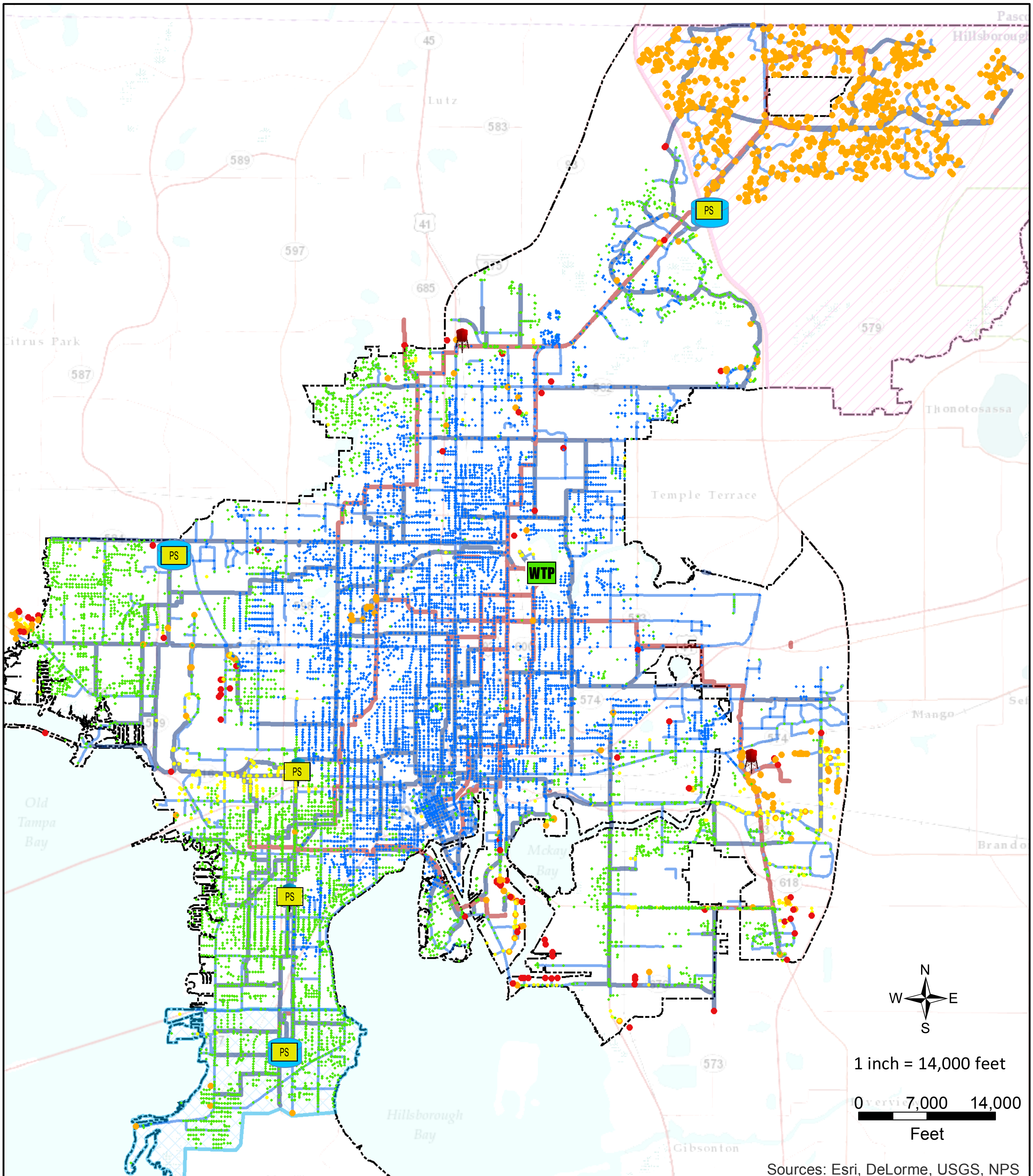
South Tampa
New Tampa
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 8.01

Proposed Base Year 2015
ADD under SS
Water Age



WTP

Pump Stations

Ground Storage Tank

Elevated Storage Tank

Proposed Elevated Tank

Water Age

- Less than 1 day
- 1 to 5 days
- 5 to 10 days
- 10 to 20 days
- Greater than 20 days

South Tampa

New Tampa

Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 8.02

Proposed Planning Year 2035 ADD under SS Water Age

Appendix B

Recommended Storage Improvements Workshop Presentation

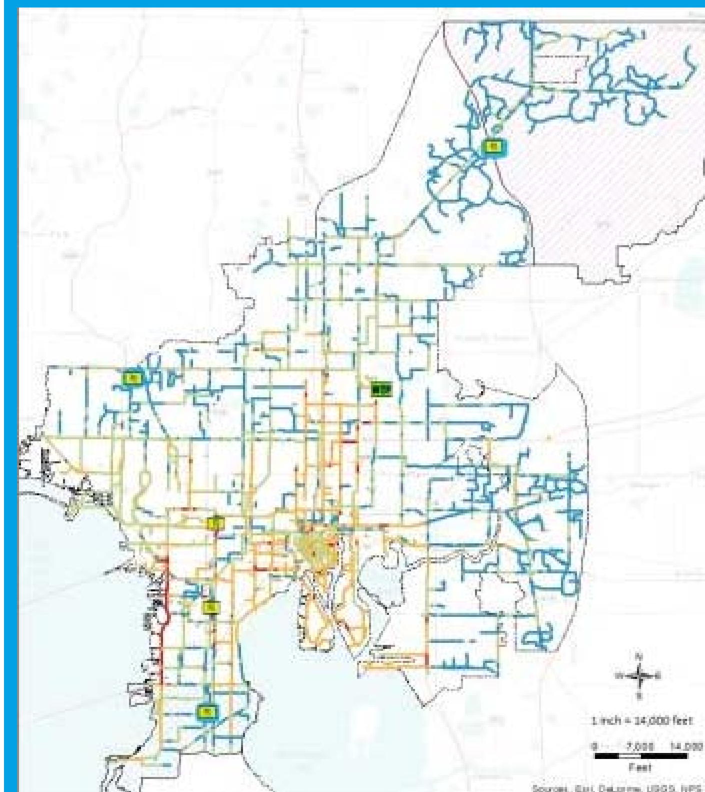
BUILDING A WORLD OF DIFFERENCE

Recommended Storage Improvements Workshop

Bobby Burchett
Amanda Schwerman

BUILDING A WORLD OF DIFFERENCE®

BLACK & VEATCH



Agenda

- Project Status Update
- Review of Distribution Storage Requirements
- Various Storage Results
- Review of Other Performance Criteria
- Next Steps and Timeline

Review of Distribution Storage Requirements

- **Total Storage (per zone) > 25% of Zone's MDD + Fire Flow Reserve, [F.A.C. 62-555.320(19)(a)]**
  - **Fire Flow Reserve = 3,500 gpm for 3 hours = 0.63 MG; [Florida Fire Code]**

PRESSURE ZONE	STORAGE FACILITY	TOTAL VOLUME (MG)	EFFECTIVE VOLUME (MG)	Minimum Storage Volume (MG) 25% of MDD + Fire Reserve[(1)] 2015	2020	2025	2035	MEETS CRITERIA (Y/N) 2015	2020	2025	2035
New Tampa	Morris Bridge RPS	10.0	7.5	2.5	3.0	3.3	3.9	Y	Y	Y	Y
South Tampa	Interbay RPS	5.0	5.0	2.4	2.6	2.7	2.7	Y	Y	Y	Y
DLTWTF	DLTWTF Total	26.0	18.5	23.9	26.4	27.4	29.6	N	N	N	N
	Clearwell	*20.0*	*12.5*								
	Northwest	*3.0*	*3.0*								
	West Tampa	*1.5*	*1.5*								
	Palma Ceia	*1.5*	*1.5*								
Deficient Storage without considering the Morris Bridge excess volume (MG)								5.4	7.9	8.9	11.1
Deficient Storage considering the Morris Bridge excess volume (MG)								0.4	3.4	4.8	7.5

1. Fire Reserve storage required is 3500 gpm for 3 hours or 0.63 MG

  - **Alternative Requirement: A demonstration showing that in conjunction with the capacity of the water system's source, treatment and finished-water pumping facilities, the water system's total useful finished water storage capacity (minus fire protection) is sufficient to meet the water systems PHD for 4 consecutive hours [F.A.C. 62-555.320(19)(b)2]**

Additional Storage Options Scope of Services

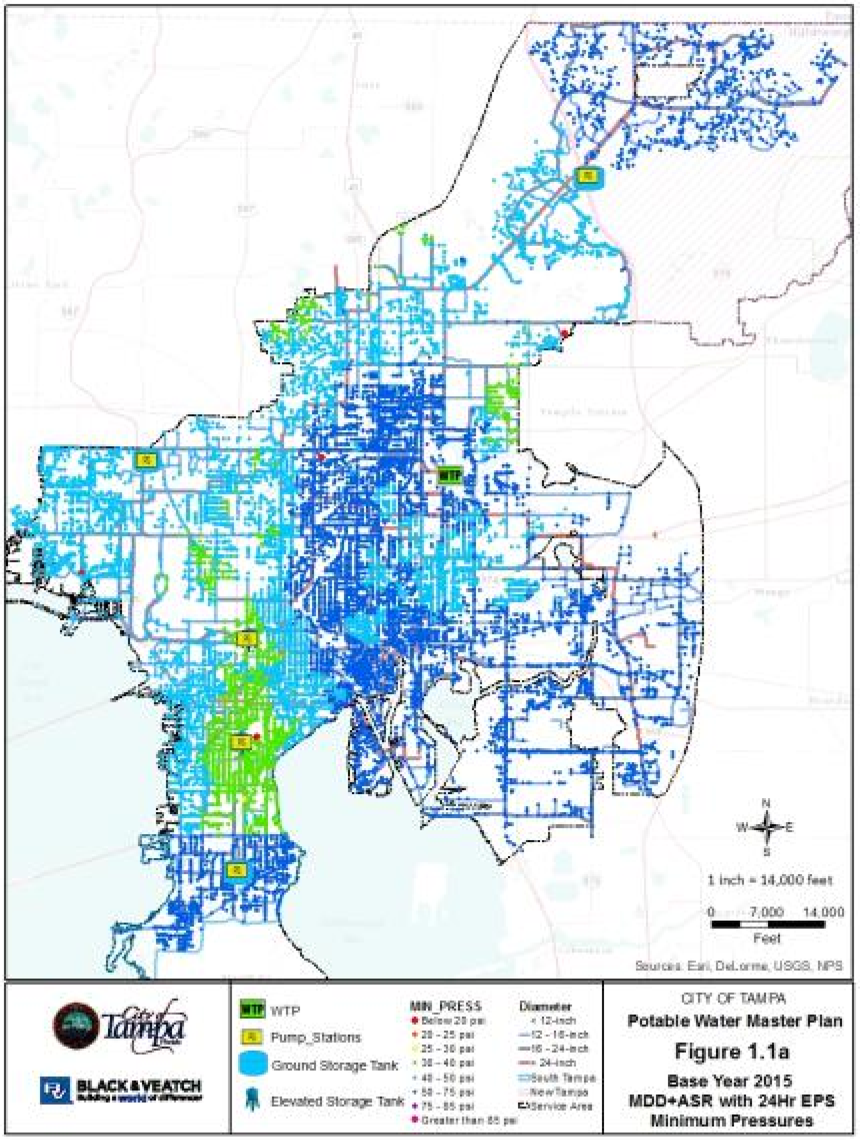
- **Additional Distribution Storage:**
  - **DLTWTF Clearwell**
  - **New Elevated Storage Tanks**
  - **Additional Ground Storage Tanks**
  - **Additional Interconnects**

- **Additional Considerations:**
  - **Impacts to transient/surge controls**
  - **Long term plan for existing elevated tanks**
  - **Increase treated water source redundancy & reliability with neighboring utilities**

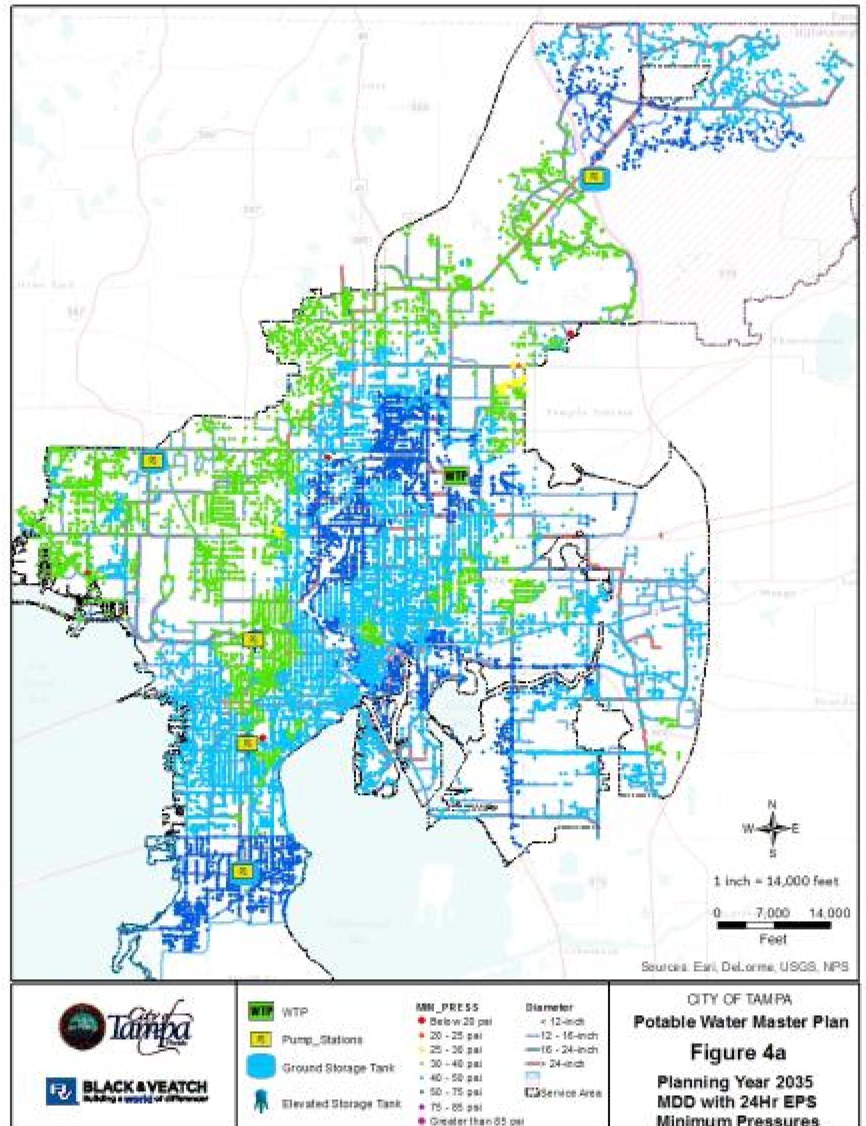
System Analysis Reminder

System Assessment – Base Year & 2035

MIN_PRESS
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

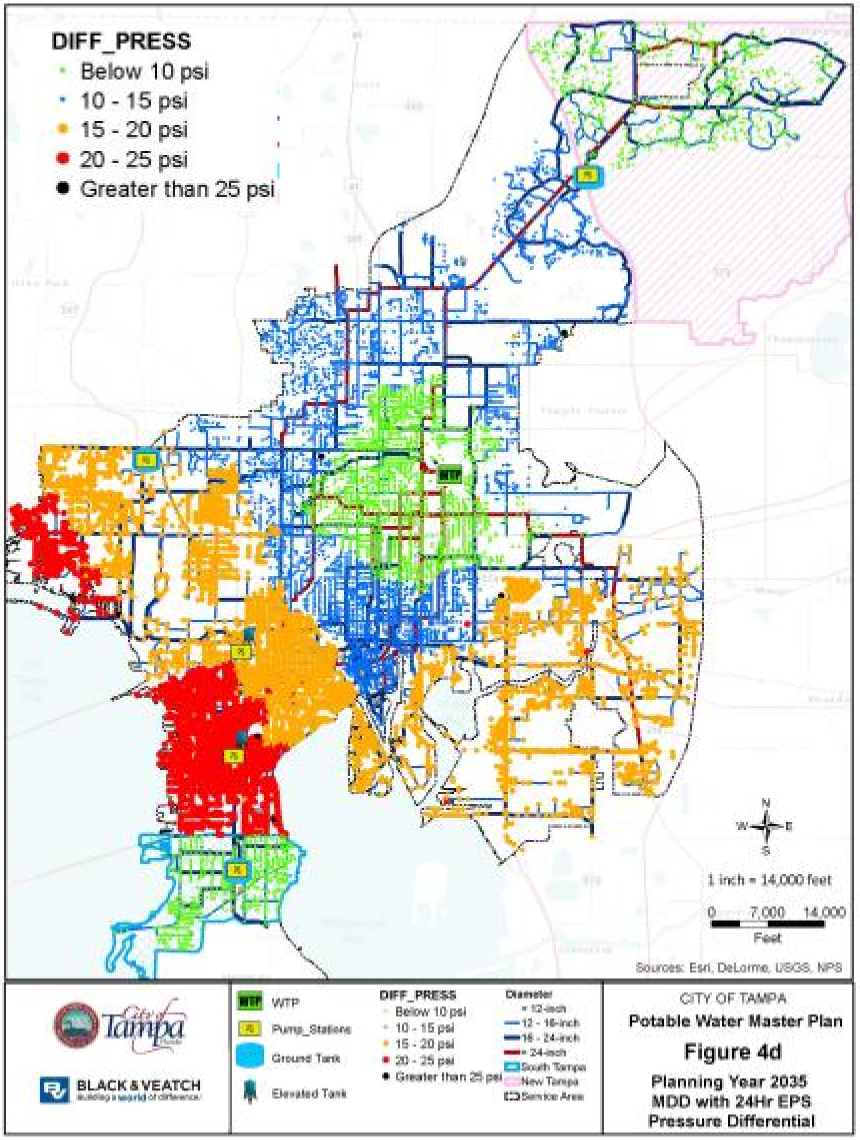


2015 Re-assessment; DLTWTF @ 65 psi

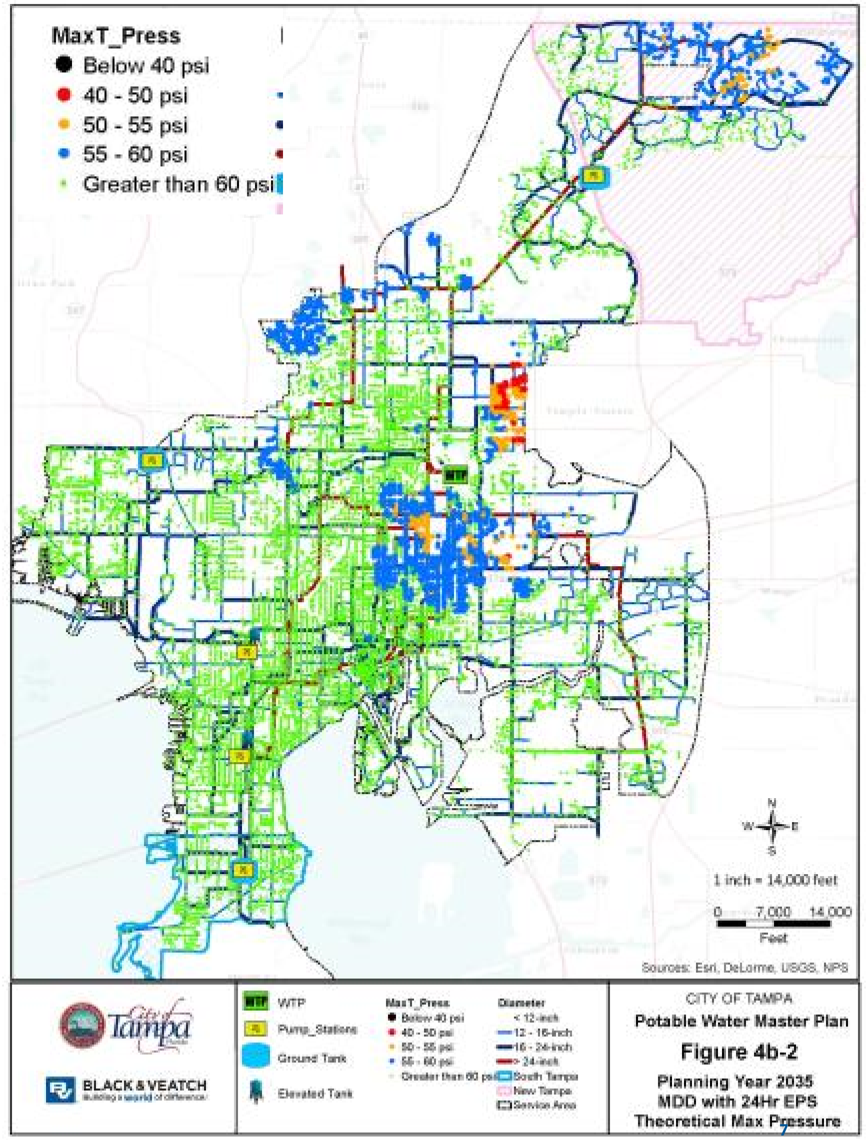


2035 Re-assessment; DLTWTF @ 65 psi

System Assessment – Additional Information

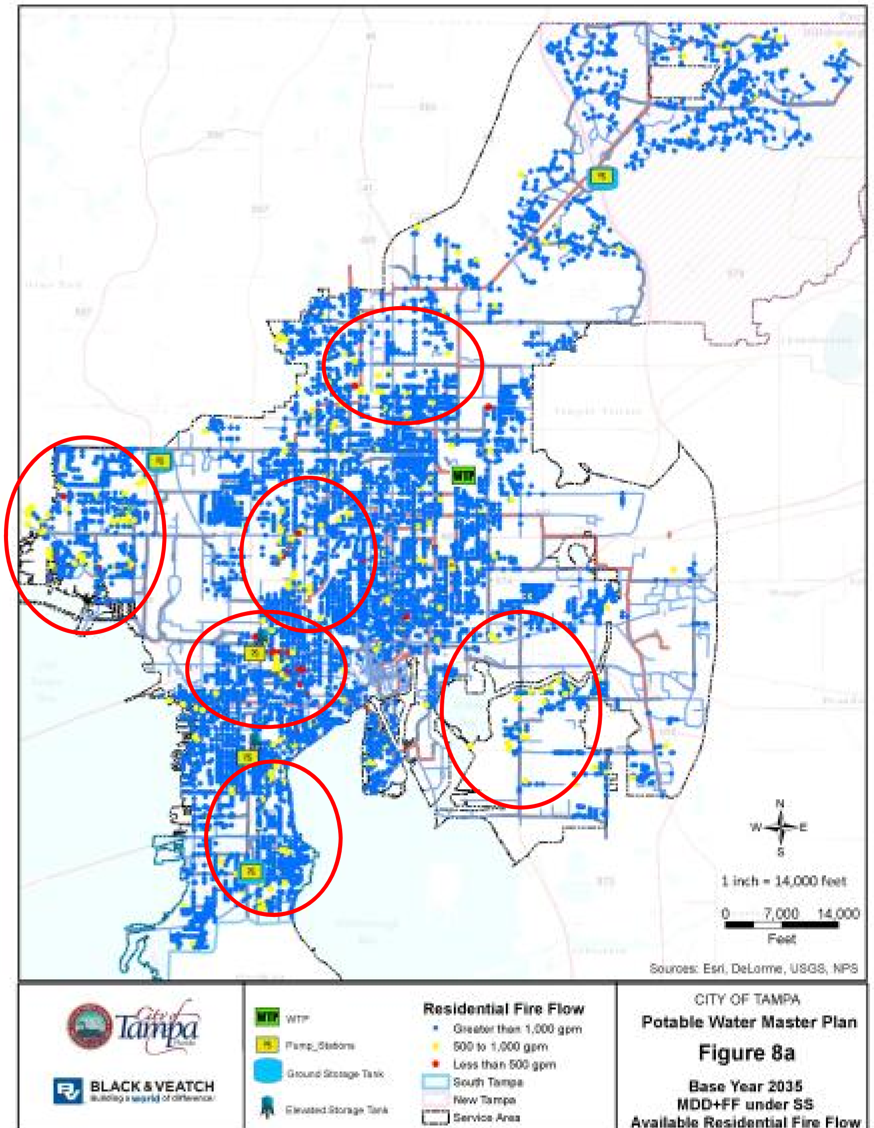


2035 Pressure Variance; DLTWTF @ 65 psi

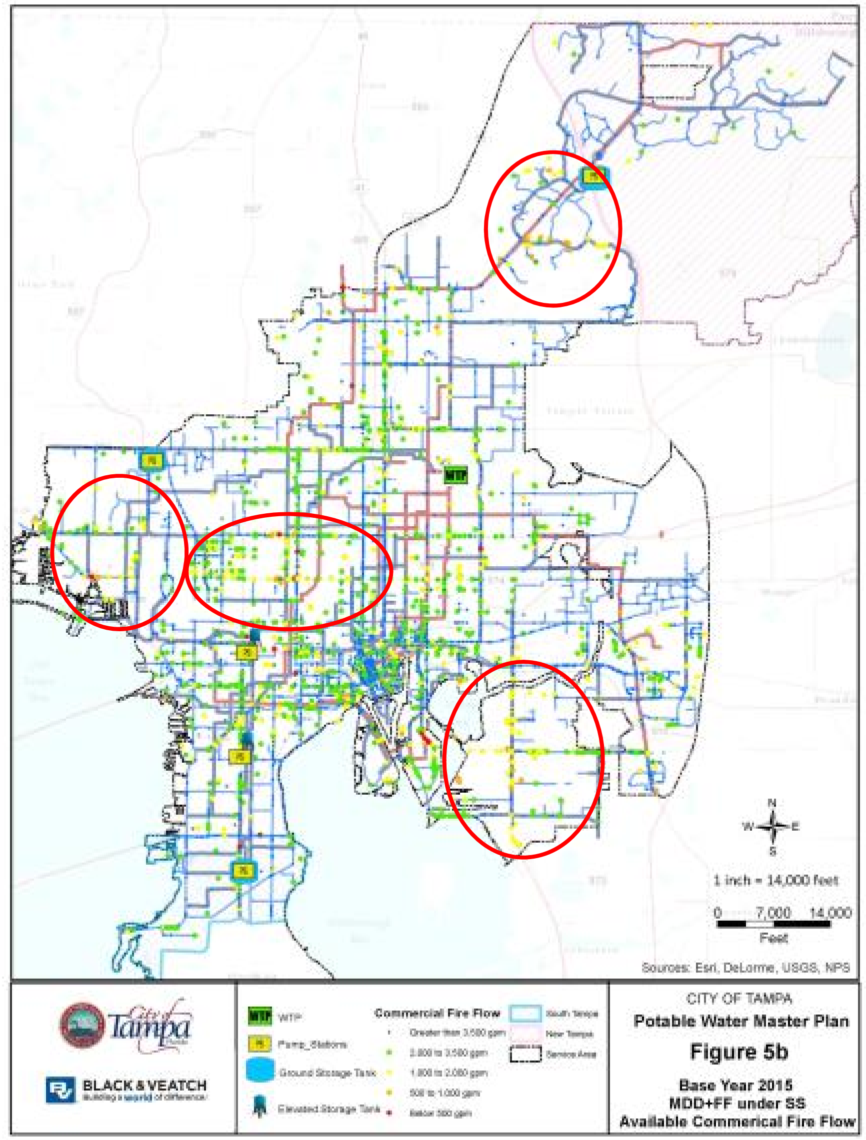


Theoretical Max Pressure based on Elevation & 65 psi

Fire Flow Assessment



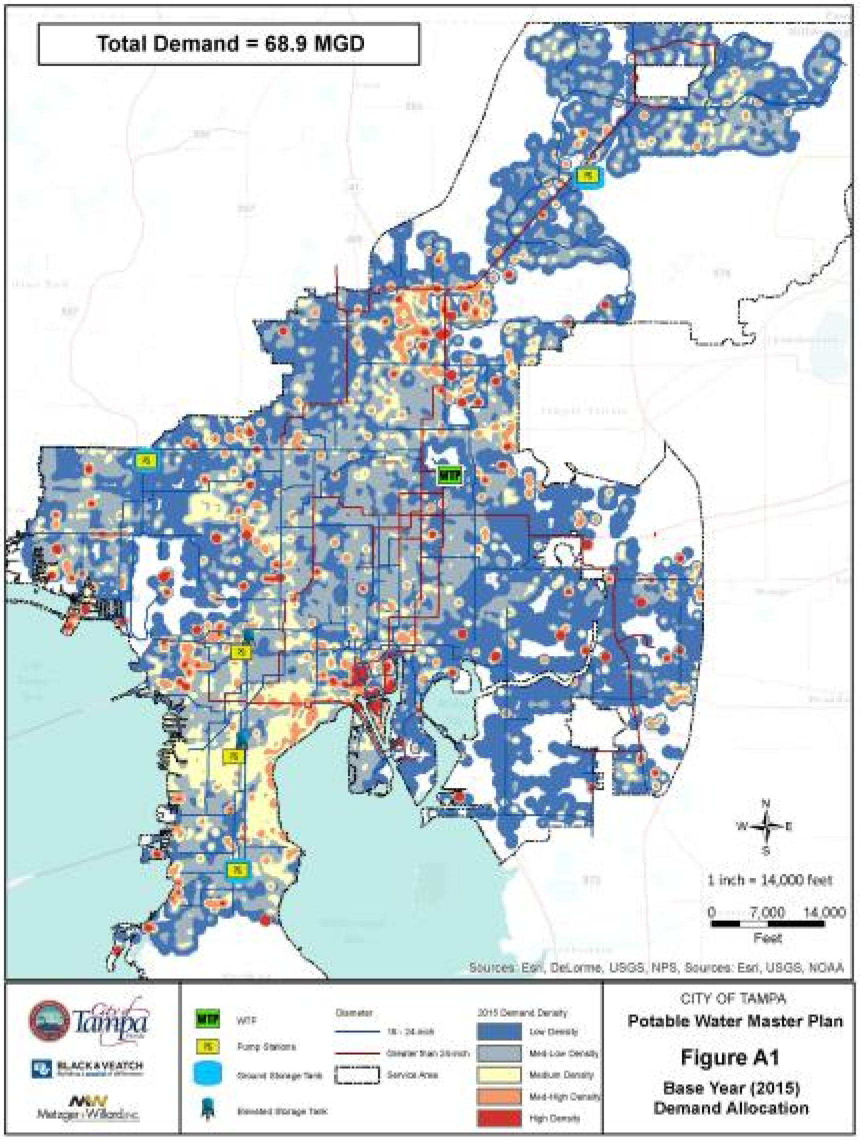
2035 – Residential



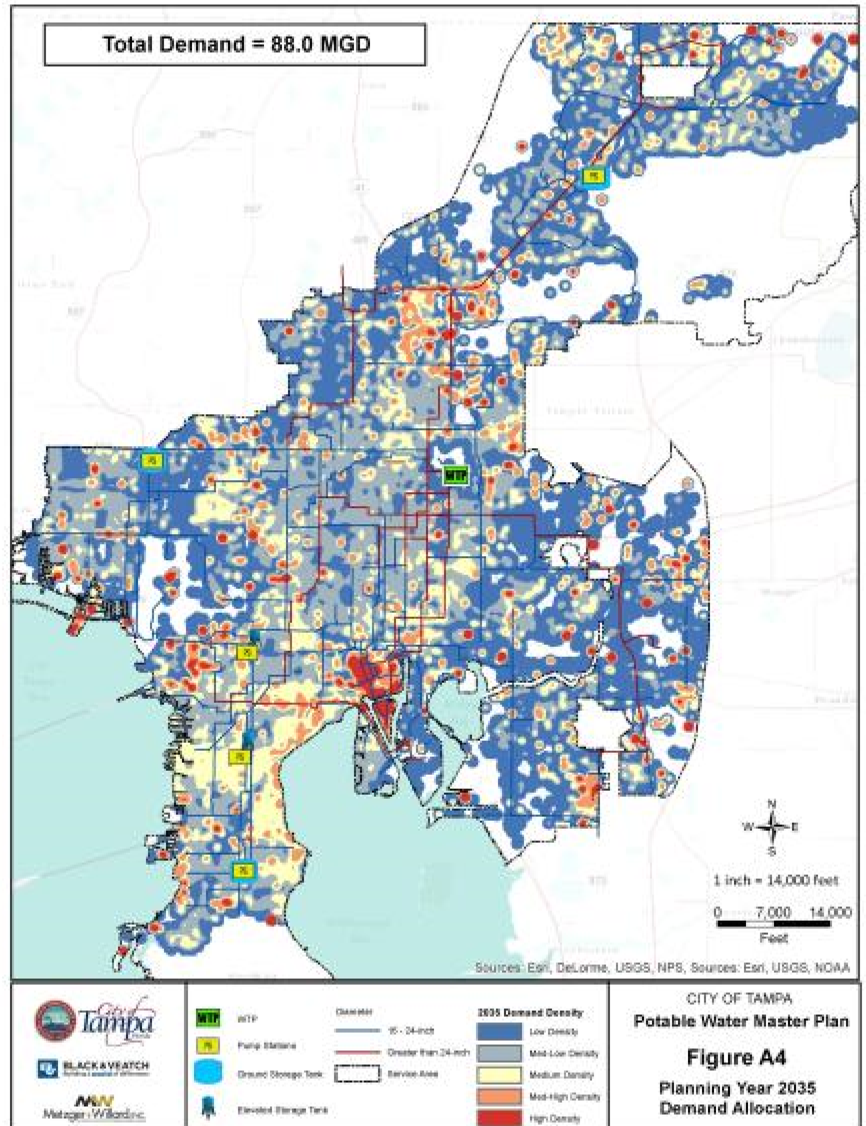
2035 - Commercial

System Demands

MIN_PRESS
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi



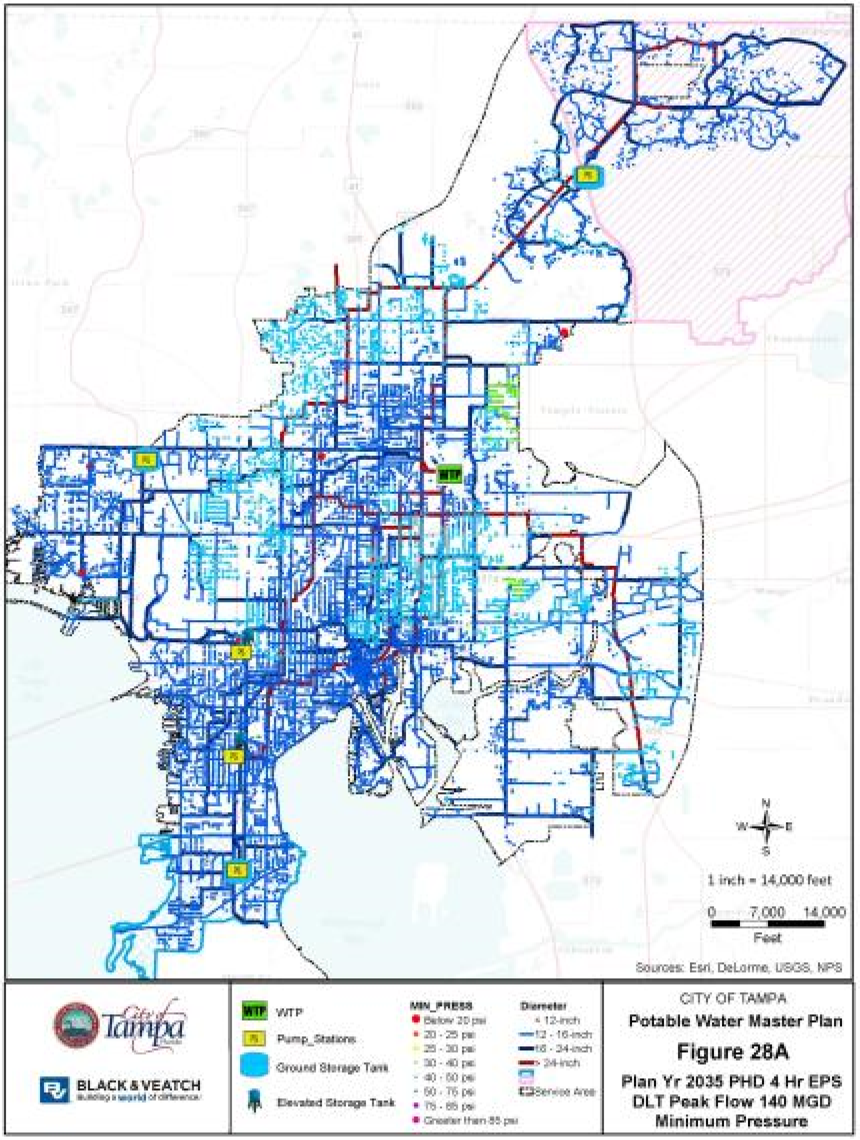
2015 Demands

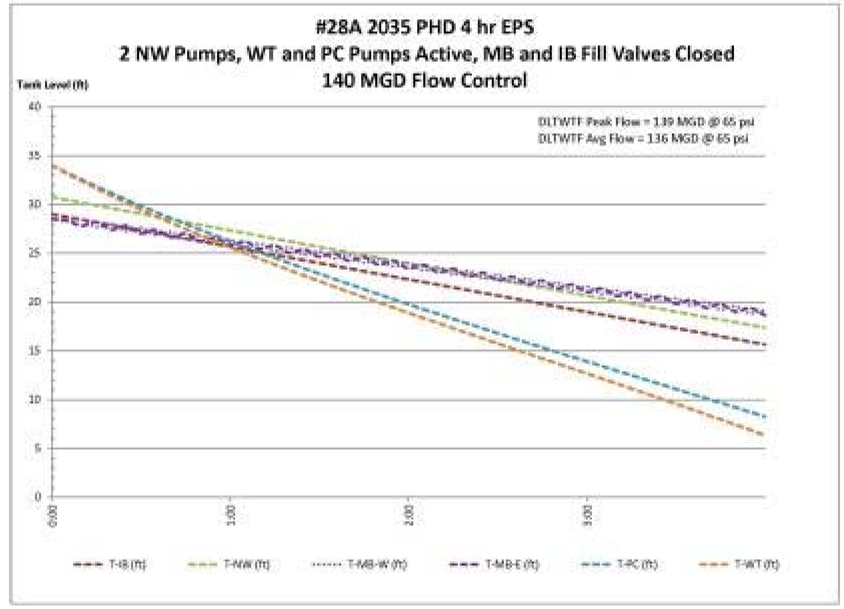


2035 Demands

Peak Hour Demand for 4 Hours

Peak Hour Results – 140 MGD @ DLTWTF; Existing Tanks

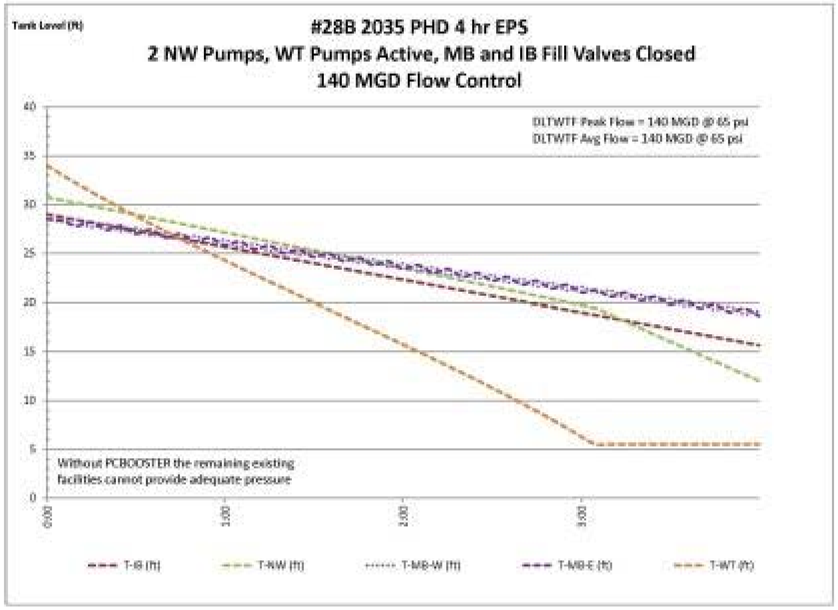




- DLTWTF Flow = 140 MGD
  - ± 2 hrs unless replenished;
  - ± 4 hrs with treatment at 69 MGD
- Northwest = Two pumps on
- Palma Ceia = Off
- West Tampa = On
- Not filling either Morris Bridge or Interbay Tanks

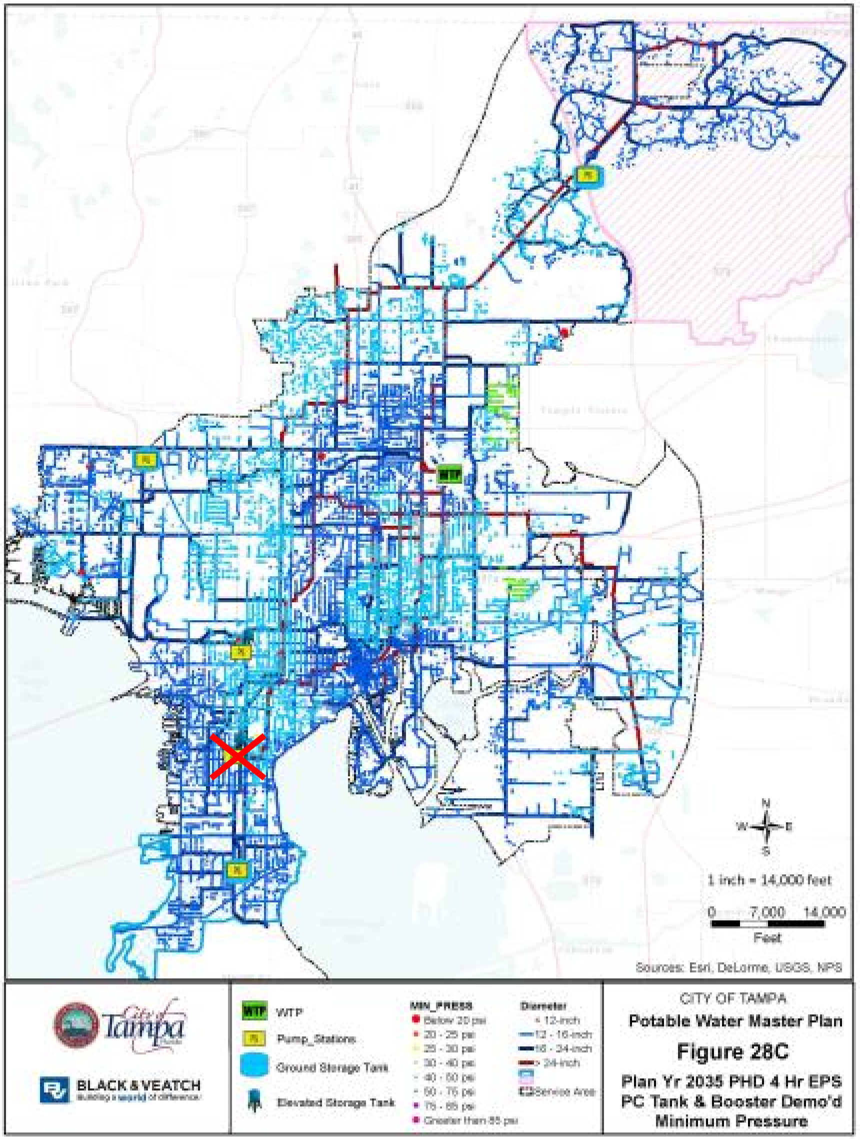
Peak Hour Results – 140 MGD @ DLTWTF; No Palma Ceia

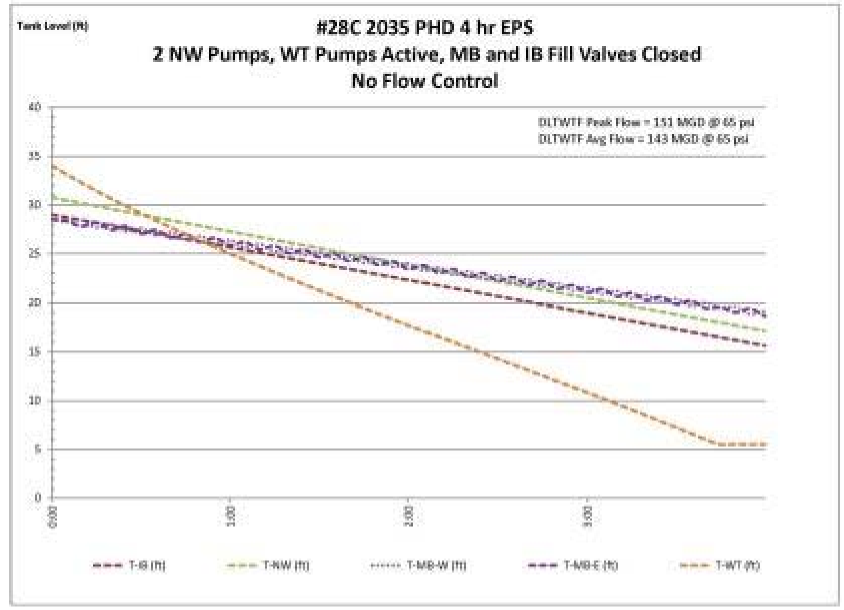
Does not work;
Storage is depleted
before the 4 hrs is
concluded.



- DLTWTF Flow = 140 MGD
  - ± 2hrs unless replenished;
  - ± 4 hrs with treatment at 69 MGD
- Northwest = Two pumps on
- Palma Ceia = Off
- West Tampa = On
- Not filling either Morris Bridge or Interbay Tanks

Peak Hour Results – 151 MGD @ DLTWTF; No Palma Ceia



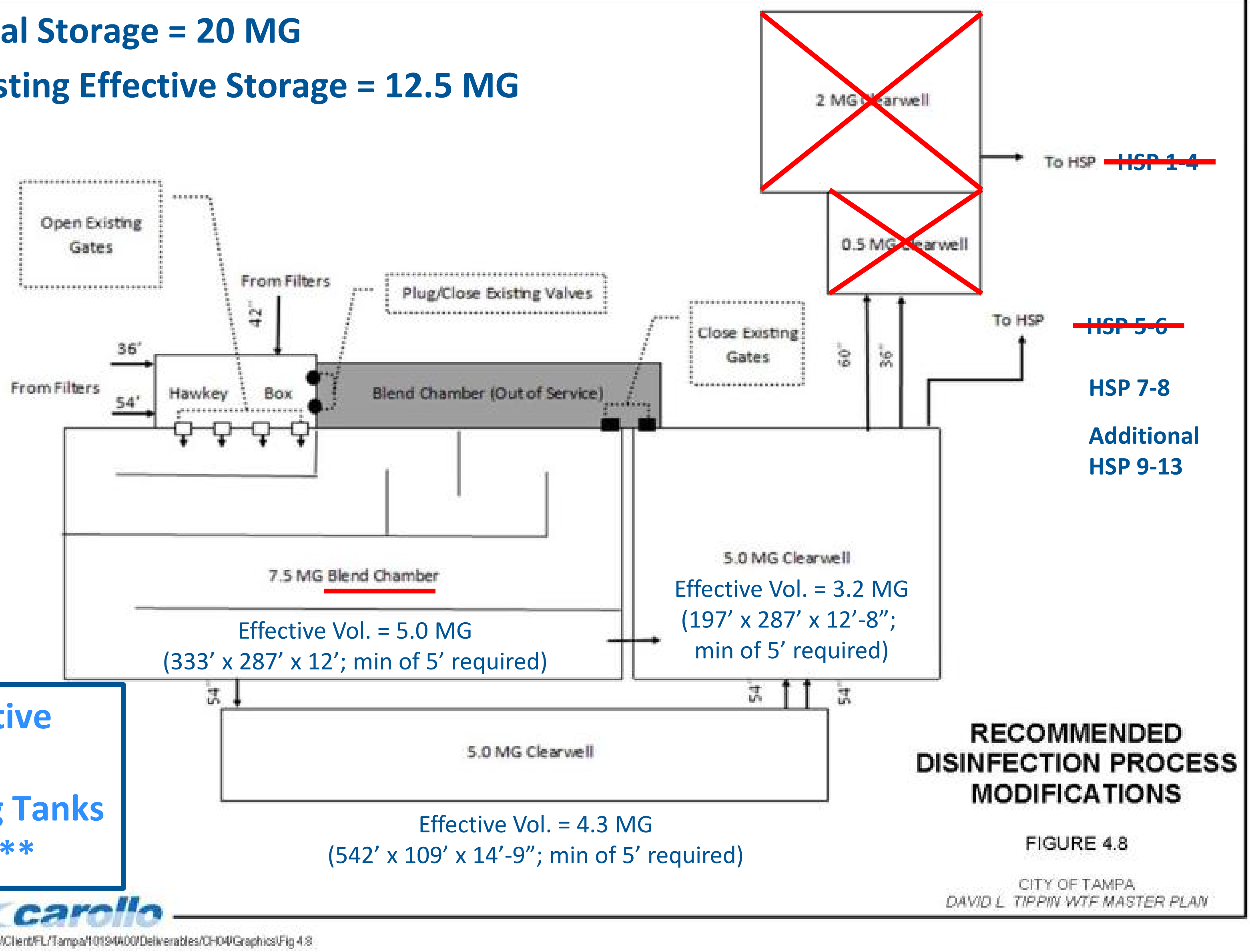


- DLTWTF Flow = 151 MGD
  - ± 2hrs unless replenished;
  - ± 4 hrs with treatment at 80 MGD
- Northwest = Two pumps on
- Palma Ceia = Off
- West Tampa = On
- Not filling either Morris Bridge or Interbay Tanks

Storage Opportunities @ DLTWTF

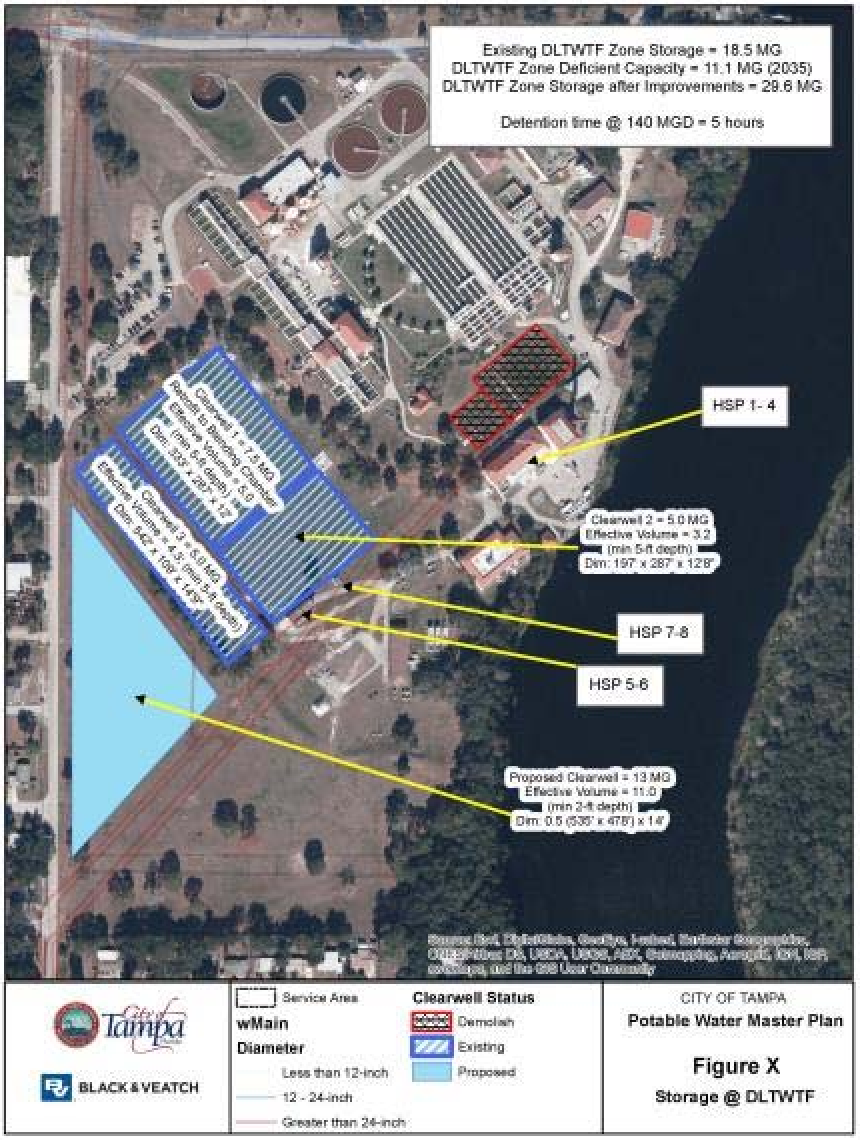
DLTWTF Clearwell

- **Total Storage = 20 MG**
- **Existing Effective Storage = 12.5 MG**



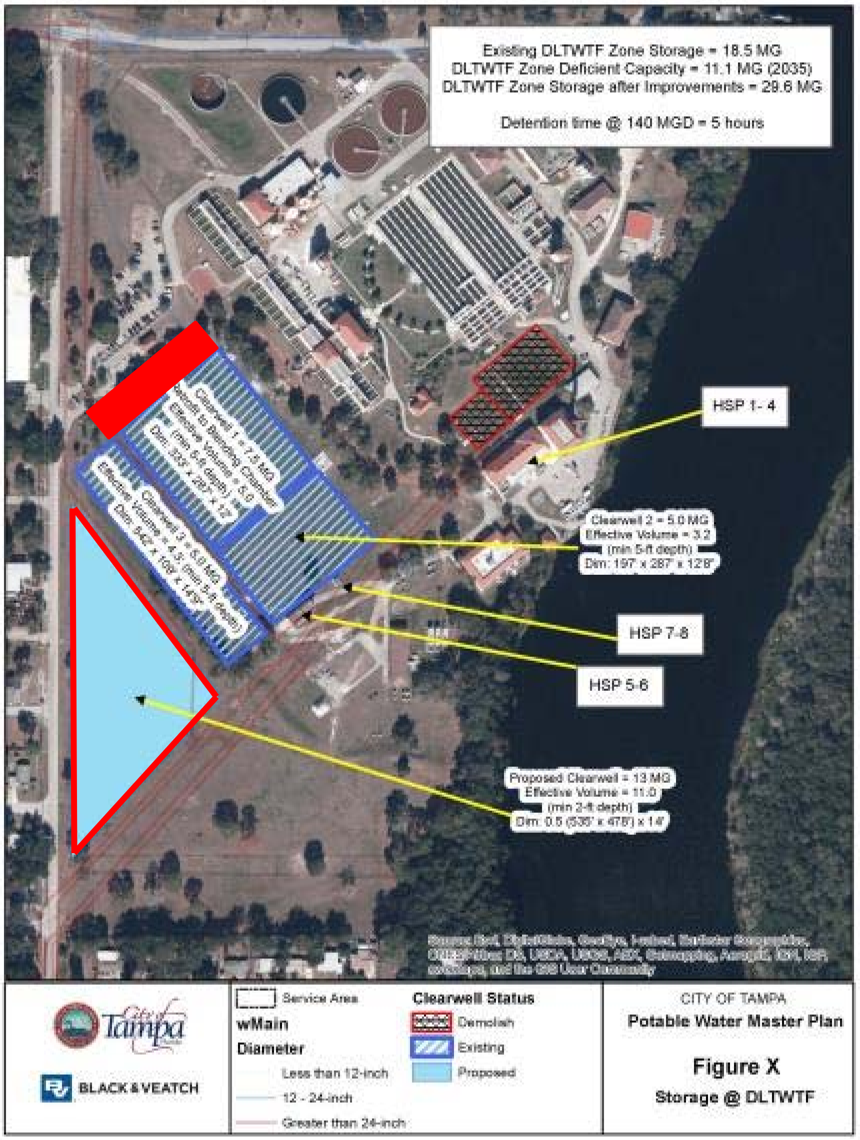
Max Effective Storage in Remaining Tanks = 12.5 MG**

DLTWTF Clearwell



- Minimum of 5-ft required in existing tanks for ballast
- If all of the Proposed Blending Tank Volume can still be used; Effective Volume = 12.5 MG
- Weirs needed on existing tanks to maintain minimum levels
- New tank volume = 13 MG
- New Tank depth = 14 – 20-ft depending on shape

DLTWTF Clearwell – Outstanding Item



- There is an issue using the Blench Chamber as Clearwell Storage, consider…
  - A new blending chamber
  - A deeper new tank

Black & Veatch will coordinate with Carollo to understand limitations of the new blending chamber

Additional Considerations - Clearwell

Pros:

- Reduces added transient / surge pressure waves within the distribution system, more consistent based load from pumps.
- Does not limit operational flexibility / changes in HGL in the future
- Minimized nitrification WQ concerns within tanks

Cons:

- Difficult constructability & ongoing operations
- Limits redundancy & reliability and increases the criticality of HSP.
- Increases demand charge for DLTWTF during peak demand times.

Elevated Storage Options

Elevated Storage Evaluation

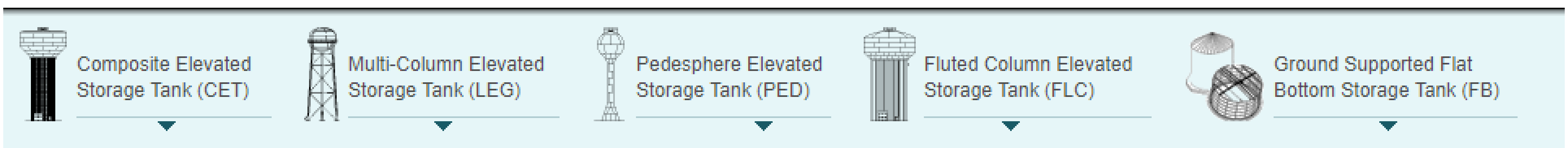
- Caldwell Tanks (http://www.caldwellwatertanks.com)
  - Composite (CET) = 3 MG
  - Multi-Column* (LEG) = 2 MG
  - Pedesphere (PED) = 1.5 MG
  - Fluted (FLC) = 3 MG
- CBI Tanks (www.cbi.com)
  - Waterspheroid = 2 MG
  - Hydropillar = 4 MG
  - Composite (CET) = 4 MG

- **West Tampa & Palma Ceia = 1.5 MG each**

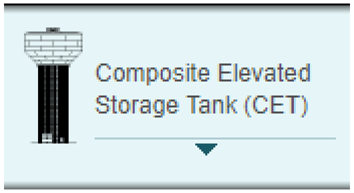
<u>Approach – Minimize # of new tanks</u>

- **Replace each with 4 MG Composite Tank → additional 5 MG storage (sufficient through 2025)**

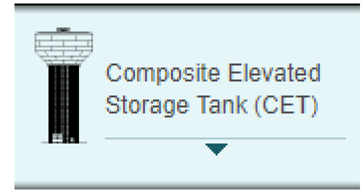
- **Then only one additional 3 to 4 MG tank would be needed for 2035**



West Tampa Tank Site

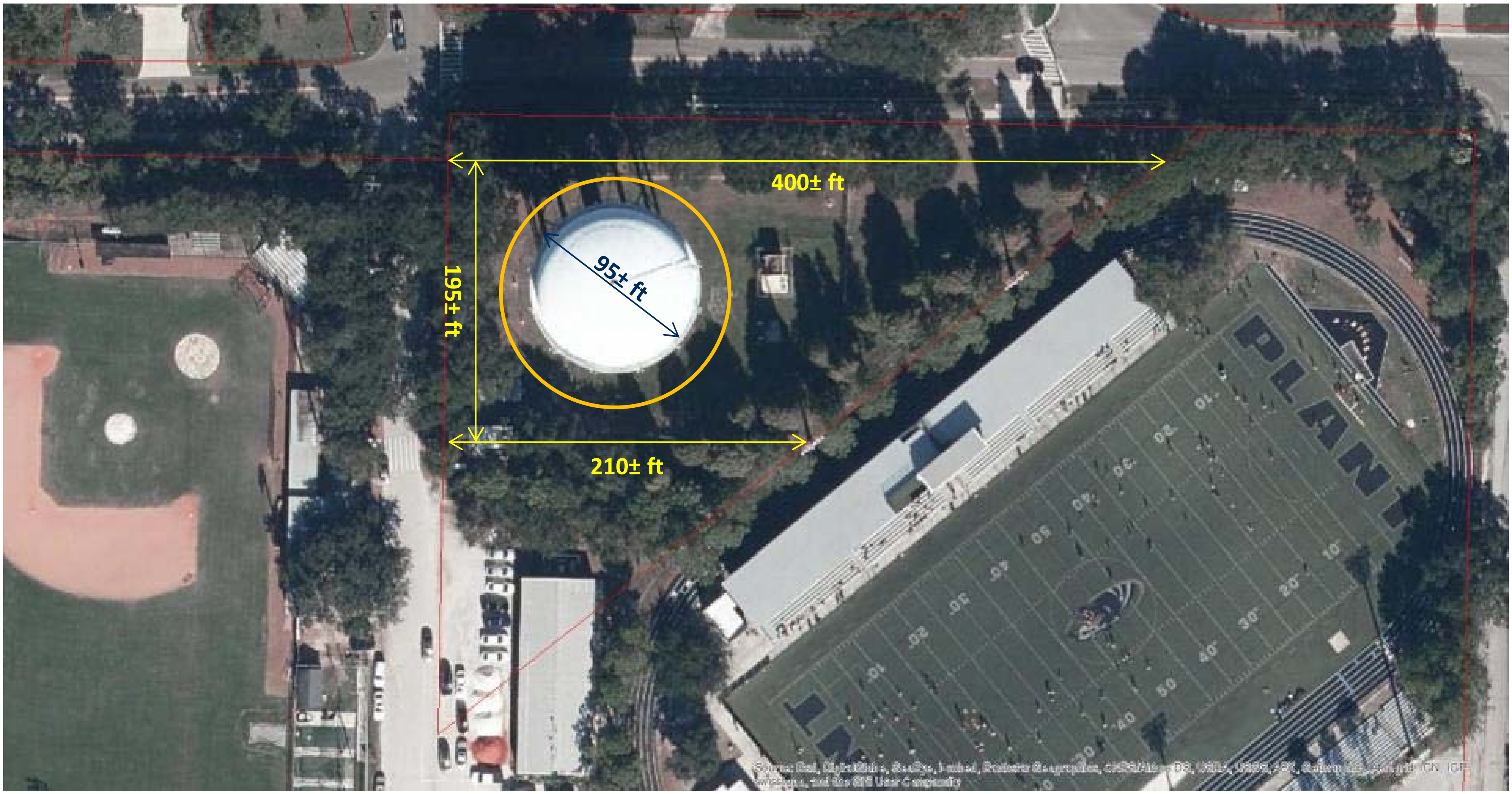


4 MG Composite Tank: 126’-0” Tank dia., 50’-0” Head Range; 60’0” Support Structure

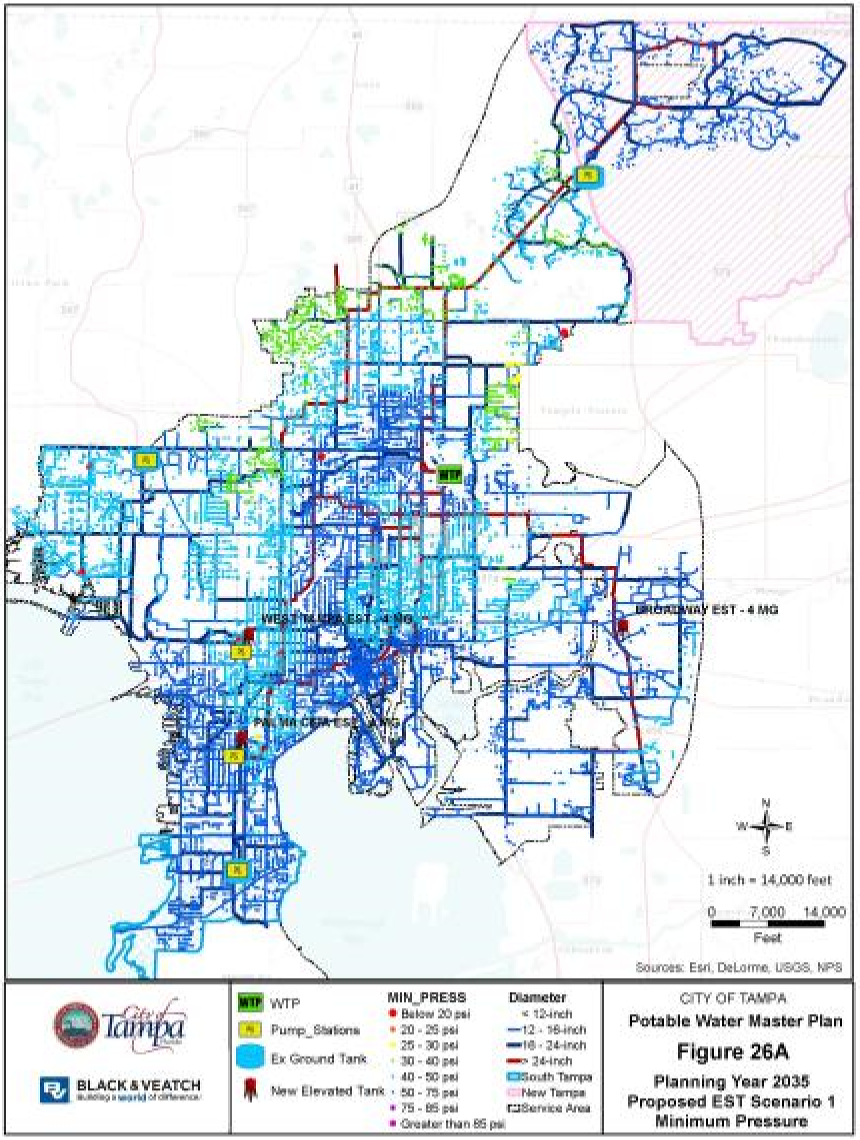


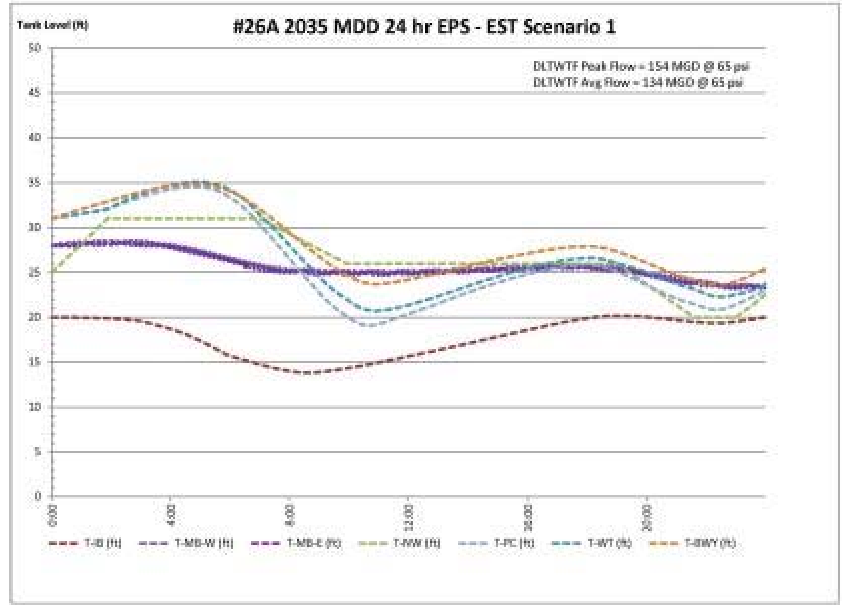
Palma Ceia Tank Site

4 MG Composite Tank: 126’-0” Tank dia., 50’-0” Head Range; 60’0” Support Structure



Impacts from Elevated Tanks – 2035 (Southeast)

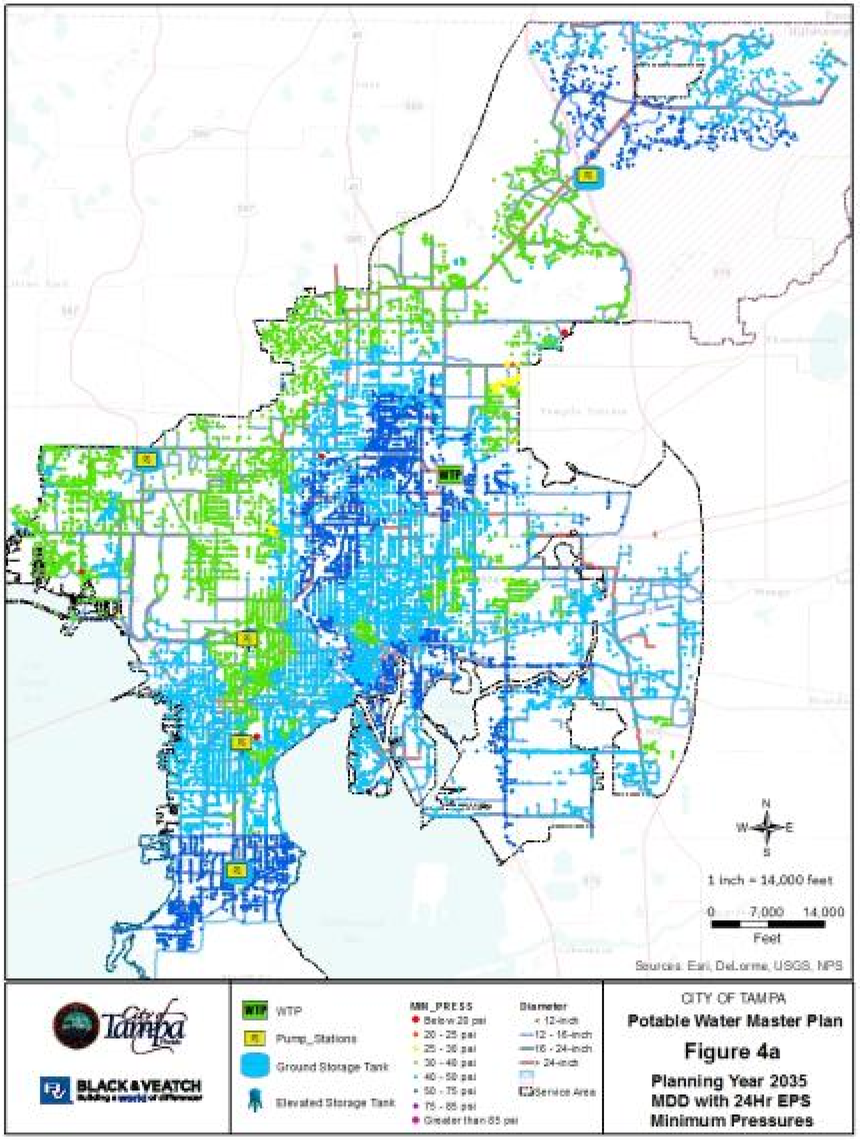




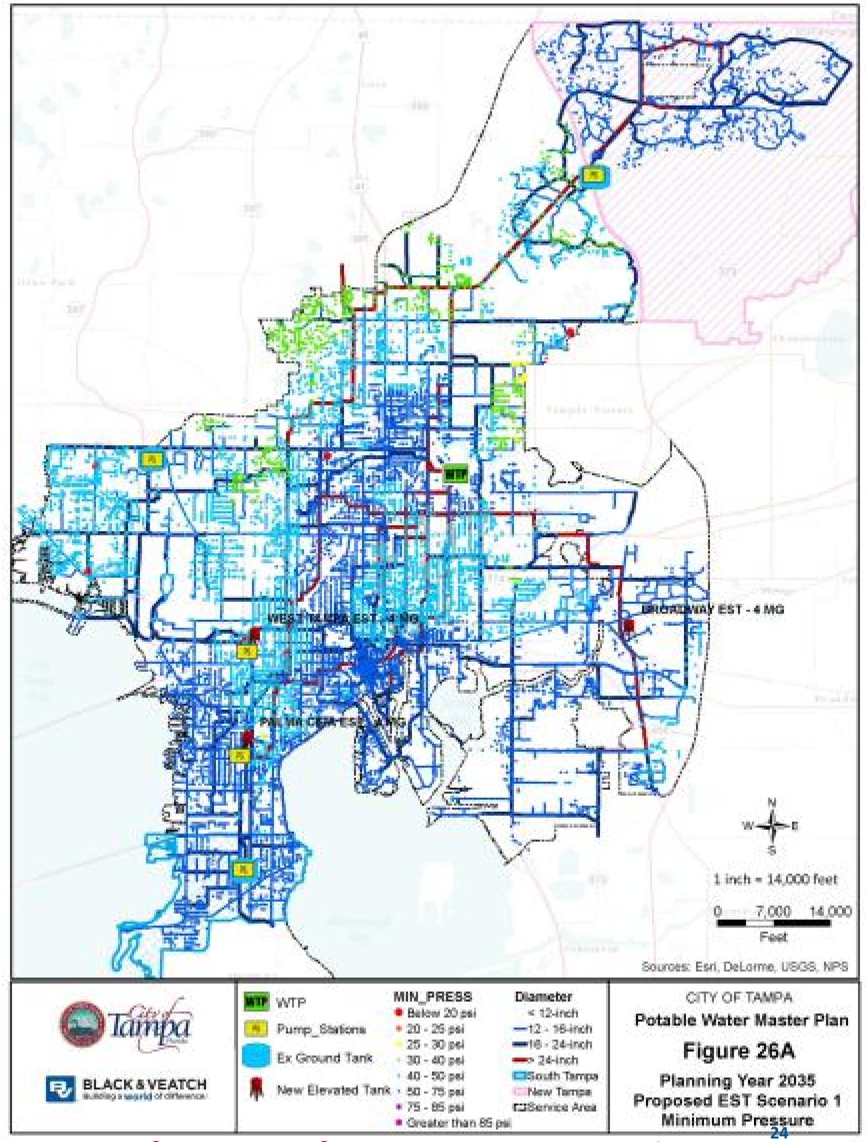
- DLTWTF Flow = 134 - 154 MGD @ 65 psi
- Northwest = One pump, Normal Cycle
- Palma Ceia = Float on system
- West Tampa = Float on system
- MB RPS & IB RPS = Constant Fill
- New Tank Heights = PC: 133’ → 145’; WT: 109’ → 130’; Southeast: 151’

MIN_PRESS
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi

Impacts from Elevated Tanks – 2035 (Southeast)

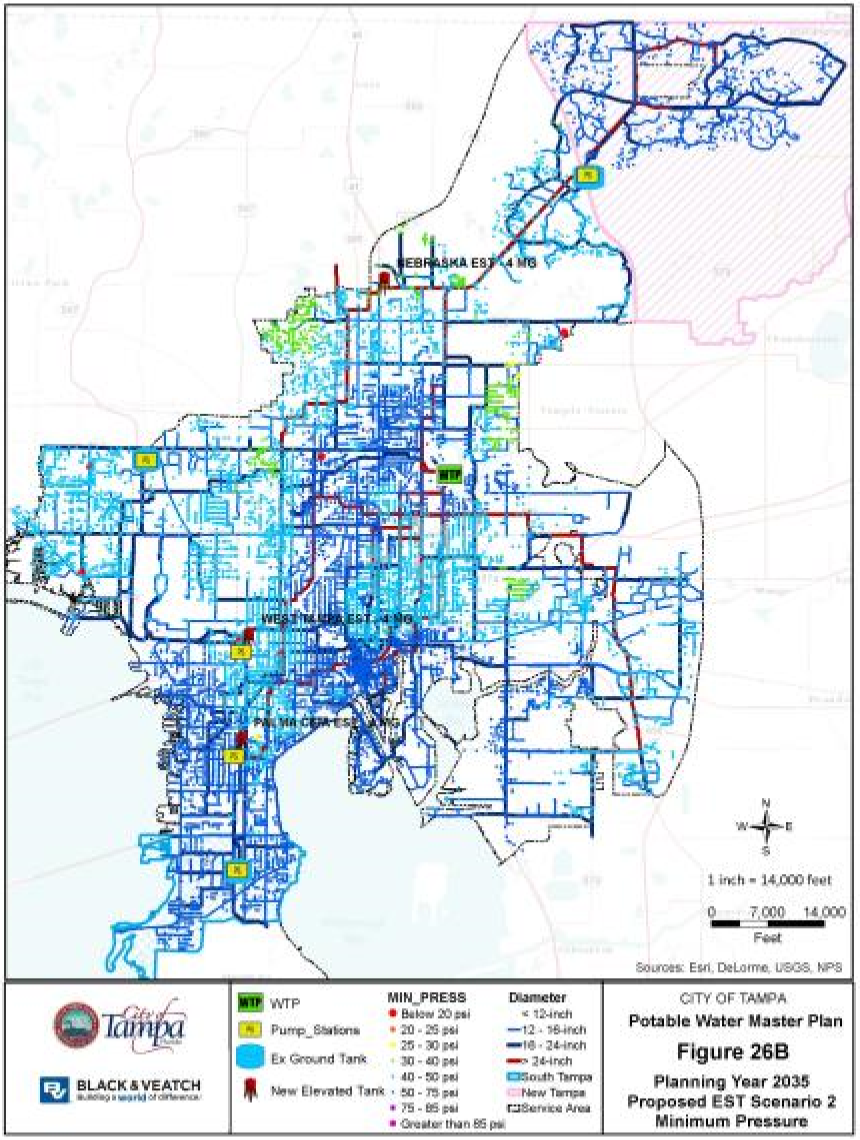


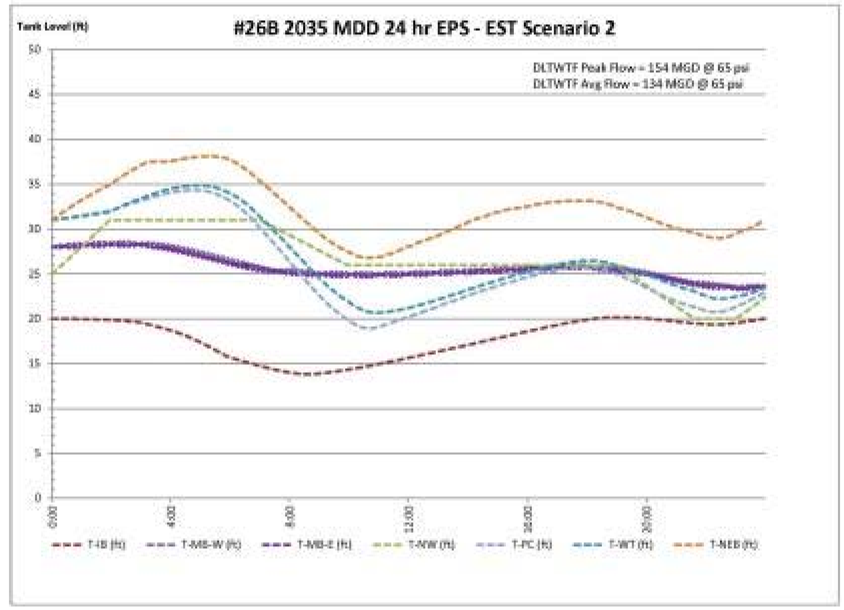
2035 Re-assessment; DLTWTF @ 65 psi



2035 Southeast Tank; DLTWTF @ 65 psi

Impacts from Elevated Tanks – 2035 (North)

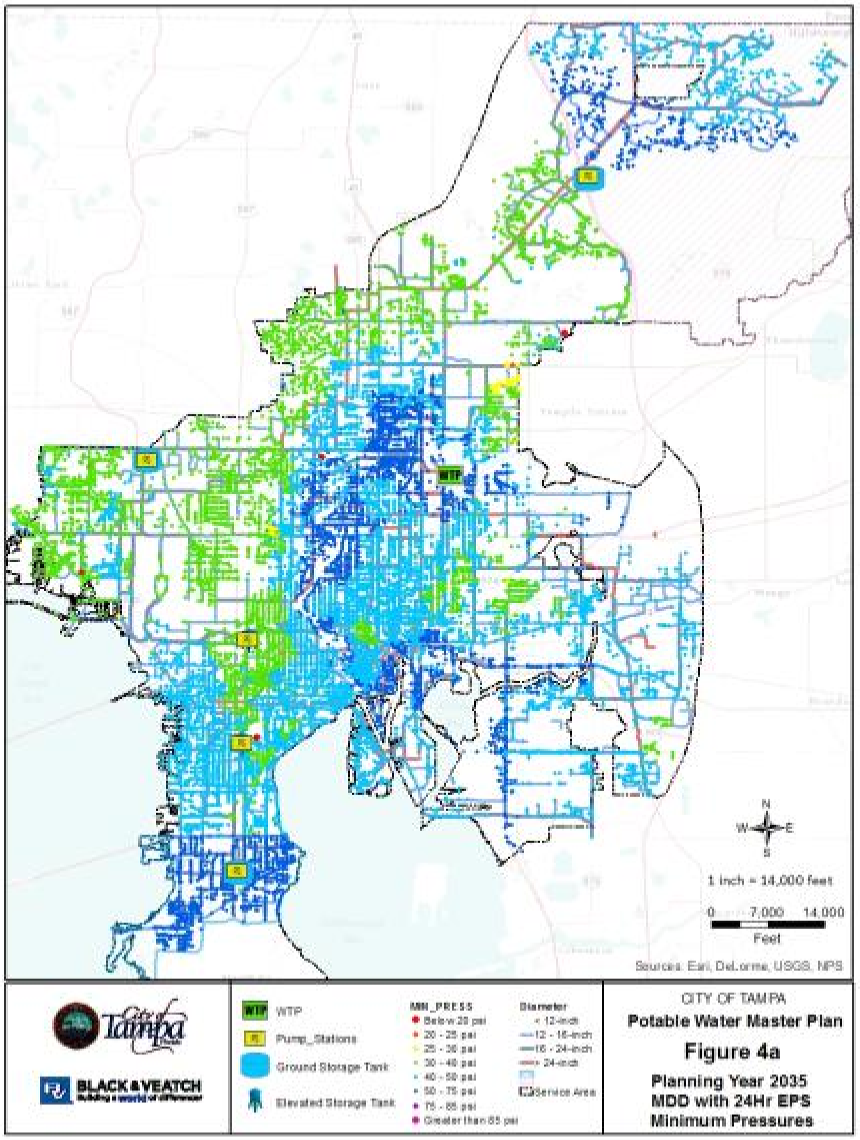




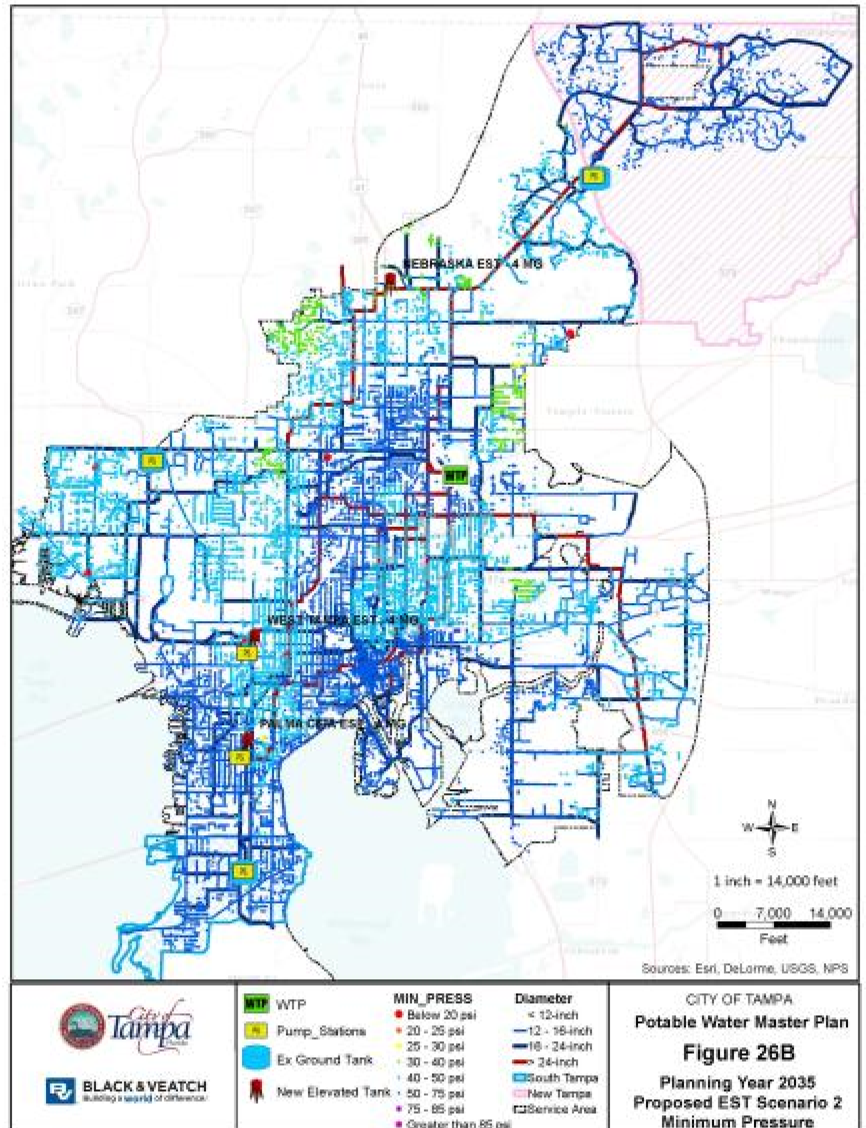
- DLTWTF Flow = 134 - 154 MGD @ 65 psi
- Northwest = One pump, Normal Cycle
- Palma Ceia = Float on system
- West Tampa = Float on system
- MB RPS & IB RPS = Constant Fill
- New Tank Heights = PC: 133’ → 145’; WT: 109’ → 130’; North: 116’

Impacts from Elevated Tanks – 2035 (North)

MIN_PRESS
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi



2035 Re-assessment; DLTWTF @ 65 psi



2035 North Tank; DLTWTF @ 65 psi

Additional Considerations – Elevated Tank

Pros:

- Ability to reduce transient / surge pressure waves acting like a surge tank and by reducing valve closures when filling tanks and pump start / stops.
- Lower annual energy costs
- Resilient to power loss
- Small revenue opportunity with wireless utilities

Cons:

- Capital costs of elevated storage is more expensive than ground storage; $2/gal vs $1/gal
- Limits operational flexibility / changes in HGL in the future
- Nitrification and water age concerns
- Maintenance by contractor, due to safety concerns
- Potential for additional locations / tanks needed due to size limits compared to GST

Ground Storage Options

Ground Storage Evaluation

Inside Diameter in Feet	Capacity in Millions of U.S. Gallons															
	.1	.2	.25	.3	.4	.5	.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	7.5	10.0
30	18'11"															
35	13'11"	27'9"	34'9"	41'8"	55'8"	69'6"										
40	10'8"	21'3"	26'7"	31'11"	42'7"	53'2"										
45	8'5"	16'10"	21'1"	25'3"	33'8"	42'0"	63'1"									
50	6'10"	13'7"	17'1"	20'6"	27'3"	34'1"	51'2"	68'2"								
55		11'3"	14'1"	16'11"	22'6"	28'2"	42'3"	56'3"								
60		9'5"	11'10"	14'2"	18'11"	23'8"	35'5"	47'4"								
65			10'1"	12'1"	16'1"	20'2"	30'3"	40'4"	60'6"							
70				10'5"	13'11"	17'5"	26'1"	34'9"	52'2"	69'6"						
75					12'1"	15'2"	22'9"	30'4"	45'5"	60'7"						
80					10'8"	13'4"	19'11"	26'8"	39'11"	53'2"	66'6"					
85						11'9"	17'8"	23'7"	35'4"	47'2"	58'11"					
90						10'6"	15'9"	21'1"	31'7"	42'1"	52'7"	63'11"				
95							14'2"	18'10"	28'4"	37'9"	47'2"	56'7"				
100							12'9"	17'1"	25'7"	34'1"	42'7"	51'1"	68'1"			
105							11'7"	15'5"	23'2"	30'11"	38'7"	46'4"	61'10"			
110							10'7"	14'1"	21'1"	28'2"	35'2"	42'3"	56'3"			
115								12'10"	19'4"	25'9"	32'2"	38'7"	51'6"	64'5"		
120								11'10"	17'9"	23'8"	29'7"	35'6"	47'4"	59'2"		
125									16'4"	21'9"	27'3"	32'9"	43'8"	54'6"		
130									15'2"	20'2"	25'2"	30'3"	40'4"	50'5"		
135									14'1"	18'8"	23'4"	28'1"	37'5"	46'8"	70'0"	
140									13'1"	17'5"	21'9"	26'1"	34'9"	43'5"	65'2"	
145									12'2"	16'3"	20'3"	24'3"	32'5"	40'6"	60'9"	
150									11'5"	15'2"	18'11"	22'9"	30'4"	37'10"	56'9"	
155											17'9"	21'3"	28'4"	35'6"	53'2"	
160											16'8"	20'0"	26'7"	33'3"	49'10"	66'6"
165												18'10"	25'0"	31'3"	46'11"	62'7"
170												17'8"	23'7"	29'5"	44'2"	58'11"
175												16'8"	22'3"	27'9"	41'8"	55'7"
180												15'10"	21'1"	26'4"	39'5"	52'6"
185													19'11"	24'10"	37'4"	49'9"
190													18'11"	23'7"	35'4"	47'2"
195													17'11"	22'4"	33'7"	44'10"
200													17'1"	21'4"	31'11"	42'6"
205														20'3"	30'4"	40'6"
210															28'11"	38'8"

Water Depth in Feet and Inches to Nearest Inch

Quick Formula For Volume in U.S. Gallons: $V = 5.875 D^2 H$

Where: V = Volume in U.S. Gallons

D = Inside Diameter in Feet

H = Liquid Depth in Feet

The Crom Corporation can build tanks to any specified dimensions. However, sizes highlighted in blue are most economical for dome covered tanks. Crom has built domed tanks in excess of 285' ID. Maximum side wall depth should be 70' 0" or lower.

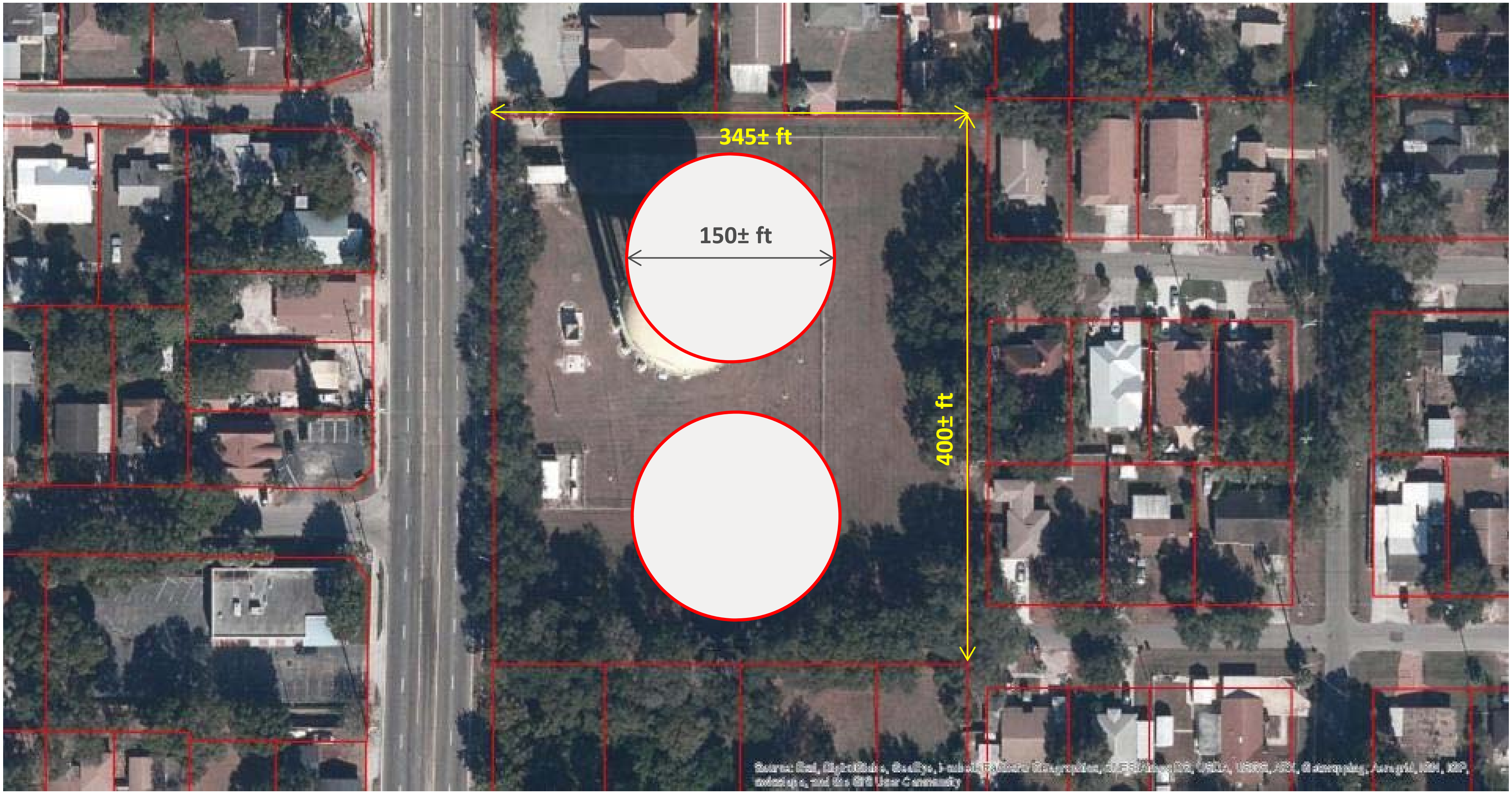
- **Northwest = 3.0 MG; add mirror Tank for additional 3.0 MG; would need to purchase property.**
- **Replace West Tampa with two 4 MG ground storage tanks with pump station for additional 6.5 MG.**
- **Would also be possible to remove Palma Ceia if needed**
- **Results in a total additional 8 MG of storage.**

Northwest Tank Site

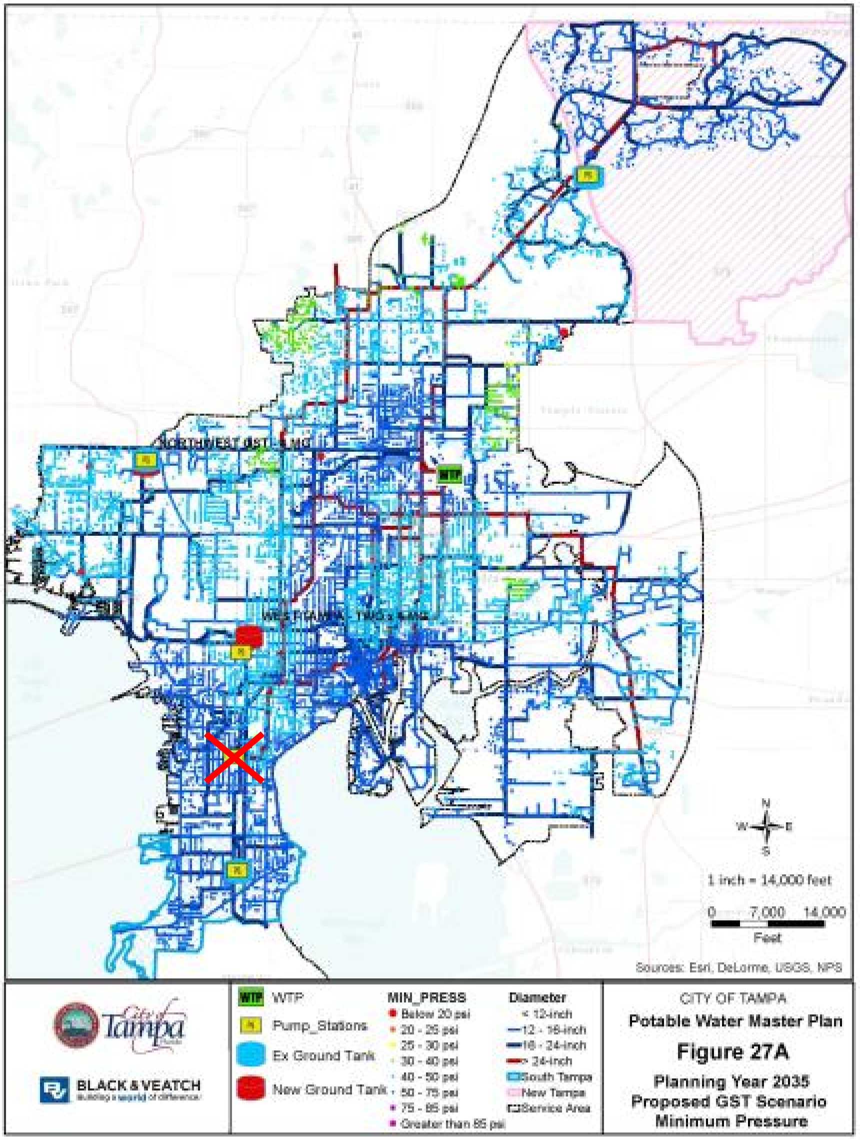
3 MG Composite Tank: 130'-0" Tank dia., 30'-0" Head Range;

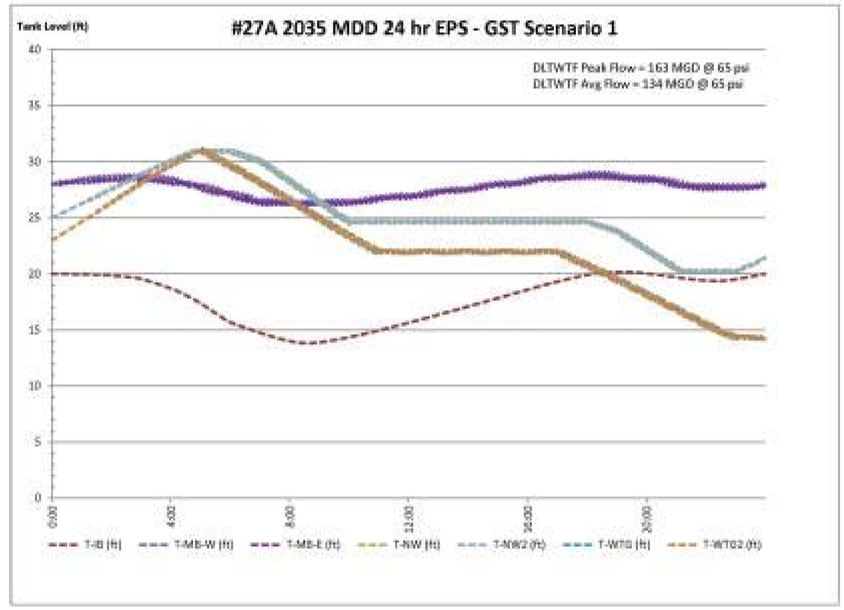
West Tampa Tank Site

4 MG Tank: 150’-0” Tank dia., 30’-0” Head Range;



Impacts from Ground Tanks – NW & WT

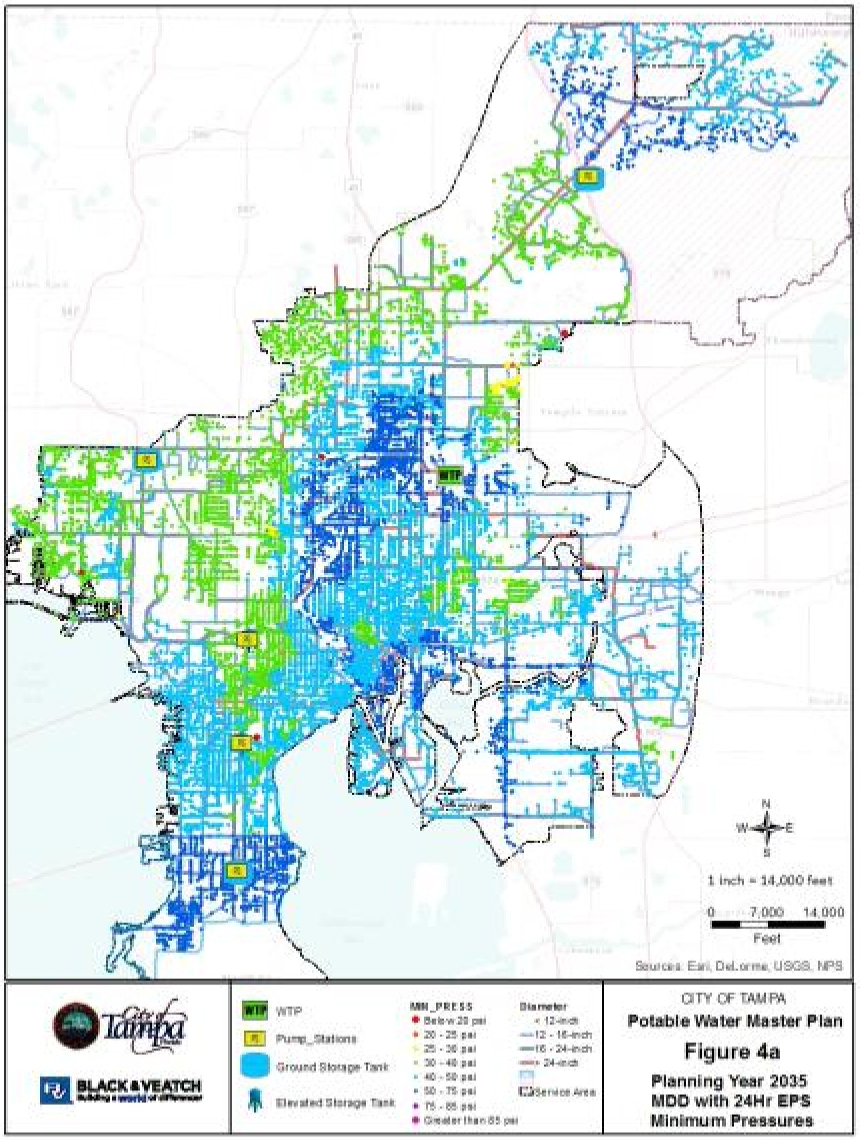




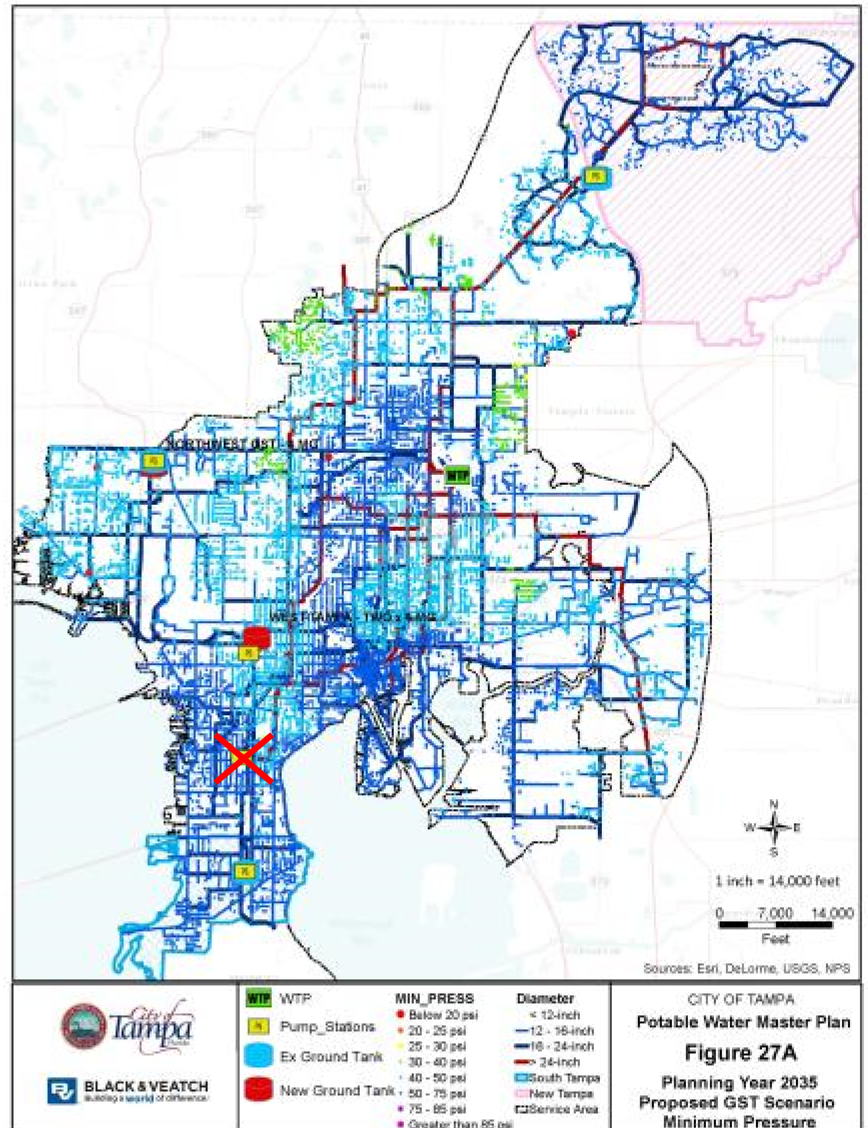
- DLTWTF Flow = 134 - <u>163</u> MGD @ 65 psi
- MB RPS & IB RPS = Constant Fill
- Northwest = One pump, Normal Cycle
- Palma Ceia = Abandoned
- West Tampa = Retrofitted to Repump with GST - Pumps turn on when local pressure drop below 45 psi.

Impacts from Ground Tanks – NW & WT

MIN_PRESS
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi



2035 Re-assessment; DLTWTF @ 65 psi



2035; DLTWTF @ 65 psi

Additional Considerations – Ground Storage

Pros:

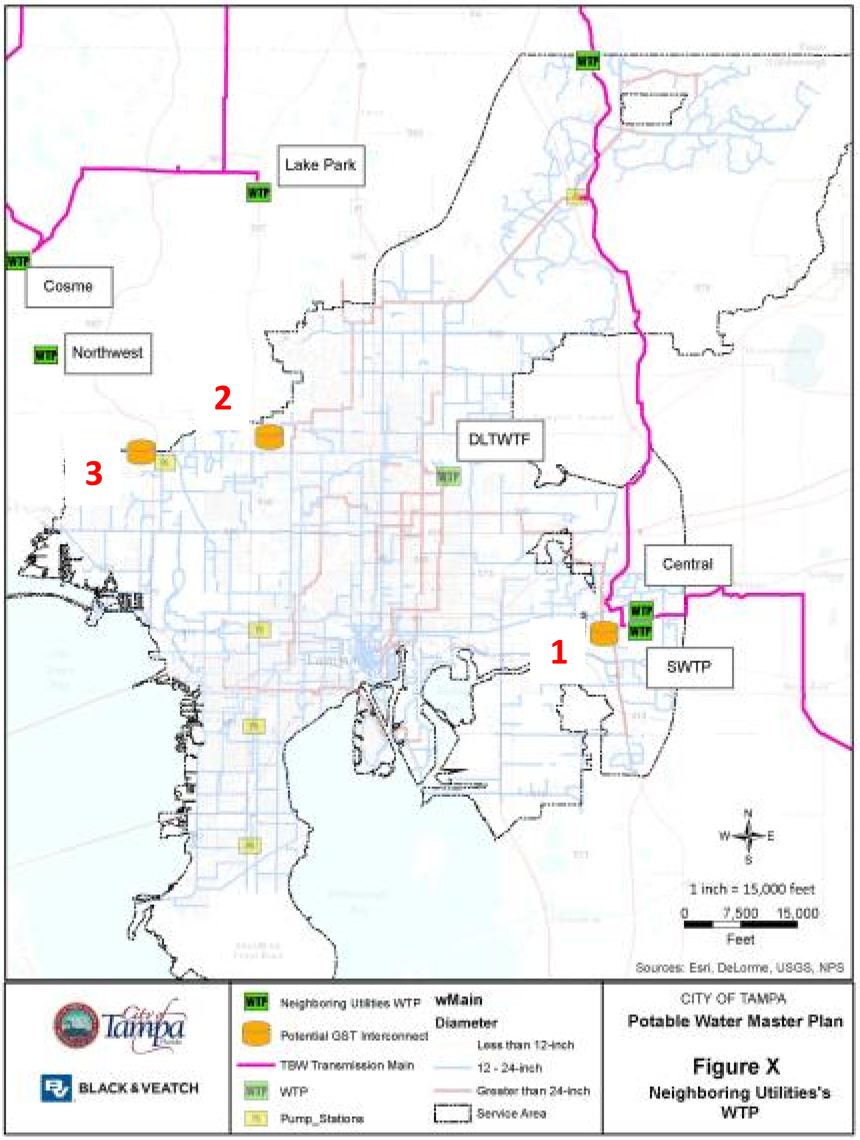
- Capital costs of ground storage is less expensive than elevated storage; $1/gal vs $2/gal
- Does not limit operational flexibility / changes in HGL in the future
- Easier to add mixing to tanks
- More easily expanded than clearwell or elevated tanks

Cons:

- Controls will be required to minimize the transient / surge potential from the pumps and valve for filling the tanks
- Additional energy costs from the additional pumps (~ 600 kWh/MGD)
- Still very large tanks with nitrification and water age concerns, but not as hot as an elevated tank
- Vulnerable to power failures or require extra capital cost for emergency generator
- Increased operational complexity

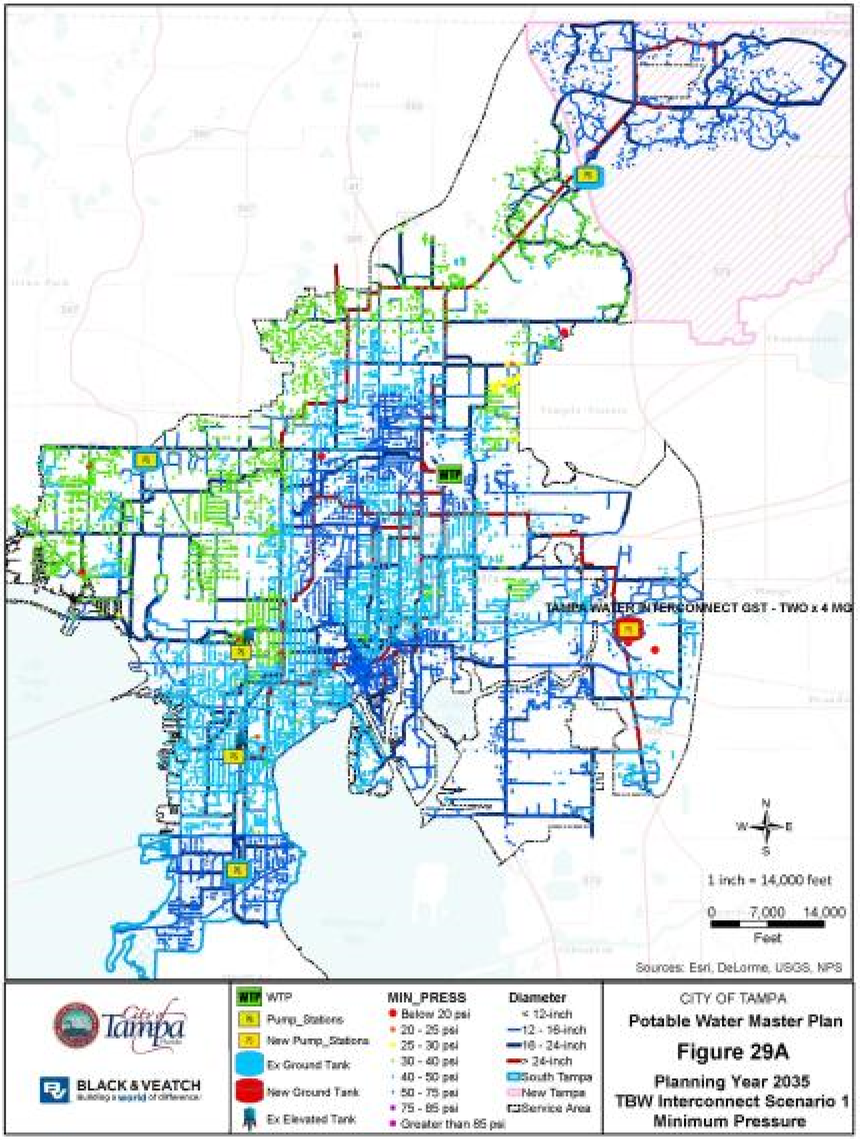
Interconnection with Neighboring Utility Options

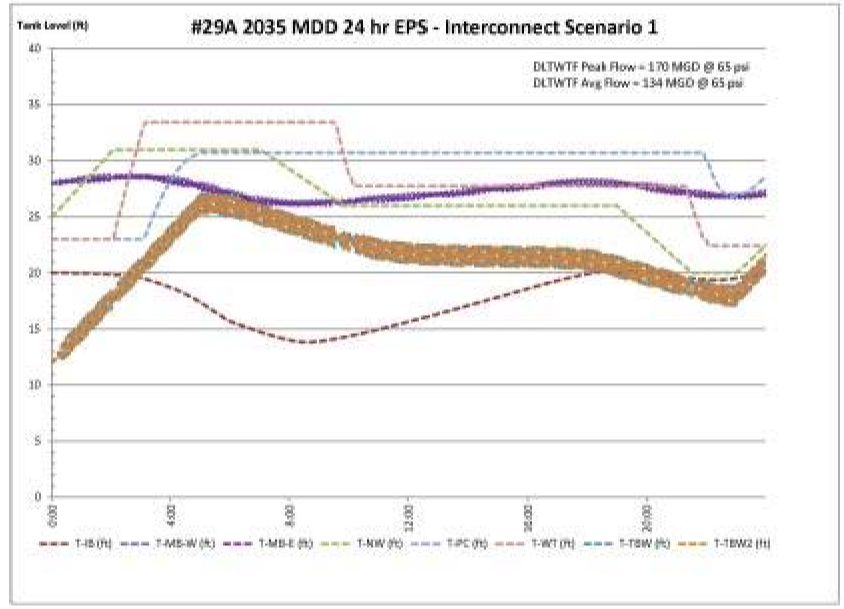
Interconnections



1. US301 Interconnect or Central WTP with new RPS
2. New RPS supplied from Northwest or Lake Park, if available transmission mains from Hillsborough County
3. Expand Northwest RPS, supplied from Northwest or Lake Park, if available transmission mains from Hillsborough County

Impacts from RPS @ Interconnect – 2035 (US-301)

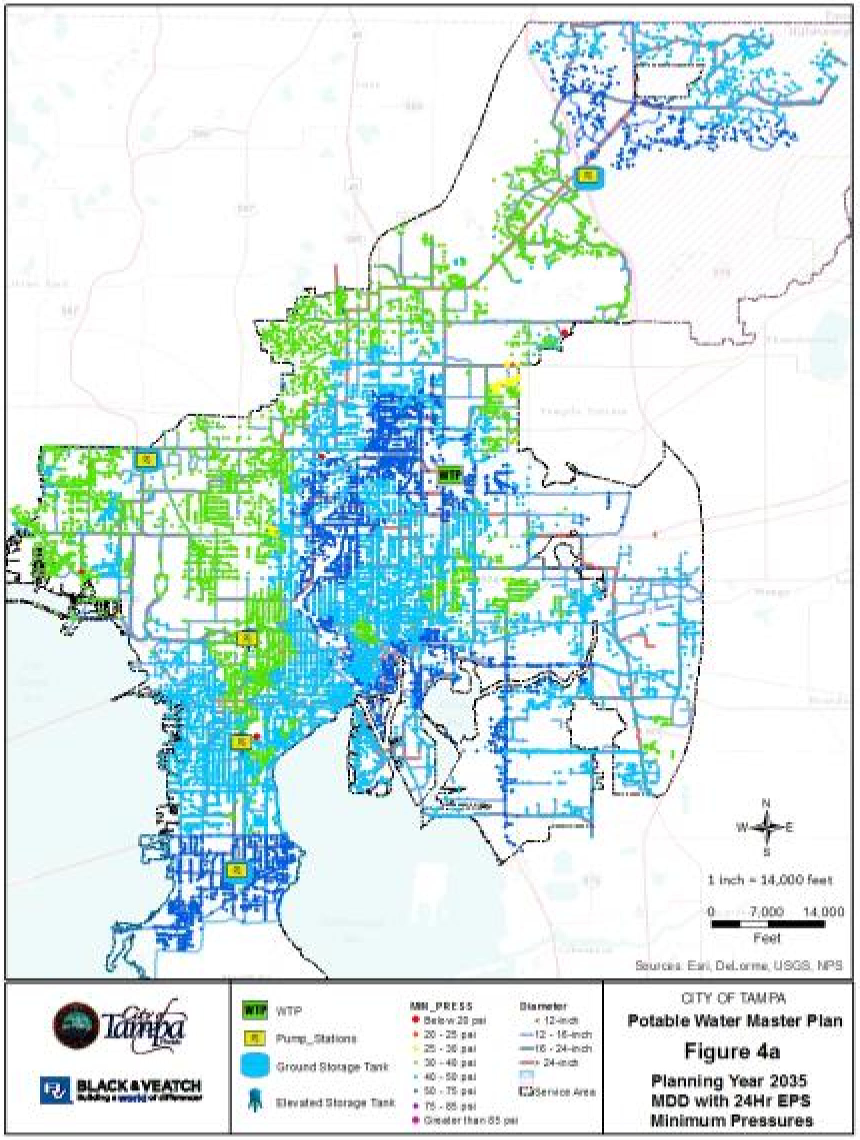




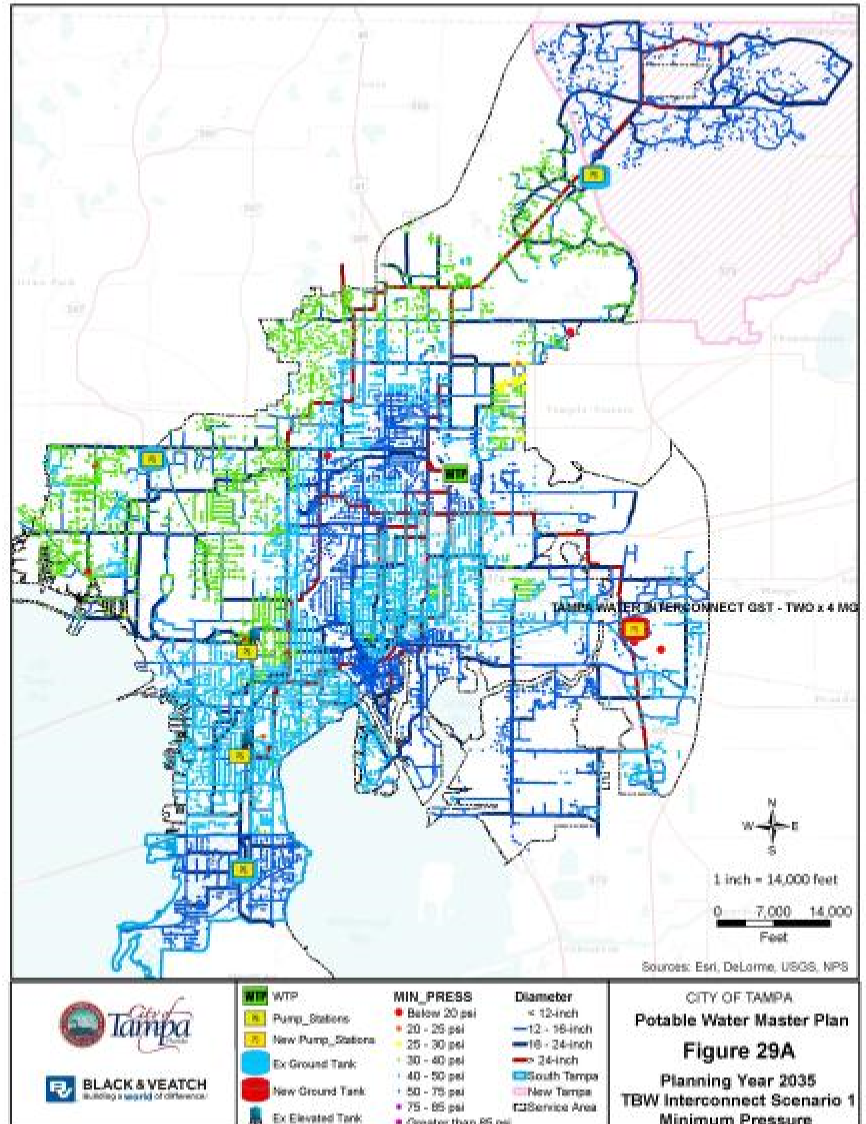
- DLTWTF Flow = 134 - <u>170</u> MGD @ 65 psi
- Northwest = One pump, Normal Cycle
- Palma Ceia = Normal Cycle
- West Tampa = Normal Cycle
- US-301 RPS = Pumps turn on during the day to cycle tank

Impacts from RPS @ Interconnect – 2035 (US-301)

MIN_PRESS
- Below 20 psi
- 20 - 25 psi
- 25 - 30 psi
- 30 - 40 psi
- 40 - 50 psi
- 50 - 75 psi
- 75 - 85 psi
- Greater than 85 psi



2035 Re-assessment; DLTWTF @ 65 psi



2035 US-301 Tanks; DLTWTF @ 65 psi

Additional Considerations – Interconnect

Pros:

- Capital costs of ground storage is less expensive than elevated storage; $1/gal vs $2/gal
- Does not limit operational flexibility / changes in HGL in the future
- Increased Fire Flow in low flow area
- Increase water supply availability / reliability with neighboring utility
- More easily expanded than clearwell or elevated tanks

Cons:

- Controls will be required to minimize the transient / surge potential from the pumps and valve for filling the tanks
- Additional energy costs from the additional pumps (~ 600 kWh/MGD)
- Still very large tanks with nitrification and water age concerns, but not as hot as an elevated tank; <u>not in a high demand area</u>
- Vulnerable to power failures or require extra capital cost for emergency generator
- Increased operational complexity
- Requires cooperation for neighboring utility

Performance Criteria

Parameter	Criteria / Description	Performance Goal	Comments
1. Demand Peaking Factor	MDD : ADD	**95th confidence interval (only exceeded 1 year out of 20 years)** [B&V]	- Ratio to be calculated based on actual system data from 2004 - 2015. - PHD:MDD data is not available for the period and will be based on 95th Percentile of 5 years (2011-2015)
	# Years of Historic Data	**12**	- 12 years were selected to include the last drought conditions in 2007.
2. Pump Station Capacity	Supply + Remote Pump Stations (w/out elevated storage)	**Firm Capacity > PHD + Fire Flow (per service area)** [F.A.C 62-555.320(15)(a)]	- Firm Capacity > PHD + Fire Demand, unless elevated finished drinking water storage is provided [F.A.C. 62-555.320 (15)(a)] - Firm Capacity + useful elevated storage capacity > greater of PHD for 4 hours or MDD+FF [F.A.C 62-555.320(15)(b)] - Firm capacity per pressure zone is the capacity with the largest pump out of service per pressure zone. • North Tampa Zone, South Tampa (Interbay) and DLT Zone
	Supply + Remote Pump Stations (w/elevated storage)	**Firm Capacity > MDD + Fire Flow (per service area)** [F.A.C 62-555.320(16)(b)]	- Existing Elevated tanks cannot be counted for F.A.C 62-555.320(15)(a) as they do not float on the system. - If elevated tank improvements were made to allow the tanks to float on the system, the criterion may be reduced to meet F.A.C. 62-555.320(15)(b). This can be evaluated as a potential improvement option.
3. Storage Volume	Total Storage (per pressure zone)	**> 25% of the System's MDD + Fire Flow (Reserve)** [F.A.C. 62-555.320 (19)(a)]	- Unless a demonstration showing that the useful finished water storage capacity (minus fire protection) is sufficient for operational equalization [F.A.C. 62-555.320(19)(b)1] - Unless a demonstration showing that the water system's total useful finished water storage capacity (minus fire protection) is sufficient to meet the water systems PHD for 4 consecutive hours [F.A.C. 62-555.320(19)(b)2] - Equalization storage should be 15-20% of max daily use. [Lindeburg] - Per discussion with the City, total storage does not include additional emergency storage due to existing WQ concerns.
	Fire Reserve	**3,500 gpm for 3 hours (per service area)**	- Minimum fire flow = 1,000 gpm for 1 hour [Florida Fire Code, Table 18.4.5.1.2] - Fire Flow between 1,500 gpm & 2,750 gpm = a duration of 2 hours; 3,000 & 3,750 gpm = a duration of 3 hours [Florida Fire Code]
4. Pressure	Minimum Pressure – Peak hour demand conditions. (Non-Fire, Non-Emergency)	**> 50 psi Transmission > 40 psi Distribution > 25 psi Metered Discharge** [TWD Tech Manual, 3.2.A.2]	- > 20 psi [F.A.C. 62-555.320 (15)(b)] - Minimum pressure at the tap should be 25 psi. Minimum pressures at fire hydrants should be 60 psi, possibly higher in commercial and industrial districts [Lindeburg] - Metered discharge pressure is on the private side of the customer meter and is not represented in the model
	Maximum Pressure	**< 75 psi**	- Florida 2010 Plumbing Code requires a service line PRV if the pressures within the building exceeds 80 psi.
5. Fire Flow	System Demand/Supply	**MDD**	- If fire protection is being provided the design capacity should be fire flow plus maximum day demand. MDD+FF [F.A.C. 62-555.320(15)(a)] - PHD+FF was not selected due to existing WQ concerns which would increase with oversized water mains.
	Minimum Flow	**1,000 gpm (residential) 3,500 gpm for 3 hours (commercial & Industrial)** [exceeds TWD Tech Manual, 3.2.A.3.c]	- Residential fire flow can be reduced to 500 gpm if building has automatic sprinkler systems and greater than 30ft separation between buildings [18.4.5.1.23, Florida Fire Code] - 1,000 gpm for 1 hour (residential) & 3,000 gpm for 3 hours (commercial & industrial)[TWD Tech Manual, 3.2.A.3.c]
	Maximum Flow	**3,500gpm for 3 hours** [ISO & AWWA M31]	The maximum flow is the maximum fire flow required from the TWD system. For system customers with fire flow requirements greater than what can be provided by the TWD system, it is assumed that those customers will construct private fire protection systems as needed to meet their own fire service needs.
	Minimum Residual Pressure	**> 25 psi** [TWD Tech Manual, 3.2]	Minimum residual pressures = 20 psi. [F.A.C. 62-555.320 (15)(a)]
6. Pipe Capacity	Maximum Velocity	**< 5 ft./sec at peak hour demands (normal, non-fire conditions) < 10 ft./sec at MDD+FF demands** [TWD Tech Manual, 3.2]	- This parameter is used to identify pipes that may be contributing to pressure and/or flow deficiencies. - Considered a secondary criteria to trigger consideration for improvement, but not automatically triggering an improvement
	Maximum Head loss (HL) per 1,000 Feet	**< 3ft (Mains >=16-inch diameter) < 5ft (Mains <16-inch diameter)**	- This parameter is used to identify pipes that may be contributing to pressure and/or flow deficiencies. - Considered a secondary criteria to trigger consideration for improvement, but not automatically triggering an improvement

Operational Control Updates

- Raising DLTWTF discharge pressure to 70 psi resolves most low pressure areas
- Consider pressure alarm / pump control for new RPSs, or VFD with local pressure lower DLTWTF
- Better tracking of normal diurnal patterns based on 3 pressure zones – to control based on time

Next Steps & Timeline

- 513 – DLT Zone Storage Deficit
- 501A – Distribution System Capacity Improvements
- 506A(2) – Recommended Storage Improvements Workshop
  - December 12, 2017
- **502A – Distribution Fire Flow Improvements**
- **505A – Water System Resiliency & Redundancy Improvements**
- **506A(3) – Distribution System Recommended Improvements Workshop**
  - **January 16, 2018**
- **Distribution System Assessment & Improvements TM**
  - **January 23, 2018**

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Appendix C

Water Main Improvement Project Descriptions

CP003

This project provides the replacement of approximately 1 mile of 8" pipe on E Fowler Ave and N 50th St with 12-inch pipe. These two 8-inch pipes are split from a 16-inch pipe on E Fowler Ave. An additional 16-inch transmission connection also serves this area from the north, on E Fletcher Ave, however, due to the proximity of this area with DLTWTF directly to the south, hydraulics dictate that most of the flow be served from the southern transmission main on E Fowler Ave. Average peak headloss per thousand feet (HL/1000) in this pipeline is 7.4 in the 2035 plan year, well above criteria. Replacing these pipelines provides significant reduction in system losses, lowering average peak HL/1000 to below 2 and providing pressure increases of > 2 psi on average.

CP004

This project provides a new distribution main to a moderately sized residential community, Grant Park, east of N 40th St bounded on the south by I-4. Flow to Grant Park is provided primarily by two 8-inch pipelines to the southwest of the community, despite the presence of a 16-inch transmission main from the south. Grant Park does not have any supply sources from the north or the east and the northern end of the community is served entirely dead-end pipelines. By installing a new 8-inch and 12-inch pipeline in E Dr. MLK Blvd and connecting to an existing dead-end 12-inch pipeline in the same road, a transmission path for the dead-end 16-inch pipeline is generated. Additionally, the losses generated by moving flow through a long dead-end path are eliminated, increasing maximum day minimum pressures by >2.5 psi, and water age is improved.

CP005

This project provides the replacement of approximately 2.1 miles of 8-inch pipeline in W Lambright St and W Sligh Ave with 12-inch pipe. The existing 8-inch pipeline connects to a 48-inch transmission main. This connection experiences high flow as a result of access to the higher transmission HGL, and high headloss as a result of the high flow through a small diameter pipe. Average peak HL/1000 in this pipeline is 3.9 in the 2035 plan year, with multiple segments within the pipeline exceeding the recommended criteria of 5. Replacing this pipeline with 12-inch provides an adequately sized distribution path to an area featuring significant amounts of 6-inch and smaller providing distribution. Replacing this pipeline also provides moderate reduction in system losses.

FF001

Two piece project which consists of connecting 8-inch dead end pipes approximately 12 feet apart in Columbus Dr. and upsizing 2,000 feet of 8-inch pipe in Columbus Dr to 12-inch. The combined effect of these two improvements increases available fire flow to this non-residential area from approximately 1,100 gpm to within the criteria. Verify if the dead-end 8-inch pipes are already connected.

FF002

Replace approximately 4,600 feet of 8-inch pipe with 12-inch pipe in Bay Pointe Dr and Lopez Dr in order to increase available fire flow to non-residential area from approximately 1,000 gpm to within the criteria. Review fire flow requirements for this area to confirm necessity of full non-residential fire flow.

FF003

Replace approximately 1,250 feet of 6-inch pipe with 8-inch pipe in Mohr Rd in order to increase available fire flow from approximately 600 gpm to within the criteria.

FF004

Replace approximately 4,600 feet of 8-inch pipe with 12-inch pipe in 82nd St Cswy in order to increase available fire flow from approximately 670 gpm to within the criteria.

FF005

Non-residential area in residential community with approximately 1,400 gpm available fire flow. Installation of 12" distribution main to connect 8-inch pipes in Herron Crossing Dr. and Meadow Pine Dr. more than doubles available fire flow. Review fire flow requirements for this area to confirm non-residential status.

FF006

Replace existing 12-inch and 8-inch pipelines to the non-residential Ben T Davis Beach area with a 16-inch pipeline, increasing available fire flow from approximately 1,900 gpm to within the criteria. Review fire flow requirements for this area to confirm necessity of full non-residential fire flow.

FF007

Replace 8-inch pipe with 10-inch or 12-inch pipe in Troydale Rd in order to increase available fire flow from approximately 920 gpm to within the criteria.

FF008

Replace approximately 800 feet of 6-inch pipe with 8-inch pipe in N 27th St in order to increase available fire flow from approximately 810 gpm to within the criteria.

FF009

Two piece project which consists of adding a connection from the existing 8-inch main to an existing 12-inch main on the opposite side of the same street, S 50th Street, as well as replacing some of the existing 8-inch dead-end pipe with 12-inch pipe. The combined effect of these two improvements increases available fire flow from approximately 800 gpm to within criteria.

FF010

Install approximately 1,100 feet of new 12-inch pipe in Hartford St in order to increase available fire flow from approximately 860 gpm to within the criteria.

FF011

Replace approximately 750 feet of 6-inch pipe with 8-inch pipe in W Melrose Ave in order to increase available fire flow from approximately 870 gpm to within the criteria.

FF012

Replace approximately 800 feet of 6-inch pipe with 8-inch pipe in 20th Ave S in order to increase available fire flow from approximately 910 gpm to within the criteria.

FF013

Two *option* project. The effect of either improvements increases available fire flow from approximately 960 gpm to within the criteria. One possible project consists of connecting an existing 12-inch pipe to a 16-inch transmission main in Cross Creek Blvd. The other project consists of replacing approximately 900 feet of 8-inch pipe with 12-inch pipe in Plantation Bay Dr.

FF014

Two *option* project. The effect of either improvements increases available fire flow from approximately 920 gpm to within the criteria. One possible project consists of connecting a 6-inch main in N West Shores Blvd to a 12-inch main in same street, approximately 40 feet away. The other project consists of replacing the 6-inch main in N West Shores Blvd which feeds an 8-inch main, with 8-inch pipe.

FF015

Replace 8-inch pipe with 10-inch pipe in Bay Crest Dr in order to increase available fire flow from approximately 920 gpm to within the criteria.

FF100

Connection dead-end 8-inch pipes on S Juanita St approximately 40 feet apart in order to increase available fire flow from approximately 360 gpm to within the criteria.

FF101

Connect 12-inch and 8-inch dead-ends in Hillsborough Ave west of the intersection of Memorial Highway and Sheldon Rd with existing 16-inch and 8-inch pipes nearby, respectively. These connections provide looping and access to fire flow for the entire community west of this intersection, increasing available fire flow from as low as 690 gpm to within the criteria. Verify that these connections do not already exist.

FF102

Connect dead-end 10-inch pipe with existing 12-inch pipe approximately 20 feet away in the non-residential University Square Mall, near Club Dr, in order to increase available fire flow from 1,030 gpm to within the criteria. Verify that this connection does not already exist.

FF103

Connect existing 16-inch pipe which serves the non-residential Rogers Parl Golf Course and crosses but does not connect to either the 36-inch or 42-inch diameter transmission main at N Willie Black Dr and E Veve Ln in order to increase available fire flow from 1,100 gpm to within the criteria. Verify that this connection does not already exist and review fire flow requirements for this property to confirm necessity of full non-residential fire flow.

FF104

Connect dead-end 6-inch pipes less than 10 feet apart in N St Peter Ave in order to increase available fire flow from to within the criteria. Verify that this connection does not already exist.

FF105

Connect dead-end 8-inch pipes approximately 16 feet apart in Blackmore Dr in order to increase available fire flow from 930 gpm to within the criteria. Verify that this connection does not already exist.

FF106

Connect dead-end 20-inch pipe in George Rd to 16-inch main in Dana Shores Dr approximately 55 feet apart in order to increase available fire flow to within the criteria. Verify that this connection does not already exist.

FF107

Connection dead-end 6-inch pipes on Brookside Ln less than 10 feet apart in order to increase available fire flow from approximately 360 gpm to within the criteria. Verify that this connection does not already exist.

FF200

Replace approximately 1,100 feet of 2-inch pipe which is providing distribution on W Cherry St with 8-inch and 12-inch pipe in order to increase available fire flow from approximately 90 gpm to within criteria. Verify existing pipe sizes.

FF201

Two piece project. Replace approximately 2,500 feet of 2-inch pipe which is providing distribution on W Sunset Blvd and S Toronto St with 8-inch pipe and connect two dead-end 8-inch pipes approximately 20 feet apart. The combined effect of these projects will increase available fire flow from approximately 120 gpm to within criteria. Verify existing pipe sizes. Verify that this connection does not already exist.

FF202

Replace approximately 1,000 feet of 2-inch pipe which is providing distribution on W McCoy St with 8-inch pipe in order to increase available fire flow from approximately 380 gpm to within criteria. Verify existing pipe sizes.

FF203

Replace approximately 300 feet of 2-inch pipe which is providing distribution on W 109th Ave with 8-inch pipe in order to increase available fire flow from approximately 430 gpm to within criteria. Verify existing pipe size.

FF204

Replace approximately 50 feet of 2-inch pipe which is located within two segments of dead-end 8-inch pipe on N 31st St in order to increase available fire flow from approximately a minimum of 420 gpm to within criteria. Verify existing pipe sizes.

FF205

Replace approximately 2,200 feet of 2-inch pipe which is providing distribution on E Cayuga St, E Emma St and E Chelsea St with 6-inch pipe in order to increase available fire flow from approximately 410 gpm to within criteria. Verify existing pipe sizes.

FF206

Replace approximately 20 feet of 2-inch pipe which is located within a segment of dead-end 12-inch pipe on Garden Vista Dr in order to increase available fire flow from approximately a minimum of 500 gpm to within criteria. Verify existing pipe sizes.

FF207

Replace approximately 20 feet of 2-inch pipe which is located within a segment of dead-end 8-inch pipe on N 70th St in order to increase available fire flow from approximately a minimum of 480 gpm to within criteria. Verify existing pipe sizes.

FF208

Replace approximately 2,300 feet of 2-inch pipe which is providing distribution on W Kentucky Ave and Woodlawn Ave with 8-inch pipe in order to increase available fire flow from approximately 640 gpm to within criteria. Verify existing pipe sizes.

FF209

Replace approximately 1,050 feet of 2-inch pipe which is providing distribution on E Wilder Ave with 8-inch pipe in order to increase available fire flow from approximately 430 gpm to within criteria. Verify existing pipe size.

FF210

Replace approximately 700 feet of 2-inch pipe which is providing distribution on S Main Ave and W Victoria Ave with 6-inch pipe in order to increase available fire flow from approximately 980 gpm to within criteria. Verify existing pipe sizes.

Appendix C-a

Model Update and Calibration Technical Memorandum

FINAL

HYDRAULIC MODEL CALIBRATION REPORT

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

22 JULY 2016

Table of Contents

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LIST OF FIGURES

LIST OF ATTACHMENTS

1. Introduction

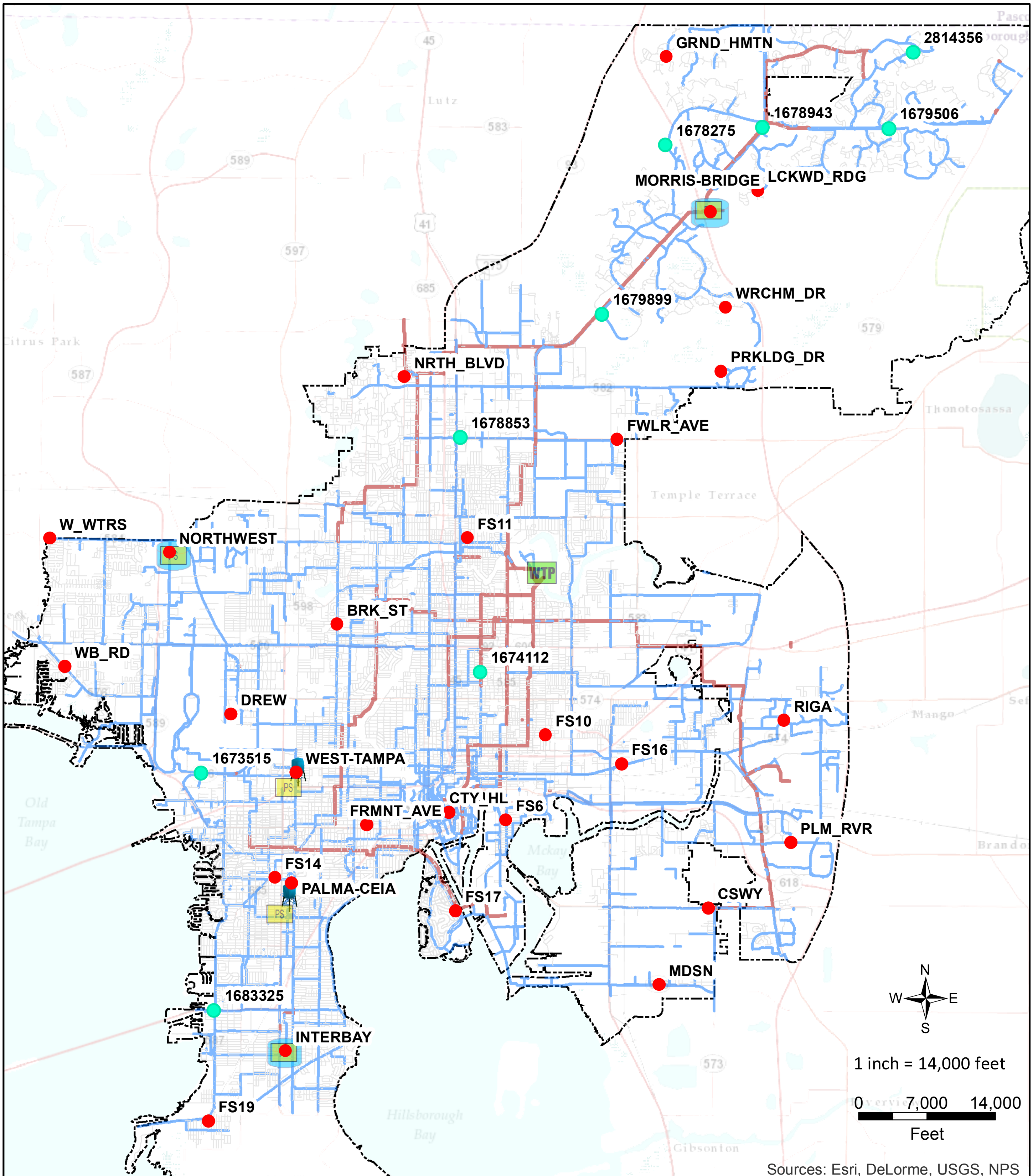
The City of Tampa Water Department (TWD) maintains a hydraulic model of its potable water distribution system to conduct various analyses on the capabilities and capacities of the system. As part of the City's 2015 Potable Water Master Plan Update, Black & Veatch updated the City's hydraulic model with updated water demand information and prepared the model for extended period simulations (EPS). A 24-hour EPS is the preferred calibration methodology and provides a clear indication of the ability of the hydraulic model to simulate system operating conditions under a number of settings. In addition, Black & Veatch completed a model calibration process to compare and validate the updated hydraulic model results with actual system operating data that was collected by the City. Most of the facilities and water mains in the distribution system had previously undergone a steady-state calibration process. To further refine the correlation between the system conditions and the hydraulic model, the calibration efforts presented in this report built upon the results of the previous calibration. However, the Palma Ceia and West Tampa tanks and associated repump stations (RPS) are new additions to the model since the last calibration efforts and did not have a baseline to start with. The following presents the steps which were followed to complete the calibration process of the City's Hydraulic Model.

2. Available Field Data

The City records and maintains Supervisory Controls and Data Acquisition (SCADA) data at each of the major system facilities including the five repump stations (RPS) and several permanent pressure loggers. The availability of this data allowed Black & Veatch to conduct an EPS model calibration of the distribution system. **Table 1** summarizes the available SCADA data. Data from 29 permanent SCADA pressure loggers and 9 temporary hydrant pressure loggers was also available for the calibration effort. **Figure 1** illustrates the location of each logger and **Table 2** illustrates the 10 facility calibration points.

Table 1 Available SCADA Data

PUMP STATION, TANK OR LOGGER	PUMP STATUS	PUMP SPEED	TOTAL FLOW	INDIVIDUAL PUMP FLOW	DISCHARGE PRESSURE	TANK LEVEL
D.L. Tippin WTF	Limited (missing data on 6, 7, & 8)	Limited (missing data on 5, 7, & 8)	Yes	-	Yes	N/A
Interbay RPS	Limited (lots of "Bad" readings)	Limited (lots of "Bad" readings, missing jockey pumps)	Yes (had a few "Bad" reading which were assumed to be zero)	-	Yes	Yes
Morris Bridge RPS	Yes (looks like there is an error with 3 & 4, assumed off)	Yes	Yes	No	Yes	Yes
Northwest RPS	Yes	N/A	Yes	No	Yes	Yes
Palma Ceia RPS	No	N/A	No	No	Yes	Yes
West Tampa RPS	Yes	N/A	No	No	Yes	Yes
North Boulevard Connection	Yes	No	Yes	No	Yes	N/A
Aquifer Storage Recovery (ASR) Recharge Flow	No	N/A	No	Yes (zero flow during monitoring period)	No	N/A



City of Tampa Florida

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Potable Water Master Plan

Figure 1

Calibration Pressure Logger Location

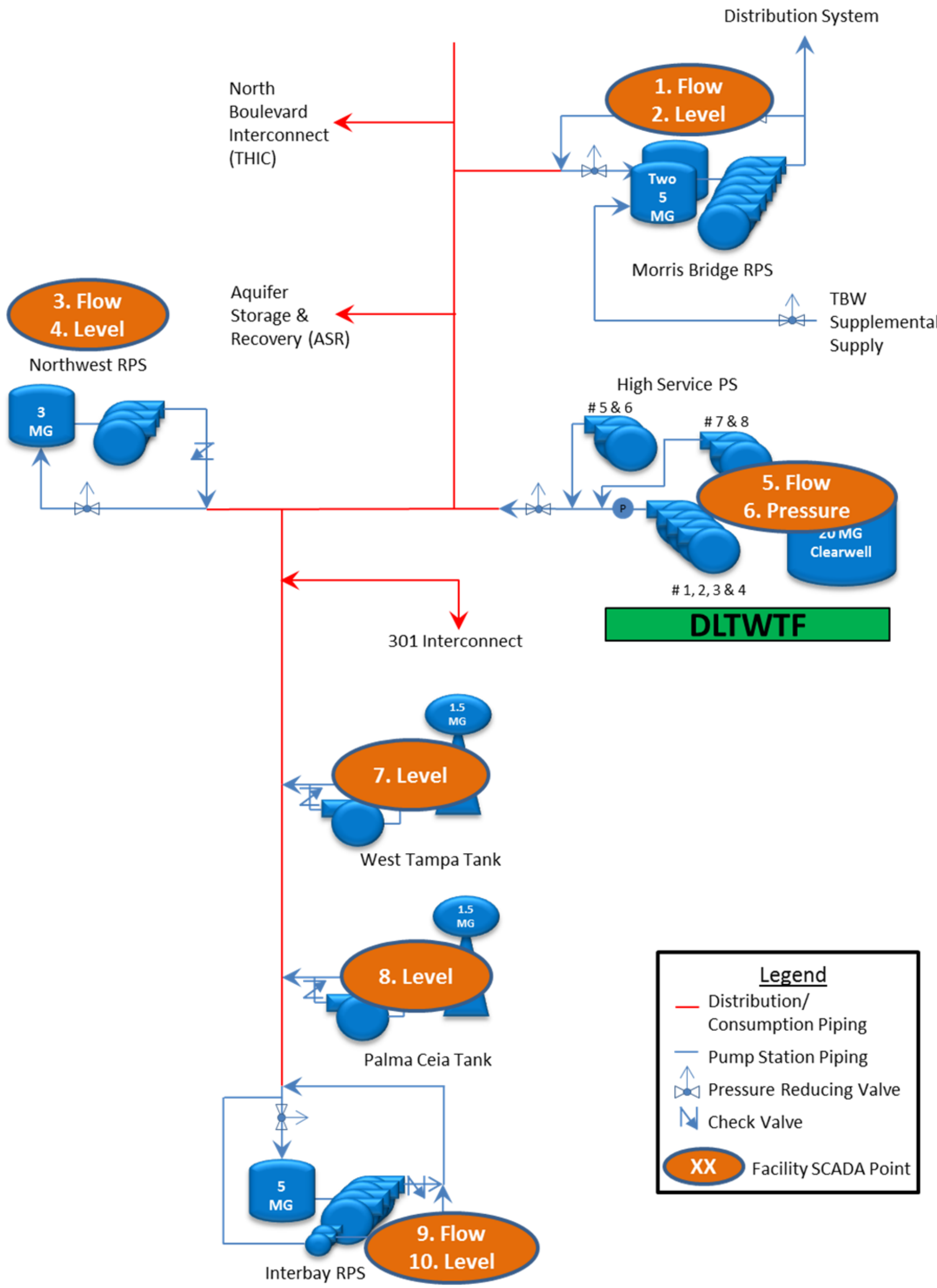


Figure 2 Facility SCADA Calibration Points

3. Model Setup

3.1 CALIBRATION VERIFICATION DAY

The City approved the calibration plan included in Attachment 3 and the earliest that were to install the temporary hydrant pressure loggers was early January 2016. Data was collected from January 5th through the 19th. The SCADA data and pressure logger data were reviewed and January 14, 2016 (Thursday) was the date selected for the EPS calibration of the model. Selection of this date included reviewing the data for consistency and data gaps. Based on the tank and pumping records for January 14, 2016 the total demand that day was 69.4 million gallons per day (MGD).

3.2 DIURNAL DEMAND CURVE DEVELOPMENT

In order to conduct a 24-hour EPS calibration of the updated model, it was necessary to calculate changes in the system demands at regular intervals throughout the 24 hour period. This was accomplished through a mass balance calculation utilizing the available SCADA data to relate pump station flows and changing tank levels (converted to flow rates) to specific demands:

Demand = Volume Produced (total pumped x time increment) ± Change in Volume – Wholesale – ASR
Volume Produced = DLTWTF + US301 Interconnect + Morris Bridge Interconnect
Volume Stored = Volume Into Tanks – Volume Out of Tanks

Based on the mass balance calculations above, time-specific demands were calculated for each time increment during the calibration day of January 14, 2016. The results of this calculation were then divided by the average demand on that day in order to generate a normalized diurnal demand curve. The diurnal pattern was calculated using the 5 minute SCADA data records. For the purpose of this calibration effort, the SCADA data was averaged each hour to develop an hourly average pattern to input into the hydraulic model. This was done to increase stability and mitigate the accuracy errors in the level transducers at such small time increments. The hourly pattern has the same general shape as the 5 minute pattern shown above without the sudden drops and peaks. This hourly pattern was used for calibration and is shown in **Figure 3**. The same process will be used for the system analysis, but will use SCADA data from a maximum demand period in 2015. NOTE: This pattern was revised during calibration to account for irrigation demand in New Tampa and is discussed further in subsequent sections.

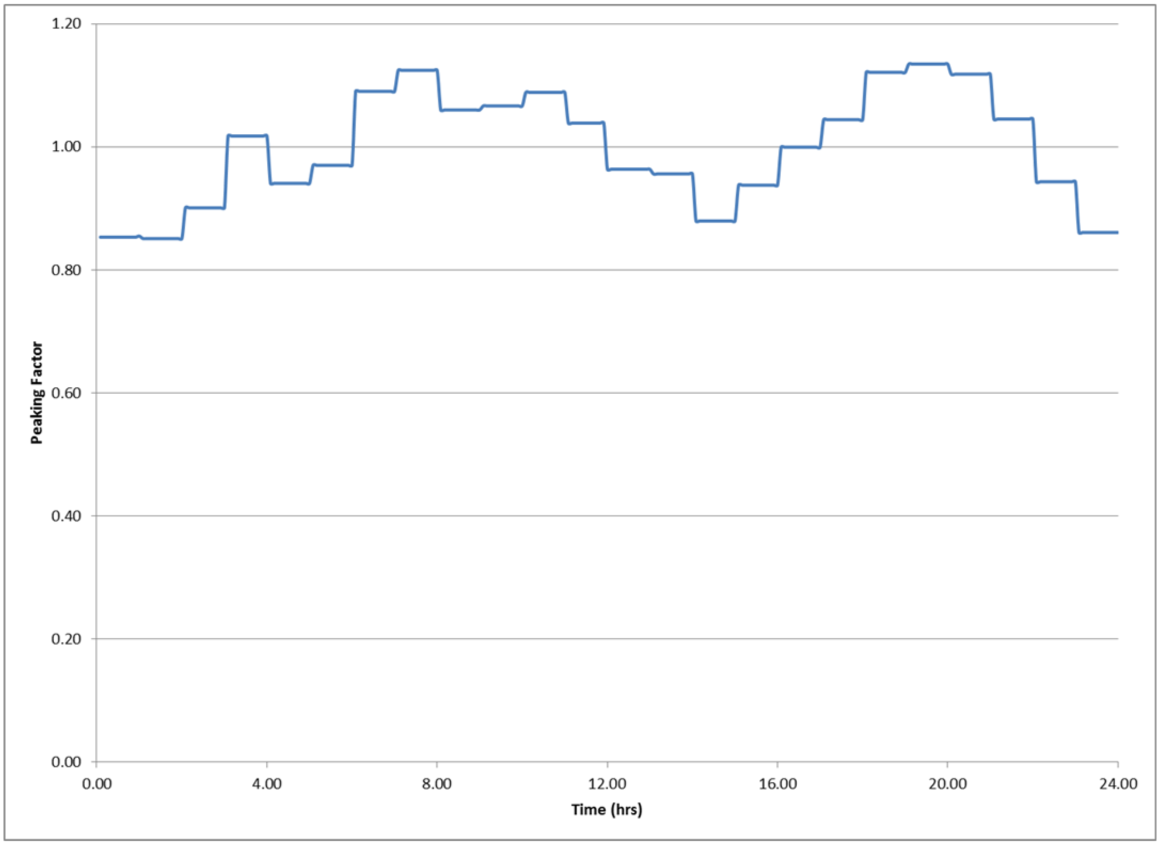


Figure 3 Initial Systemwide Hourly Calibration Pattern

3.3 CONTROLS

Valve and pump controls were added to the model to replicate the actual operation of the distribution system on the selected calibration day. Details on the calibration controls are summarized below. Additional details regarding the typical operation of the distribution system can be found in Attachment 4. All of the system controls, with the exception of the variable frequency drive (VFD) pumps at the High Service Pump Station (HSPS), are operator controlled. Operators work in three firsts and the shifts are described as follows: First – 7:00 AM to 3:00 PM; Second – 3:00 PM to 11:00 PM; Third – 11:00 PM to 7:00 AM.

3.3.1 Tank Fill Valve Controls

The fill valves located at tank sites are opened remotely by operations staff at the system operations console at the David L. Tippin Water Treatment Facility (DLTWTF) to fill the tanks. There are no automated controls associated with the valves. An operator must manually control the filling process, and typically this occurs during the Third operator shift (night). The valves are not flow control or percent open valves, but rather are either open or closed with a low pressure safety set at 35 psi where the valve would throttle to ensure system pressure remain above 35 psi.

The Morris Bridge and Interbay tanks are filled first, followed by the Northwest tank, then the West Tampa elevated tank, and finally the Palma Ceia elevated tank. The valves were modeled as “Throttle Control Valves” (TCV). The individual controls were based on decreasing the minor loss of the valve during filling to simulate when the valve was set to open, and increasing the minor loss when the valve was closed. This method was used to mimic how the same valves do not completely close and allow a small flow to divert into the tanks. This occurrence is illustrated in **Figure 4** below. Additionally, the tank valve controls are summarized in **Table 2** below.

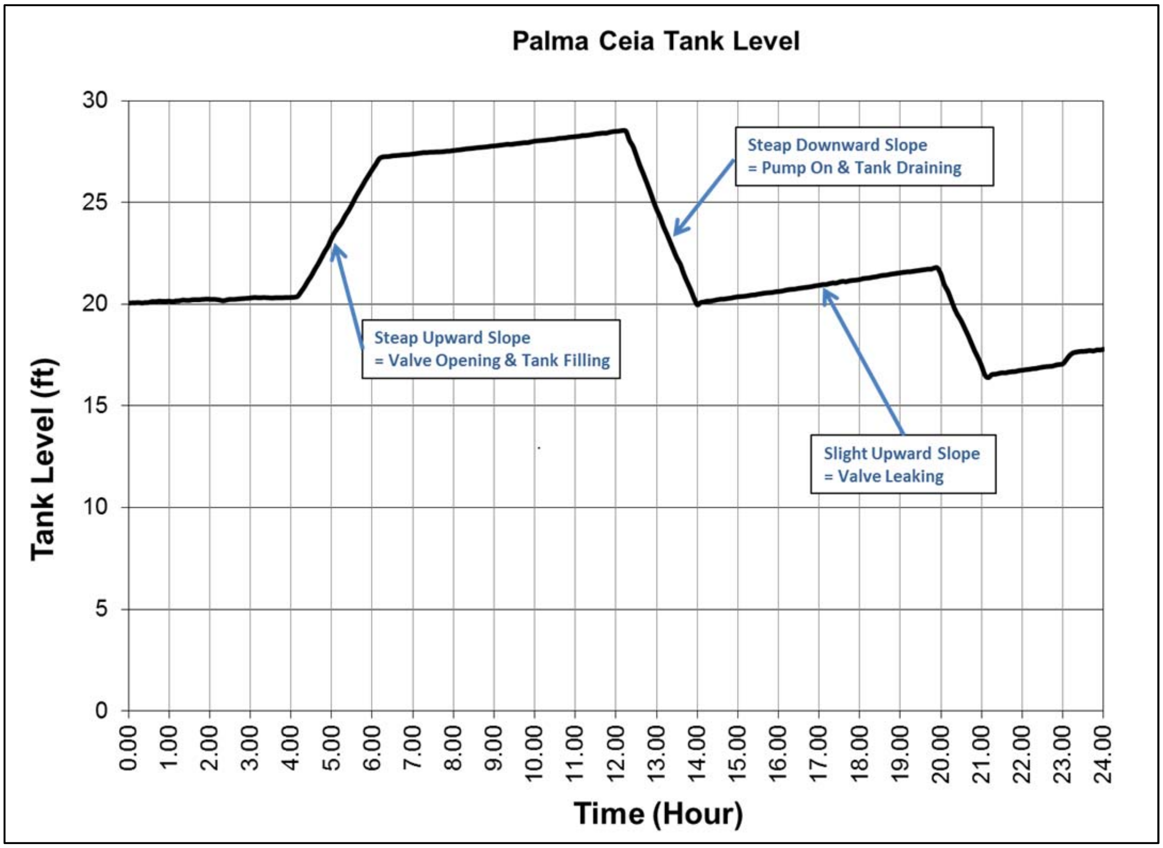


Figure 4 Valve Leaking Occurrence

Table 2 Valve Controls for Calibration.

TANK VALVE	INITIAL STATUS	TANK LEVEL TO CLOSE (FT)	TIME STAMP / MINOR LOSS 1	TIME STAMP / MINOR LOSS 2	TIME STAMP / MINOR LOSS 3
Interbay RPS	Open	27.5	0:00 / 200 (OPEN)	2:25 / 150,000 (CLOSED)	23:00 / 200 (OPEN)
Morris Bridge RPS	Open	27	0:00 / 25.0 (OPEN)	2:05 / 100,000 (CLOSED)	22:55 / 25.0 (OPEN)
Northwest RPS	Closed	28	0:00 / 500,000 (CLOSED)	1:55 / 75 (OPEN)	3:15 / 10,000,000 (CLOSED)
Palma Ceia RPS	Closed	27	0:00 / 80,000 (CLOSED)	4:15 / 5.0 (OPEN)	6:15 / 80,000 (CLOSED)
West Tampa RPS	Closed	29	0:00 / 10,000,000 (CLOSED)	3:20 / 5.0 (OPEN)	4:15 / 10,000,000 (CLOSED)

3.3.2 Pump Controls

As with the tank valves, the pumps are remotely turned on and off by operations staff to manage tank levels / tank turnover, and maintain system pressures. Typically each shift will turn on pumps to drawdown the tanks by 5 to 6 feet to allow for at least a third tank turn over each day. The Morris Bridge and Interbay tanks are pumped first, followed by the Northwest tank, then the West Tampa tank, and finally the Palma Ceia tank. During increased demand periods, the Morris Bridge pumps are also operated to maintain pressures in the New Tampa area and may operate for longer periods. **Table 3** below summarizes the pump controls for the calibration day.

Table 3 Pump Controls for Calibration.

PUMP STATION	NO.	TIME STAMP / OPERATION 1	TIME STAMP / OPERATION 2	TIME STAMP / OPERATION 3	TIME STAMP / OPERATION 4	TIME STAMP / OPERATION 5
Interbay RPS	1	0:00 / CLOSED	-	-	-	-
	2	0:00 / CLOSED	16:50 / 0.9 Speed	21:35 / CLOSED	-	-
	3	0:00 / CLOSED	6:45 / 0.94 Speed	12:25 / CLOSED	-	-
	4	0:00 / CLOSED	-	-	-	-
	5	0:00 / CLOSED	2:30 / 0.2 Speed	6:30 / CLOSED	-	-
	6	0:00 / CLOSED	-	-	-	-
Morris Bridge RPS	1	0:00 / CLOSED	-	-	-	-
	2	0:00 / CLOSED	-	-	-	-
	3	0:00 / CLOSED	-	-	-	-
	4	0:00 / CLOSED	-	-	-	-
	5	0:00 / CLOSED	6:14 / 0.99 speed	9:50 / CLOSED	-	-
	6	0:00 / CLOSED	19:14 / 0.8 speed	22:09 / CLOSED	-	-
Northwest RPS	1	0:00 / CLOSED	17:20 / OPEN	19:00 / CLOSED	-	-
	2	0:00 / CLOSED	10:00 / OPEN	13:30 / CLOSED	-	-
	3	0:00 / CLOSED	-	-	-	-
Palma Ceia RPS	1	0:00 / CLOSED	12:10 / OPEN	14:00 / CLOSED	19:55 / OPEN	21:10 / CLOSED
West Tampa RPS	1	0:00 / CLOSED	13:40 / OPEN	14:45 / CLOSED	18:15 / OPEN	19:05 / CLOSED

4. Calibration Verification Results

The hydraulic model was setup to simulate the distribution system conditions on January 14th in order to compare the results to the field data and verify if the model was calibrated. Based on the availability of SCADA data summarized in **Table 1**, there were a total of 10 facility points of calibration (flow & tank level) and 38 points of calibration at the permanent and temporary pressure loggers over 288 different time steps. **Table 4** summarizes the calibration goals and limits. The calibration goal represents the desired tolerance in the hydraulic model results compared to the field data which should be achieved overall systemwide. There are no set industry standard calibration goals, but the goals listed below are typical throughout the industry and were agreed to by the TWD during the calibration review meeting as appropriate for the City's distribution system.

Table 4 Calibration Goals.

CALIBRATION POINT TYPE	LOCATION	CALIBRATION GOAL
Tank Level	Interbay, Morris Bridge, Northwest, Palma Ceia and West Tampa	+/- 3 ft
Flow	DLTWTF, Interbay, Morris Bridge, Northwest, ASR Recharge	+/- 10%
Pressures	See Figure 1	+/- 3 psi

4.1 CALIBRATION PROCESS & OBSERVATIONS

The following is a brief summary of the calibration process used.

4.1.1 Hydraulic Gradeline / Tank Levels:

The process was started by calibrating the hydraulic gradeline (HGL) with no pump curves or controls by using negative demand junctions to simulate the correct amount of flow from each pump station at the correct time. This allowed for the tanks to be balanced, closed valves to be found and verified, C-factors to be adjusted, and possible restrictions (like partially closed valves) to be identified.

Observations:

- Previous calibration efforts of assigning C-factors based on pipe material and age to match the field conditions were still valid and no C-factors were required to be adjusted. The C-factors range from 40 to 155 based on the age and material of the water main.
- No new valve closures were identified and existing closures were confirmed.
- The pipe lengths of the water main feeding the West Tampa tank were updated from user input to auto calculated. The user input was set at half a mile for each pipe segment totaling 2 miles, when the total length is actually around 200 ft.
- West Tampa Tank: *Note that the discussion below occurred during the calibration review meeting and has been updated based on field investigation performed by the TWD.*

  The elevation of the base of the bowl of the West Tampa elevated tank was adjusted to match the HGL as indicated by the SCADA data. The initial elevation of the bowl base was set at 120 ft., however to be able to fill the tank at the rate indicated by SCADA while still matching the pressures at the logger just downstream of the tank, the elevation was required to be reduced to 110 ft.

  In order for the tank to fill, the HGL of the distribution system should be higher than the HGL of the water in the tank, and in order for the tank to fill at 7,000 gpm as indicated by the change in tank level over a few hours, the HGL of the system should be significantly higher than the tank HGL. **Figure 5** below is a comparison of the HGL of the tank with a base elevation of 120 ft. and the field HGL of the pressure logger just downstream of the tank (HR_WT). The figure shows that the elevation of the West Tampa tank cannot be 120 ft. since the HGL of the system is lower than the HGL of the tank.

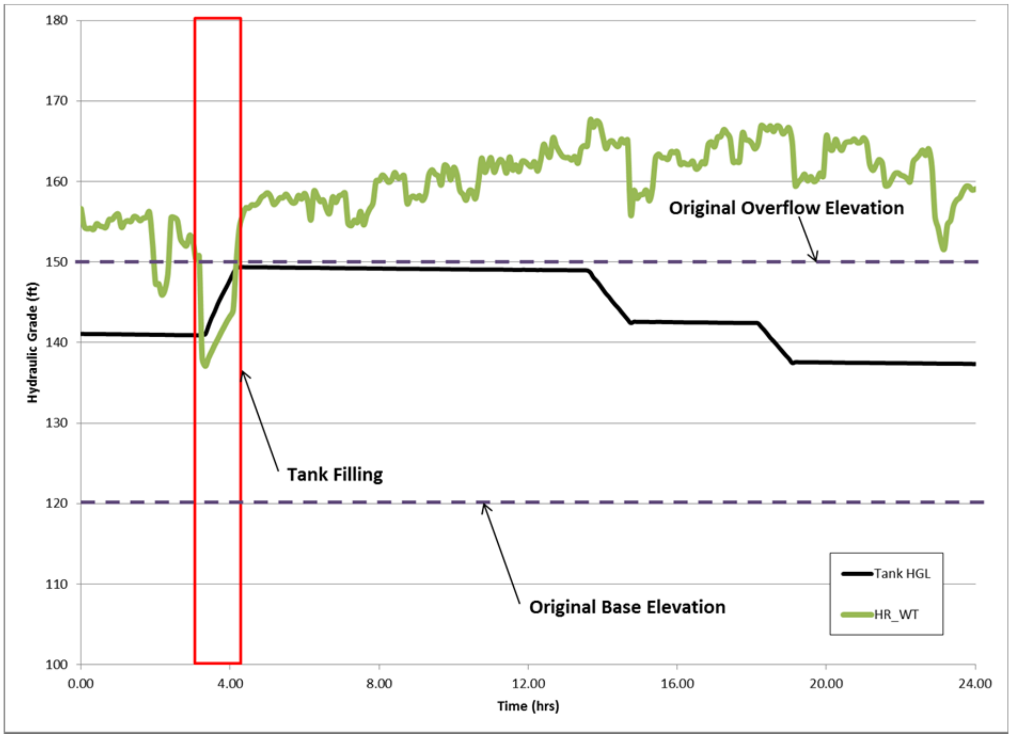


Figure 5 West Tampa Elevated Tank @ 120 ft. and Logger HGL Comparison

The West Tampa tank was installed decades ago when the overall HGL of the distribution system was lower. However, over the years the HGL of the system was increased to meet the expanding service area and needs of the customers. As a result, the elevated tank was converted to a repump station and is isolated from the distribution system except when filling the tank. During times when the tank is not being filled it is normal that the HGL of the distribution system is significantly higher than the HGL of the tank due to the newer operating procedures of the system and the tank being isolated from the system.

NOTE: Subsequent field investigation confirmed the calibration results. The height of the bowl base was measured to be approximately 75 ft. above grade. With contour shapefiles indicating the grade elevation to be approximately 36 ft., the field investigation confirmed the elevation of the base of the bowl to be approximately 110 to 111 ft. NOTE: A similar investigation was performed on the Palma Ceia elevated tank and the bowl base elevation was confirmed to be 120 ft.

4.1.2 Hydraulic Gradeline / Pressure Loggers Observations

Once the tank levels were calibrated, the pressure logger HGLs were analyzed and calibrated.

- Most of the model results at the pressure logger locations readily matched the corresponding field data within the calibration goals. A few of the junction elevations were adjusted to better match the 1 ft. contours provided by the TWD and then to match the field pressure data. Elevations were only adjusted for junctions where the pattern of the model results matched the pattern of the field data. Matching patterns indicate that the friction losses and demands are accurately represented and that the static pressure is inaccurate, thus the change in elevation. **Table 5** summarizes the elevation changes.

Table 5 Pressure Logger Elevation Changes.

#	LOGGER / SCADA POINT NAME	INITIAL JUNCTION ELEVATION (FT)	CONTOUR ELEVATION (FT)	UPDATED JUNCTION ELVATION (FT)	DIFFERENCE (UPDATED – INITIAL) (FT)
1	Drew	25	23	21	4
2	Cty_HL	20	19	18	2
3	WRCHM	30	29	28	2
4	WB_RD	5.62	5	3	3
5	MDSN	9.79	8	6	4
6	W_WTRS	11.67	14	10	2
7	FS11	34.89	33	33	2
8	WT[1]	35	36	30	5
9	PC[1]	16.92	18	11	6
10	IB[1]	10	12	6	4
11	FS19	5	5	1	4
12	1674112	52.44	50	49	3
13	1673515	12.92	13	10	2
14	1683325	5	5	1	4
15	1679506	54.03	52	52	2
16	Morris Bridge[1]	40	44	37	2
17	1678275	45	43	43	2
18	1679899	36	36	34	2

1. The pressure loggers at these locations are known to be in valve vaults below grade.

- **Fowler Ave Logger**: *Note that the discussion below occurred during the calibration review meeting and has been updated based on field investigation performed by the TWD.*

One logger location that was well outside of the calibration goals; the HR_FWLR_AVE_PSR. This logger is located near the intersection of E. Fowler Ave & N. 51st St. and the model data is about 15 psi lower than the field data creating a percent error around 30%. However, all of the model results and field data for the loggers in close proximity to the Fowler Ave logger matched. Those loggers include: HR_FS11_PSR, HR_PRKLDG_DR_PSR and 1678853. **Figure 6** shows the location of all the loggers.

As the loggers get further away from the WTF, located near the HR_HSP_DSCHRG_PV, their HGLs should start decreasing but still be similar to the nearby loggers. **Figure 7** illustrates the HGLs of the above mentioned loggers according to the SCADA data. The figure shows the HGL of the Fowler Ave logger to be inconsistent with and much lower than the furthest logger (HR_PRKLDG_DR_PSR). A review of this information suggests the possibility that the Fowler Ave logger may be downstream of a pressure reducing valve (PRV).

Further indications of a possible PRV include the relatively smooth pressure readings of the Fowler Ave logger compared to the other loggers, and the spikes in pressure that reach up to where the HGL of the logger is expected. These spikes may have occurred when a downstream customer quickly closed a connection and the PRV required some reaction time to modulate to a further closed position to maintain the pressure set point for the PRV.

B&V recommends confirming the existence of the PRV, and if the PRV is on the main distribution system then it should be included in the model. If the PRV is on a customer connection, then the City should consider moving the pressure logger to a location upstream of the PRV.

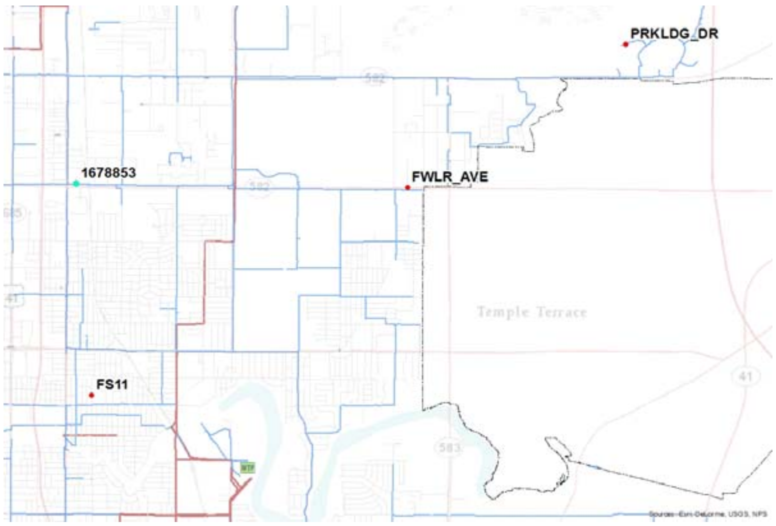


Figure 6 Fowler Ave Logger Locations

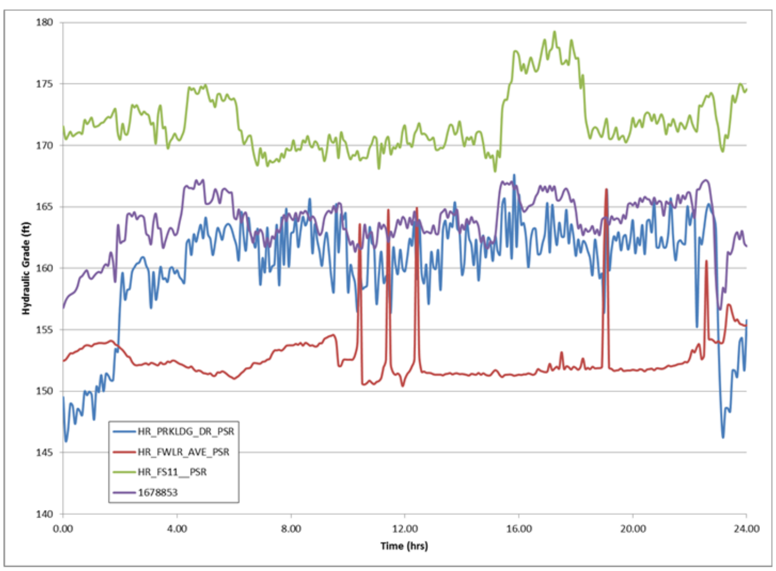


Figure 7 HGL of Loggers near the Fowler Ave Logger

NOTE: Subsequent field investigation confirmed that the permanent SCADA logger on Fowler Ave is not downstream of a PRV, but was malfunctioning due to a damaged communication analog and circuit board. Therefore the logger was removed from the calibration efforts.

- **CSWY Logger**: The SCADA pattern for the CSWY logger is inconsistent in comparison to the other loggers in East Tampa with the large dip in pressures in the early morning. The data shows a significant decrease in pressure from around 2 AM to 4 AM which none of the surrounding loggers show. This pressure drop occurs at the same time when the Northwest tank (see NW-EFF below) is filling. The CSWY logger is too far away from the Northwest RPS for the RPS to have much effect on the pressures and thus it appears there may be a SCADA reporting error for the CSWY logger. It is recommended that the CSWY logger be removed from calibration. **Figure 8** below shows the pressure pattern for the East Tampa loggers and the effluent of the Northwest RPS to illustrate the phenomenon described.

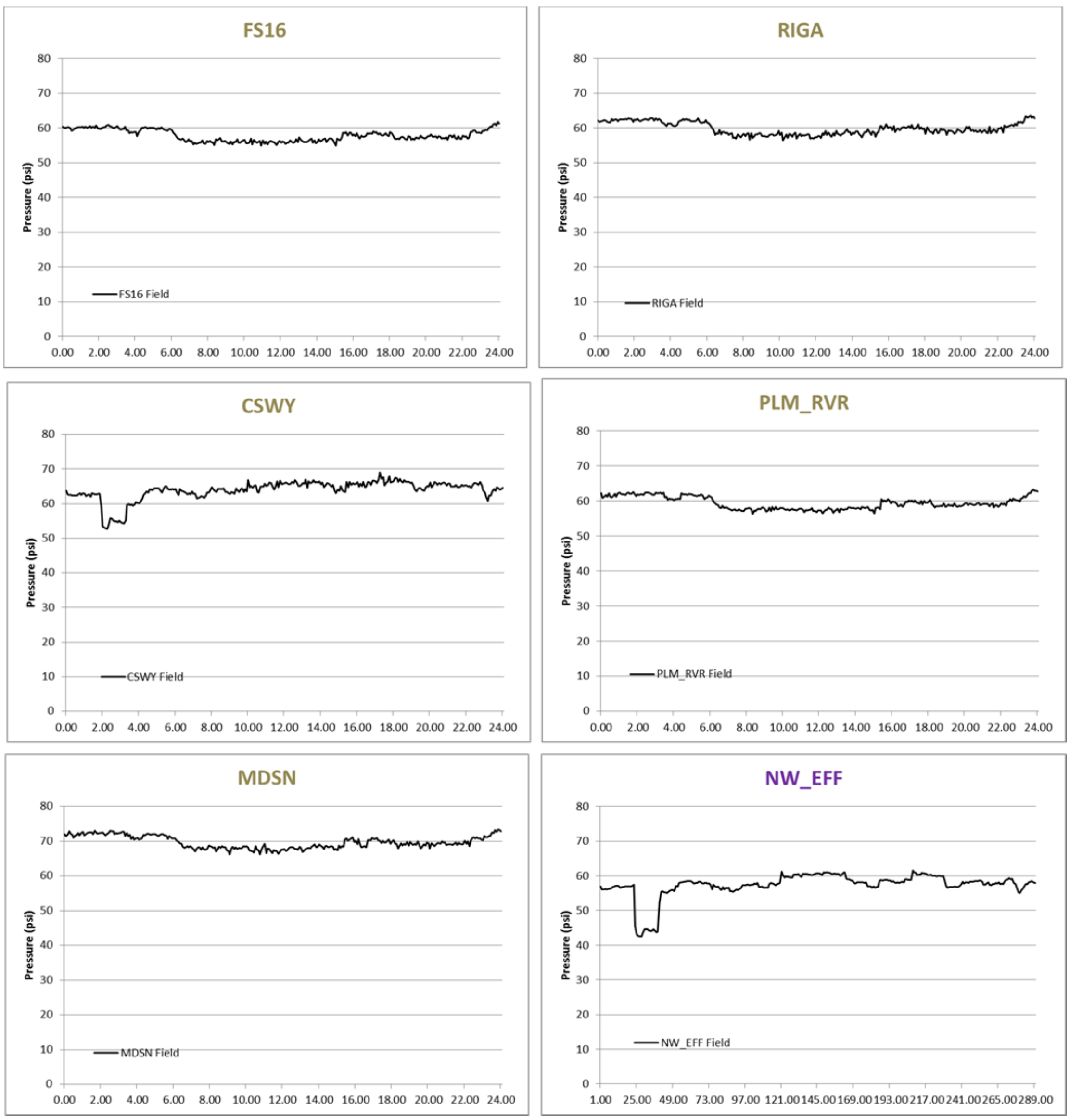


Figure 8 HGL of Loggers near the Fowler Ave Logger

- **South Tampa / MacDill AFB:** MacDill Air Force Base (AFB) is a large user within the City of Tampa. The AFB receives water from the distribution through a few connections in the South Tampa area to fill onsite storage tanks. From the pressure logger data it appears that the AFB fills its tanks during the early morning hours between Midnight and 6 A.M. **Figure 9** illustrates the diurnal pattern created to fill the tanks and best match the South Tampa pressure loggers.

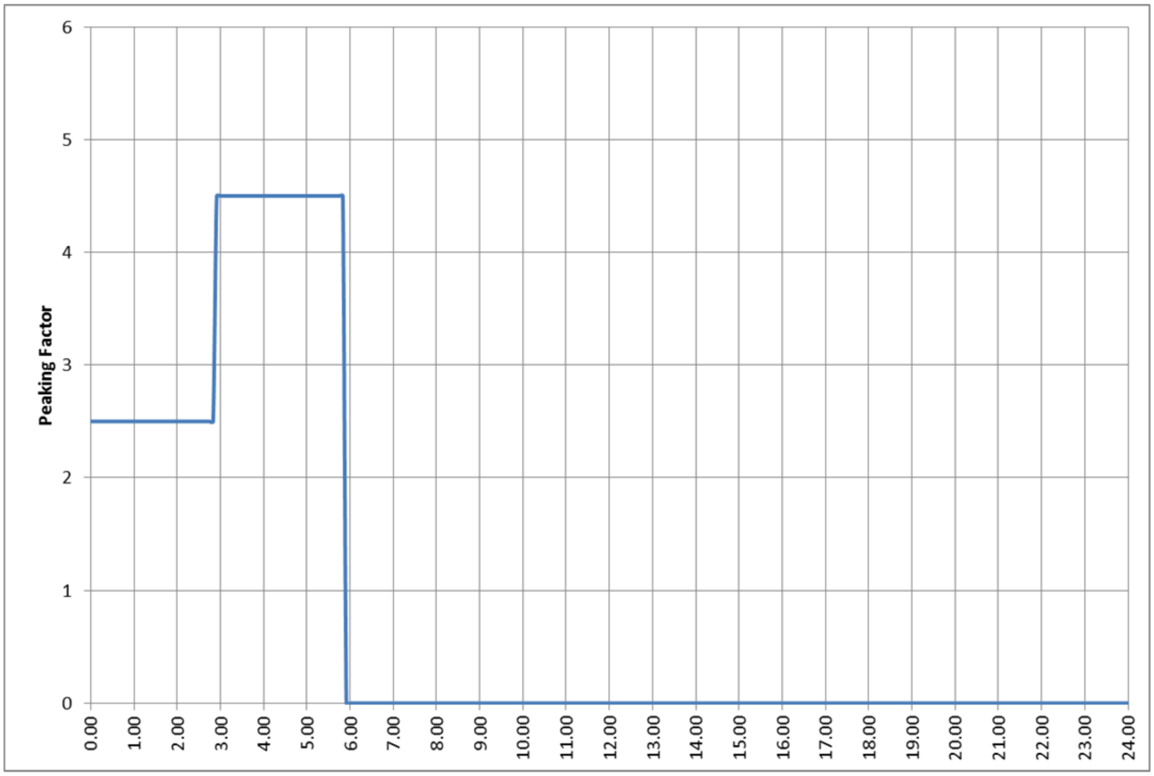


Figure 9 MacDill Calibration Diurnal Demand Pattern

- **New Tampa Loggers**: The pressure loggers (hydrant and permanent) in the New Tampa area show a slow pressure increase throughout the morning hours during the calibration day. However, the model results when using the systemwide diurnal pattern show a nearly instantaneous pressure increase after the valve to the Morris Bridge tanks is closed, shown in **Figure 10**. For the purposes of this report, New Tampa is considered the portion of the distribution system east of Interstate 75 around Bruce B. Downs Blvd.

  The discrepancy in pressure patterns was investigated under several theories which included:

  - A time varying restriction: a valve that was closed between Morris Bridge RPS and New Tampa to restrict flow and allow the other remote tanks to fill in conjunction with a closed valve on the 24-inch Interstate crossing north of Morris Bridge RPS.
  - Closed valves: a series of closed valves on the 16-inch and 36-inch from Morris Bridge to New Tampa and on the 24-inch Interstate crossing.
  - High irrigation demands in New Tampa.

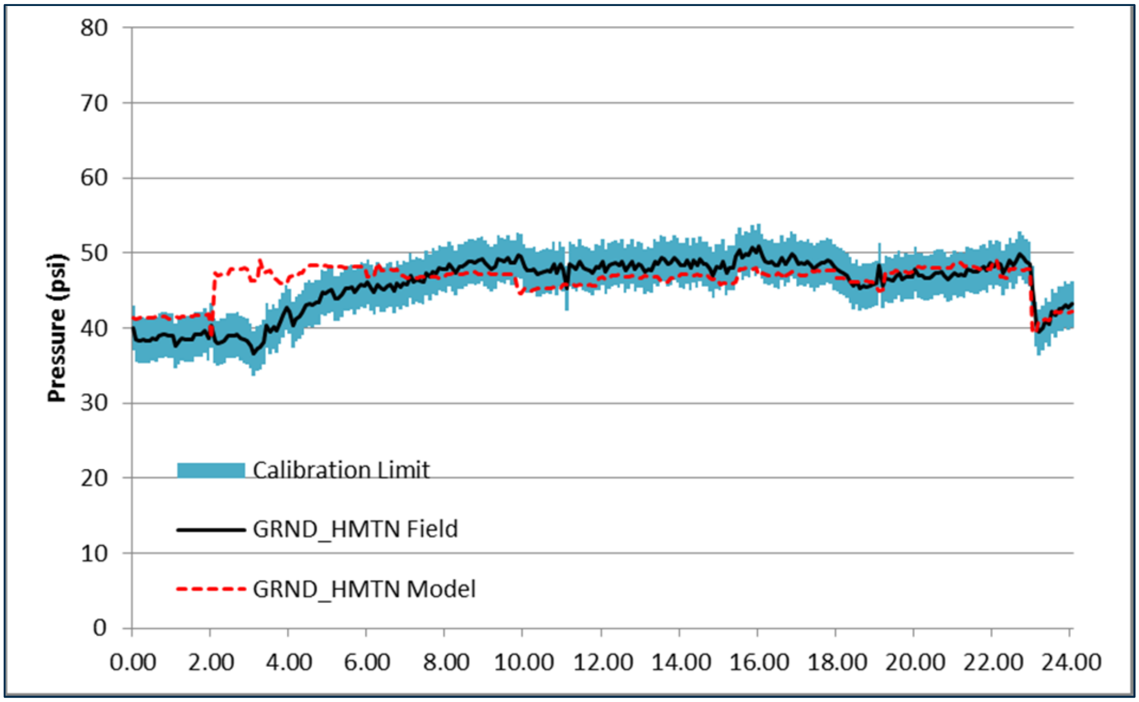


Figure 10 Pressure Pattern Discrepancy using Universal Diurnal Pattern Only

Time Varying Restriction

Modeling a time varying restriction such as a throttled control valve on the 36-inch main downstream of the Morris Bridge RPS in conjunction with a closed valve on the 24-inch main crossing the Interstate north of Morris Bridge RPS provided results closely matching the field data. However, interviews with operations staff and review of the valves on the 36-inch main eliminated this theory. There are no actuated valves on the main to automatically or remotely throttle a valve and the operators are not manually opening or closing any valves.

Closed Valves

A number of different valve closure scenarios were investigated and model results seemed to indicate a potential closure along the 24-inch main that crosses Interstate-75 north of Bruce B. Downs. However, field crews physically verified and performed field shutdown tests and confirmed that the valves along the main were open. Therefore, additional valve closures were eliminated as the cause of the slow pressure increase.

High Irrigation Demand Scenario

During the investigation of high irrigation demands in New Tampa the pressure data collected during the calibration data collection period was analyzed according to the day of the week which included two weeks of data. The patterns for each day of the week were consistent between the two weeks, but varied from day to day. The data shows a slow pressure increase pattern for every day except Sunday shown in **Figure 11**. The Sunday pressure pattern more closely resembles the model results using the universal diurnal pattern shown in **Figure 10**. The pressure graphs per week day are included in Attachment 1.

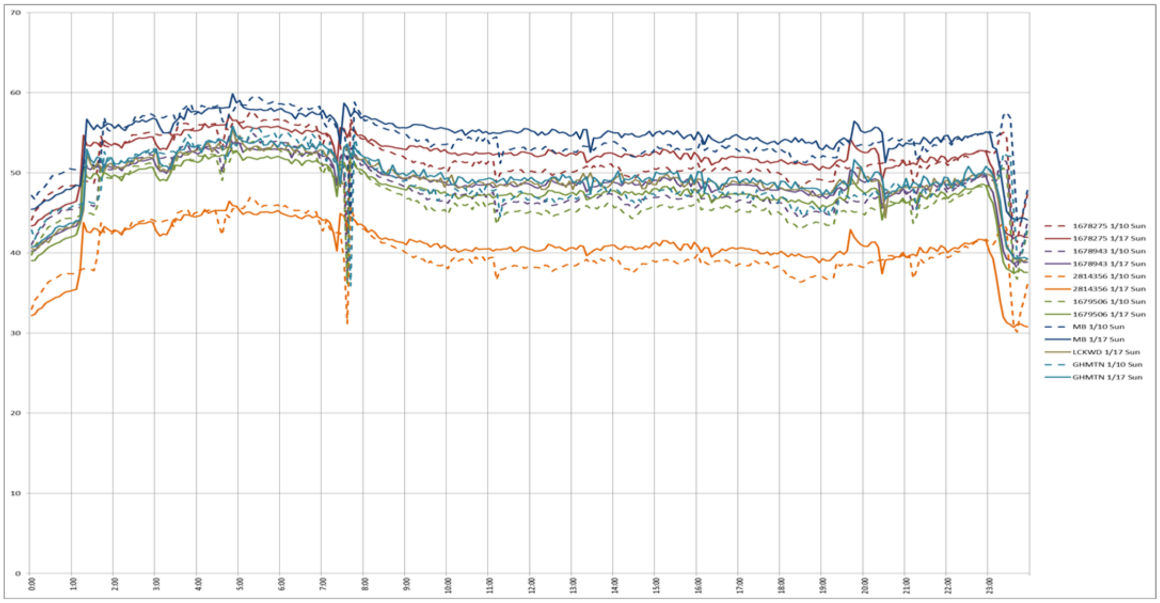


Figure 11 HGL of Loggers near the Fowler Ave Logger

For conservation purposes the City of Tampa restricts irrigation with potable water to between the hours of Midnight and 8 A.M. or between 6 P.M. and midnight on two designated days per week based on address location as summarized in **Table 6**. Note that the restrictions do not allow irrigation on Sundays.

Table 6 Watering Schedule.

LOCATION	M	TU	W	TH	F	SA	SU
Address ending in 0, 1, 2, or 3	X			X			
Address ending in 4, 5 or 6		X			X		
Address ending in 7, 8 or 9			X			X	
Common Areas (no address)			X			X	
1. Watering is only allowed midnight – 8AM & 6PM – midnight.							

This information supports the theory that the slow pressure increase is due to increased irrigation within New Tampa. However, without flow metering into New Tampa it is difficult to accurately create a separate diurnal pattern specific to the area based on the mass balance approach discussed in previous sections. Instead a trial and error approach was used using the pressure pattern and watering restrictions to create an irrigation pattern for New Tampa.

Figure 10 above shows that the model results and field data more closely match after approximately 8 A.M., which is when irrigation must stop, and the model pressures are higher than the field data between midnight and 8 A.M. with the largest discrepancy at 2 A.M. and tapering off to 8 A.M. indicating that more flow resulting in increased headloss is required during those hours. The irrigation pattern shown in **Figure 12** below was created to mirror the difference between the model results and field pressure during irrigation hours. It was refined based on the comparison of the model results and field data.

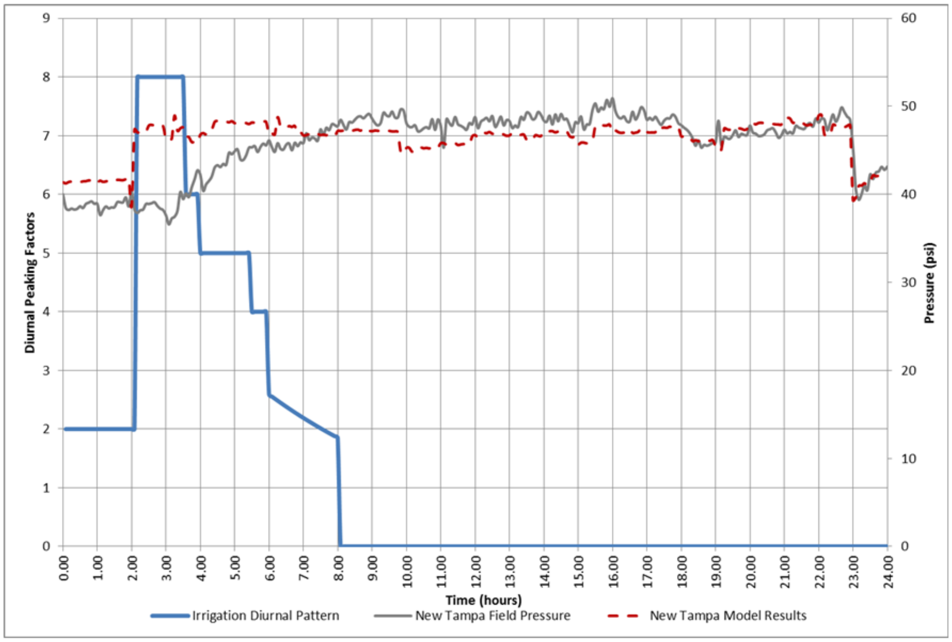


Figure 12 New Tampa Irrigation Pattern

The iterative process included setting an irrigation demand of 1 gpm demand to each of the 823 junctions in New Tampa. The irrigation diurnal pattern in **Figure 12** was then applied to the irrigation demand. Concurrently, the systemwide diurnal pattern was applied to the billing meter consumption. The average and peak irrigation flow rates are approximately 3,400 gpm and 6,700 gpm, respectively. Afterwards, the irrigation demands and other demands were combined and used to create the separate New Tampa diurnal pattern as illustrated in **Figure 13**.

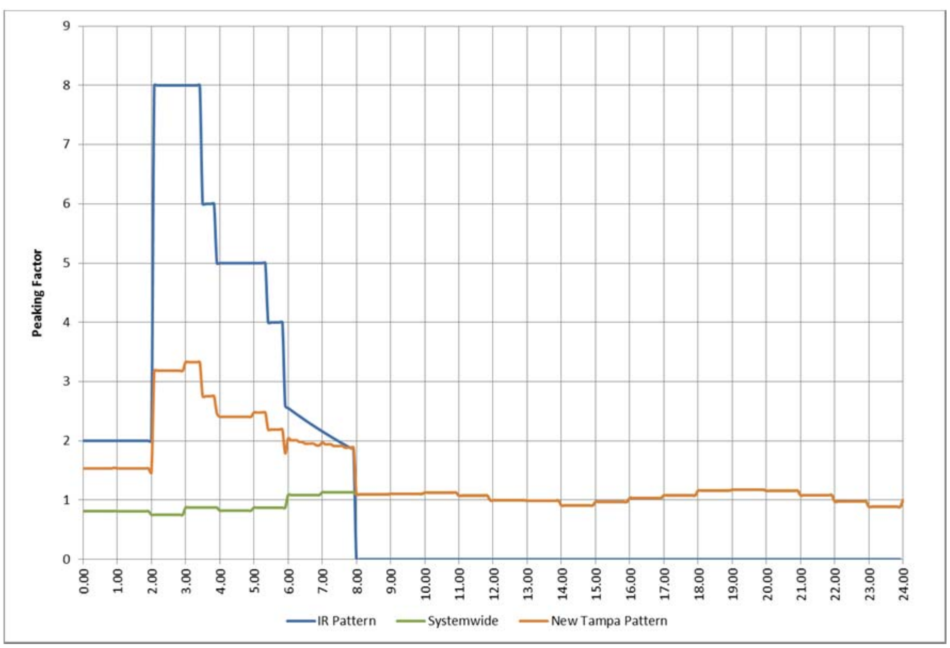


Figure 13 New Tampa Calibration Diurnal Demand Pattern

The systemwide diurnal pattern was then updated using the following mass balance formula and is illustrated in **Figure 14** below. The combination of the New Tampa pattern and revised systemwide diurnal pattern resulted in the model results and field data the more closely matched within New Tampa with 91% of the pressure data points within the calibration goal. **Figure 15** is an example of a final pressure calibration graph for New Tampa.

Demand = Volume Produced ± Change in Volume – Wholesale – ASR ***– AFB Demand - New Tampa Demand***

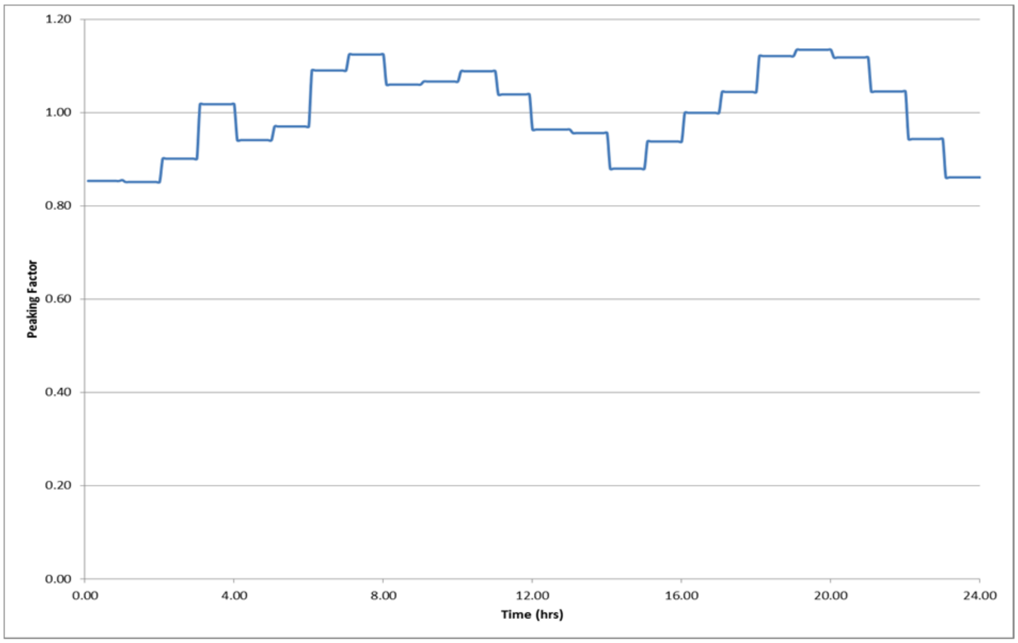


Figure 14 Revised Systemwide Hourly Diurnal Demand Pattern

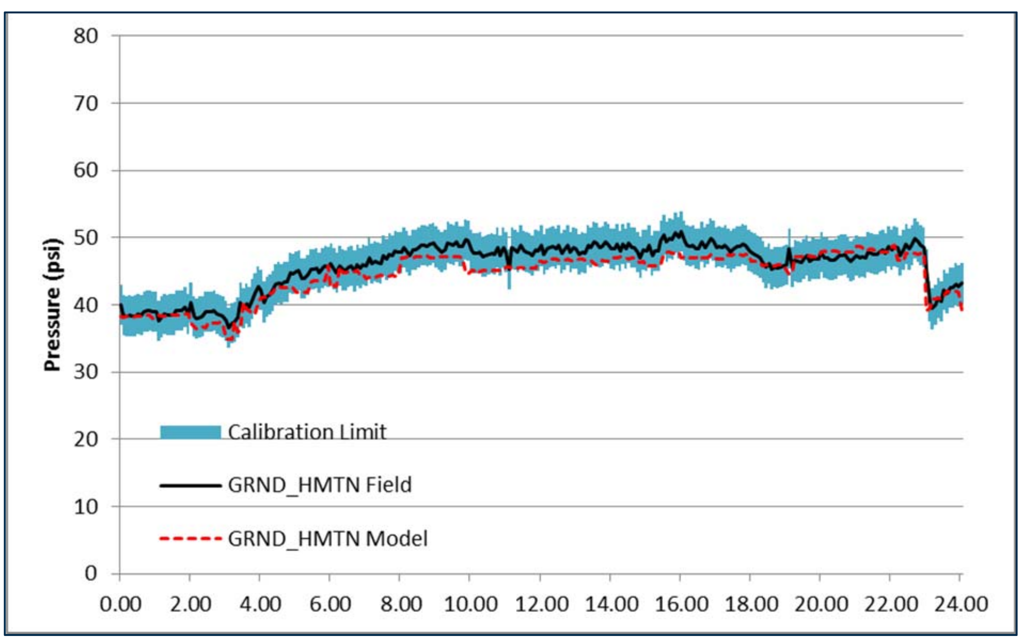


Figure 15 New Tampa Irrigation Pattern

- **South Tampa Loggers**: The pressure loggers (hydrant and permanent) in the New Tampa area show a slow pressure increase throughout the morning hours during the calibration day. However, the model results when using the systemwide diurnal pattern show a nearly instantaneous pressure increase after the valve to the Morris Bridge tanks is closed, shown in **Figure 10**. For the purposes of this report, New Tampa is considered the portion of the distribution system east of Interstate 75 around Bruce B. Downs Blvd.

4.1.3 Pump Flows / Curves:

Once the HGL was calibrated, the pump curves were modeled with time-based controls. The manufacturer curves were a fit for most of the pump stations.

- **DLTWRF**: Since a number of the tags for the high service pump station (HSPS) were missing, it was difficult to simulate the correct combination of pumps. Therefore a reservoir with variable head was modeled in place of the pumps for calibration. The reservoir head pattern was set to match the HSPS discharge pressure and the total flows from the WTF were monitors to verify the validity of the reservoir. The average percent error between the SCADA data and model results was very good at 3%. This caused the modeled pressure at one of the SCADA loggers (HSP) to exactly match the field data. NOTE: The pumps and curves will be used during the system analysis.

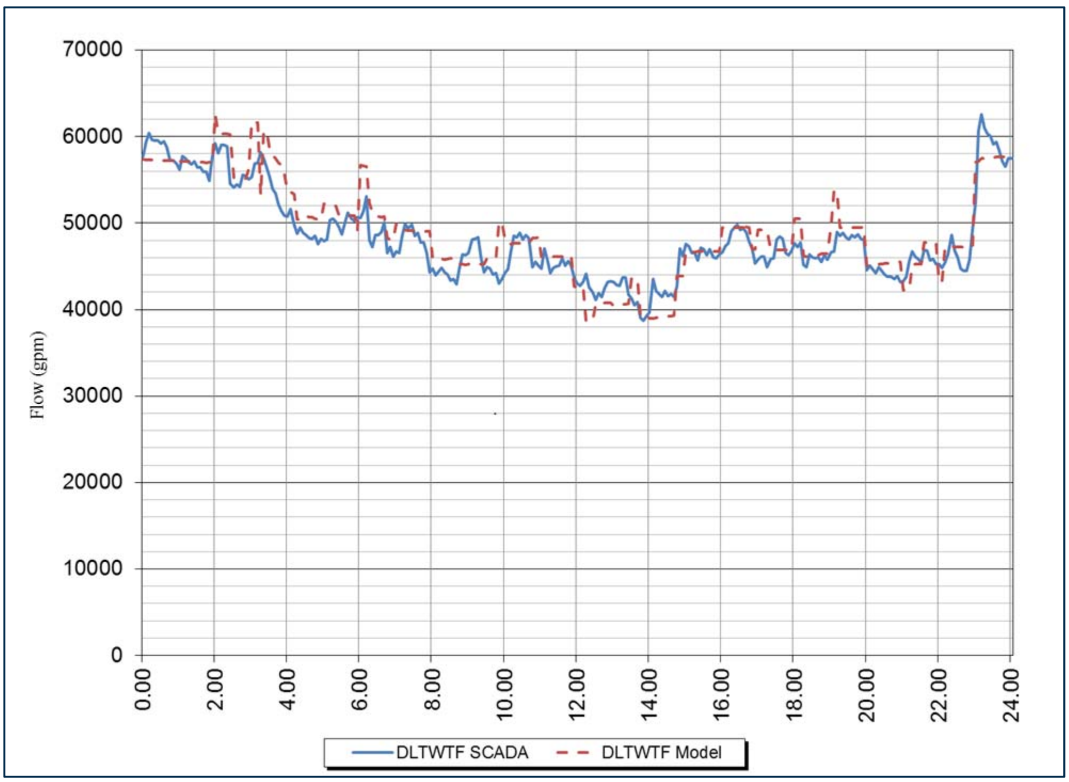


Figure 16 DLTWTF/ HSPS Discharge Flow Comparison

- **Interbay RPS**: Due to the limited information available on pump status and speed at the Interbay RPS the exact configuration of the pump station was not known during calibration. The pumps were controlled to best match discharge flow and tank levels, but discharge pressure did not match as closely.

4.2 RESULTS AND CONCLUSIONS

The results of calibration show a very high correlation between the field SCADA data and the tank levels and pumped flows. One hundred percent of the 2880 data points covering all of the facility locations were within the calibration goals. Likewise, the calibration results of the pressure points also had a good correlation with closely matching daily patterns and 92% of the 10,115 data points within the calibration goal.

4.2.1 Pump Stations

As was mentioned above, there was a high correlation between the field data and model results for the pumped flows. One hundred percent of the modeled pumped flows were within the calibration goal. The largest degree of uncertainty is around the Interbay RPS due to the lack of SCADA data regarding the pump status and speed; thus status and speed assumptions were made to best match the flow data. This is believed to account for the lower pressure correlation in the South Tampa pressure points. The time-series flow plots for each pump station are included in Attachment 2.

4.2.2 Tank Levels

As was mentioned above, there was a high correlation between the field data and model results for the tank levels. One hundred percent of the modeled tank levels were within the calibration goal with the largest difference between the field data and model results being 1.2 ft. The elevation of the base of the tank bowl for both the West Tampa and Palma Ceia elevated tanks were adjusted to better match the field data. West Tampa went from 120 ft. to 110 ft. and Palma Ceia went from 120 ft. to 118 ft. It is recommended that the elevation of each tank be surveyed in the future to confirm the elevations. The time-series level plots for each tank are included in Attachment 2.

4.2.3 Pressure Points

There was a total of 10,115 data points analyzed during calibration covering 35 permanent and temporary pressure loggers; two were removed from calibration (FWLR_AVE & CSWY). Ninety percent of those data points met or exceeded the calibration goal resulting in a well calibrated pressure model. **Table 7** below summarizes the results of the pressure point calibration based on seven different areas of the city. **Figure 17** and **Figure 18** illustrate the results per logger systemwide. The results show a very high correlation around Downtown, East Tampa, North Tampa, New Tampa and Central Tampa and an acceptable but lesser correlation around South Tampa. The time-series level plots for each pressure point are included in Attachment 2.

Table 7 Pressure Logger Results Summary.

#	AREA	LOGGERS INCLUDED	% MET GOAL		
			AVE.	BEST LOGGER	WORST LOGGER
1	Downtown	CTY_HL; FRMT_AVE; FS17; FS6	97%	100%	88%
2	East Tampa	FS16; MSDN; PLM_RVR; RIGA	97%	100%	87%
3	North Tampa	1678853; NRTH_BLVD; PRLKDG_DR; WRCHM_DR	90%	100%	82%
4	New Tampa	1678275; 1678943; 1679506; 1679899; 2814356; GRND_HMTN; LCKWD_RDG_NEW; MB_HS501_PSI	91%	99%	83%
5	South Tampa	1683325; FS14; FS19; IB; PC	89%	96%	81%
6	Central Tampa	1674112; FS10; FS11; BRK_ST	96%	100%	92%
7	West Tampa	1673515; DREW; NW_EFF; W-WTRS; WB_RD; WT	86%	98%	76%

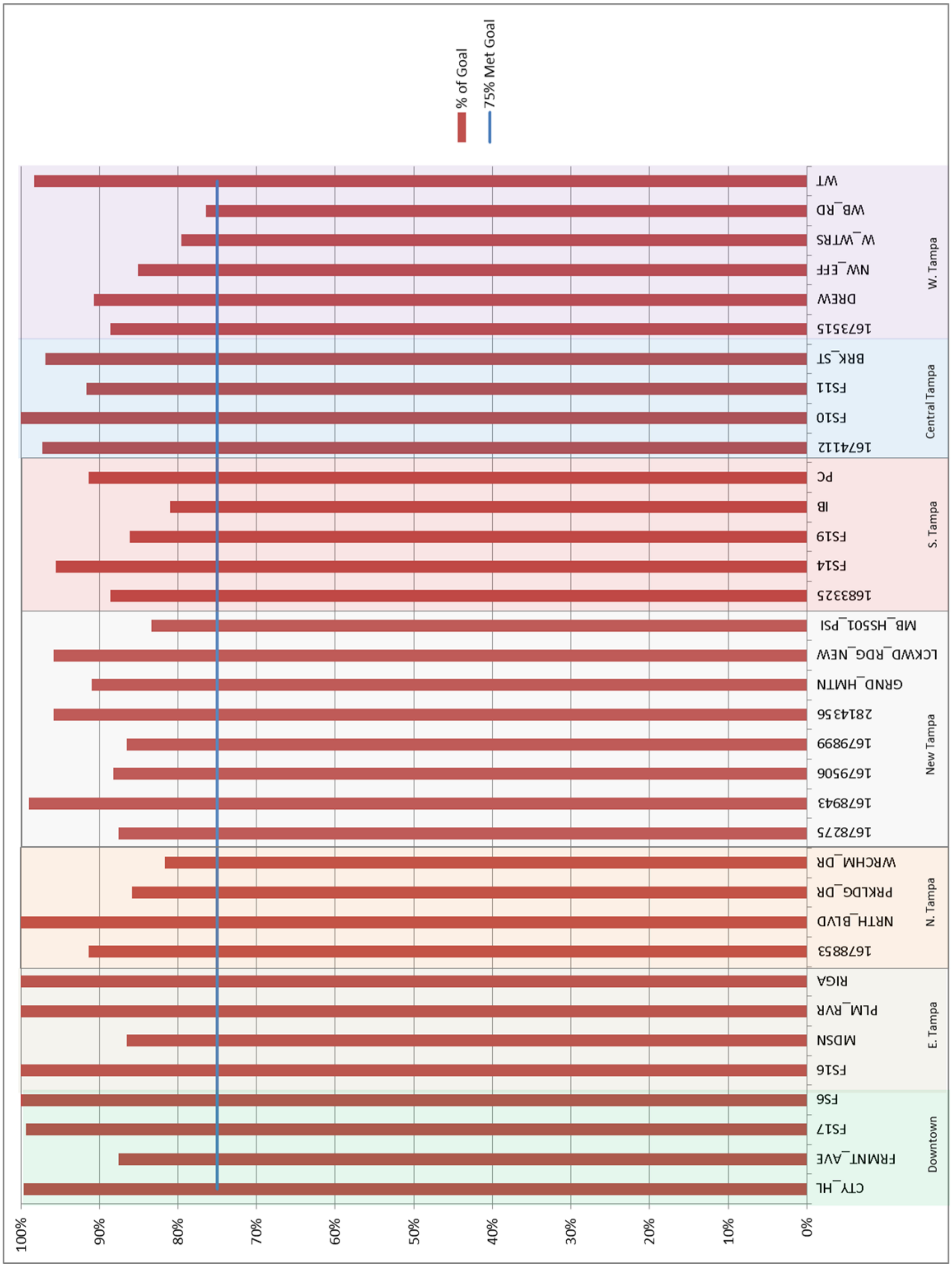
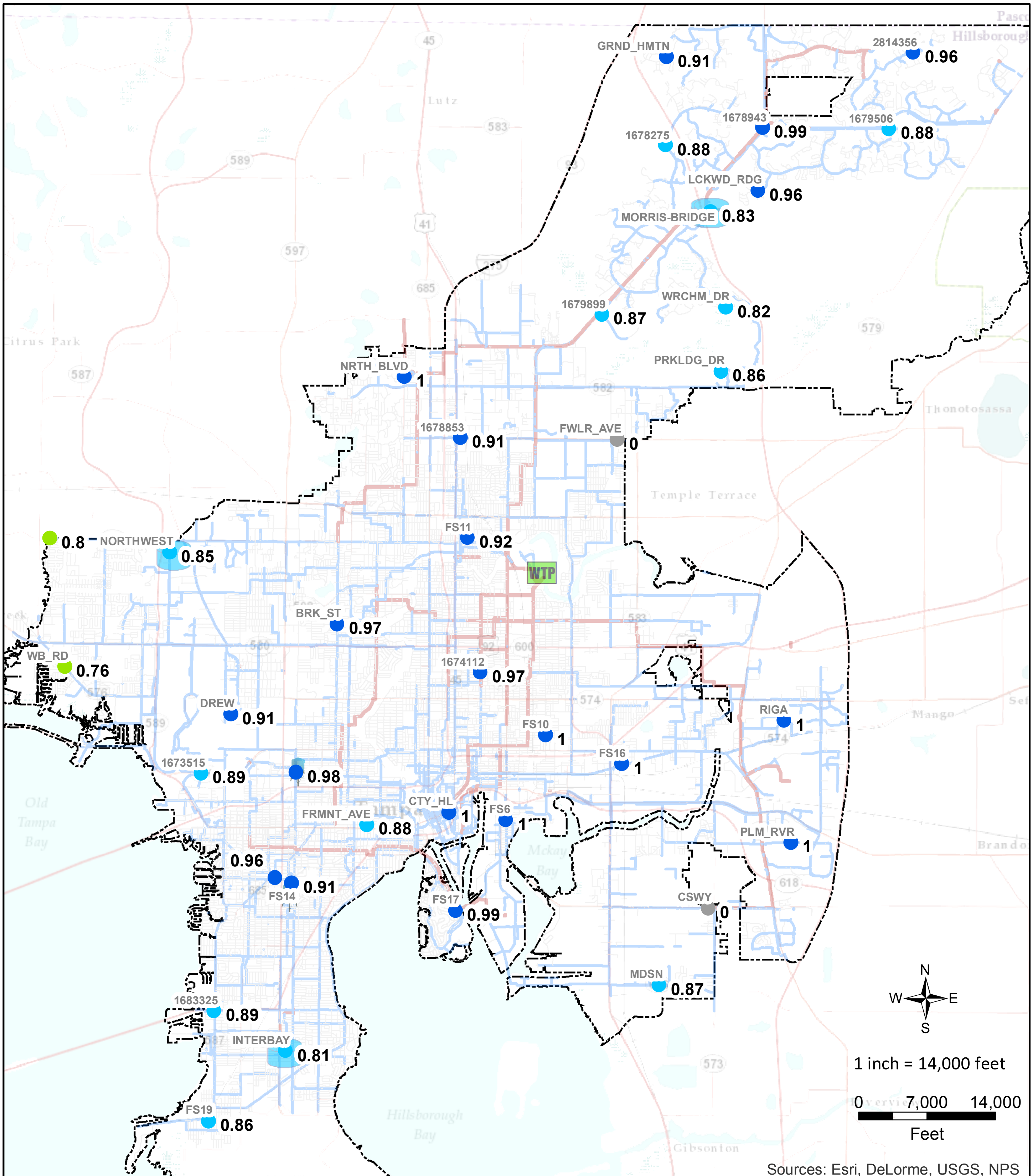


Figure 17 Pressure Logger % of Goal Results



% of Points that Met Goal

- Removed from Calibration
- Less the 50%
- 50% to 75%
- 75% to 80%
- 80% to 90%
- 90% to 100%

Diameter

- Less than 12-inch
- 12 - 24-inch
- Greater than 24-inch
- Service Area

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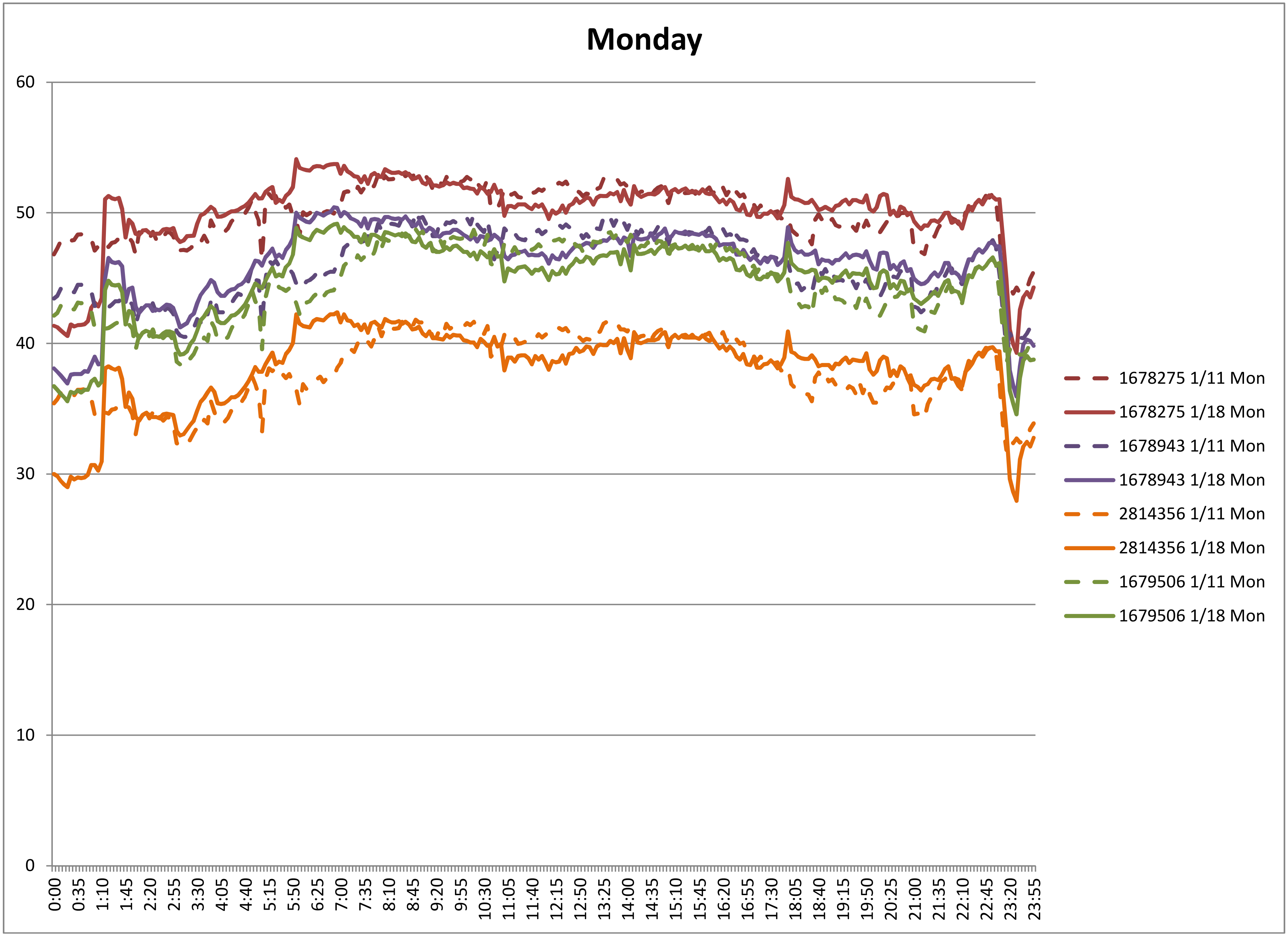
CITY OF TAMPA

Potable Water Master Plan

Figure 18

Calibration Results Summary

Attachment 1 – New Tampa Field Data



Monday
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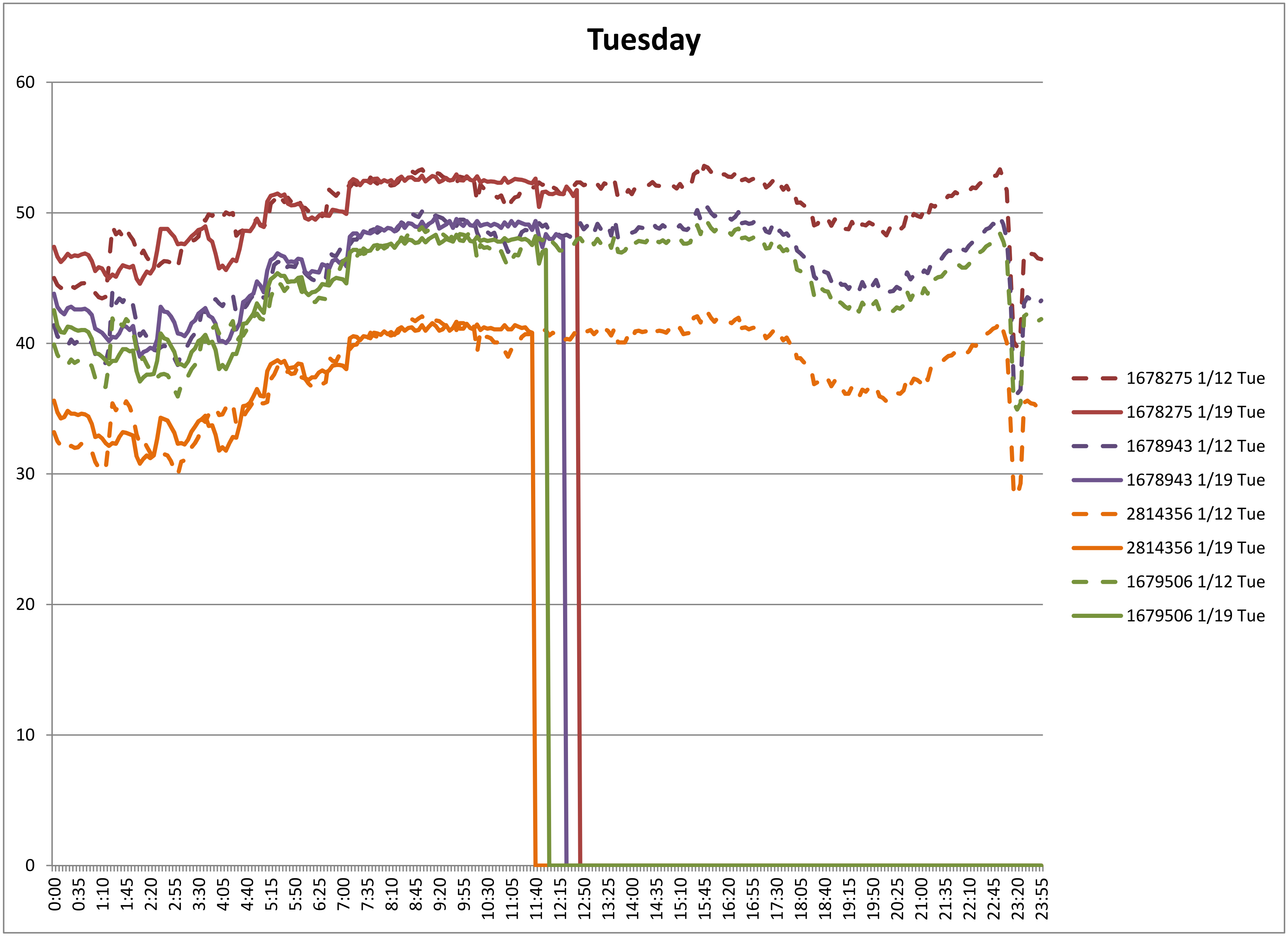
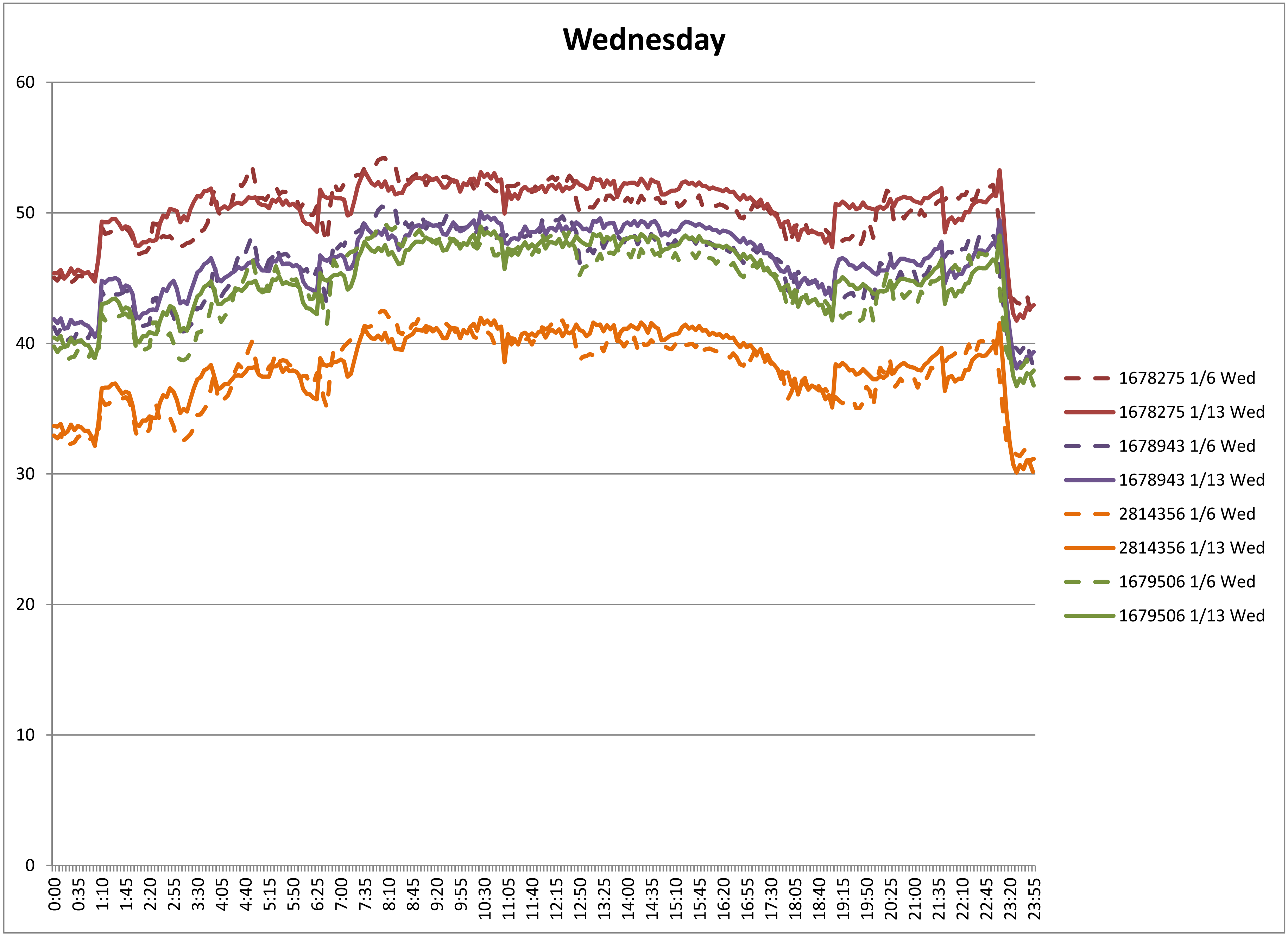
2814356 1/11 Mon
2814356 1/18 Mon
1679506 1/11 Mon
1679506 1/18 Mon



Tuesday
60
50
40
30
20
10
0
0:00
0:35
1:10
1:45
2:20
2:55
3:30
4:05
4:40
5:15
5:50
6:25
7:00
7:35
8:10
8:45
9:20
9:55
10:30
11:05
11:40
12:15
12:50
13:25
14:00
14:35
15:10
15:45
16:20
16:55
17:30
18:05
18:40
19:15
19:50
20:25
21:00
21:35
22:10
22:45
23:20
23:55
1678275 1/12 Tue
1678275 1/19 Tue
1678943 1/12 Tue
1678943 1/19 Tue
2814356 1/12 Tue
2814356 1/19 Tue
1679506 1/12 Tue
1679506 1/19 Tue



Wednesday
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50
40
30
20
10
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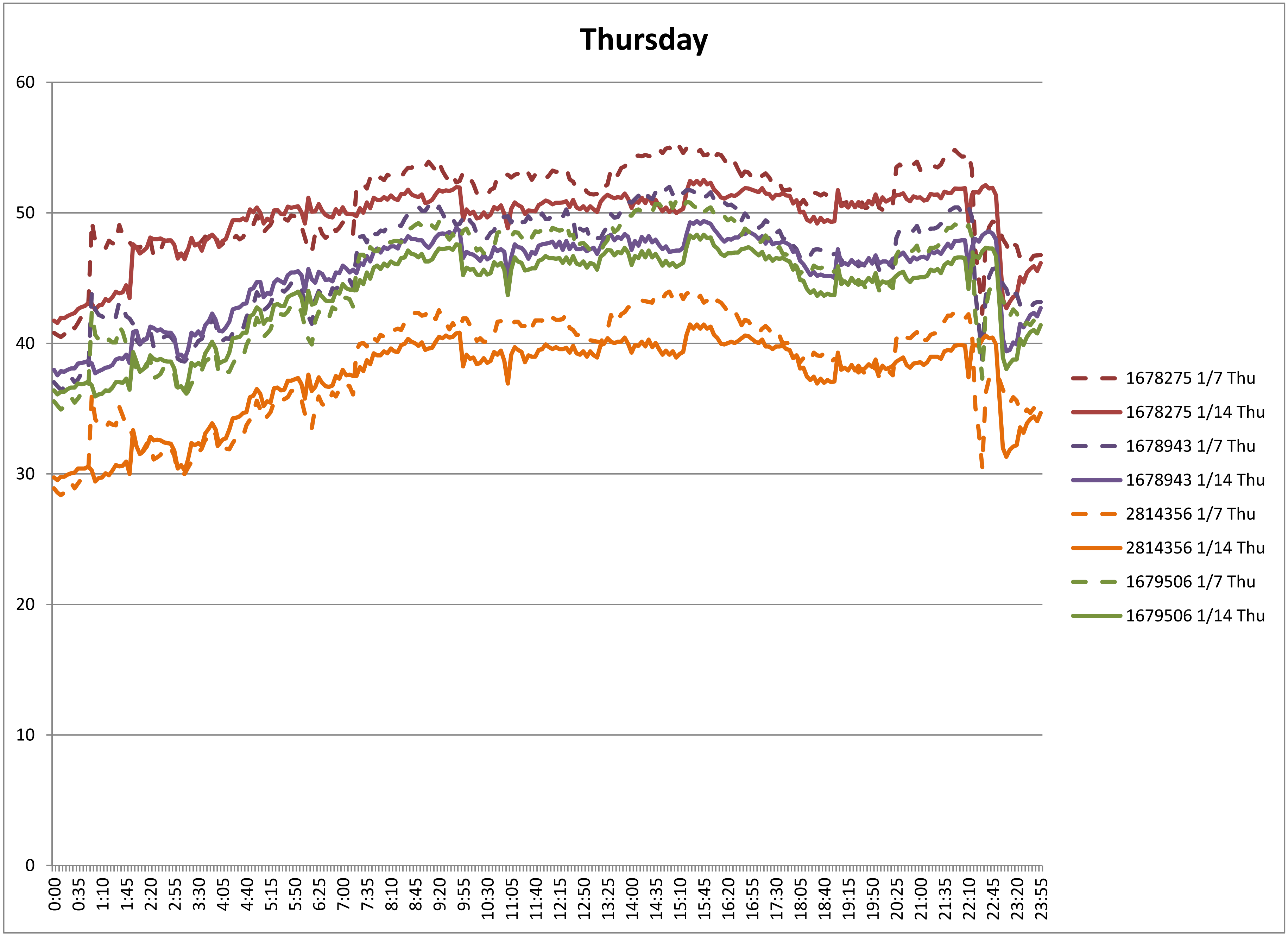
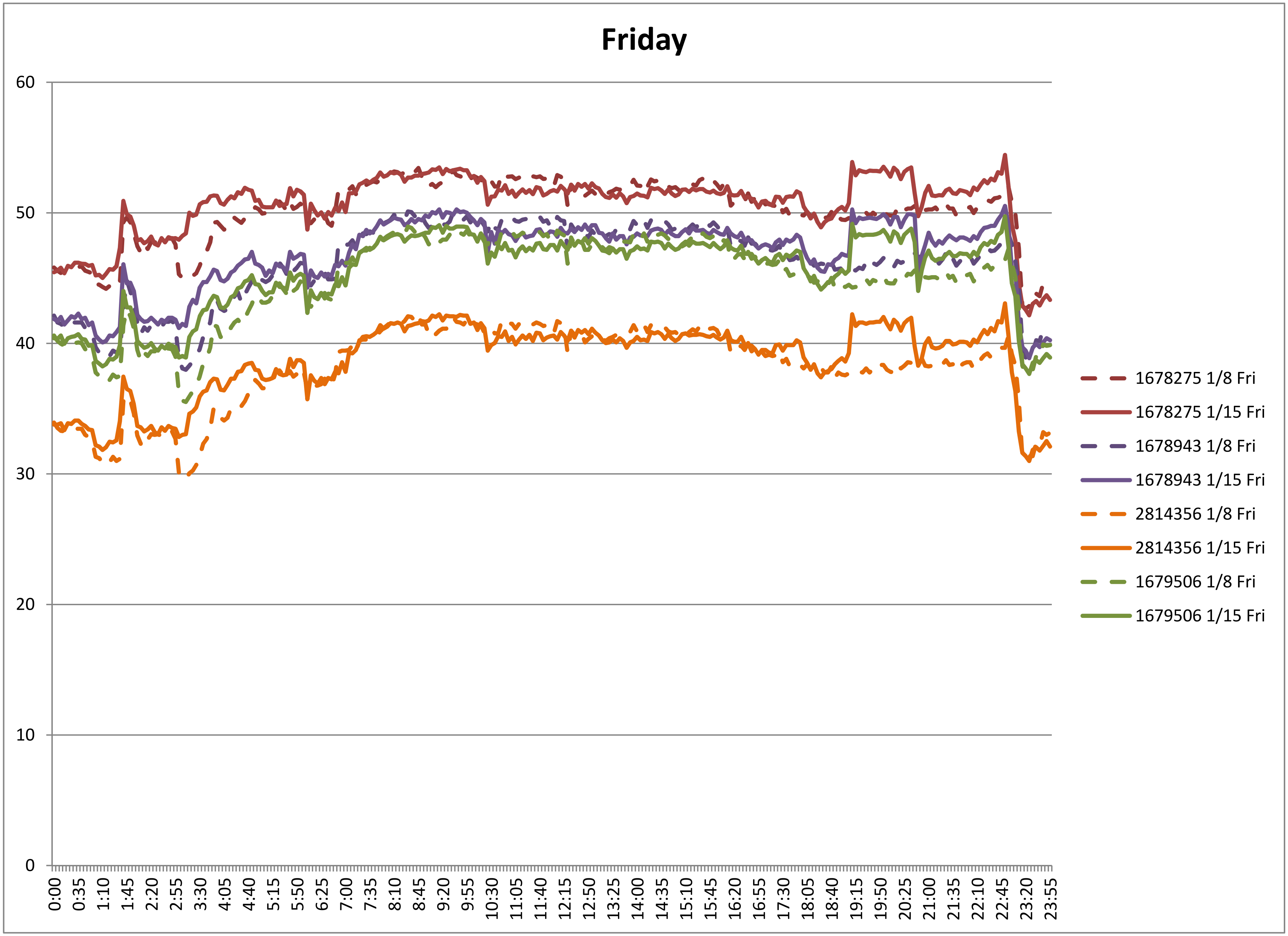
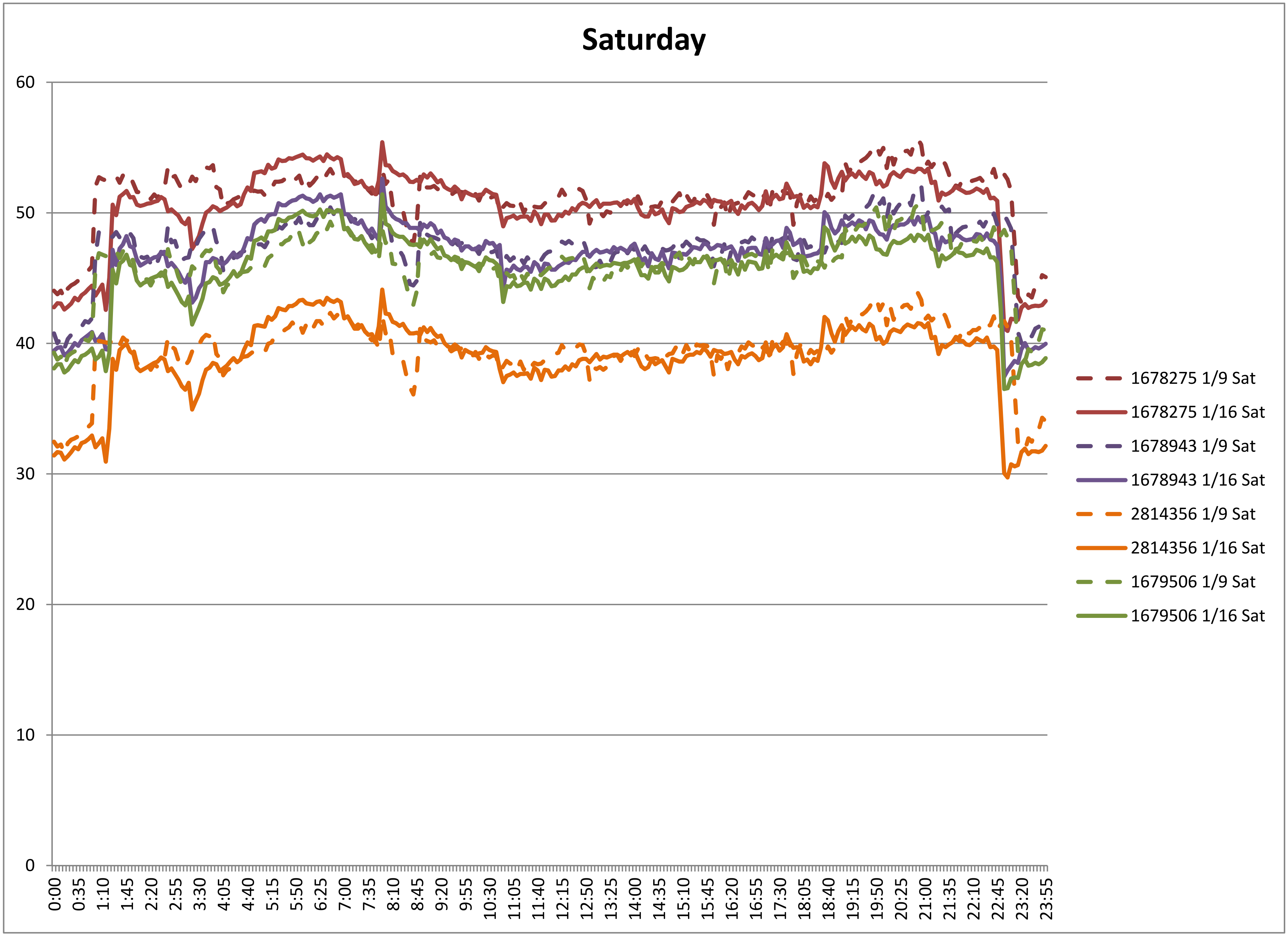
0:00
0:35
1:10
1:45
2:20
2:55
3:30
4:05
4:40
5:15
5:50
6:25
7:00
7:35
8:10
8:45
9:20
9:55
10:30
11:05
11:40
12:15
12:50
13:25
14:00
14:35
15:10
15:45
16:20
16:55
17:30
18:05
18:40
19:15
19:50
20:25
21:00
21:35
22:10
22:45
23:20
23:55
1678275 1/6 Wed
1678275 1/13 Wed
1678943 1/6 Wed
1678943 1/13 Wed
2814356 1/6 Wed
2814356 1/13 Wed
1679506 1/6 Wed
1679506 1/13 Wed

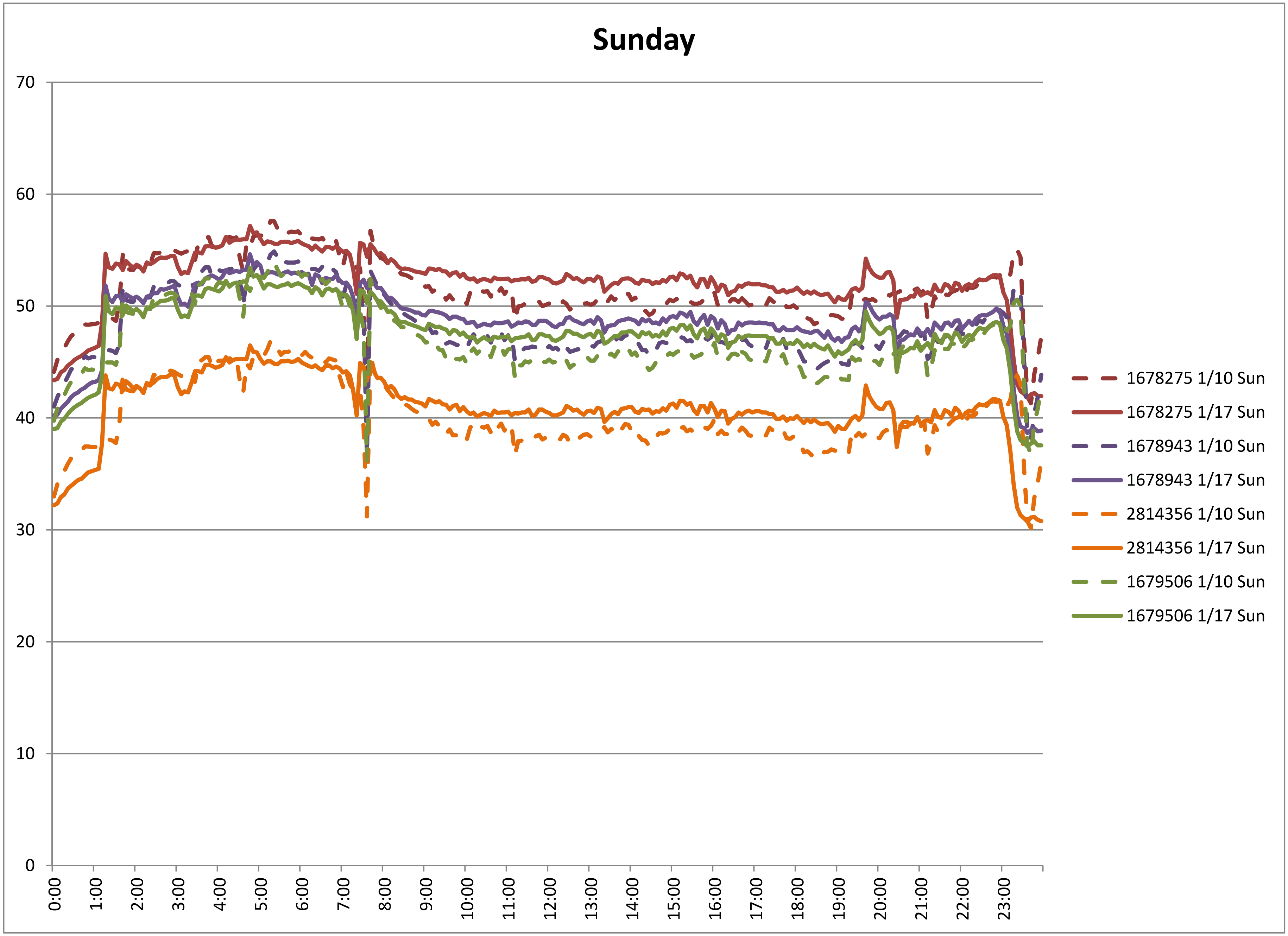


Thursday
60
50
40
30
20
10
0
0:00
0:35
1:10
1:45
2:20
2:55
3:30
4:05
4:40
5:15
5:50
6:25
7:00
7:35
8:10
8:45
9:20
9:55
10:30
11:05
11:40
12:15
12:50
13:25
14:00
14:35
15:10
15:45
16:20
16:55
17:30
18:05
18:40
19:15
19:50
20:25
21:00
21:35
22:10
22:45
23:20
23:55
1678275 1/7 Thu
1678275 1/14 Thu
1678943 1/7 Thu
1678943 1/14 Thu
2814356 1/7 Thu
2814356 1/14 Thu
1679506 1/7 Thu
1679506 1/14 Thu

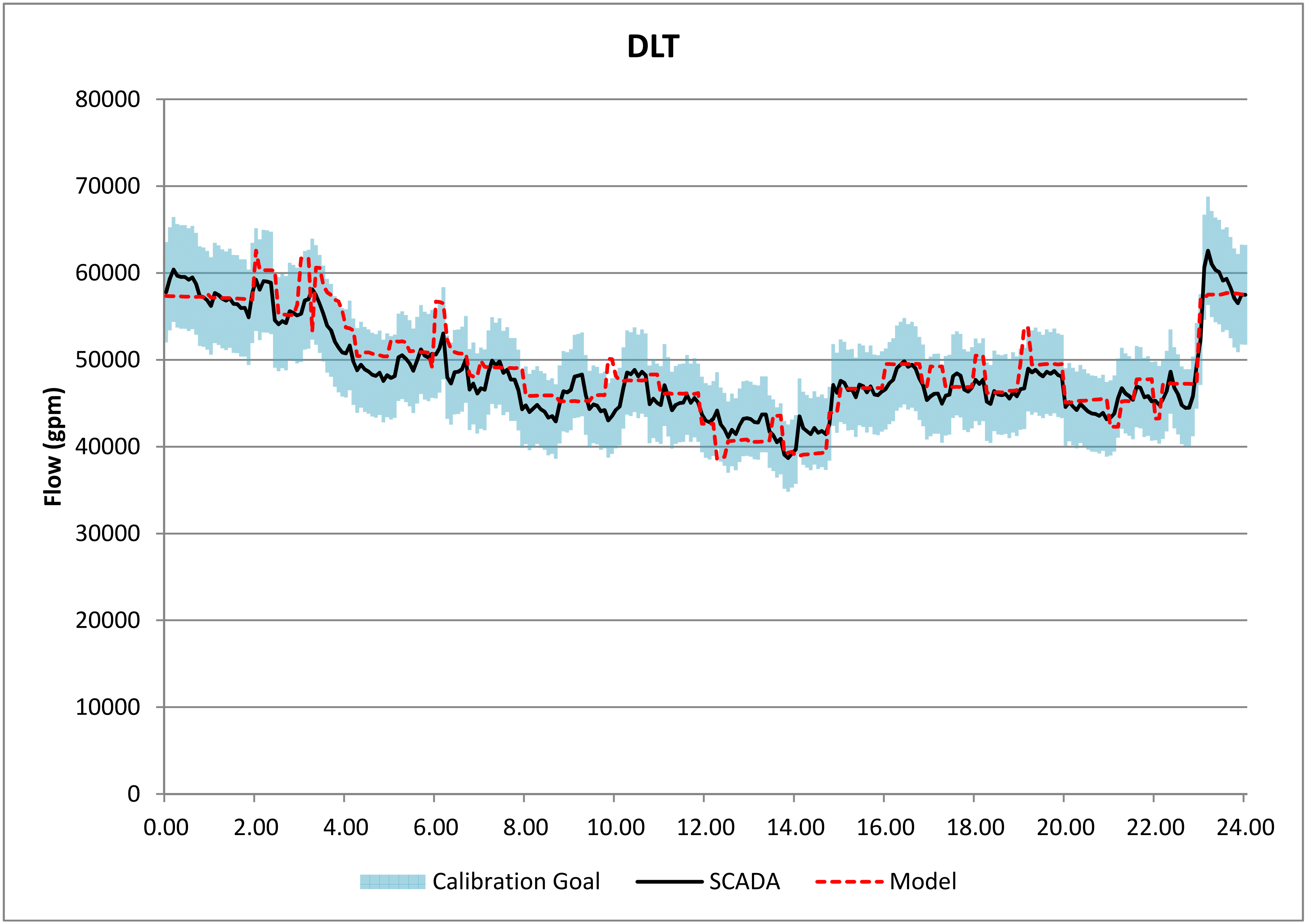


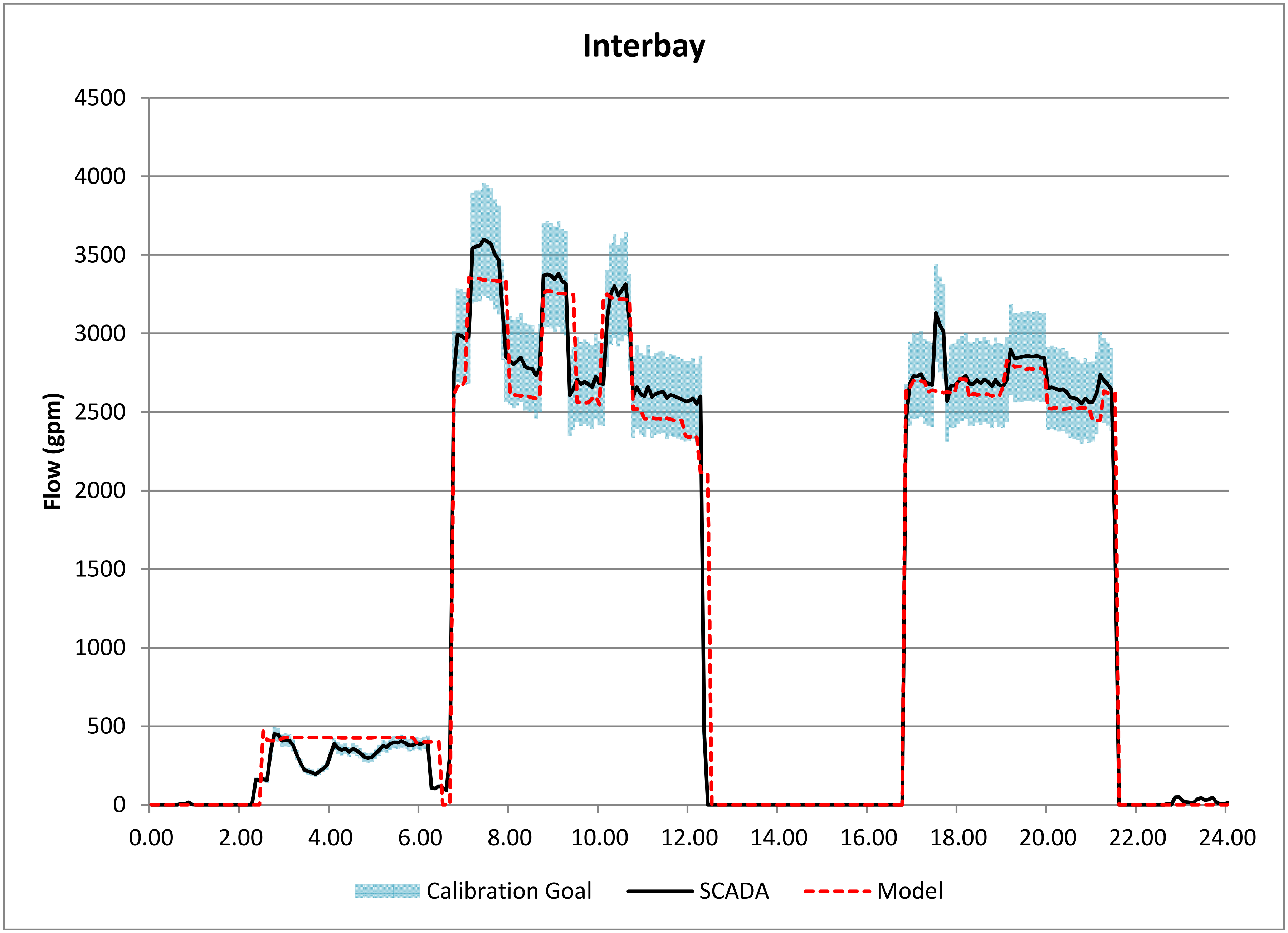
Friday
60
50
40
30
20
10
0
0:00
0:35
1:10
1:45
2:20
2:55
3:30
4:05
4:40
5:15
5:50
6:25
7:00
7:35
8:10
8:45
9:20
9:55
10:30
11:05
11:40
12:15
12:50
13:25
14:00
14:35
15:10
15:45
16:20
16:55
17:30
18:05
18:40
19:15
19:50
20:25
21:00
21:35
22:10
22:45
23:20
23:55
1678275 1/8 Fri
1678275 1/15 Fri
1678943 1/8 Fri
1678943 1/15 Fri
2814356 1/8 Fri
2814356 1/15 Fri
1679506 1/8 Fri
1679506 1/15 Fri


Saturday
60
50
40
30
20
10
0
0:00
0:35
1:10
1:45
2:20
2:55
3:30
4:05
4:40
5:15
5:50
6:25
7:00
7:35
8:10
8:45
9:20
9:55
10:30
11:05
11:40
12:15
12:50
13:25
14:00
14:35
15:10
15:45
16:20
16:55
17:30
18:05
18:40
19:15
19:50
20:25
21:00
21:35
22:10
22:45
23:20
23:55
1678275 1/9 Sat
1678275 1/16 Sat
1678943 1/9 Sat
1678943 1/16 Sat
2814356 1/9 Sat
2814356 1/16 Sat
1679506 1/9 Sat
1679506 1/16 Sat

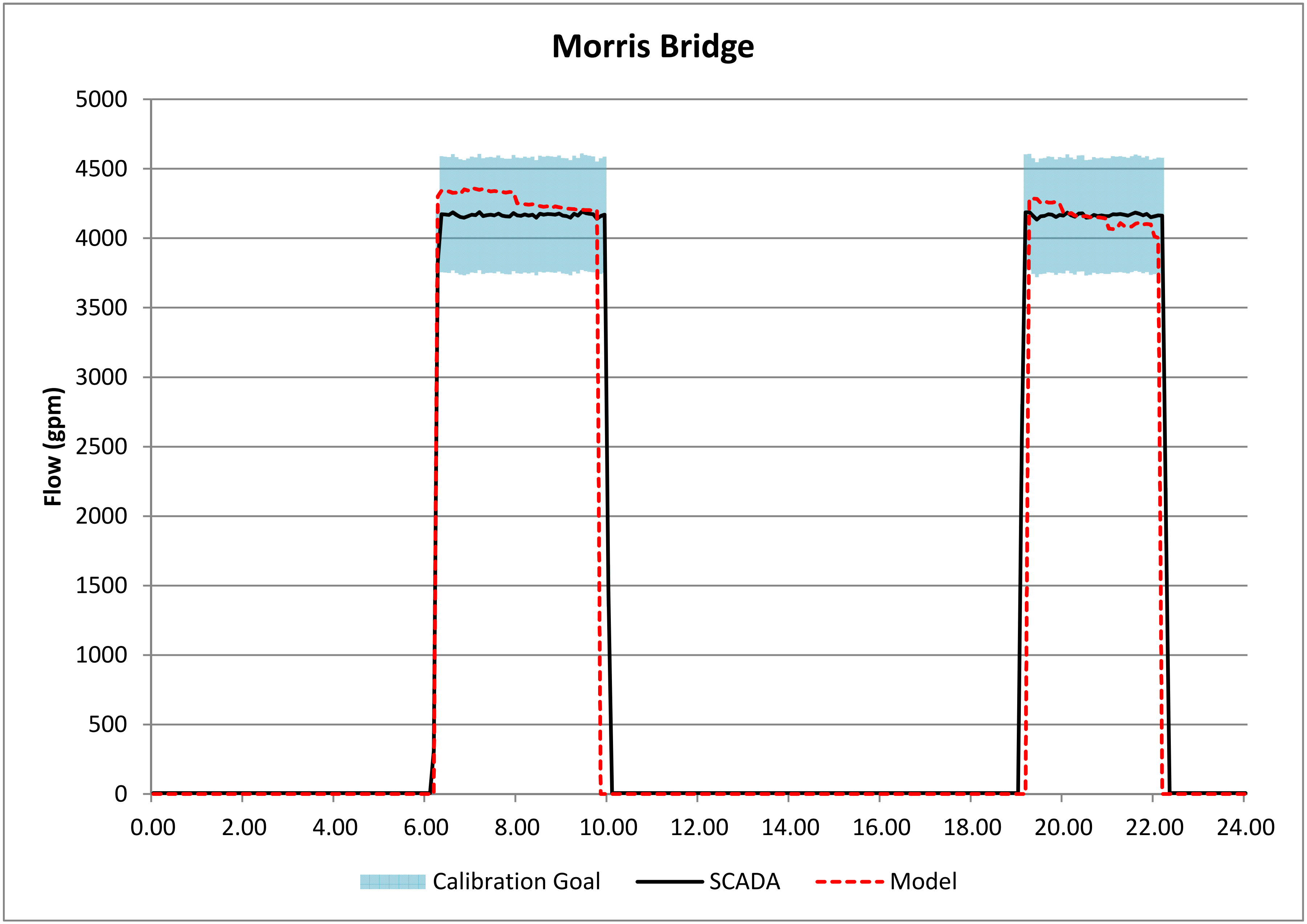

Sunday
70
60
50
40
30
20
10
0
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
1678275 1/10 Sun
1678275 1/17 Sun
1678943 1/10 Sun
1678943 1/17 Sun
2814356 1/10 Sun
2814356 1/17 Sun
1679506 1/10 Sun
1679506 1/17 Sun

Attachment 2 – Calibration Plots

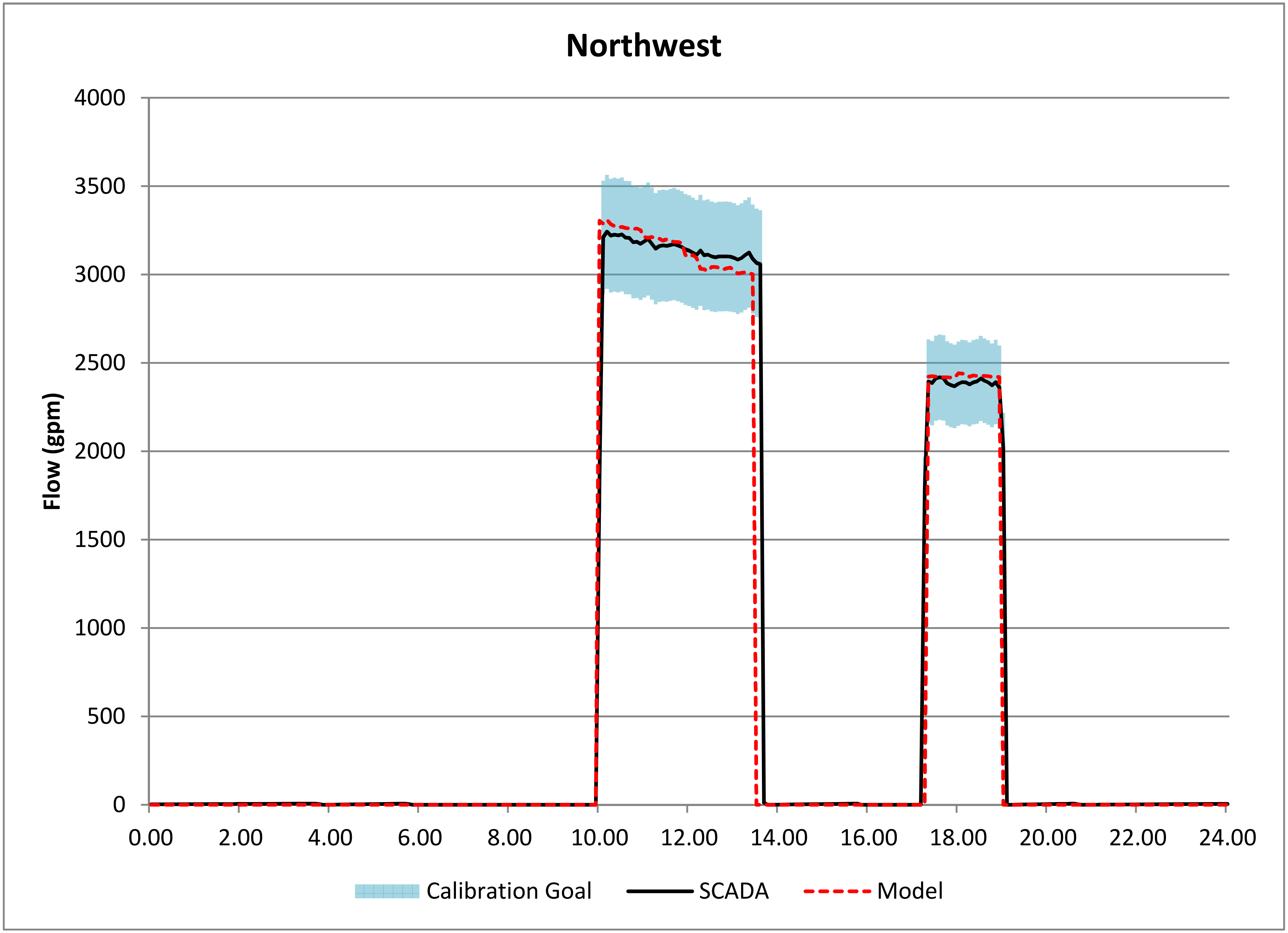

DLT
Flow (gpm)
80000
70000
60000
50000
40000
30000
20000
10000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



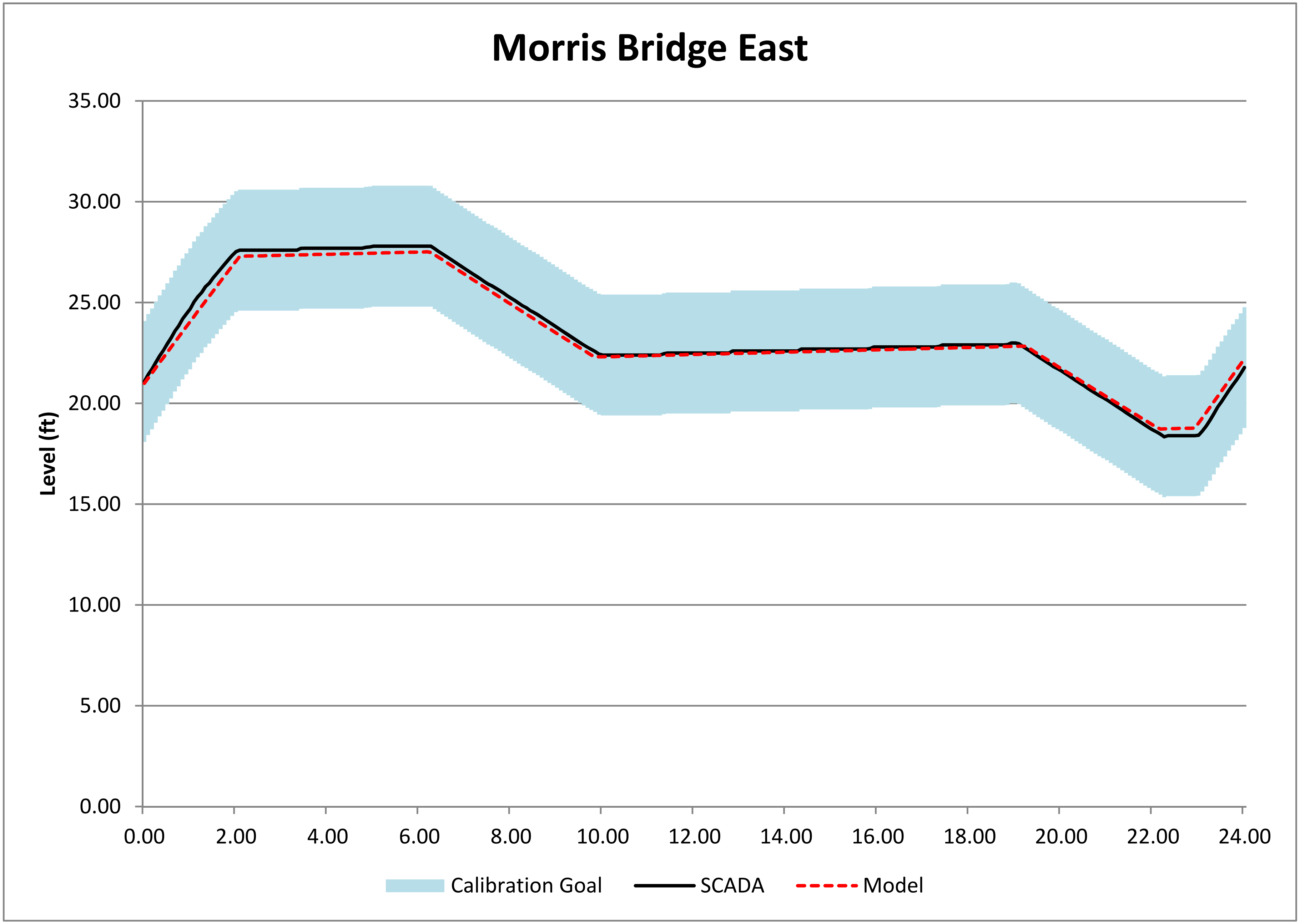
Interbay
Flow (gpm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

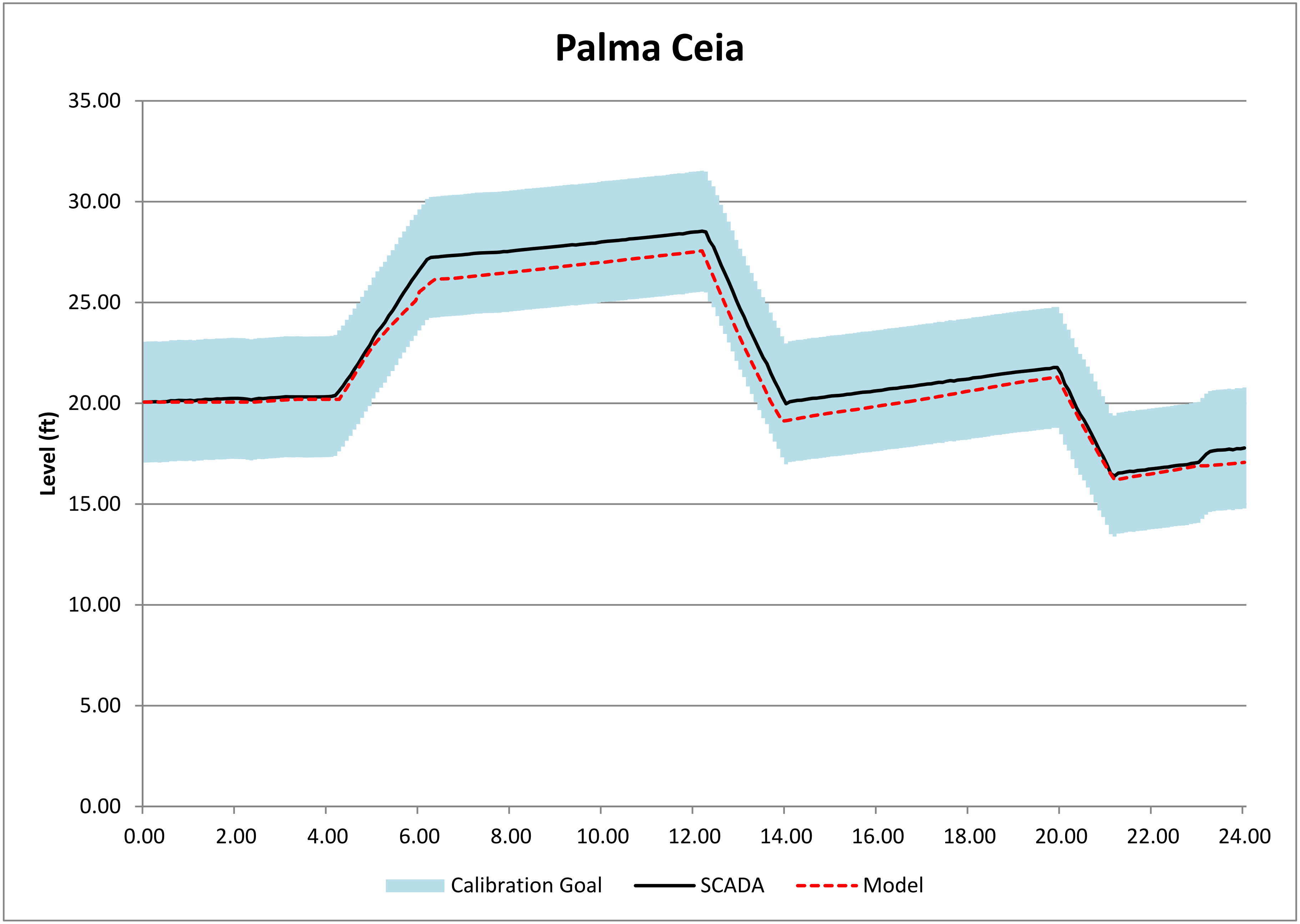


Morris Bridge
Flow (gpm)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

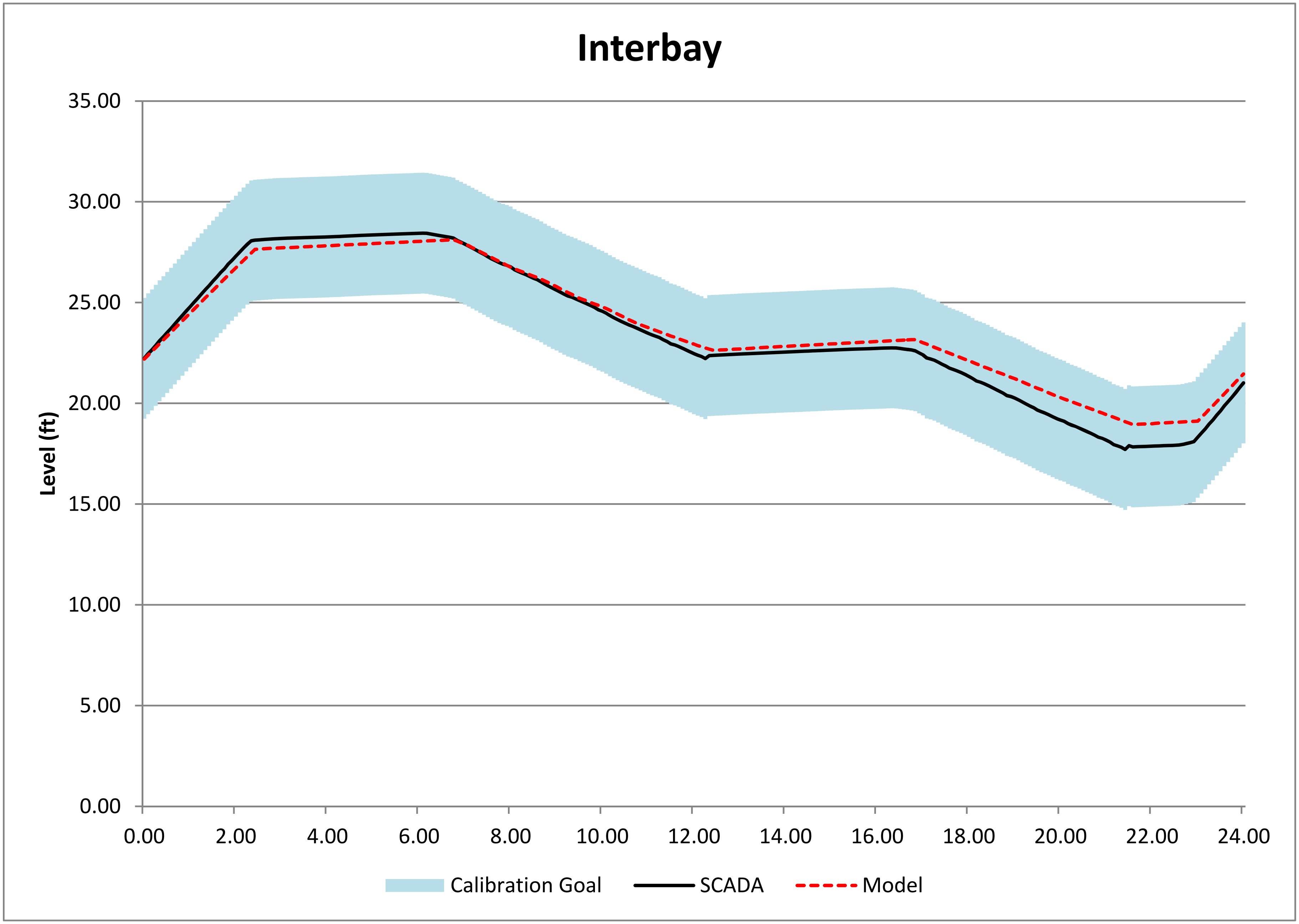


Northwest
Flow (gpm)
4000
3500
3000
2500
2000
1500
1000
500
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

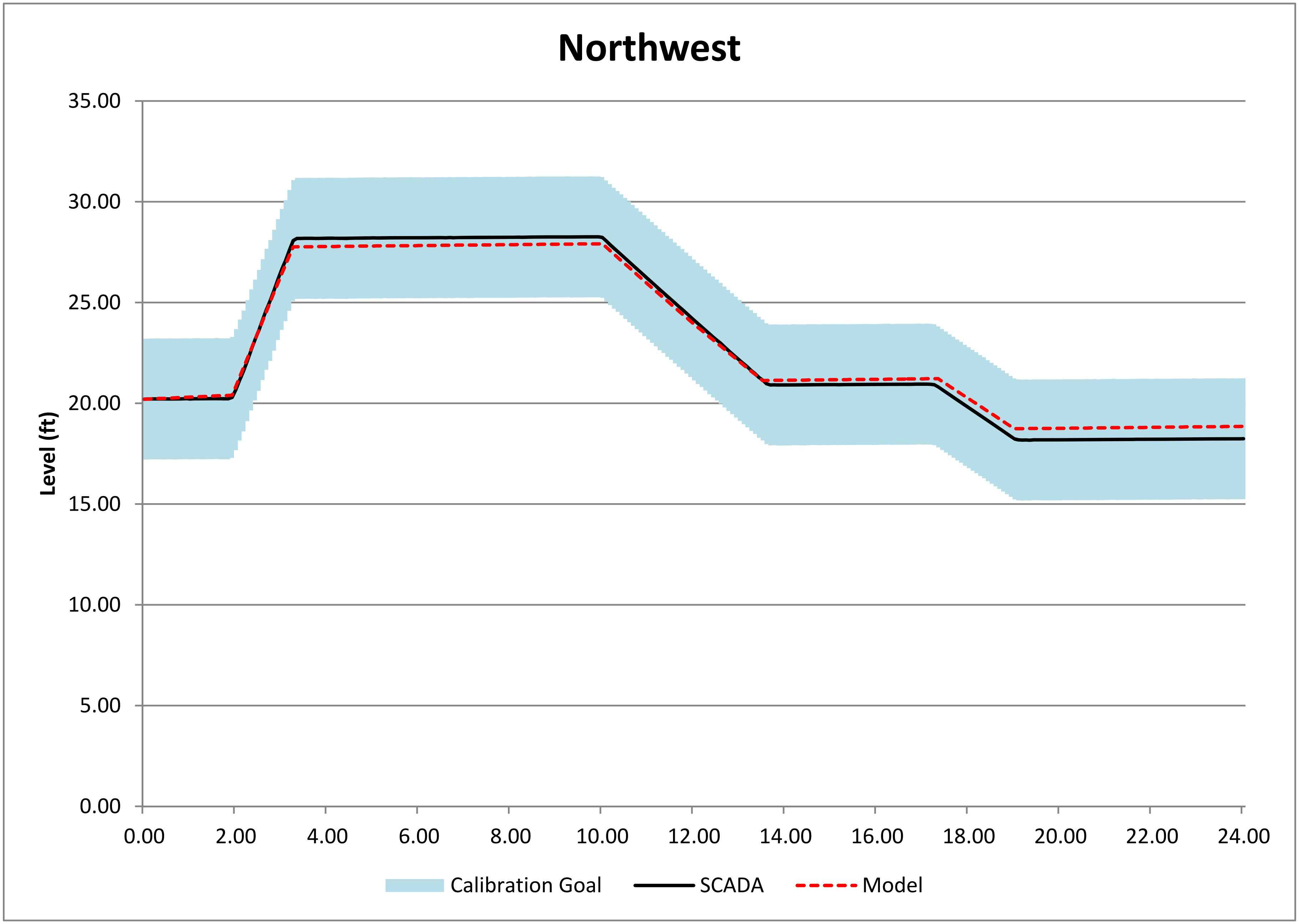

Morris Bridge East
Level (ft)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



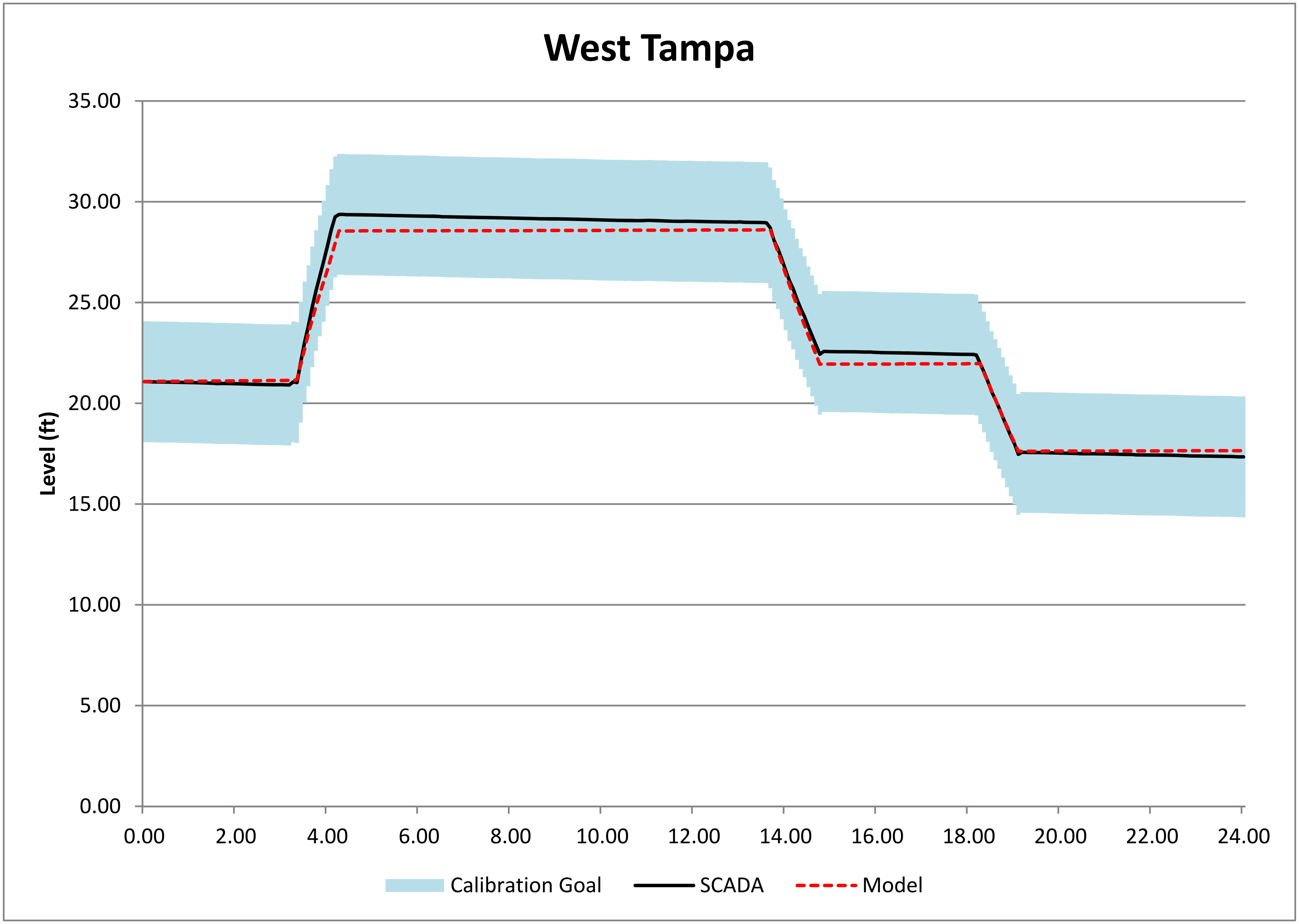
Palma Ceia
Level (ft)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

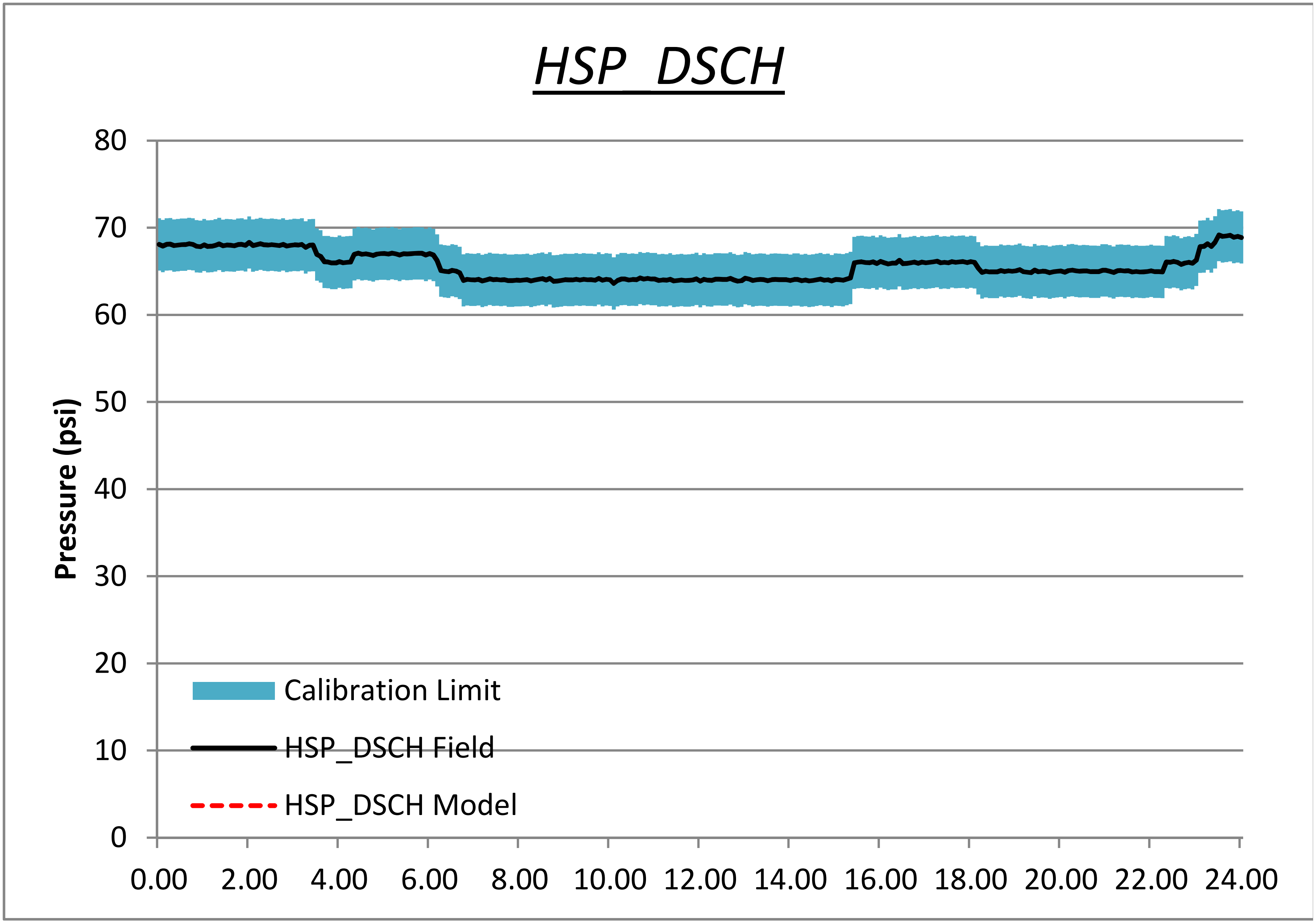


Interbay
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Level (ft)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

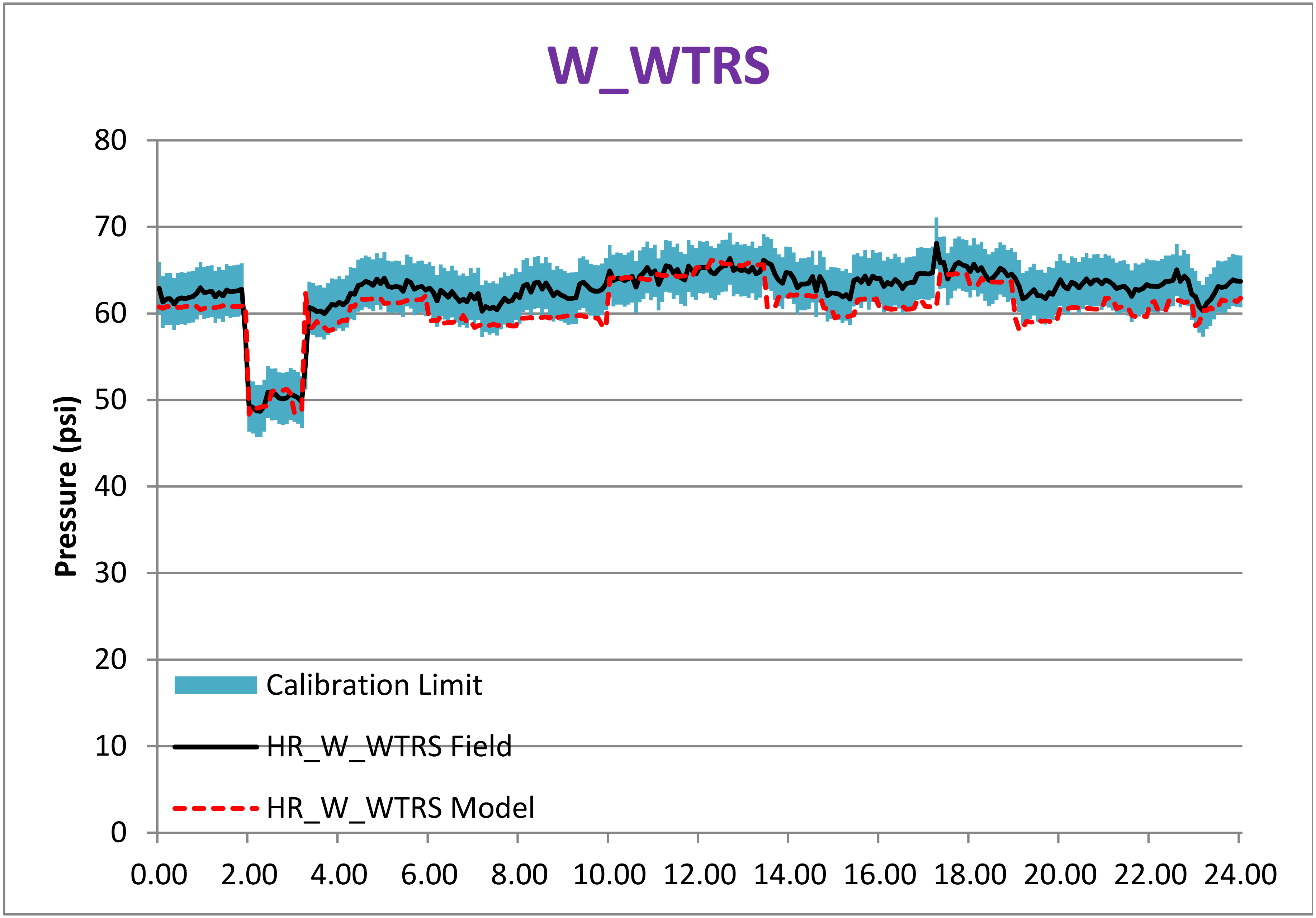


Northwest
Level (ft)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

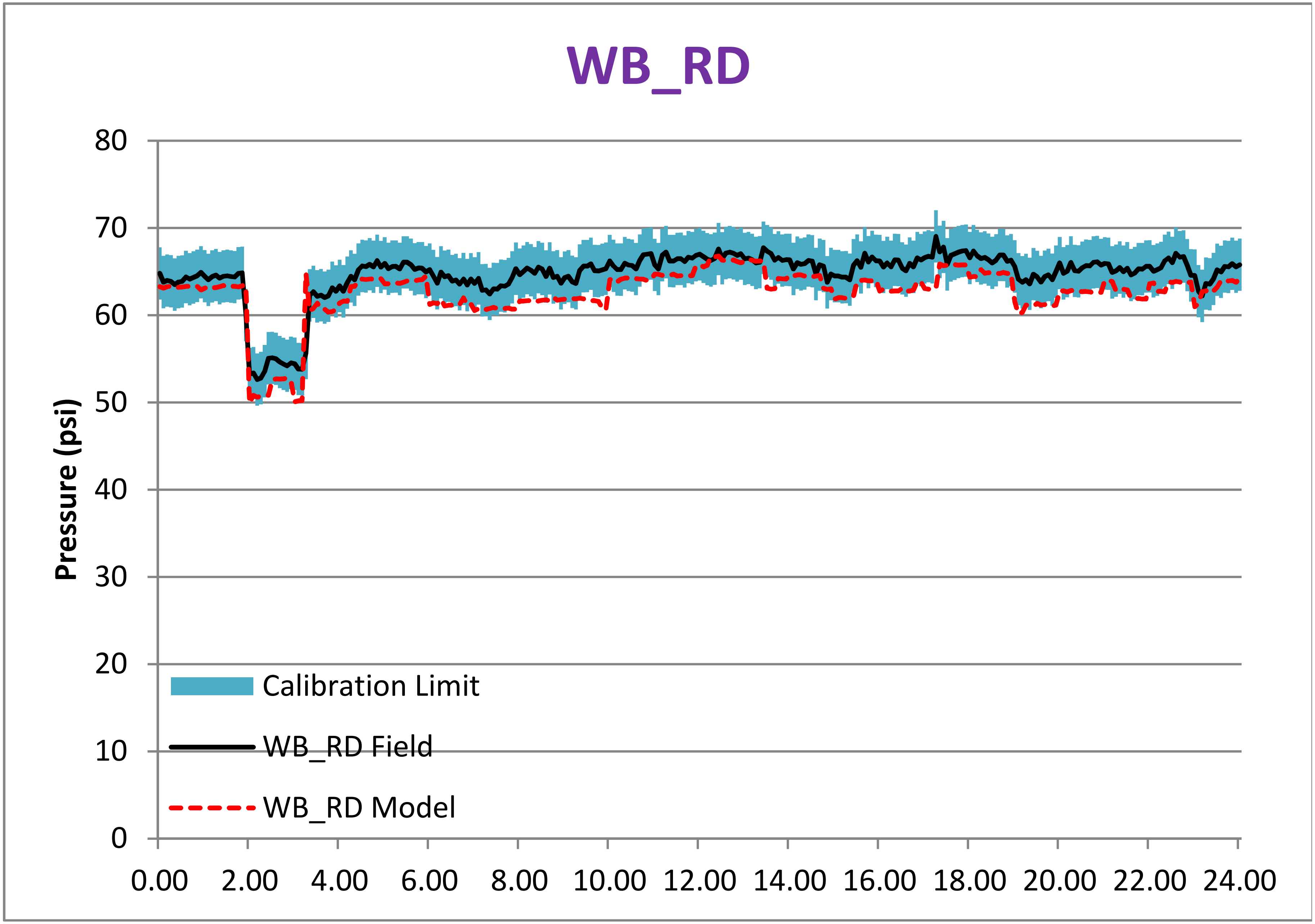

West Tampa
Level (ft)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



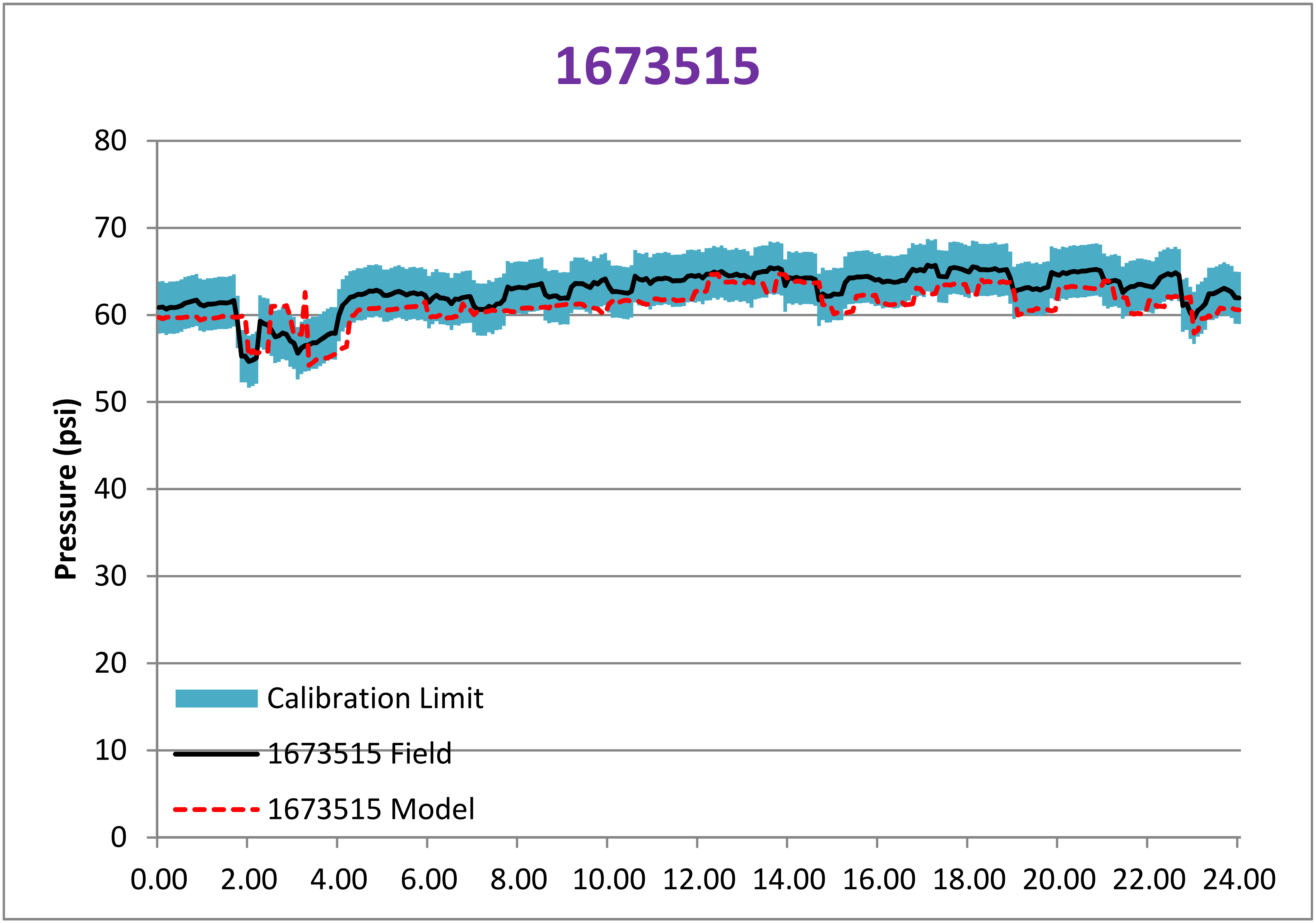
HSP_DSCH
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
HSP_DSCH Field
HSP_DSCH Model



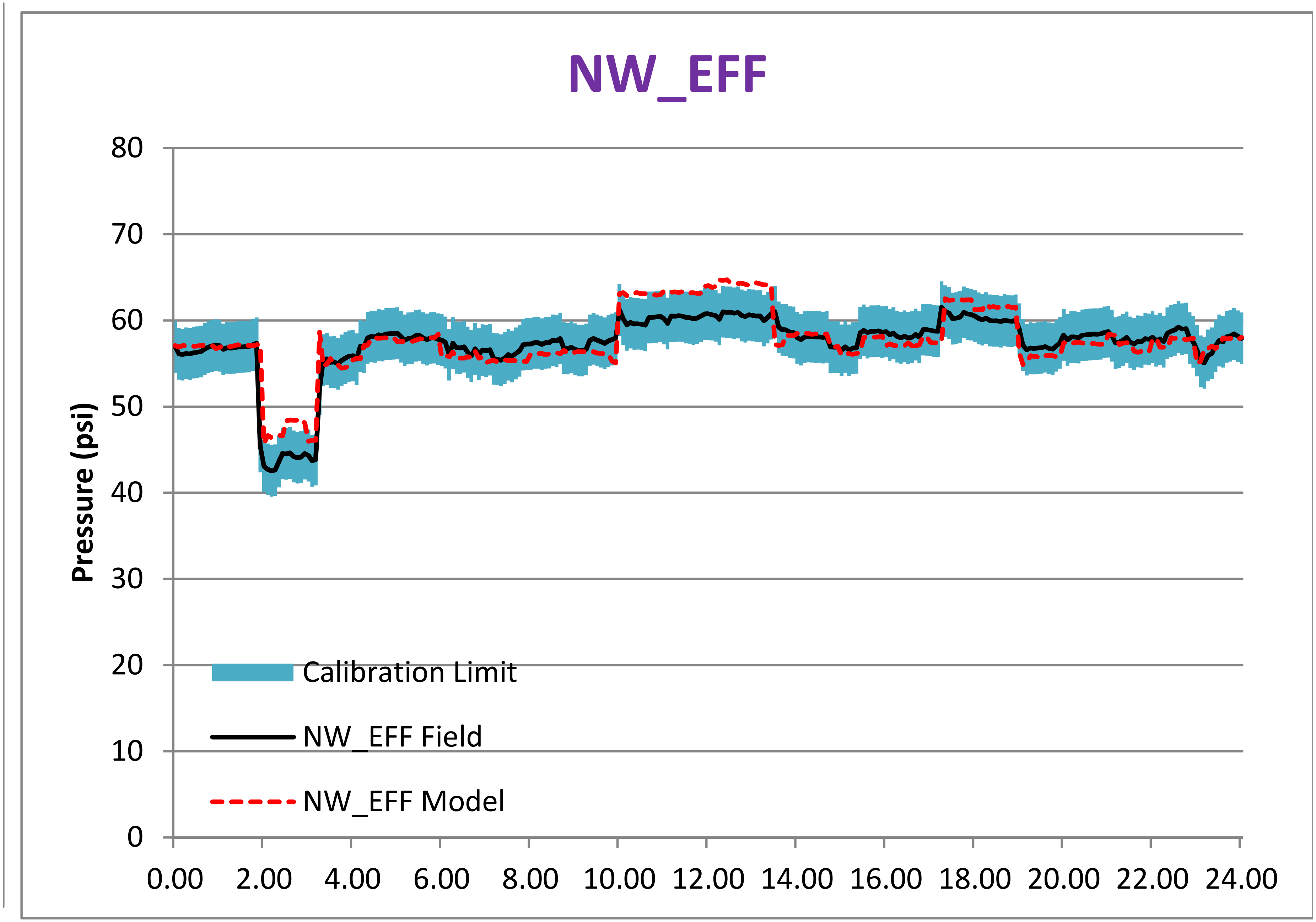
W_WTRS
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
HR_W_WTRS Field
HR_W_WTRS Model



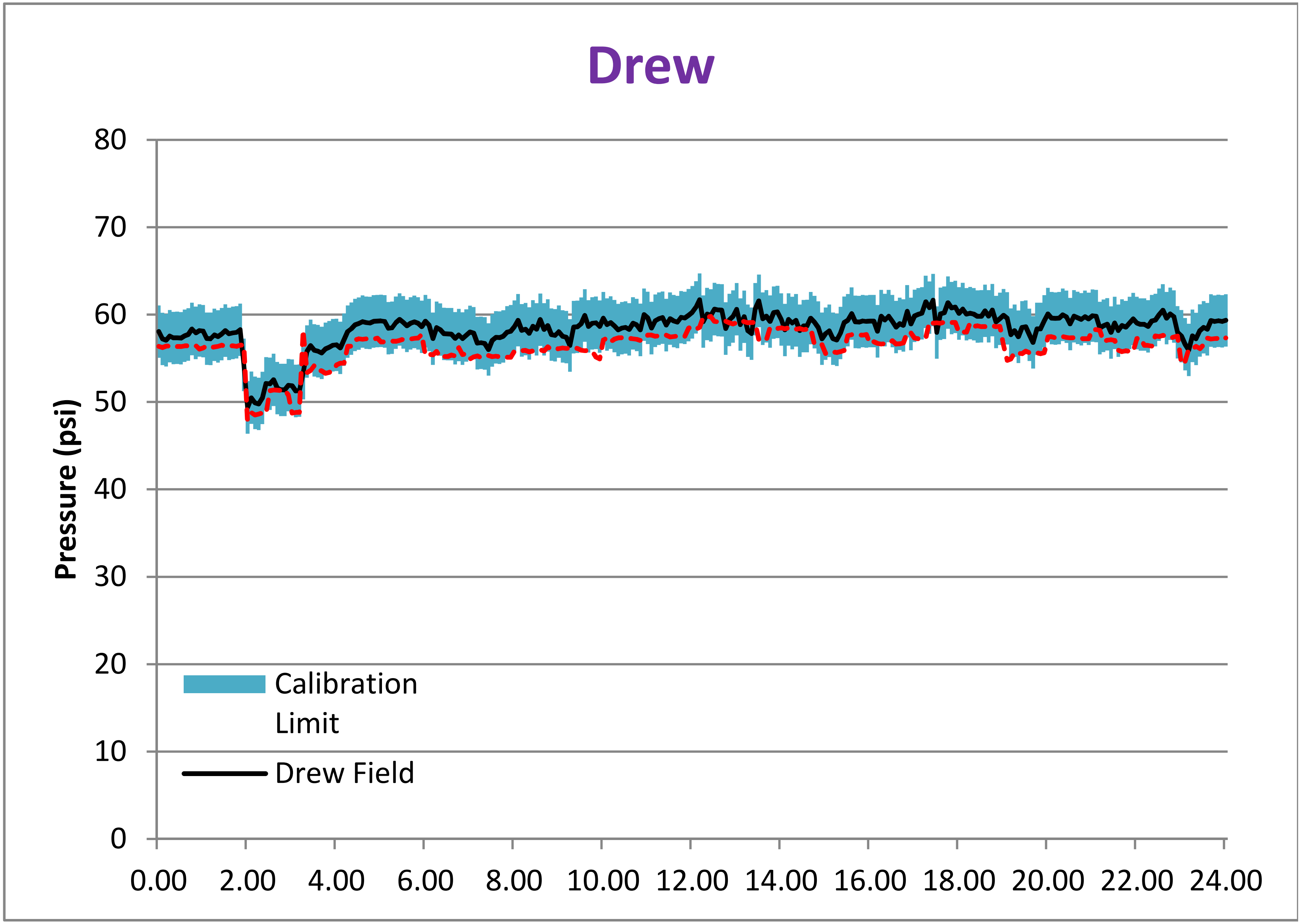
WB_RD
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
WB_RD Field
WB_RD Model

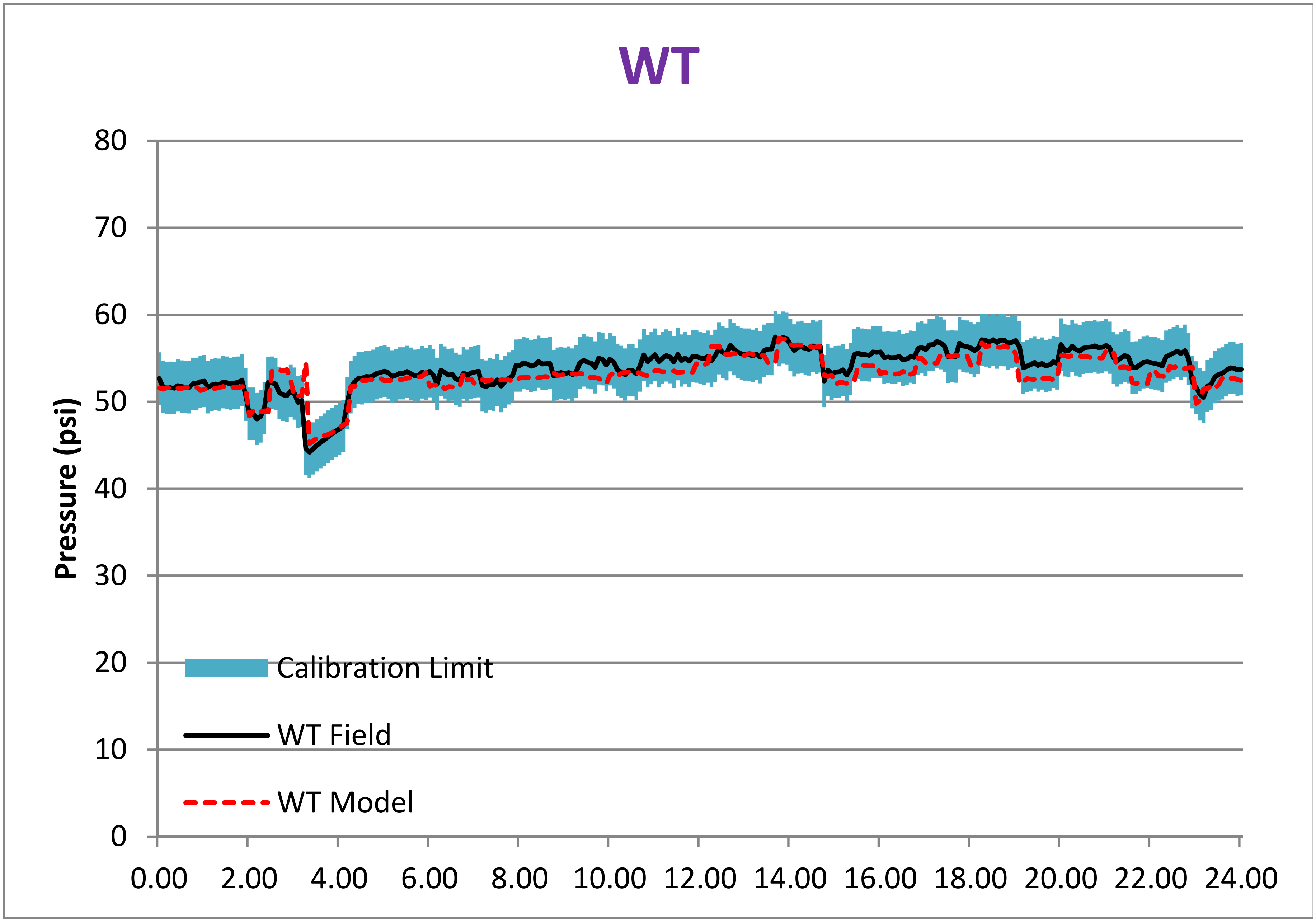


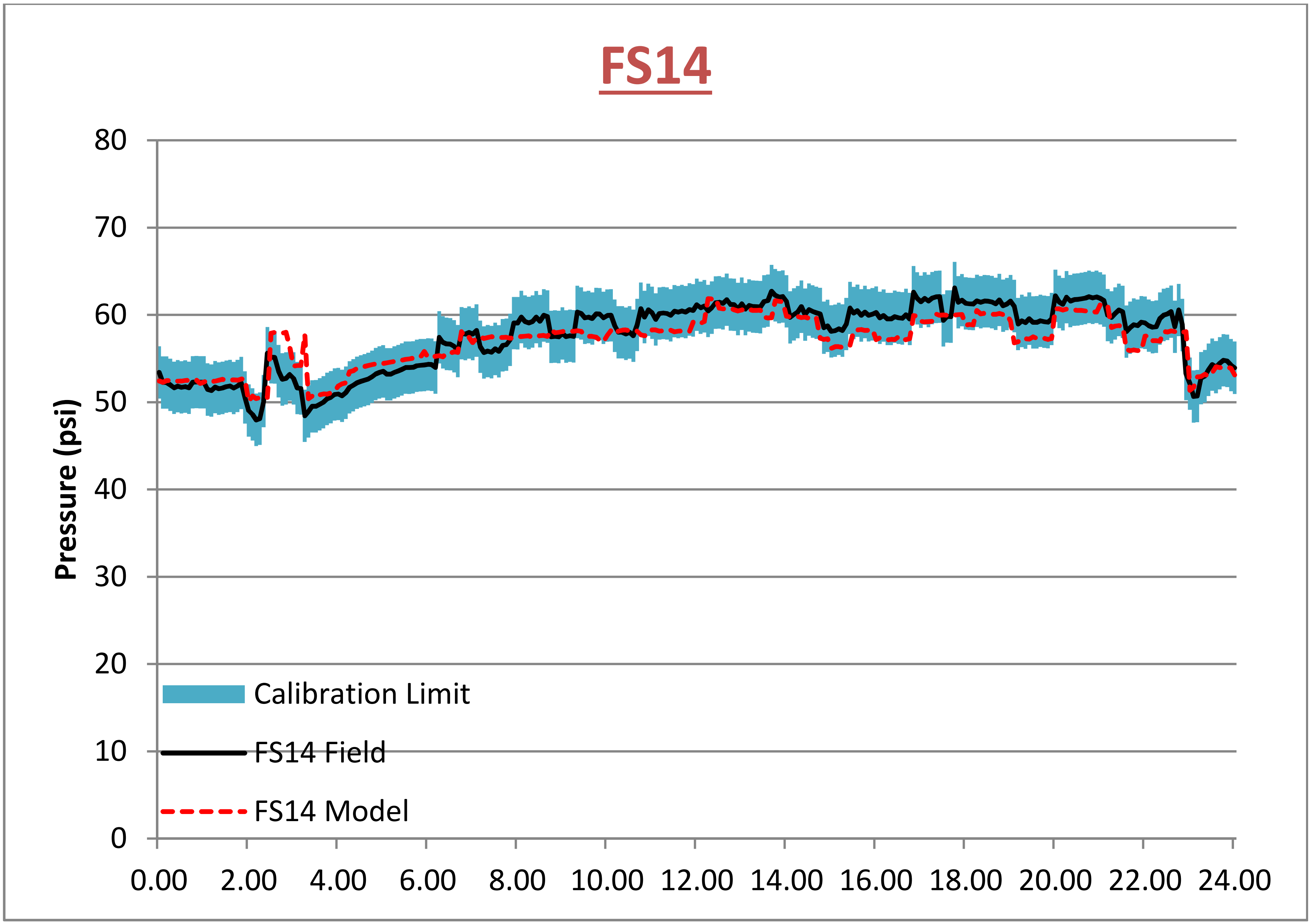
1673515
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1673515 Field
1673515 Model

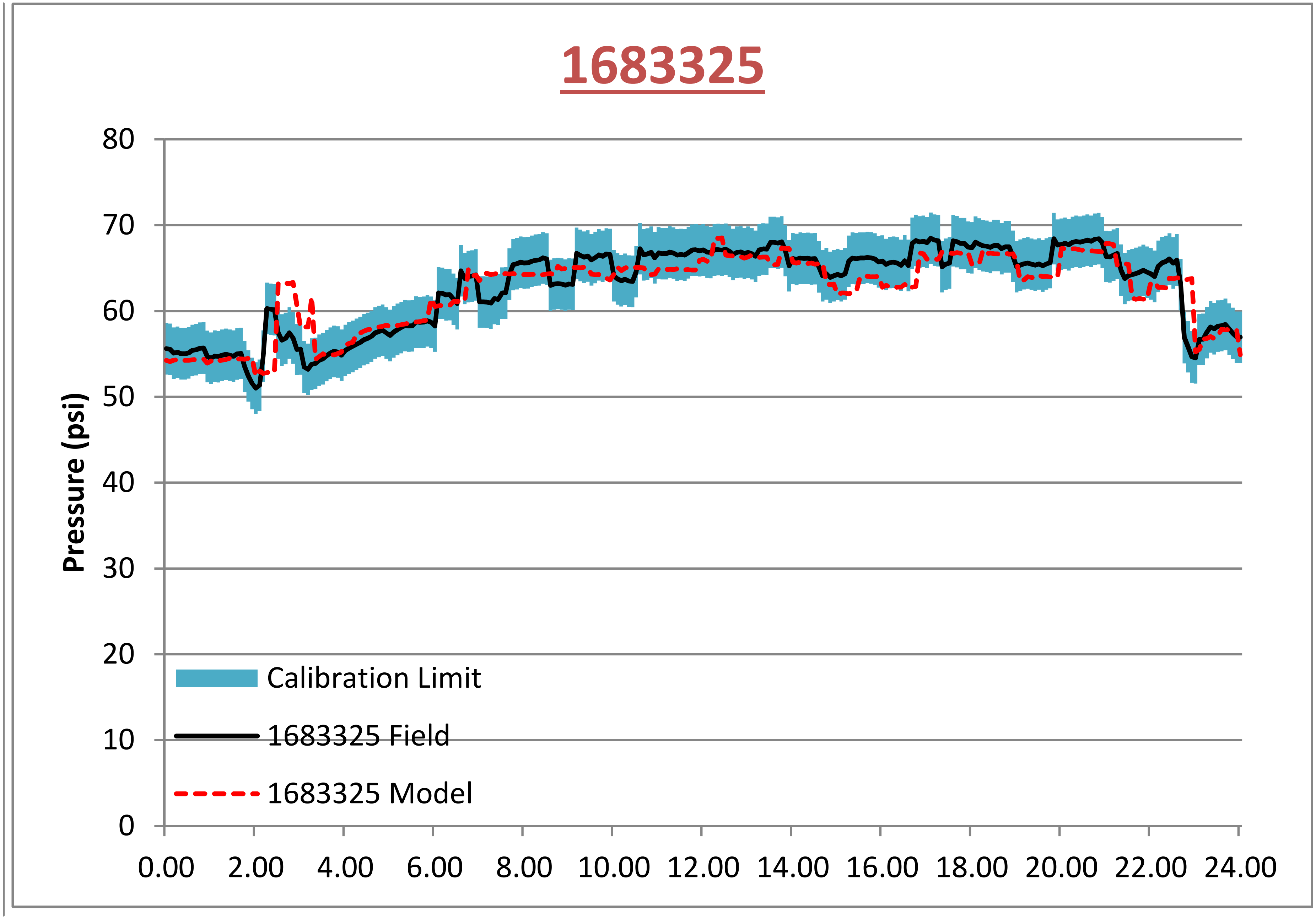


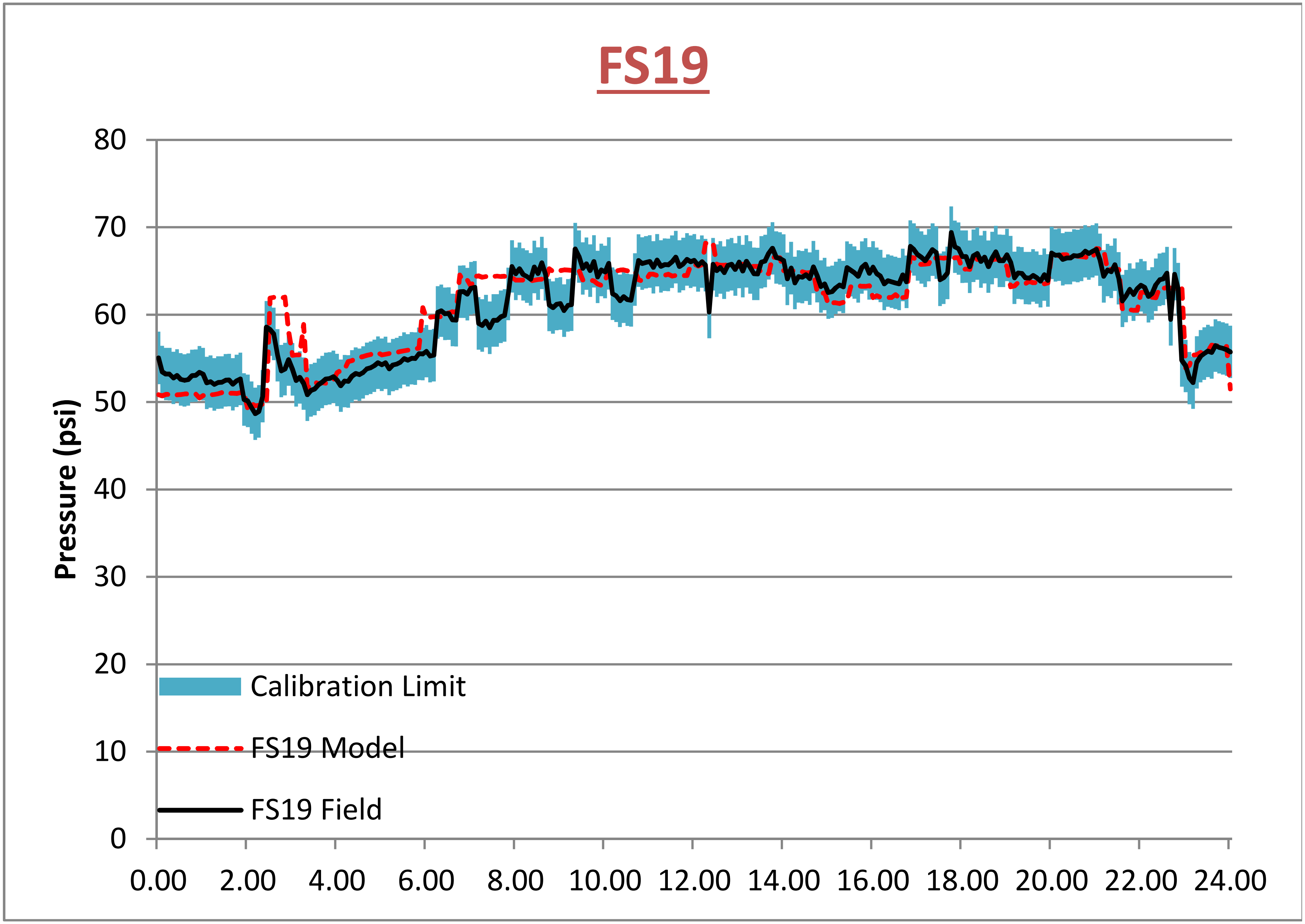
NW_EFF
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
NW_EFF Field
NW_EFF Model


Drew
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
Drew Field

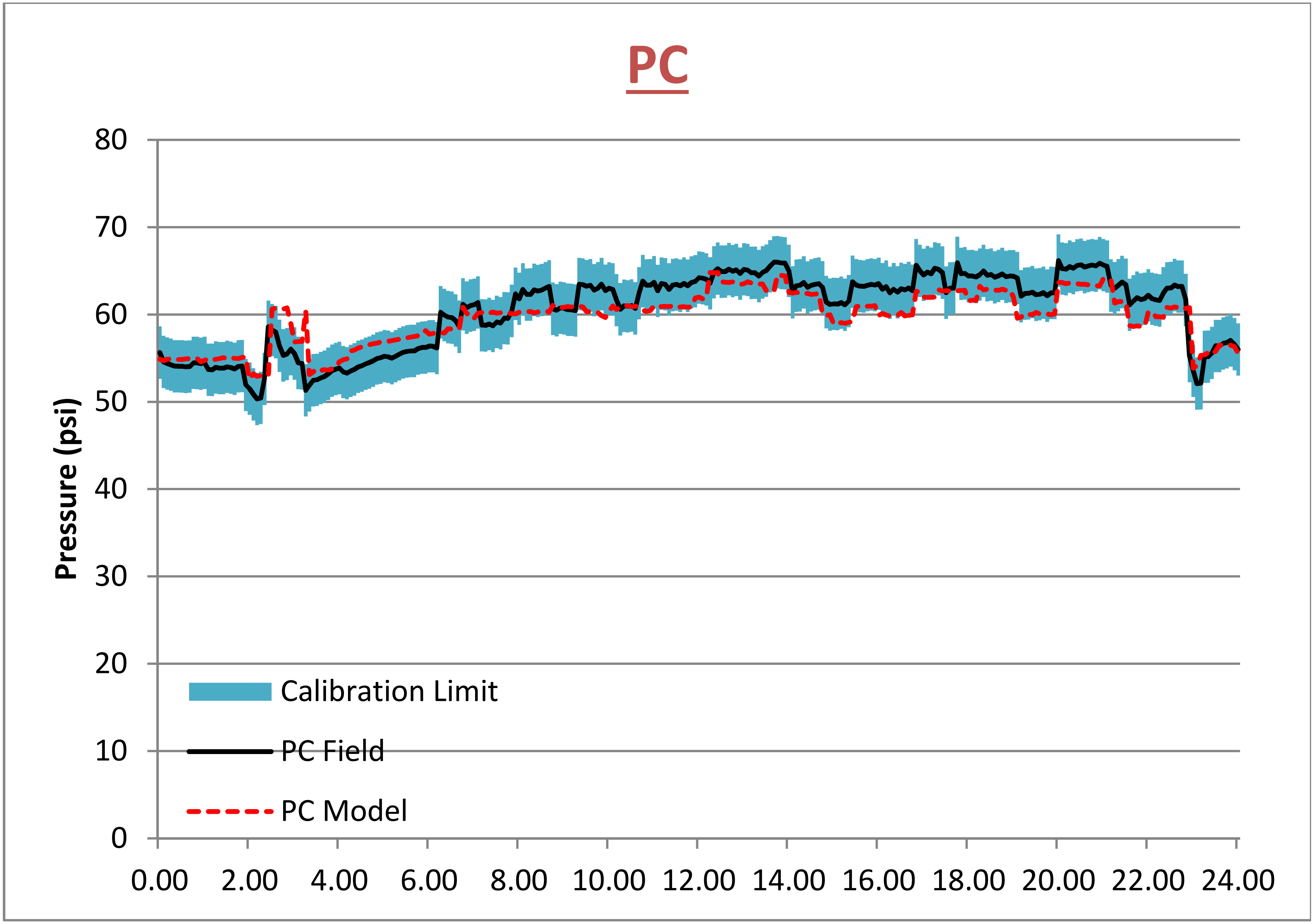

WT
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
WT Field
WT Model


FS14
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS14 Field
FS14 Model

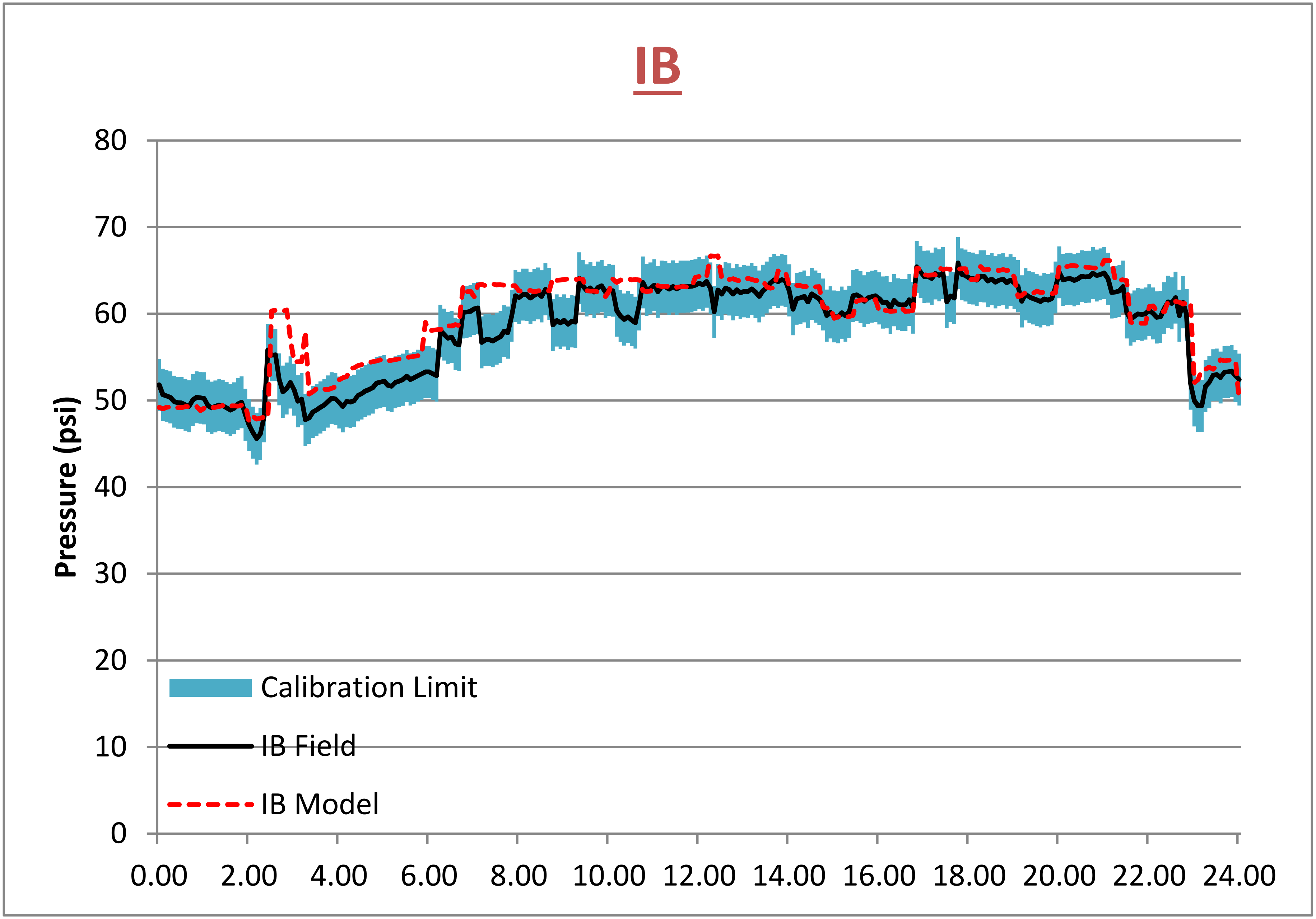

1683325
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1683325 Field
1683325 Model

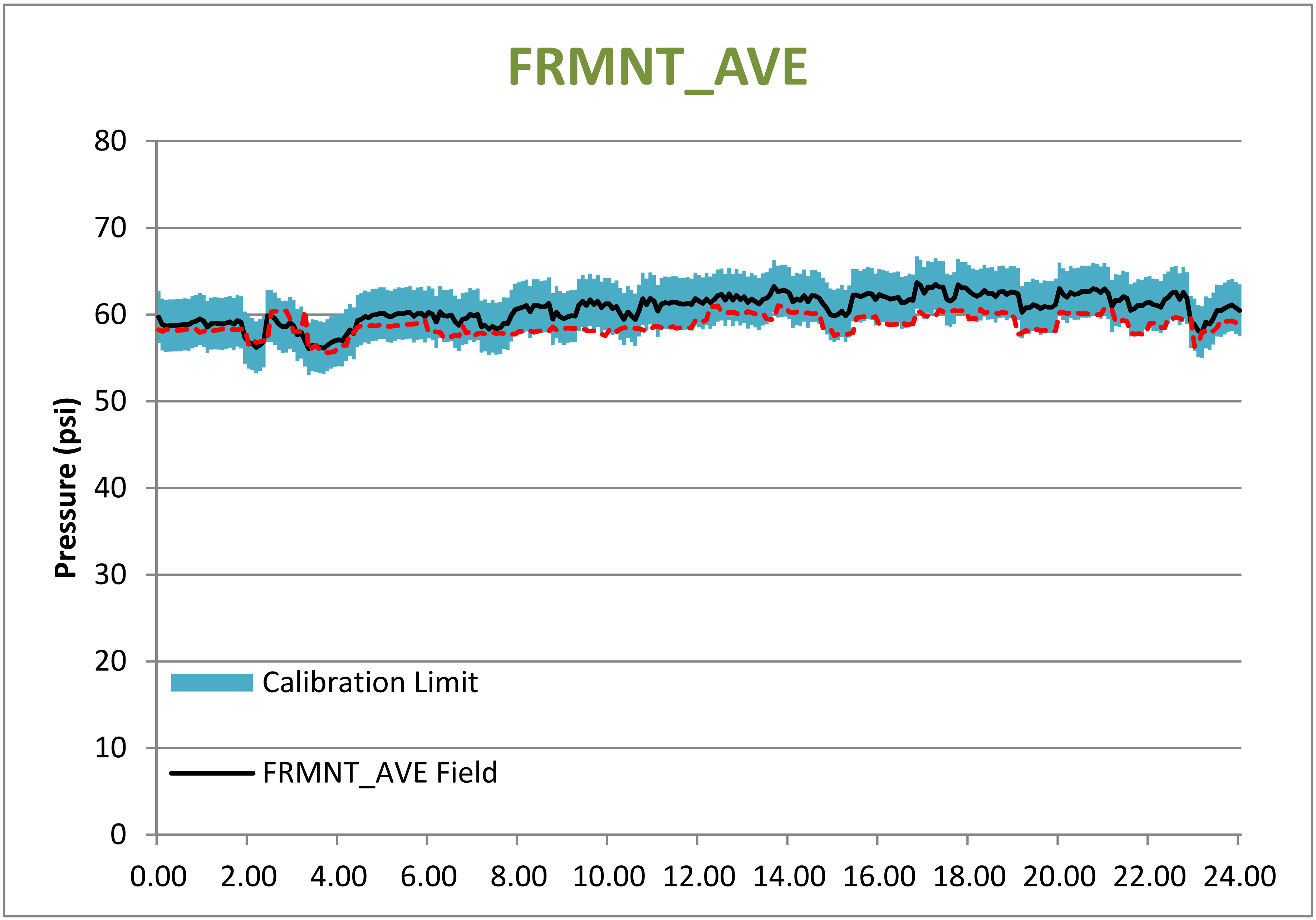


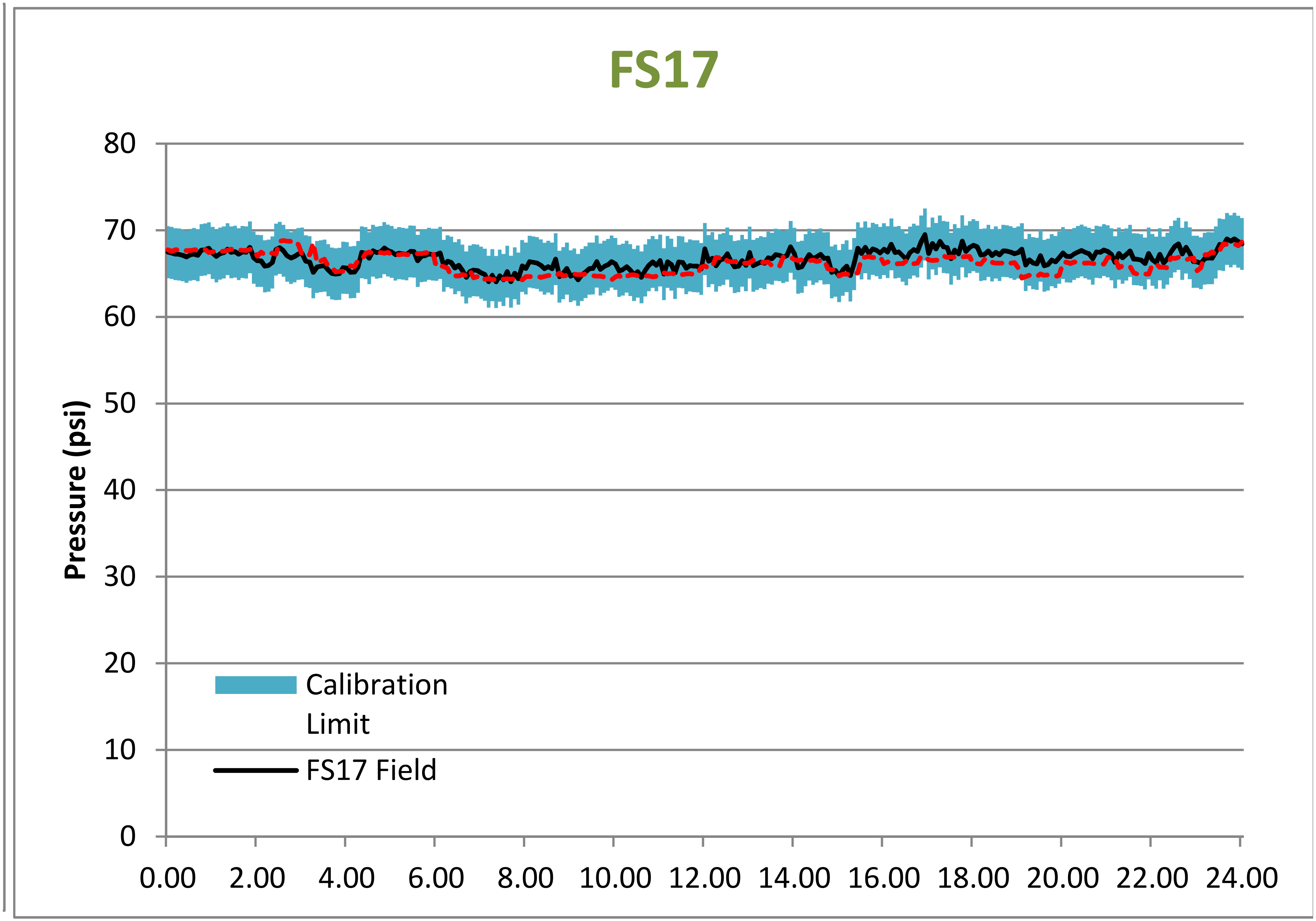
FS19
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS19 Model
FS19 Field



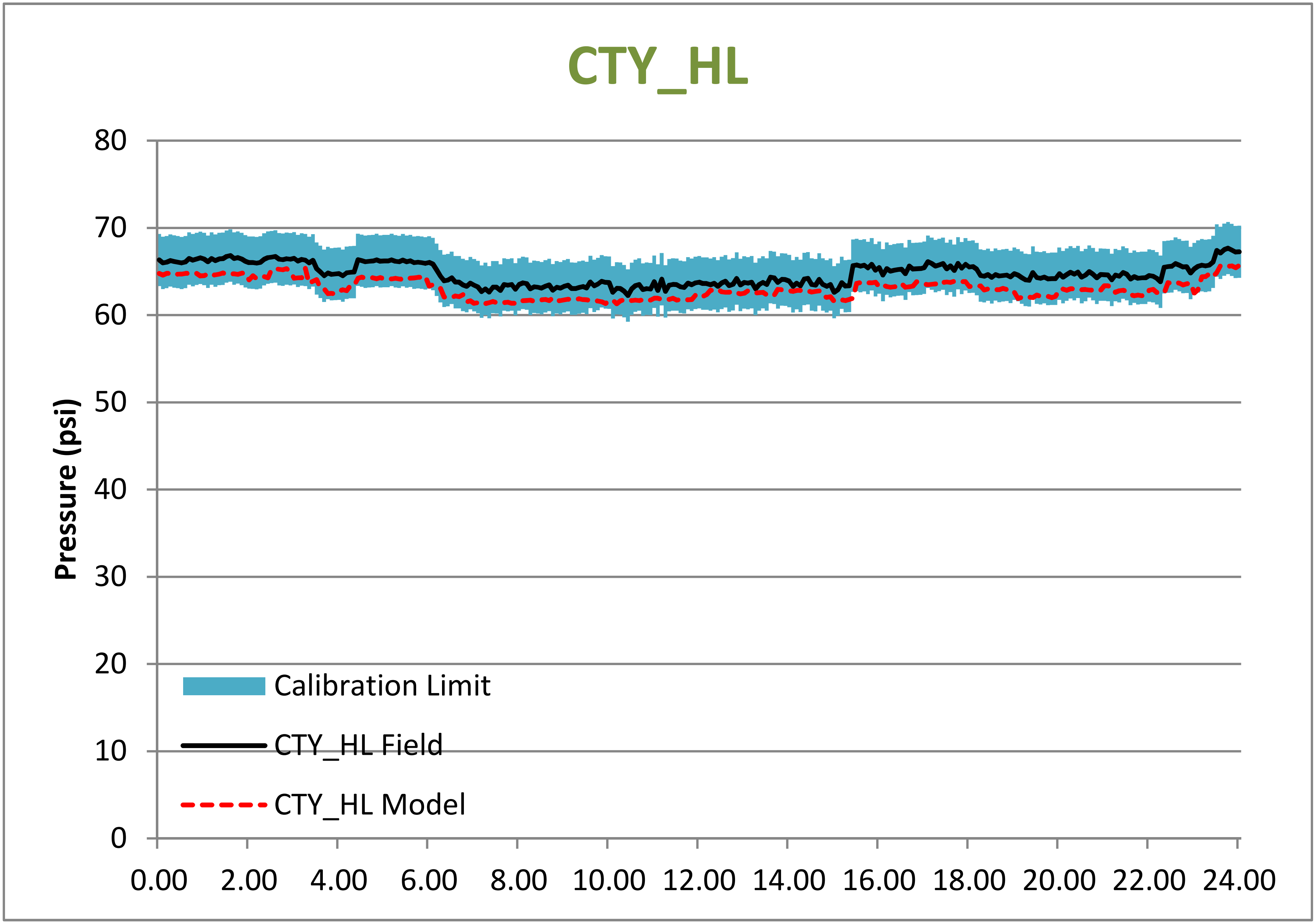
PC
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
PC Field
PC Model


IB
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
IB Field
IB Model

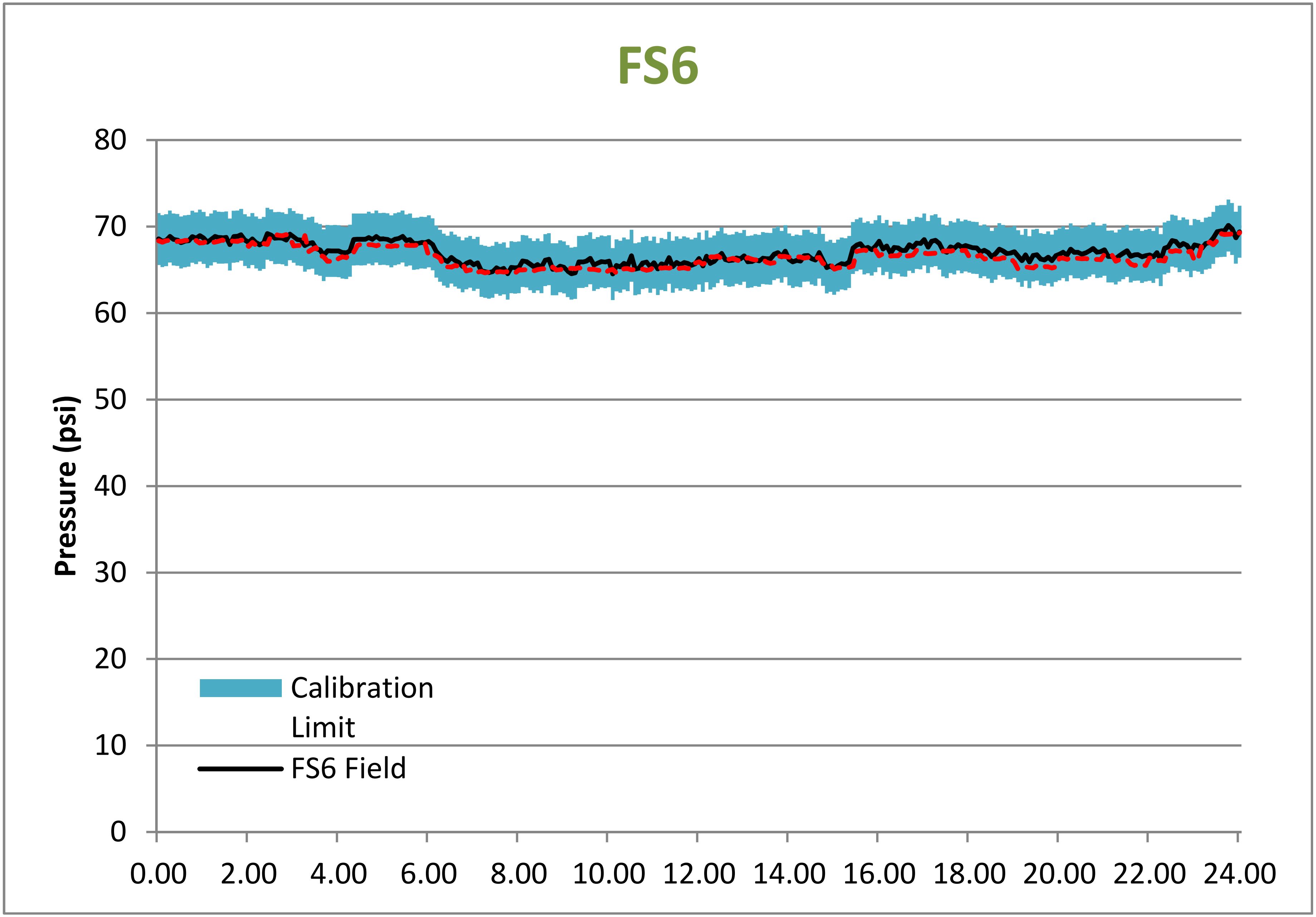

FRMNT_AVE
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FRMNT_AVE Field

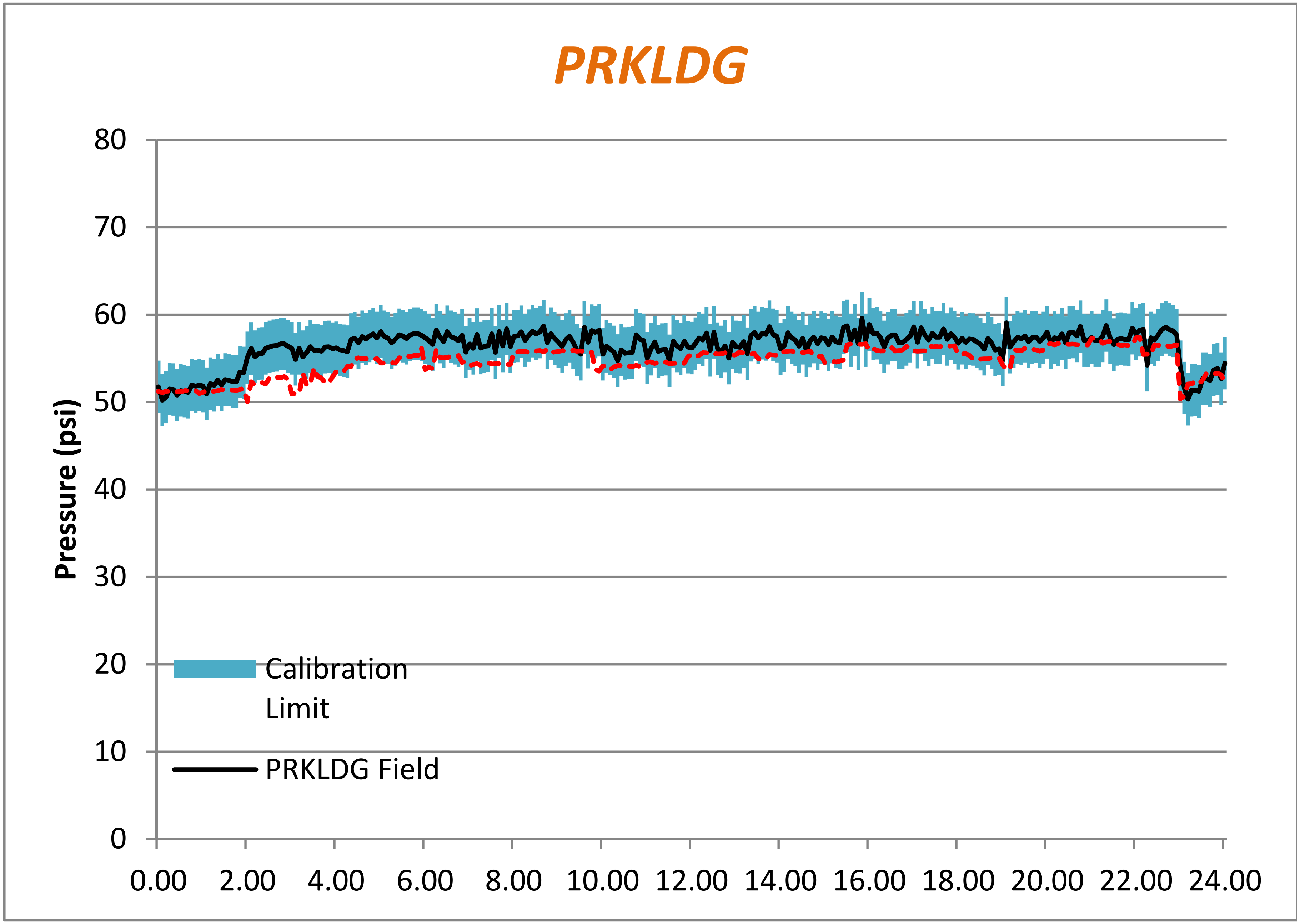


FS17
80
70
60
50
40
30
20
10
0
Pressure (psi)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS17 Field

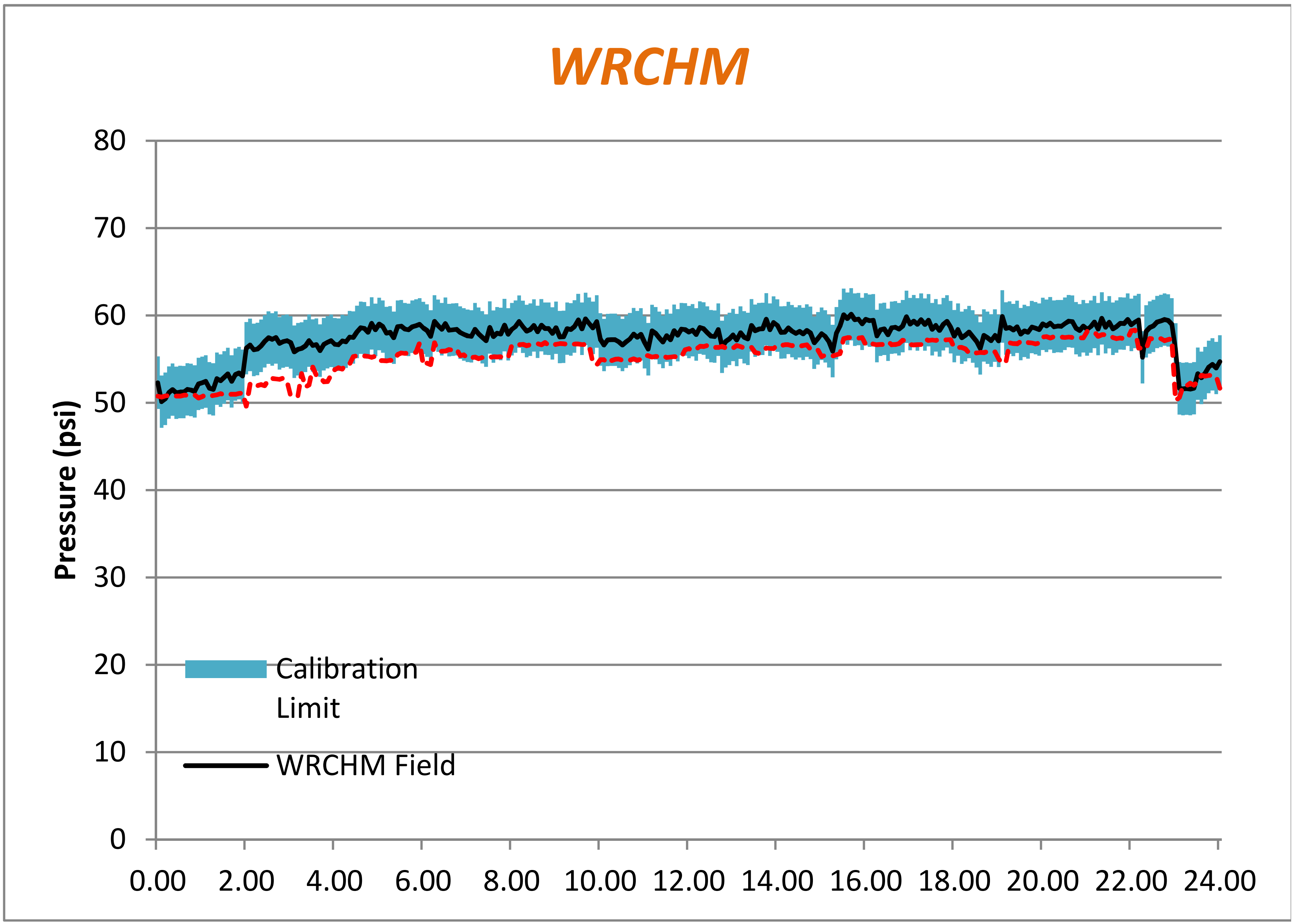


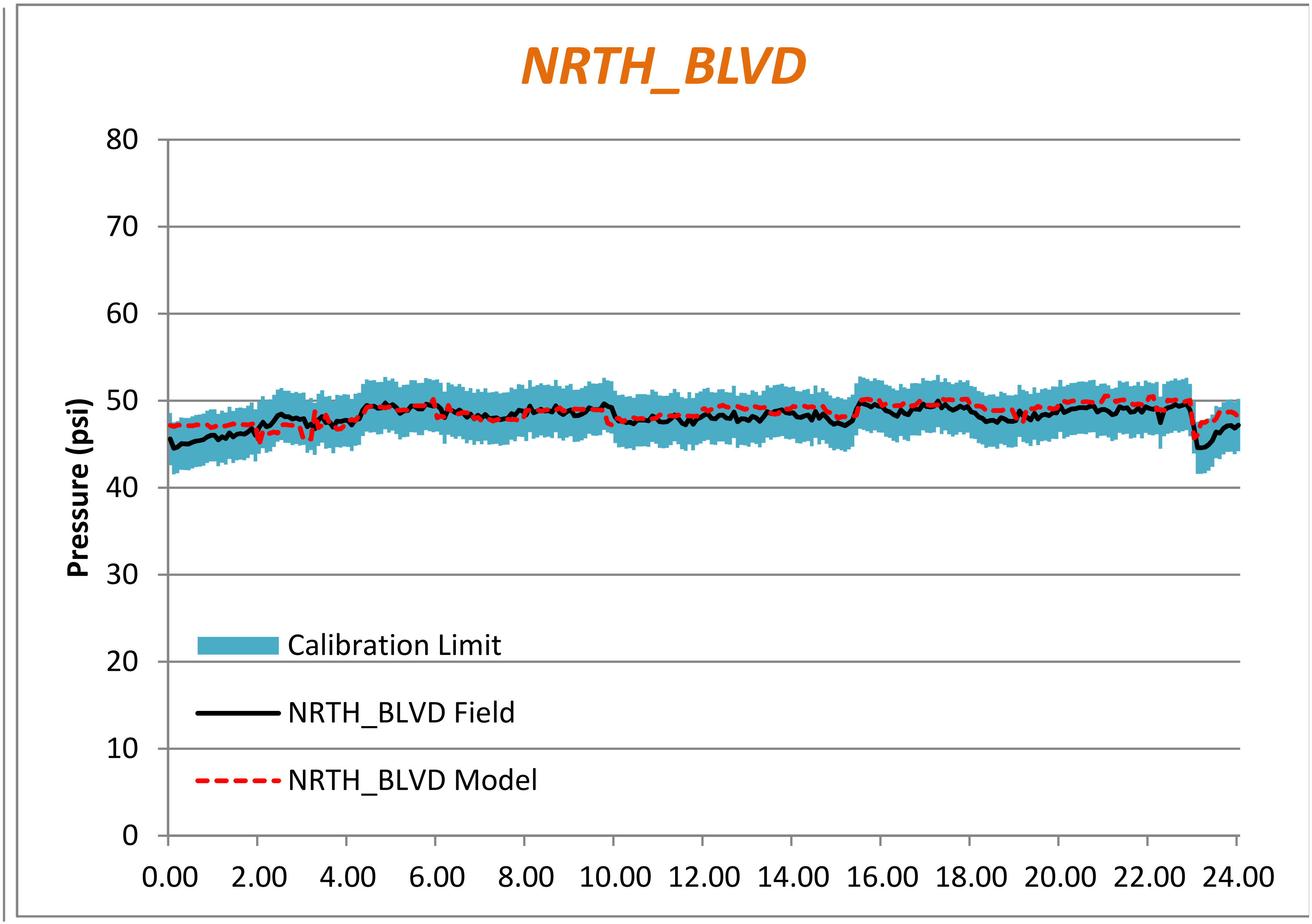
CTY_HL
80
70
60
50
40
30
20
10
0
Pressure (psi)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
CTY_HL Field
CTY_HL Model


FS6
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS6 Field



PRKLDG
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
PRKLDG Field


WRCHM
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
WRCHM Field


NRTH_BLVD
Pressure (psi)
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70
60
50
40
30
20
10
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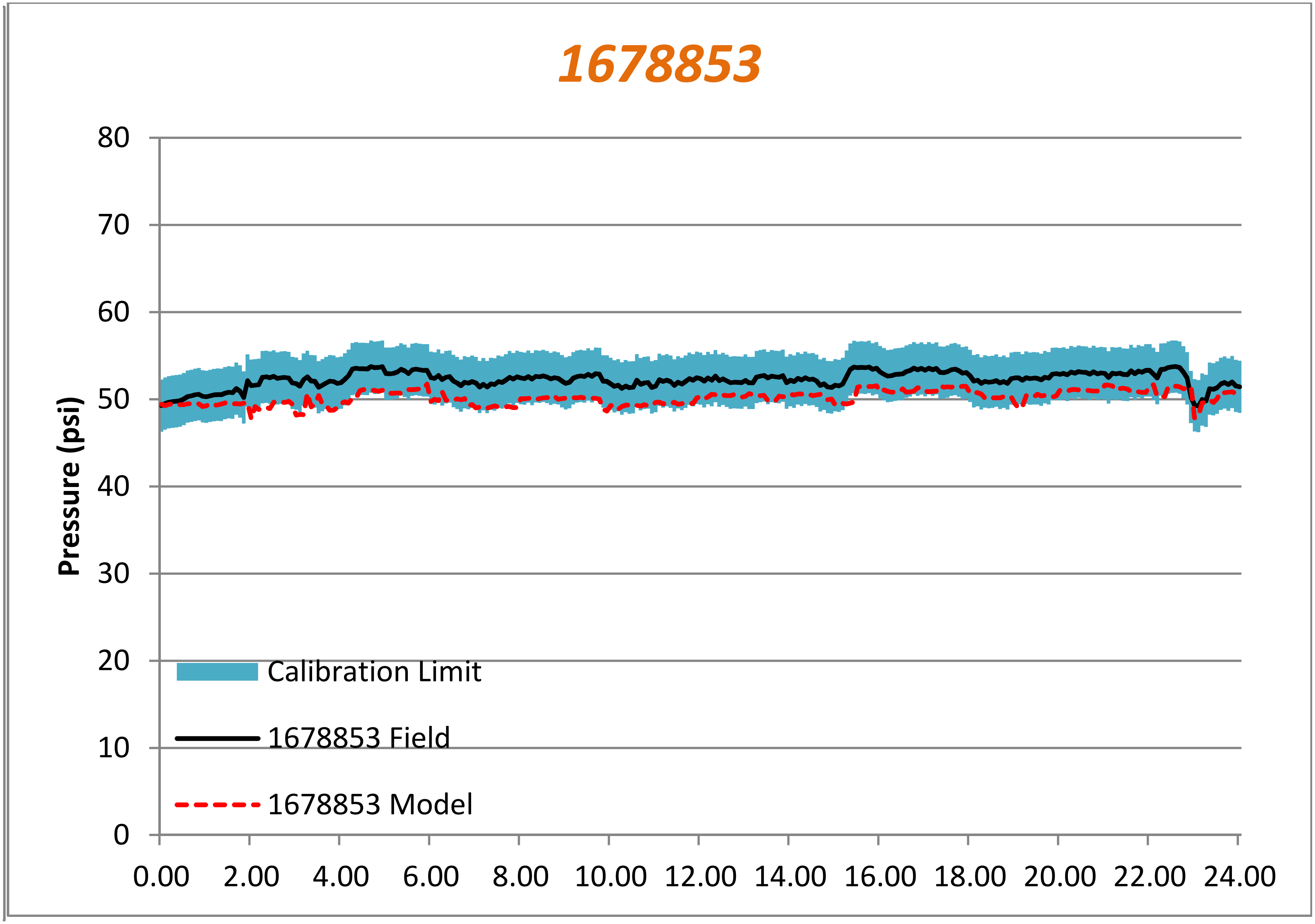
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
NRTH_BLVD Field
NRTH_BLVD Model



1678853
Pressure (psi)
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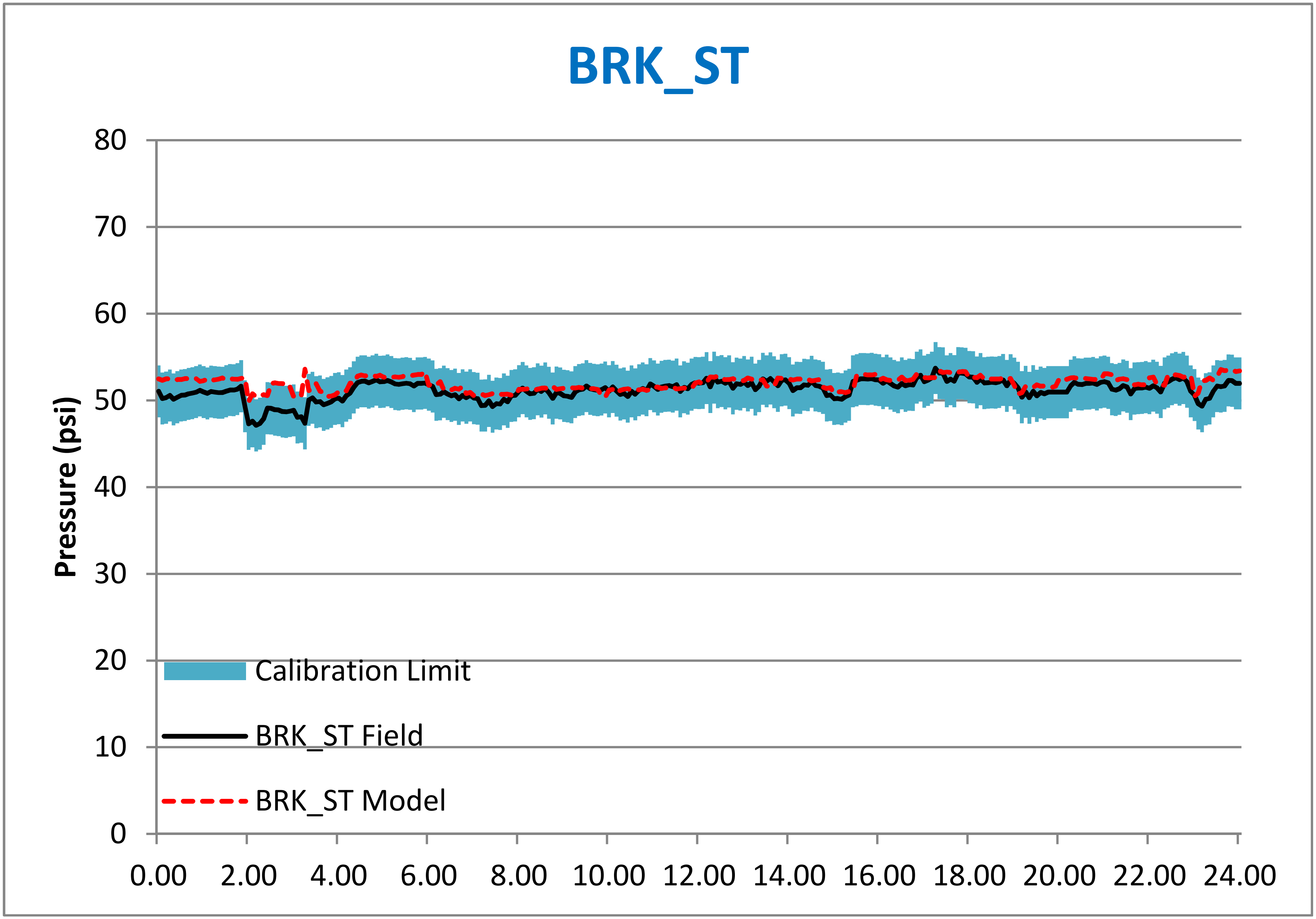
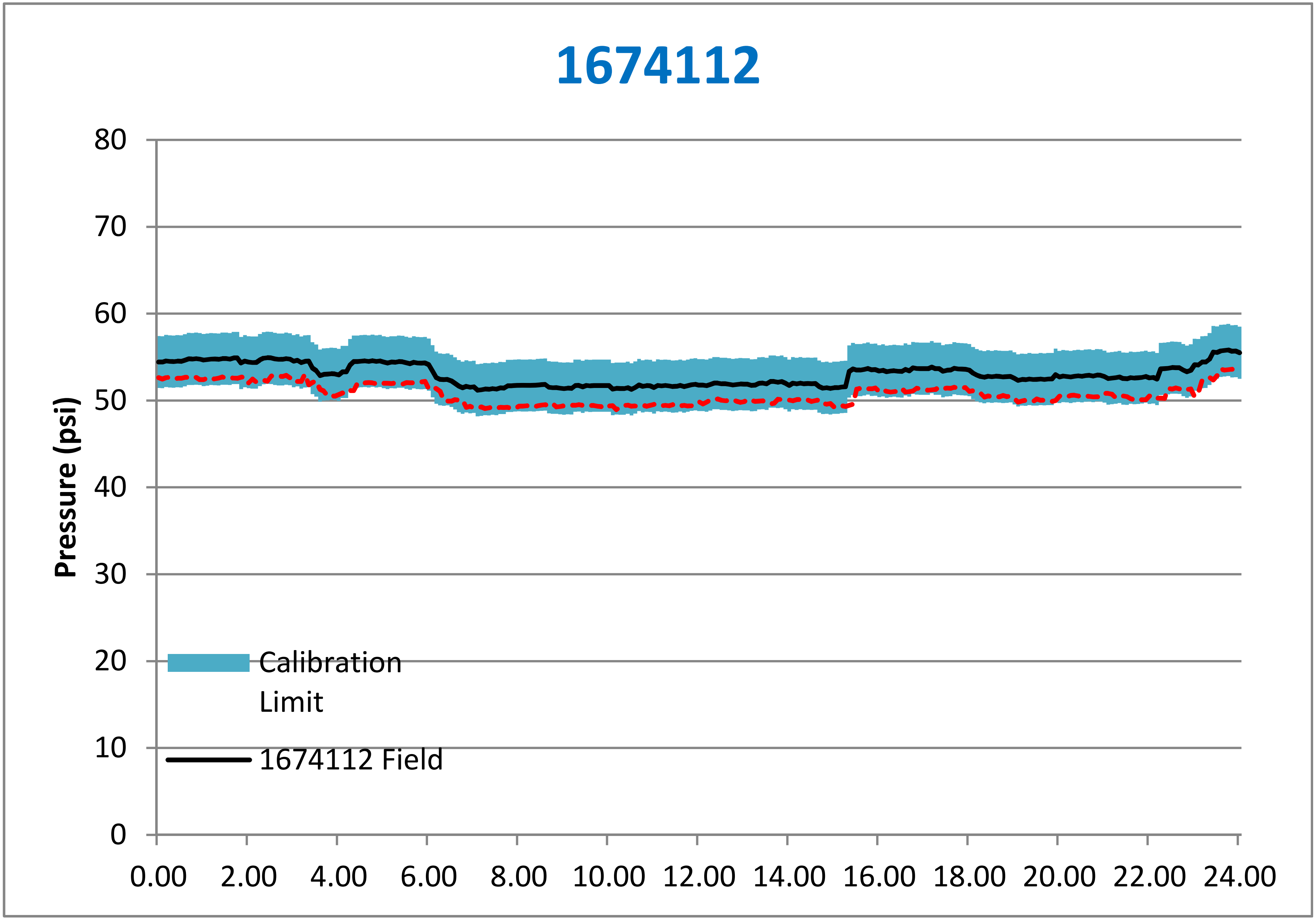
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1678853 Field
1678853 Model



BRK_ST
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
BRK_ST Field
BRK_ST Model



1674112
Pressure (psi)
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30
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10
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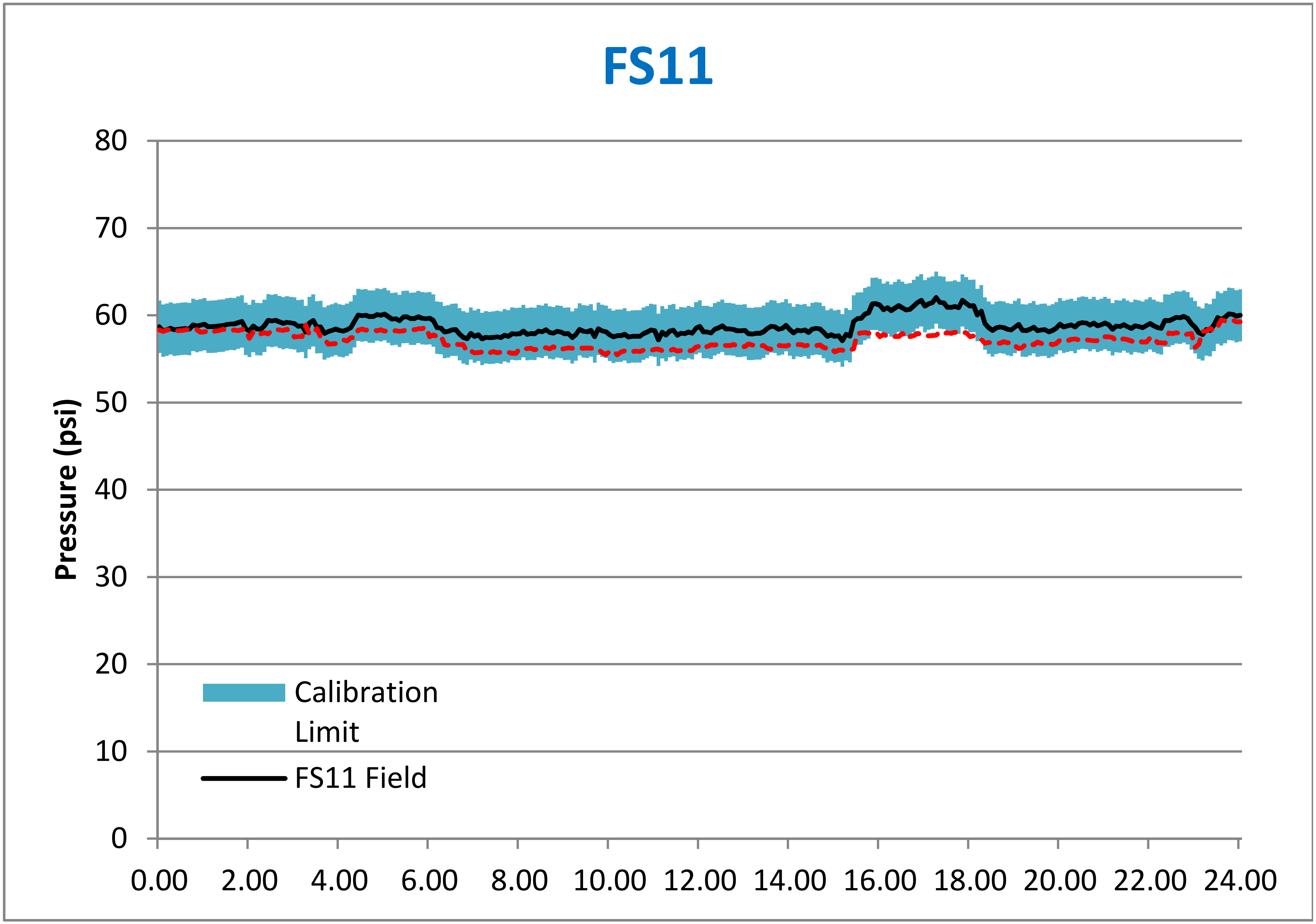
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1674112 Field


FS11
Pressure (psi)
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4.00
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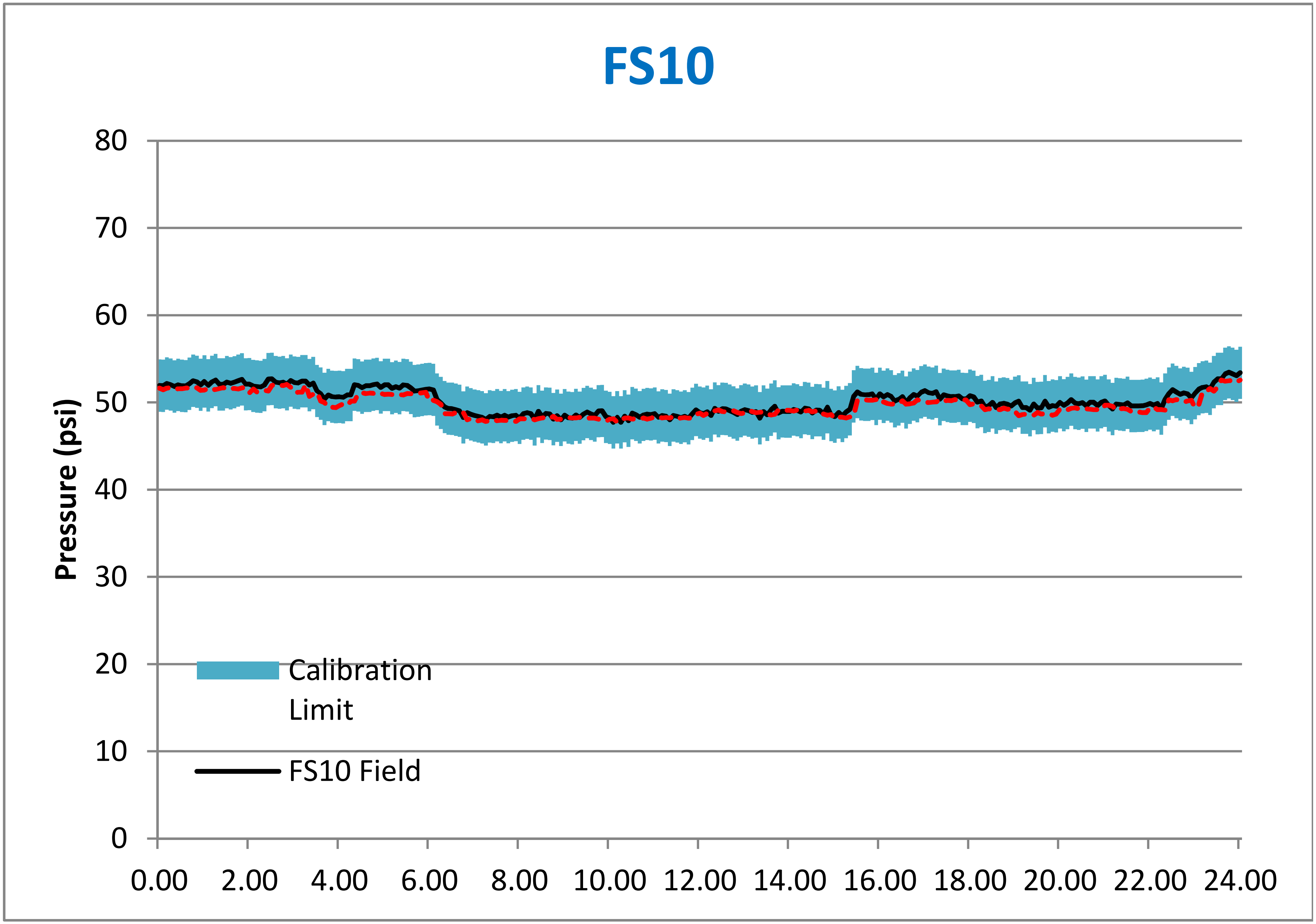
18.00
20.00
22.00
24.00
Calibration Limit
FS11 Field



FS10
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Pressure (psi)
Calibration Limit
FS10 Field
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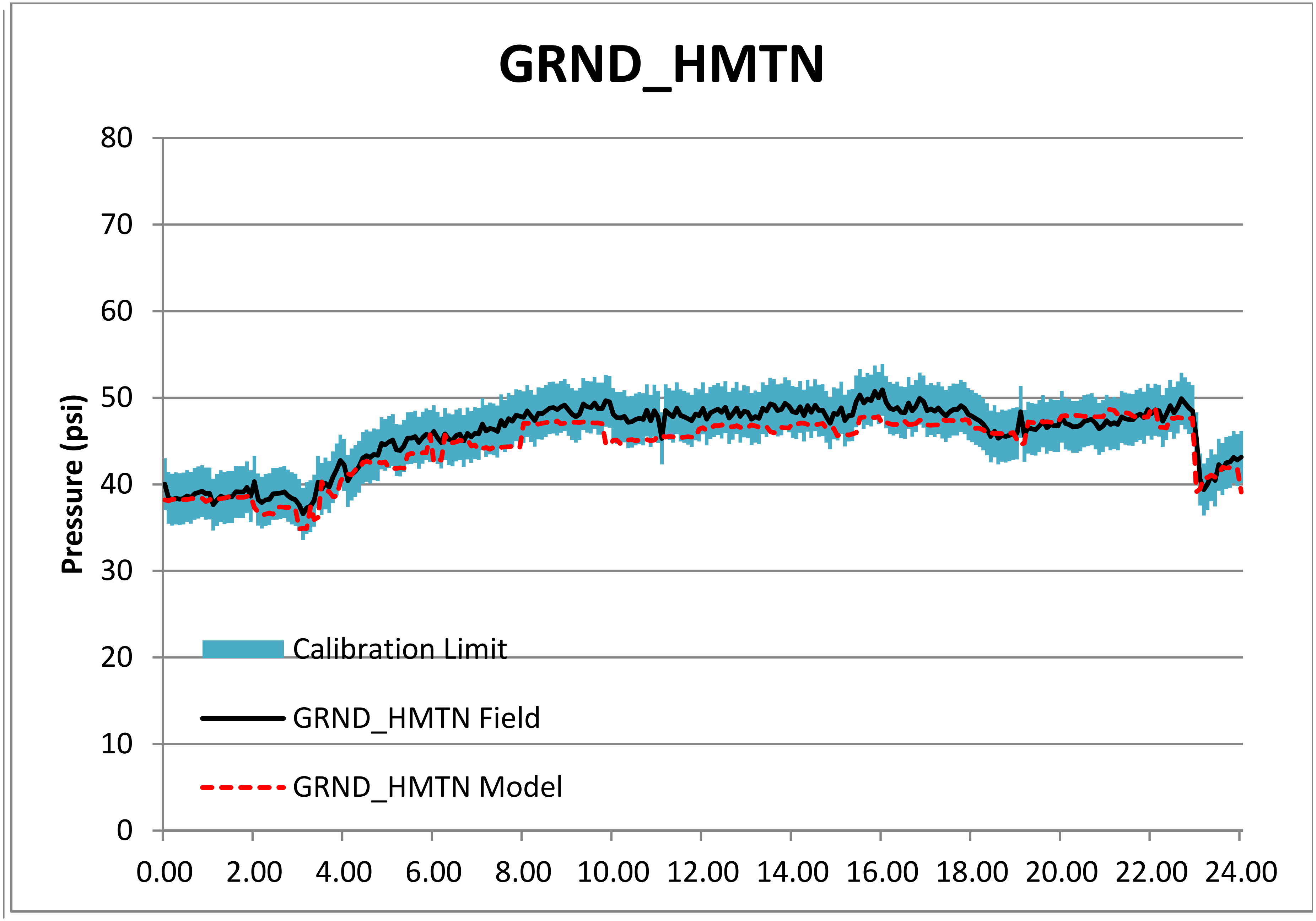
20.00
22.00
24.00


GRND_HMTN
Pressure (psi)
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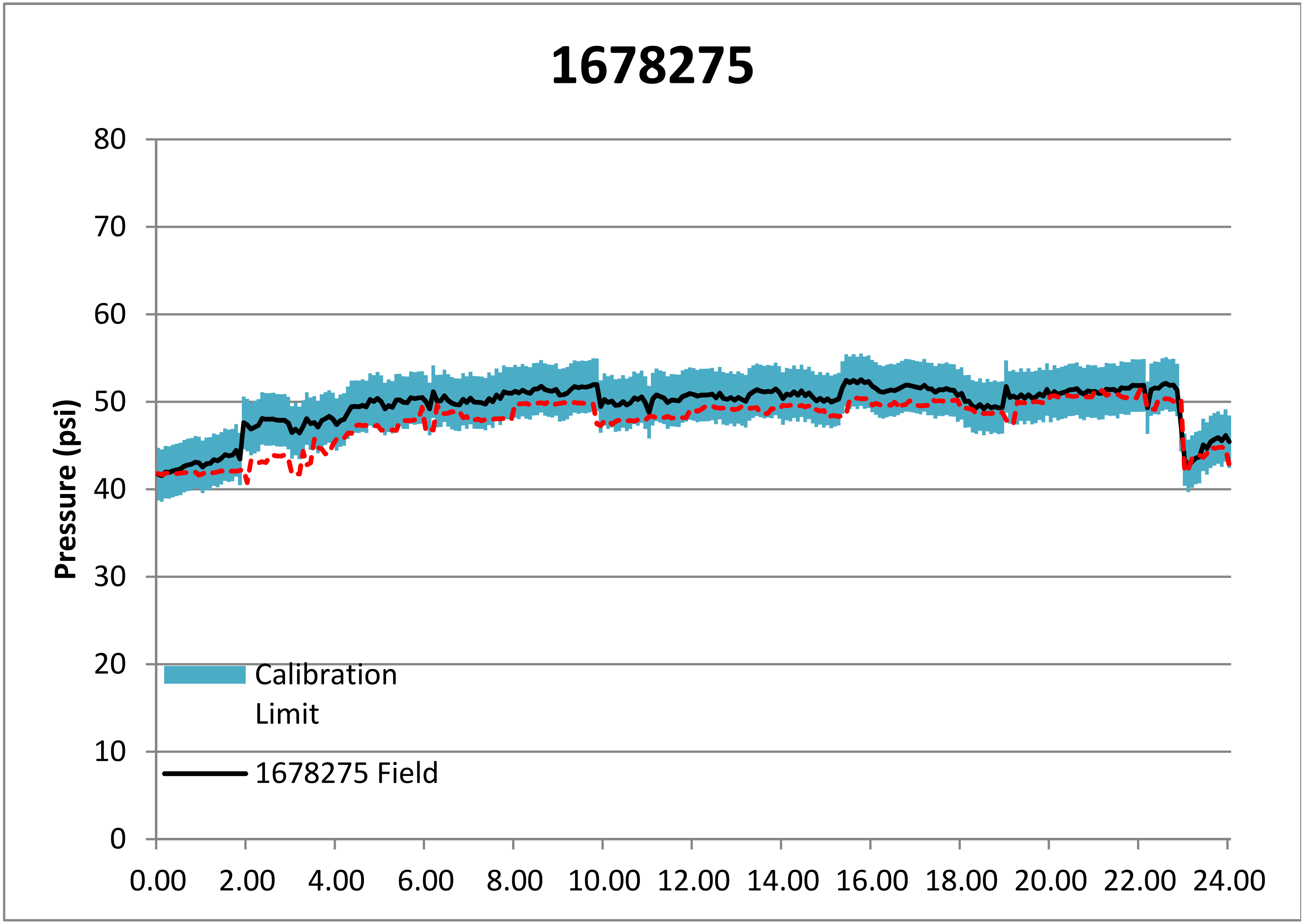
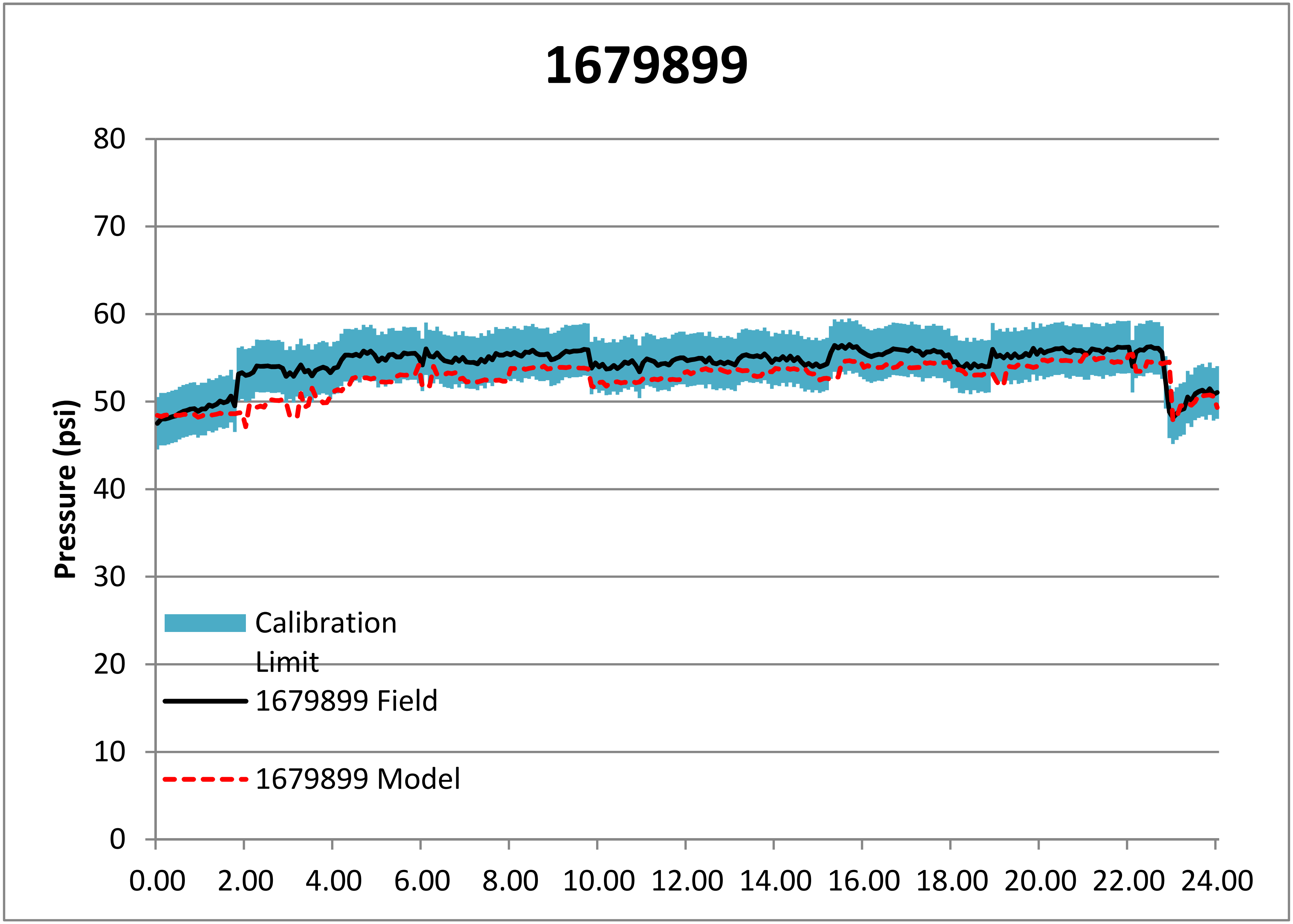
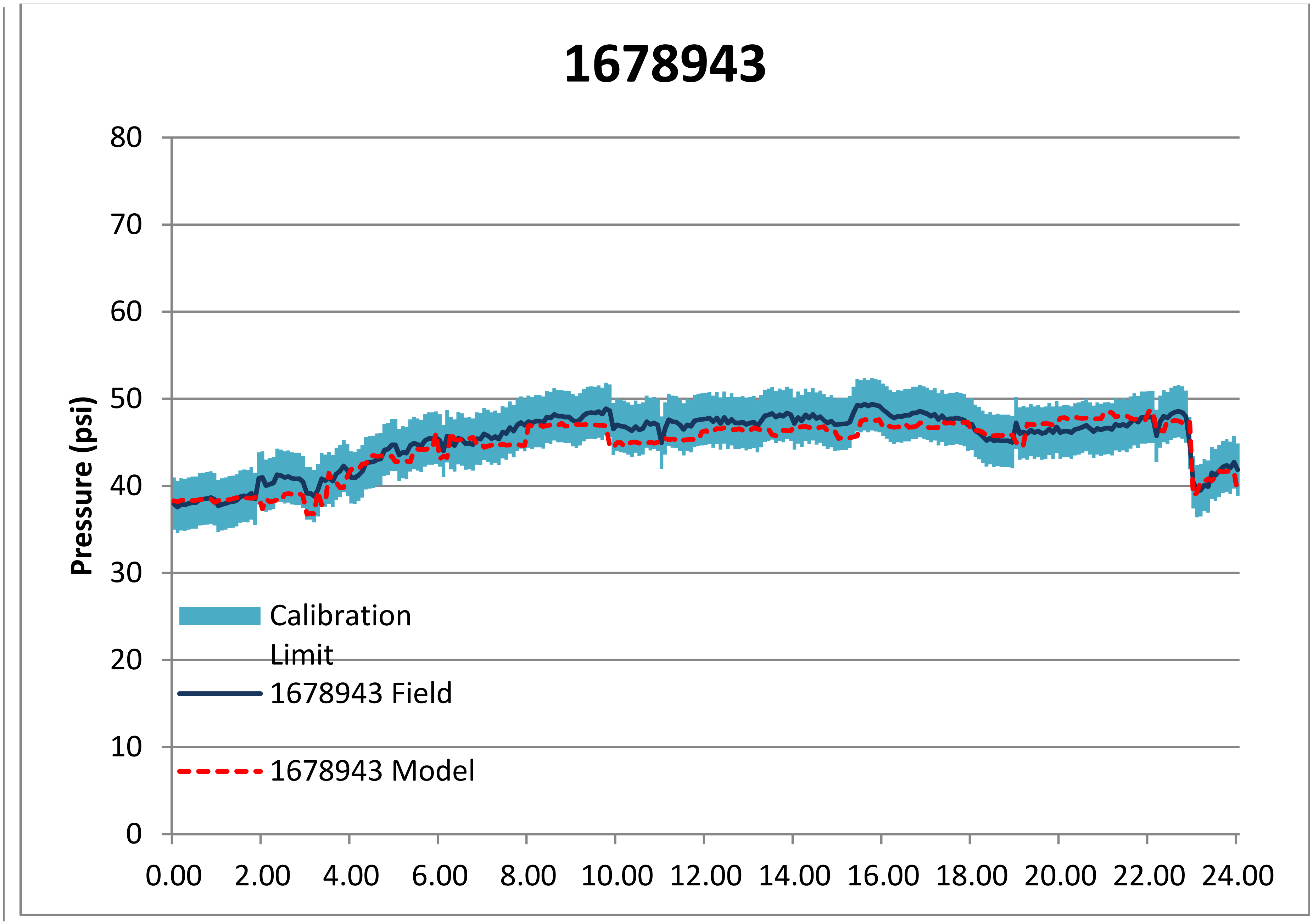
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
GRND_HMTN Field
GRND_HMTN Model



1678275
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1678275 Field



1679899
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1679899 Field
1679899 Model


1678943
Pressure (psi)
80
70
60
50
40
30
20
10
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0.00
2.00
4.00
6.00
8.00
10.00
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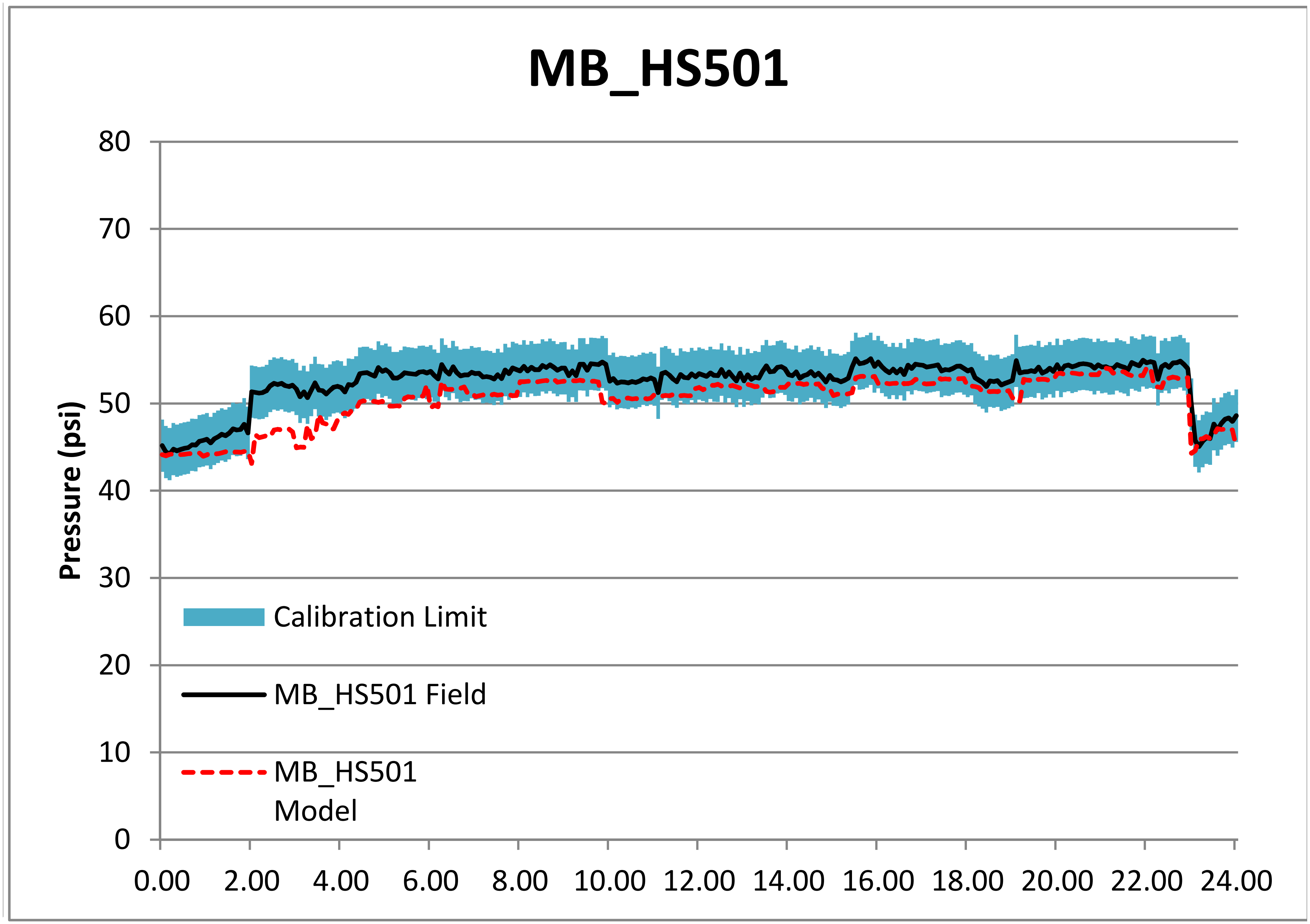
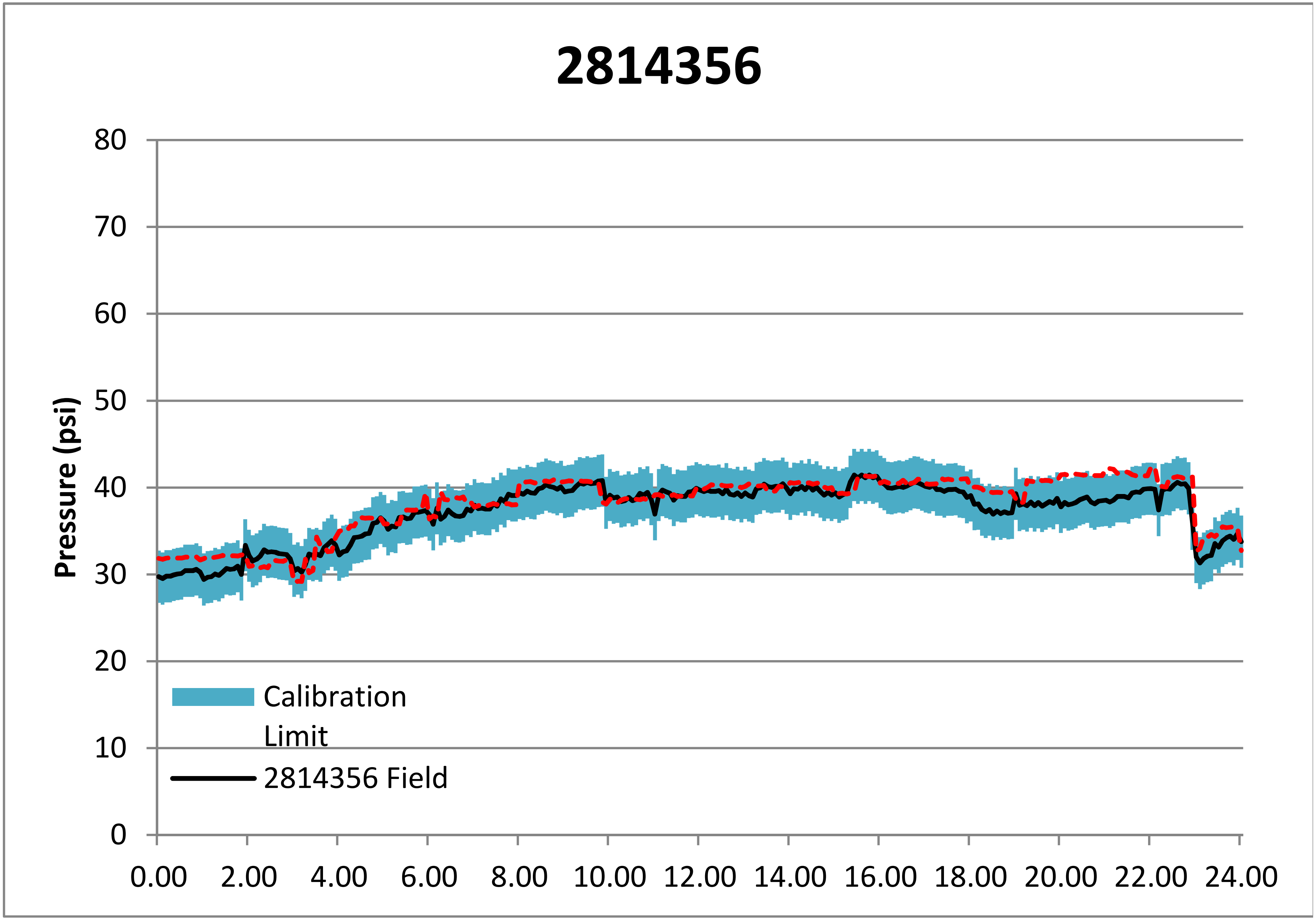
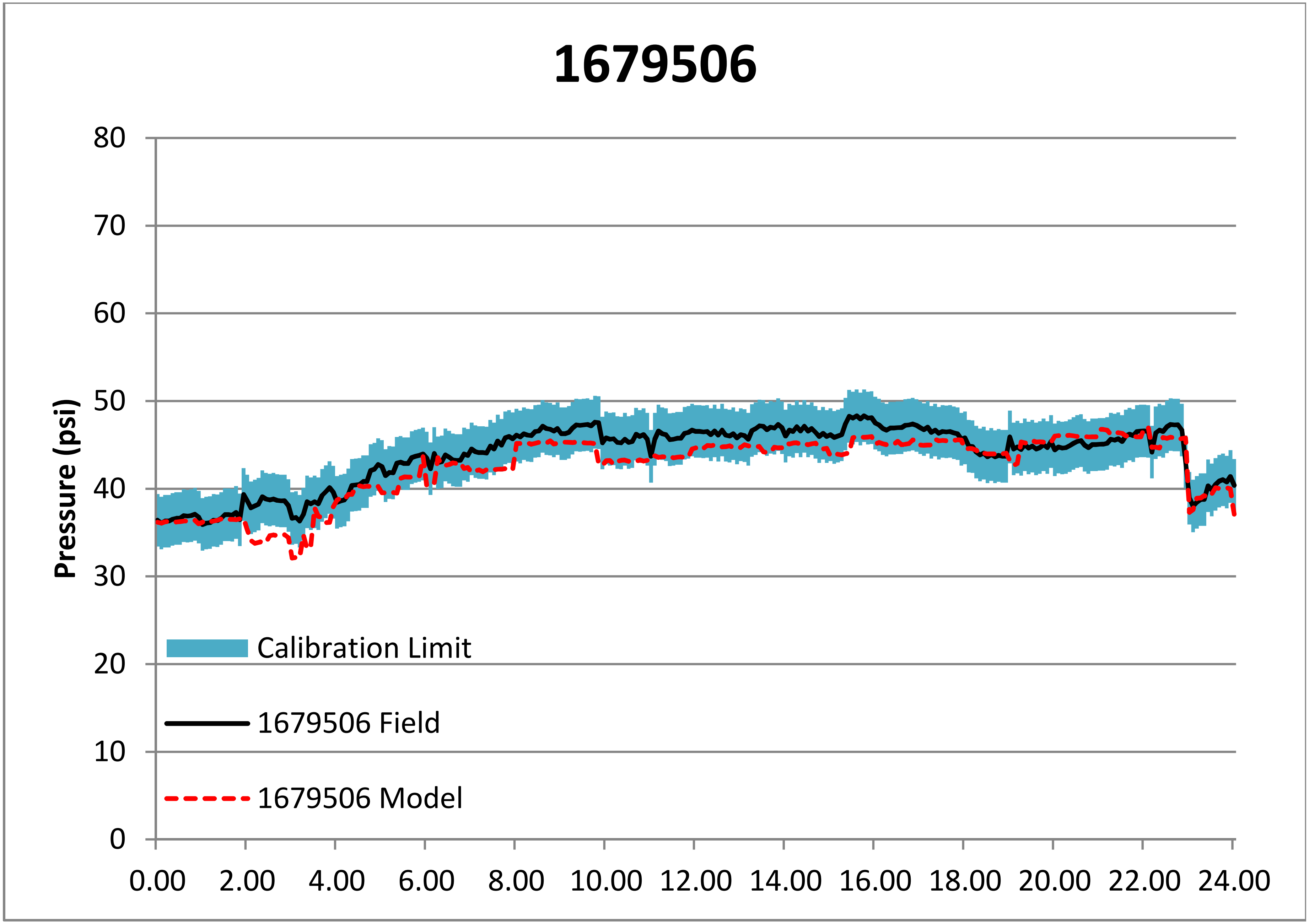
20.00
22.00
24.00
Calibration Limit
1678943 Field
1678943 Model



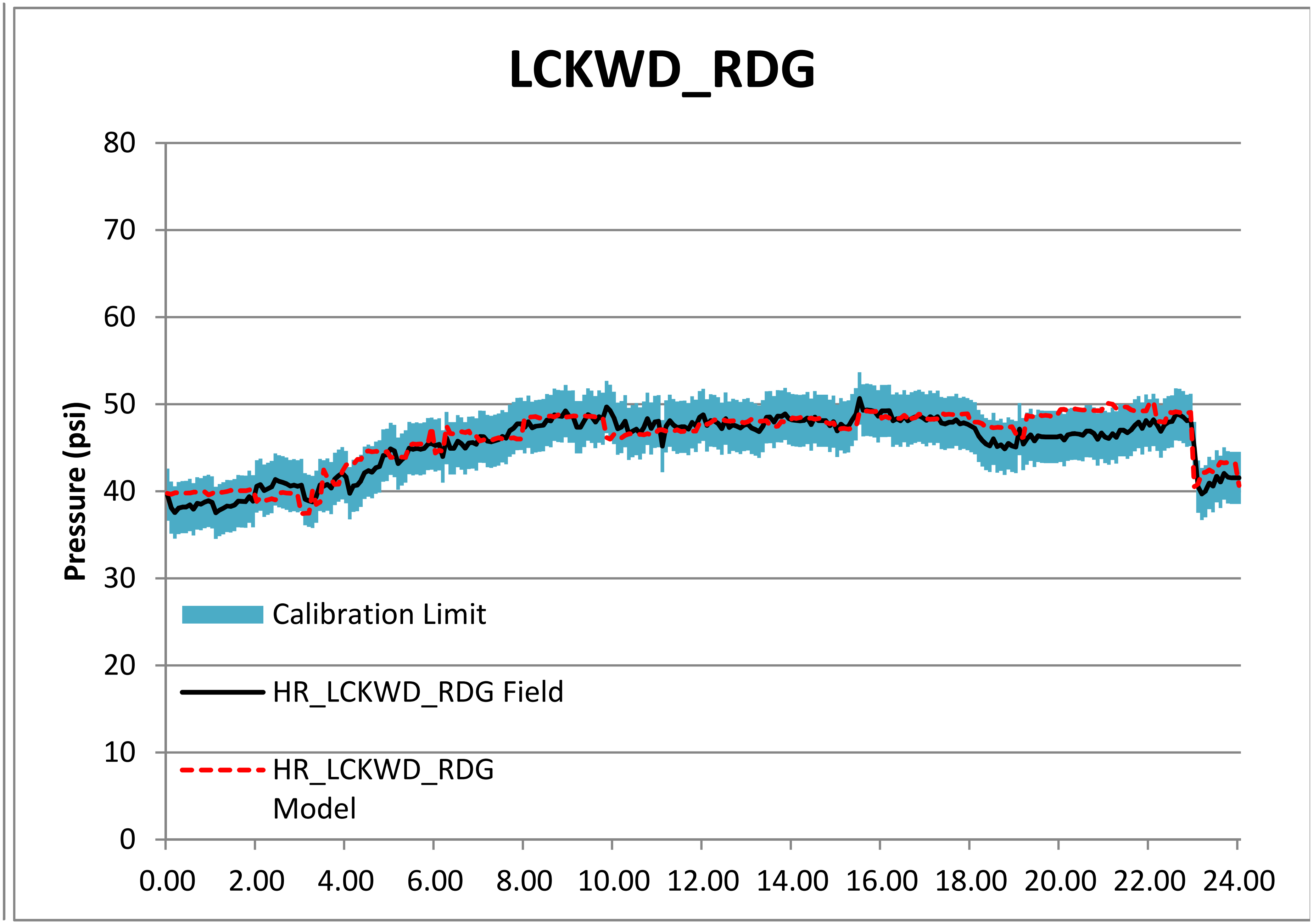
MB_HS501
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
MB_HS501 Field
MB_HS501 Model

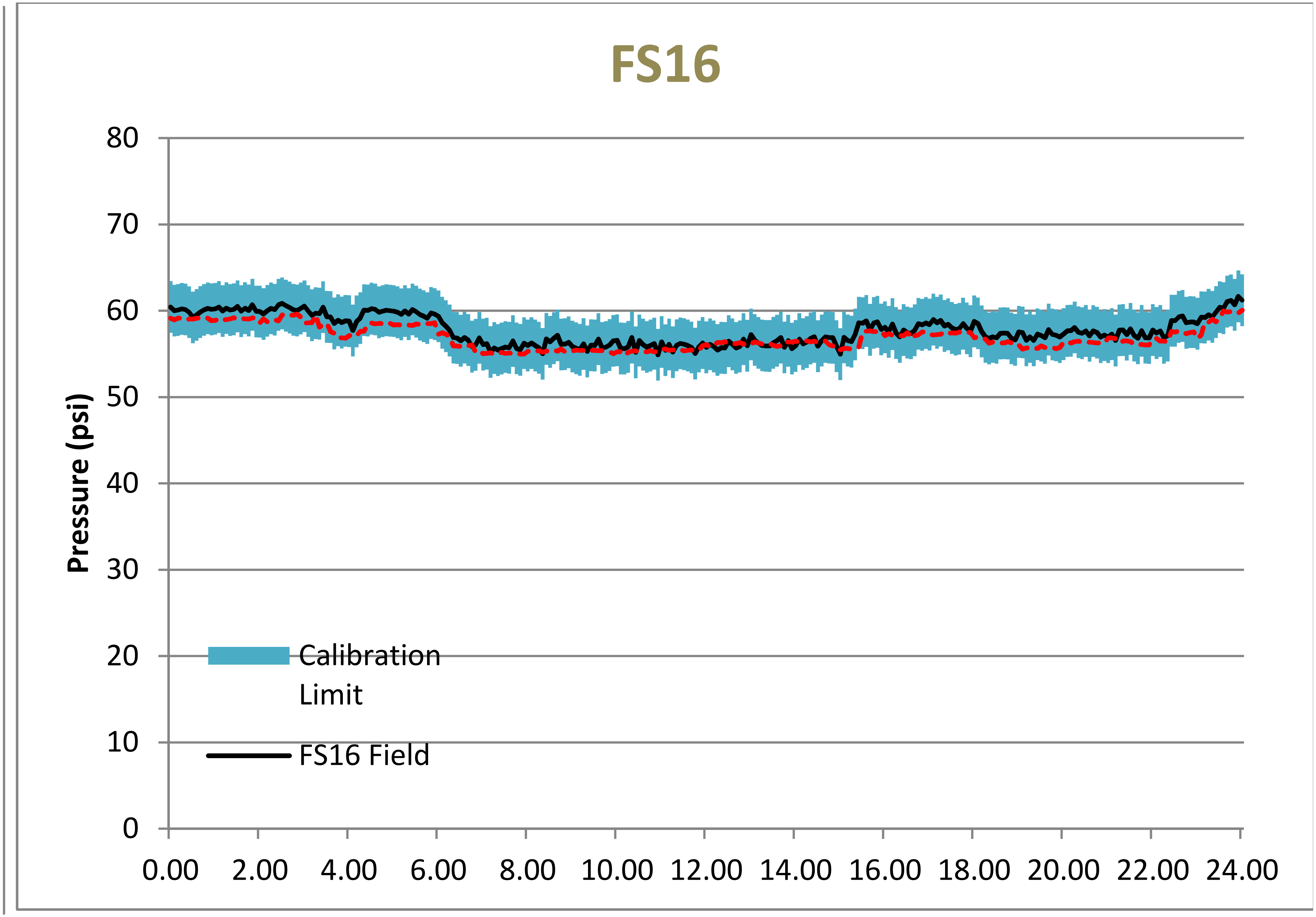


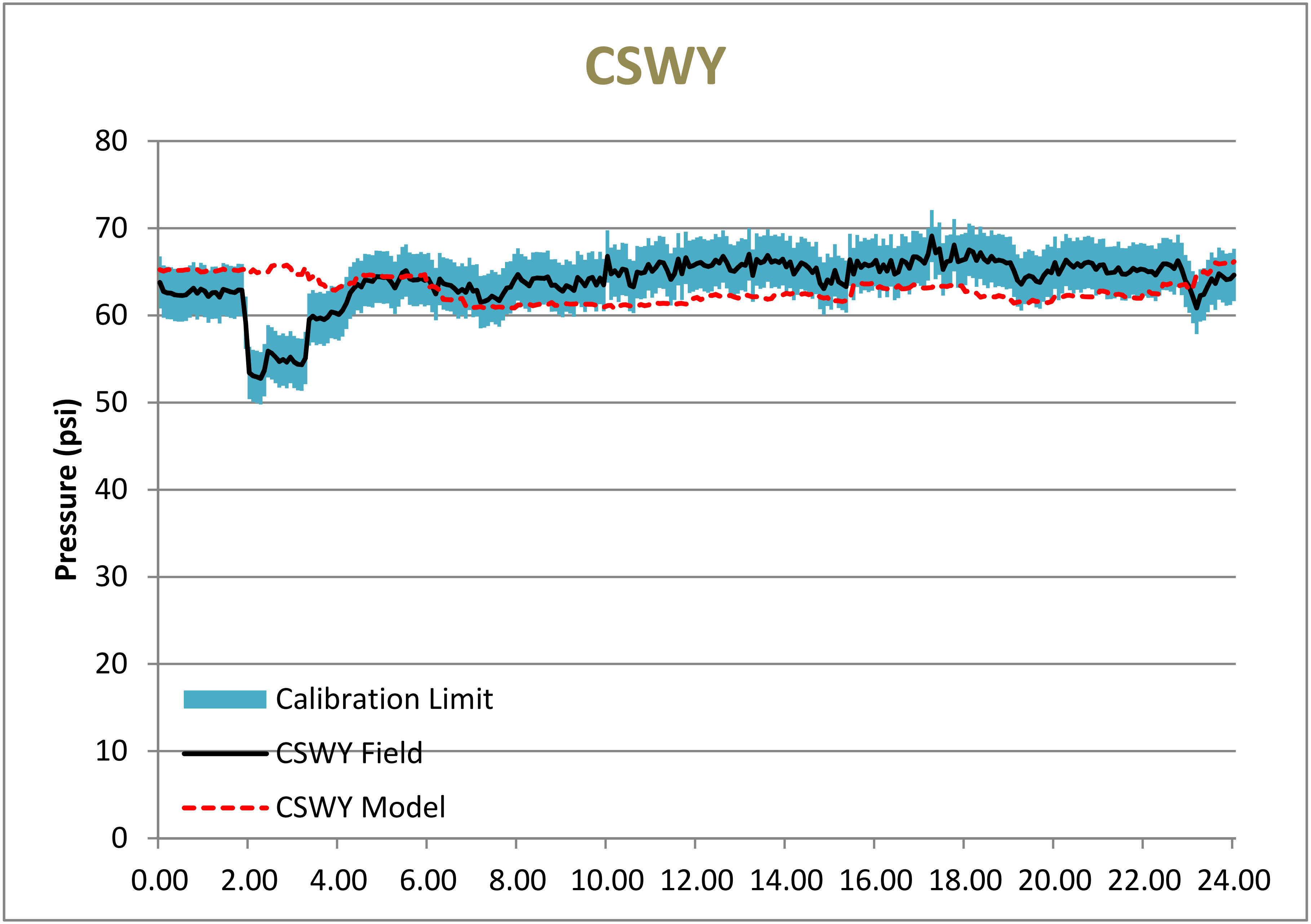
2814356
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
2814356 Field

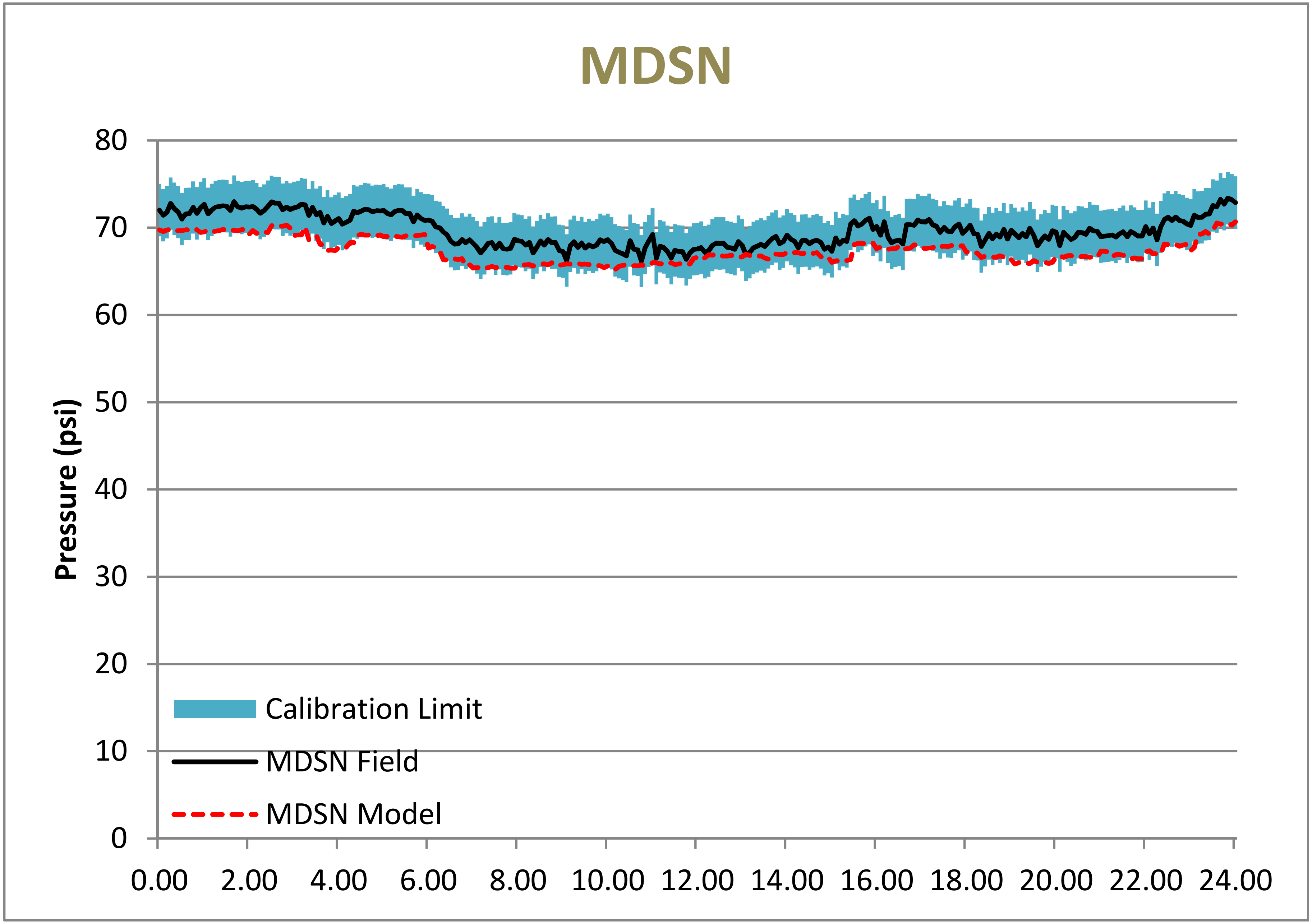


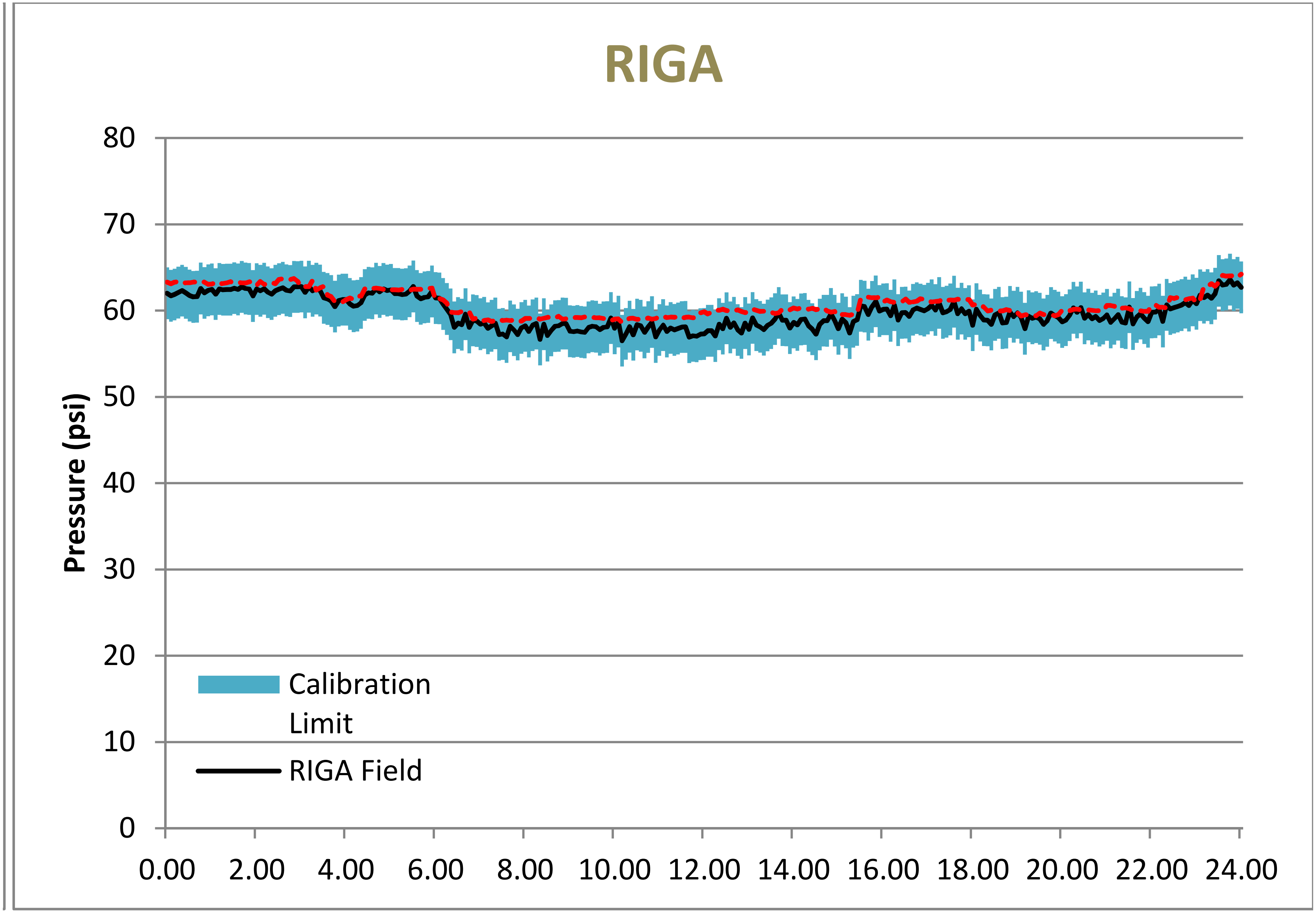
1679506
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1679506 Field
1679506 Model

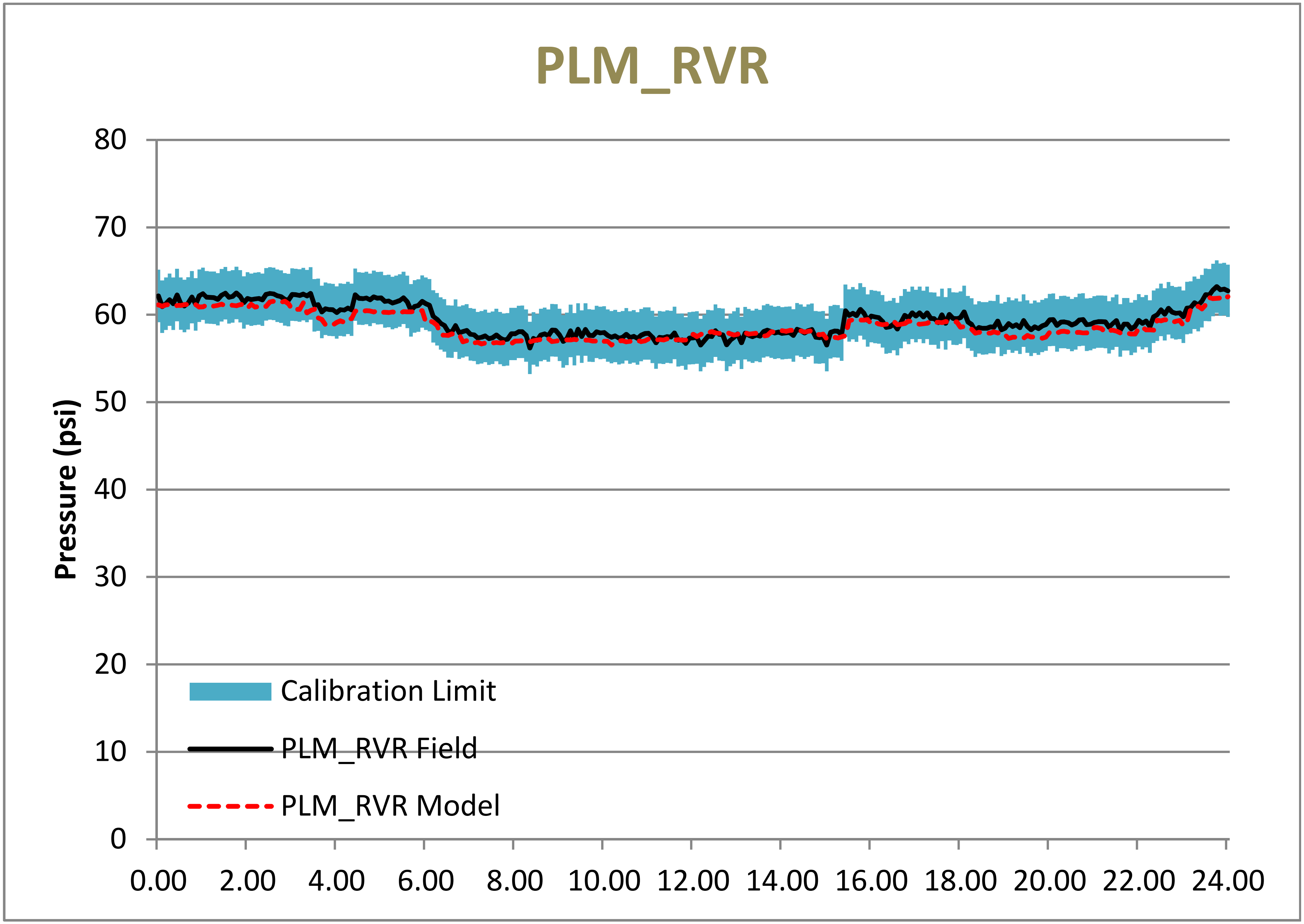

LCKWD_RDG
80
70
60
50
40
30
20
10
0
Pressure (psi)
Calibration Limit
HR_LCKWD_RDG Field
HR_LCKWD_RDG Model
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00


FS16
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS16 Field


CSWY
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
CSWY Field
CSWY Model


MDSN
80
70
60
50
40
30
20
10
0
Pressure (psi)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
MDSN Field
MDSN Model


RIGA
80
70
60
50
40
30
20
10
0
Pressure (psi)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
RIGA Field



PLM_RVR
80
70
60
50
40
30
20
10
0
Pressure (psi)
Calibration Limit
PLM_RVR Field
PLM_RVR Model
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00

CALIBRATION PLAN

City of Tampa
Potable Water Master Plan

B&V Project 190020
B&V File 41.0000.200
November 17, 2015

1. Data Collection Time Frame

- November 2015
- Two week initial period; checking data each week to determine if the data collection window needs to be extended.

2. Pressure Monitoring

- Output **interval at 5 minutes**; polling time to be determine by the City with memory & battery length kept no shorter than two weeks.
- 29 Permanent pressure loggers read from SCADA weekly.
- 9 Temporary loggers: manually downloaded weekly.

Table 1. Location of Temporary Loggers

#	NEIGHBORHOOD / AREA	ADDRESS	HYDRANT FACILITY IDENTIFIER
1	Carrollwood	NEC 9th St & Fowler Ave	1678853
2	New Tampa	SS Amberly Dr; 343 E of S.R. 581 (Bruce B Downs)	1679899
3	New Tampa	WS Bruce B Downs; 553' SW of New Tampa Blvd	1678943
4	New Tampa	SS New Tampa Blvd; 133' E of Commerce Pk	1678275
5	New Tampa	NWC Wild Tamerind Dr. & Early Violet St	2814356
6	New Tampa	SS Cory Lakes Dr; 992' E Cross Creek Dr	1679506
7	Gandy & Westshore	SWC of Gandy Blvd & Westshore Blvd	1683325
8	Seminole Heights	NWC Osborne Abe & 15th St	1674112
9	South of Tampa International Airport	NS TIA S Commerical Rd; 150' W of Obrien St (NEC of Obrien St & W Spruce St)	1673515

B&V Project 190020
B&V File 41.0000.200
November 17, 2015

3. Operational Data/SCADA Information

- Data to be pulled from SCADA on **5 minute intervals** weekly
- Pump Station / Pumps:
    1. On/off status of the pumps for each pump
    2. Pump discharge pressures, final pump station discharge is ok
    3. Pump flow rate; total pump station flow is ok
- Storage Tanks:
    1. Tank levels
    2. Inlet pressures
- PRV / Altitude Valve settings: based on information provided by City during time of data collection
- ASR: Is flow being diverted to the ASR wells? If so what is the flow?
- Any changes in operational strategy or control logic during calibration

4. Miscellaneous Information

Any actions or events that affect typical distribution system pressures and flows should be avoided if possible. However, if any actions/events do occur and impact distribution system pressures or flows, please note with the time, date, location and description of event. If the action/event caused water loss, approximate volume lost should be provided as well. Actions/events affecting the distribution system include, but are not limited to, the following:

- Hydrant Flushing
- Automatic flushing for water quality
- Line breaks
- Fires
- Power failure affecting pumps
- SCADA or Pressure logger failure
- Line replacement/maintenance
- Connection of new large services

5. Communication Protocol

Fire Department: Inform the Fire Department that additional pressure loggers will be installed for a minimum of two weeks and up to one month. Let them know to contact you incase with questions. Provide them with the list and figure illustrating the location of hydrants out of service.

Operations: Inform the Operations Staff that we are collection data for calibration. Request that they refrain from maintenance items that would skew the data from normal conditions like calibrating pumps or flushing water mains. Ask them to report if unusual conditions occur. They are always welcome to call B&V if they have questions. Schedule a meeting with them just prior to or after data collection to review operating procedures during calibration and for the system analysis.

B&V Project 190020
B&V File 41.0000.200
November 17, 2015

6. Calibration Result Comparison

- Storage Tanks
  1. Interbay (Level)
  2. Northwest (Level)
  3. Morris Bridge (Level, East & West)
  4. Palma Ciea (Level, Pressure)
  5. West Tampa (Level, Pressure)

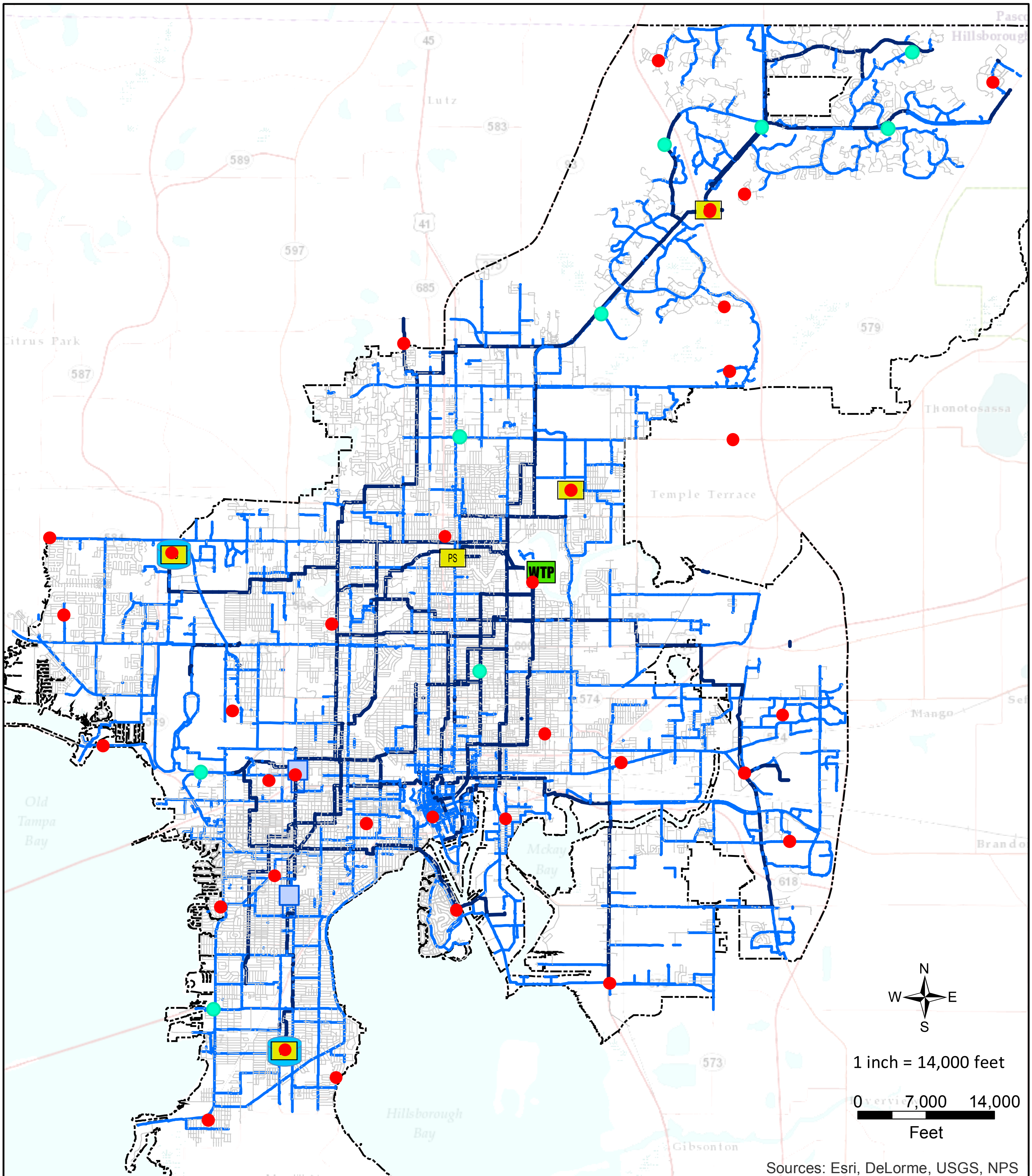
- Pump Stations
  1. DLTWTF (Pressure, Flow, Speed)
  2. MB Repump (Pressure, Flow)
  3. Busch (Pressure, Flow, Status)
  4. Interbay (Suction/Discharge pressure, Flow, Venturi Flow, Speed)
  5. Northwest (Pressure, Flow)
  6. Palma Ceia (Pressure, Flow)
  7. West Tampa (Pressure, Flow)
  8. NB Booster, Sulphur Springs

- Valves
  1. FPSV-IB-1(Status)
  2. PSV-MB1(Status)

- Interconnection Flow & Pressures
  1. Morris Bridge POC (Flow)
  2. US 301 / TBI (Flow)
  3. THIC (Flow)

- Pressures at loggers = 39 locations, 29 permanent & 9 temporary listed above

- Operating Protocols



CITY OF TAMPA

Potable Water Master Plan

Figure A

Pressure Logger Location

DRAFT

EXISTING PUMP STATIONS, TANKS AND CONTROL LOGIC

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

31 MARCH 2016

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Introduction

The City of Tampa Water Department (TWD) maintains and operates the potable water distribution system throughout the City of Tampa service area. This memorandum summarizes the existing distribution system facilities and their control strategies.

Existing Pump Station and Tank Summary

The distribution system consists of six pump stations containing 25 pumps and six storage tanks (excluding the David L. Tippin WTF clearwells). **Table 1 and 2** below summarize the location and size of the various distribution system tanks and pumps, and **Figure 1** illustrated the relative connectivity of the pump stations. NOTE: the Busch Gardens pump station is no longer in operation and the Sulphur Springs pump station is a raw water station and thus are not included in this summary.

Table 1: Existing Water Distribution Storage Tanks

STORAGE TANK	NO.	TYPE (GROUND/ ELEVATED)	DIA. (FT)	BASE ELEV. (FT)	SIDEWATER DEPTH (FT)	STORAGE VOL. (MG)	TOTAL VOL. (MG)	TOTAL EFFECTIVE VOL. (MG)
D.L. Tippin Clearwell	1	Buried	333 x 288	20.5 -21.5	12.5	7.5	20.0	12.5
	1	Buried	108 x 542	19.5 – 20	13.75	5		
	1	Buried	289 x 199	19.5	14	5		
	1	Buried	92 x 92	22	10.1	0.5		
	1	Buried	180 x 120	18.5	12.6	2		
Morris Bridge Ground Tank	2	Ground	170	40	29.5	5.0	10.0	7.5
Northwest Ground Tank	1	Ground	128	20	31.75	3.0	3.0	3.0
Interbay Ground Tank	1	Ground	163	10.65	30	5.0	5.0	5.0
West Tampa Elevated Tank	1	Elevated	varies	110	35	1.5	1.5	1.5
Palma Ceia Elevated Tank	1	Elevated	varies	120	35	1.5	1.5	1.5

Table 2: Existing Water Distribution Pump Stations

PUMP STATION (INSTALL YEAR)	NO.	RATED CAPACITY (GPM / MGD)	RATED TDH (FT)	MOTOR (TYPE)	POWER REDUNDANCY	TOTAL CAPACITY (MGD)	FIRM CAPACITY (RATED / MODELED)
D.L. Tippin WTP - High Service Pump Station	1	8,000 / 11.5	233	Constant	2 Utility Feeds and Generators[a]	173.0	148.0 / 148.0
	2	5,500 / 7.9	267	Constant			
	3	6,000 / 8.6	240	Constant			
	4	6,600 / 9.5	236	Constant			
	5	9,000 / 13.0	240	VFD			
	6	10,000 / 14.4	235	Constant			
	7	12,000 / 17.3	230	VFD			
	8	12,000 / 17.3	230	VFD			
Morris Bridge Repump Station	1	11,200 / 16.1	142	VFD	2 Utility Feeds and Generator	91.0[b]	60.0 / 54.5
	2	11,200 / 16.1	142	VFD			
	3	11,200 / 16.1	142	VFD			
	4	11,200 / 16.1	142	VFD			
	5[c]	3,111 / 4.5	149	VFD			
	6[c]	4,132 / 6.0	188	VFD			
Northwest Repump Station	1[c]	3,000 / 4.3	181	Constant	1 Utility Feed and Generator	12.0[b]	8.0[b] / 7.7
	2	2,100 / 3.0	154	Constant			
	3[c]	2,100 / 3.0	154	Constant			
Interbay Repump Station	1	3,000 / 4.3	150	VFD	1 Utility Feed and Generator	18.0[b]	13.0[b] / 11.4
	2	3,000 / 4.3	150	VFD			
	3	3,000 / 4.3	150	VFD			
	4[c]	3,000 / 4.3	150	VFD			
	5	1,000 / 1.4	35	VFD			
	6	1,000 / 1.4	35	VFD			
West Tampa Repump (1991)	1	5,000 / 7.2	45	Constant	1 Utility Feed	7.2	0.0 / 0.0
Palma Ceia Repump (2000)	1	5,000 / 7.2	45	Constant	1 Utility Feed	7.2	0.0 / 0.0

(a) Generator Capacity is limited to approximately 82 MGD capacity.

(b) Total and Firm Capacities were taken from the 2009 City of Tampa Master Plan, however they do not match the curves in the model.

(c) Rating points were compared to the best available pump curves. Possible discrepancies exist for Morris Bridge Pump #5, Morris Bridge Pump #6, North West Pump #1, North West Pump #3, and Interbay Pump #4. The City would benefit from performing pump curves in situ.

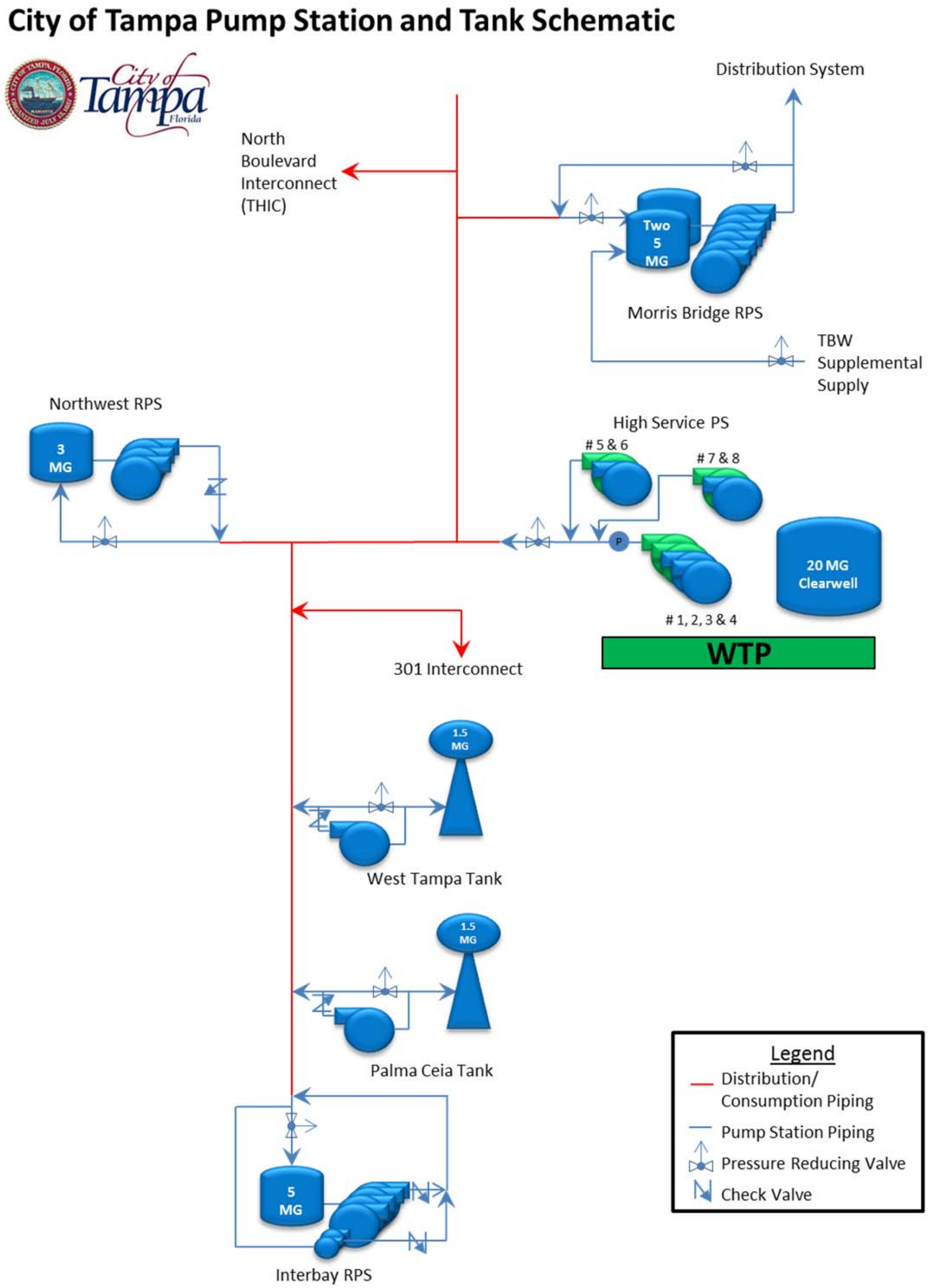

Figure 1: Pump Station and Tank Schematic

Controls

HIGH SERVICE PUMP STATION

The high service pump stations are located on the D.L. Tippin WTF site. There are three sets of pumps which manifold inside the WTP property. All of the pumps have similar head capacities. Half of the pumps are powered by the Tampa Electric Company (TECO) connection "A" and the other half is powered by the second connection "C". Operators manually select a combination of pumps that allow at least 1 pump from each power supply source to be in use at all times. This operating strategy reduces the potential for a power outage event to result in a temporary total loss of supply being delivered into the distribution system.

In addition to the selection of pumps to balance the incoming power supply, operators manually select a combination of pumps to maintain a set discharge pressure. The pressure is measured in the main pump house that houses Pumps 1 – 4 and is typically set at 65 pounds per square inch (psi). Pumps 5, 7 and 8 are equipped with variable frequency drives (VFD). The remaining pumps have constant speed drives. Operators select a combination of constant speed and VFD pumps to maintain the pressure control setting.

The minimum to maximum level range noted for the clearwell is 6 to 12 feet, with a typical goal of trying to avoid levels below 8 feet. The discharge pressure control set point may be lowered by Operators to allow the clearwell to fill, or the control set point may be increased to drawdown the clearwell. The goal of the operators is to maintain a near constant flow throughout the WTP into the clearwell to maximize treatment efficiency. For the purposes of the system analysis, the WTP discharge setting will be constant at 65 psi, unless specifically noted otherwise.

Flow from the WTP is measured by 5 venturi flow meters.

AQUIFER STORAGE AND RECOVERY

Flow to the aquifer storage and recovery (ASR) system is controlled by flow control valves (FCV) at each injection well. There are no dedicated transmission mains to transfer flow from the WTP to the ASR injection wells; rather the ASR injection system utilizes the potable water transmission system to transfer flow. When in operation, the flow to the ASR injection system is typically maintained at a constant 10 million gallons per day (MGD) and does not require additional pressure beyond the normal transmission system pressures to inject water into the aquifer. Water recovered from the ASR system is returned to the Tippin WTP through a dedicated raw water transmission line.

NORMAL PUMP STATION AND TANK OPERATIONS

All of the pump stations and associate storage tanks in the system act as repump stations (RPS). The water levels in the elevated storage tanks are below the hydraulic grade line (HGL) of the system. Therefore, control valves are used to control the flow into the elevated tanks, and pumps are used to send water from the elevated tanks into the distribution system. The TWD turns over a minimum of 1/3rd of the volume of each storage tank daily to keep the water fresh and maintain appropriate disinfectant residuals.

Tank Filling Controls

The tanks are typically filled at night and then drained down at specific periods throughout the day. However, they are normally bypassed. The typical tank filling sequence starts around 11 PM with the third shift. The following is the order in which the tanks are filled:

1. Morris Bridge RPS / Interbay RPS (typically begin filling at 11pm)
2. Northwest RPS
3. West Tampa Elevated Tank
4. Palma Ceia Elevated Tank

Typically the Morris Bridge RPS will complete filling first and once it's full the Northwest RPS is opened for filling. The West Tampa Elevated Tank is only opened for filling once the Interbay and Northwest RPSs are full. Finally, the Palma Ceia Elevated Tank is filled once the West Tampa Elevated Tank is full. The whole process typically takes around 6 hours (11PM to 5 AM) and the goal is to complete all filling before the morning peak demand period, starting approximately at 5 AM.

Each tank is equipped with an altitude valve to allow filling of the tanks without dropping the distribution system pressures below desired levels.

Normal Pump Controls

During average day conditions the repump stations are manually operated to force tank turn over. The goal of each shift is to lower the tank water levels by approximately 5 to 6 ft. The pump operation order follows the same order as the tank filling listed above. NOTE: The Morris Bridge RPS and Northwest RPS are rarely filled or operated at the same time due to proximity with each other. Similarly, the West Tampa and Palma Ceia Elevated tanks are rarely filled or pumped out of at the same time.

MORRIS BRIDGE REPUMP STATION

The Morris Bridge RPS is located in the northeast portion of the system, serving the area called New Tampa, located east of Interstate 75 (I-75) along Bruce B. Downs Blvd and Cross Creek Blvd. The station has two 5 MG ground storage tanks and six pumps with VFDs. During minimum or average day demands there is only one tank in operation and the pumps are operated to turn over the water within the tank as described above. However, during elevated demand periods, the pumps are operated to manage the pressures within the New Tampa area and the tanks may be filled during the day.

There are three permanent pressure loggers installed east of I-75 located at Hampton Lake Dr., Pictoral Park Dr. and Lockwood Ridge Rd. Operators monitor the pressures at these three locations to support decisions regarding the operation of the Morris Bridge RPS. Typically, the operation is based on maintaining a minimum of 40 psi at the Lockwood Ridge Rd pressure logger. Pump selection and control set point are manually controlled by the operators.

There are separate tank fill lines and pump suction lines connecting the tank and it is possible to fill the tank and operate the pumps simultaneously, however there will be some recirculating of flow with the current configuration. There are plans underway to update the piping to eliminate the recirculation and allow flow to be fully directed to the New Tampa area.

The minimum to maximum level range noted for the ground storage tanks is 6 to 29 feet, with a typical goal of trying to avoid levels below10 feet.

Tampa Bay Water Supplemental Supply @ Morris Bridge

The Morris Bridge RPS is one of the locations where the TWD may obtain supplemental supply when the distribution system demands cannot be met by the WTP either due to treatment capacity or limitations on the source water supply. The agreement between the City and Tampa Bay Water (TBW) allows the TWD to purchase up to 40 MGD of finished water supply from through the Morris Bridge Interconnect.

Flow through the interconnect is controlled by TWD operators via a flow control valve and is discharged into one of the ground storage tanks on the Morris Bridge RPS site. All of the flow from the TBW interconnect is repumped by the Morris Bridge RPS. NOTE: There is a 2-inch bypass around the FCV to maintain fresh water and an appropriate disinfectant residual in the transmission main between the TBW system and the tank at Morris Bridge RPS.

NORTHWEST REPUMP STATION

The Northwest RPS is located in the northwest portion of the distribution system. The station has one ground storage tank and three pumps, which have constant speed drives. The station is third in line for filling and pump operation, and is only operated once the Morris Bridge RPS tank is full / pumps are off.

INTERBAY REPUMP STATION

The Interbay RPS is located in the most southern portion of the system just north of MacDill Air Force Base (MacDill) in the area known as South Tampa. The station has one ground storage tank and six pumps; three pumps are the same size, the fourth is a slightly larger pump, and two are jockey pumps. The pumps are equipped with VFDs, but are typically operated at full speed when on and manually turned on/off. This station is filled and the pumps are operated at the same time as the Morris Bridge RPS.

Pressure control options are available at the station allowing the larger pumps to maintain a constant discharge pressure of 50 psi and the jockey pumps to maintain 65 psi, but those controls are rarely used. Additionally, the jockey pumps are not used on a daily basis.

There is also a check valve between the distribution system and the tank fill line to prevent any short-circuiting of flow in the system.

WEST TAMPA AND PALMA CEIA ELEVATED TANKS AND REPUMP STATIONS

Both the West Tampa and Palma Ceia RPS are located in South Tampa and are connected to the same transmission main as the Interbay RPS. Each station has one 1.5 MG elevated storage tank and one constant speed pump. These tanks are the last two tanks to be filled and the pumps are the last two to operate during each shift.

Even though the storage tanks are elevated, these tanks are operated as repump stations since the HGL of the distribution system is higher than the overflow level within the tanks, and the tanks therefore cannot float on the system pressure. The stations are never filled at the same time and the pumps are never operated at the same time due to their close proximity to each other.

INTERCONNECTIONS

The City has three interconnections with TBW. Two interconnections allow TBW to supply the TWD with supplemental flow, Morris Bridge and US 301, and one interconnection allows TWD to supply Hillsborough County on behalf of TBW. The interconnection with Hillsborough County is known as either the North Blvd Interconnect or the Tampa Hillsborough Interconnect (THIC).

The controls for the Morris Bridge interconnect are described above.

The US 301 Interconnect is currently used for emergency purposes only and is rarely used.

The North Blvd interconnect is not controlled by the TWD and is normally set at a constant flow rate of 1.14 MGD.

The City also has a number of interconnections with Hillsborough County; however these operate as a normal customer connection and are controlled by demand.

EMERGENCY CONTROL SETTINGS AT REPUMP STATIONS

There are automated emergency controls associated with each repump station, such as pumps turning on if the system pressure drops below 35 psi. Details regarding these emergency controls were not discussed and are outside of the scope of work associated with this Potable Water Master Plan update.

CONTROL SUMMARY

Tables 3, 4, 5 and 6 below summarize the controls that will be used for the Potable Water Master Plan. **Table 3** shows the normal tank filling controls that occurs once daily.

Table 4 shows the tank filling controls during elevated demands and when the TWD decides to purchase water from TBW. **Table 5** shows the normal pump operation per shift at each pump station. **Table 6** shows the pump operation during elevated demand periods. It is difficult to maintain pressures in New Tampa during elevated demands and the Morris Bridge RPS needs to operate more often and using pressure controls.

Table 3: Tank Fill during Normal Operation

STORAGE TANK	OPERATION	CONTROLTYPE	CONTROL LOCATION	CONTROL VALUE
Morris Bridge Ground Tank	OPEN	Time Based	NA	11:00 PM
	CLOSED	Level Based	Morris Bridge Tank	28.0 ft
Northwest Ground Tank	OPEN	Level Based	Morris Bridge Tank	28.0 ft
	CLOSED	Level Based	Northwest Tank	28.0 ft
Interbay Ground Tank	OPEN	Time Based	NA	11:00 PM
	CLOSED	Level Based	Interbay Tank	28.0 ft
West Tampa Elevated Tank	OPEN	Level Based	Interbay Tank	28.0 ft
	CLOSED	Level Based	West Tampa Tank	29.0 ft
Palma Ceia Elevated Tank	OPEN	Level Based	West Tampa Tank	29.0 ft
	CLOSED	Level Based	Palma Ceia Tank	27.0 ft

Table 4: Tank Fill when Accepting Supplemental Flow

STORAGE TANK	OPERATION	CONTROLTYPE	CONTROL LOCATION	CONTROL VALUE
Morris Bridge Ground Tank	OPEN	Time Based	NA	11:00 PM
	CLOSED	Level Based	Morris Bridge Tank	28.0 ft
Northwest Ground Tank	OPEN	Level Based	Morris Bridge Tank	28.0 ft
	CLOSED	Level Based	Northwest Tank	28.0 ft
Interbay Ground Tank	OPEN	Time Based	NA	11:00 PM
	CLOSED	Level Based	Interbay Tank	28.0 ft
West Tampa Elevated Tank	OPEN	Level Based	Interbay Tank	28.0 ft
	CLOSED	Level Based	West Tampa Tank	29.0 ft
Palma Ceia Elevated Tank	OPEN	Level Based	West Tampa Tank	29.0 ft
	CLOSED	Level Based	Palma Ceia Tank	27.0 ft

Table 5: Pump Operation Average Day Demands

STORAGE TANK	OPERATION	# OF PUMPS	CONTROLTYPE	CONTROL LOCATION	CONTROL VALUE
High Service Pumps	ON	1-8 VFD	Discharge Pressure	High Service Pump Station	65 psi
Morris Bridge	ON	2	Time Based	NA	5:00 AM
	OFF		Level Based	Morris Bridge Tank	24.5 ft
	ON		Time Based	NA	7:00 AM
	OFF		Level Based	Morris Bridge Tank	19.5 ft
	ON		Time Based	NA	3:00 PM
	OFF		Level Based	Morris Bridge Tank	14.5 ft
Northwest	ON	1	Level Based	Morris Bridge Tank	24.5 ft
	OFF		Level Based	Northwest Tank	26.75 ft
	ON		Level Based	Morris Bridge Tank	19.5 ft
	OFF		Level Based	Northwest Tank	21.75 ft
	ON		Level Based	Morris Bridge Tank	14.5 ft
	OFF		Level Based	Northwest Tank	16.75 ft
Interbay	ON	1	Time Based	NA	5:00 AM
	OFF		Level Based	Interbay Tank	14.0 ft
	ON		Time Based	NA	7:00 AM
	OFF		Level Based	Interbay Tank	11.0 ft
	ON		Time Based	NA	3:00 PM
	OFF		Level Based	Interbay Tank	8.0 ft
West Tampa	ON	1	Level Based	Interbay Tank	14.0 ft
	OFF		Level Based	West Tampa Tank	30.0 ft
	ON		Level Based	Interbay Tank	11.0 ft
	OFF		Level Based	West Tampa Tank	25.0 ft
	ON		Level Based	Interbay Tank	8.0 ft
	OFF		Level Based	West Tampa Tank	20.0 ft
Palma Ceia	ON	1	Level Based	West Tampa Tank	30.0 ft
	OFF		Level Based	Palma Ceia Tank	30.0 ft
	ON		Level Based	West Tampa Tank	25.0 ft
	OFF		Level Based	Palma Ceia Tank	25.0 ft
	ON		Level Based	West Tampa Tank	20.0 ft
	OFF		Level Based	Palma Ceia Tank	20.0 ft

Table 6: Pump Operation Elevated Demands (Maximum Day Demands)

STORAGE TANK	OPERATION	# OF PUMPS	CONTROLTYPE	CONTROL LOCATION	CONTROL VALUE
High Service Pumps	ON	1-8 VFD	Discharge Pressure	High Service Pump Station	65 psi
Morris Bridge	ON	2	Time Based	NA	5:00 AM
	ON		Pressure	Lockwood Logger	40 psi
	OFF		Time Based	NA	10:00 AM
	ON		Time Based	NA	5:00 PM
	ON		Pressure	Lockwood Logger	40 psi
	OFF		Time Based	NA	8:00 PM
Northwest	ON	1	Time Based	NA	10:00 AM
	OFF		Level Based	Northwest Tank	21.75 ft
	ON		Time Based	NA	8:00 PM
	OFF		Level Based	Northwest Tank	16.75 ft
Interbay	ON	1	Time Based	NA	5:00 AM
	OFF		Level Based	Interbay Tank	14.0 ft
	ON		Time Based	NA	7:00 AM
	OFF		Level Based	Interbay Tank	11.0 ft
	ON		Time Based	NA	3:00 PM
	OFF		Level Based	Interbay Tank	8.0 ft
West Tampa	ON	1	Level Based	Interbay Tank	14.0 ft
	OFF		Level Based	West Tampa Tank	30.0 ft
	ON		Level Based	Interbay Tank	11.0 ft
	OFF		Level Based	West Tampa Tank	25.0 ft
	ON		Level Based	Interbay Tank	8.0 ft
	OFF		Level Based	West Tampa Tank	20.0 ft
Palma Ceia	ON	1	Level Based	West Tampa Tank	30.0 ft
	OFF		Level Based	Palma Ceia Tank	30.0 ft
	ON		Level Based	West Tampa Tank	25.0 ft
	OFF		Level Based	Palma Ceia Tank	25.0 ft
	ON		Level Based	West Tampa Tank	20.0 ft
	OFF		Level Based	Palma Ceia Tank	20.0 ft

Appendix C-b

Hydraulic Model Recalibration Technical Memorandum

FINAL

HYDRAULIC MODEL RECALIBRATION REPORT

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

5 JANUARY 2018

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1. Introduction

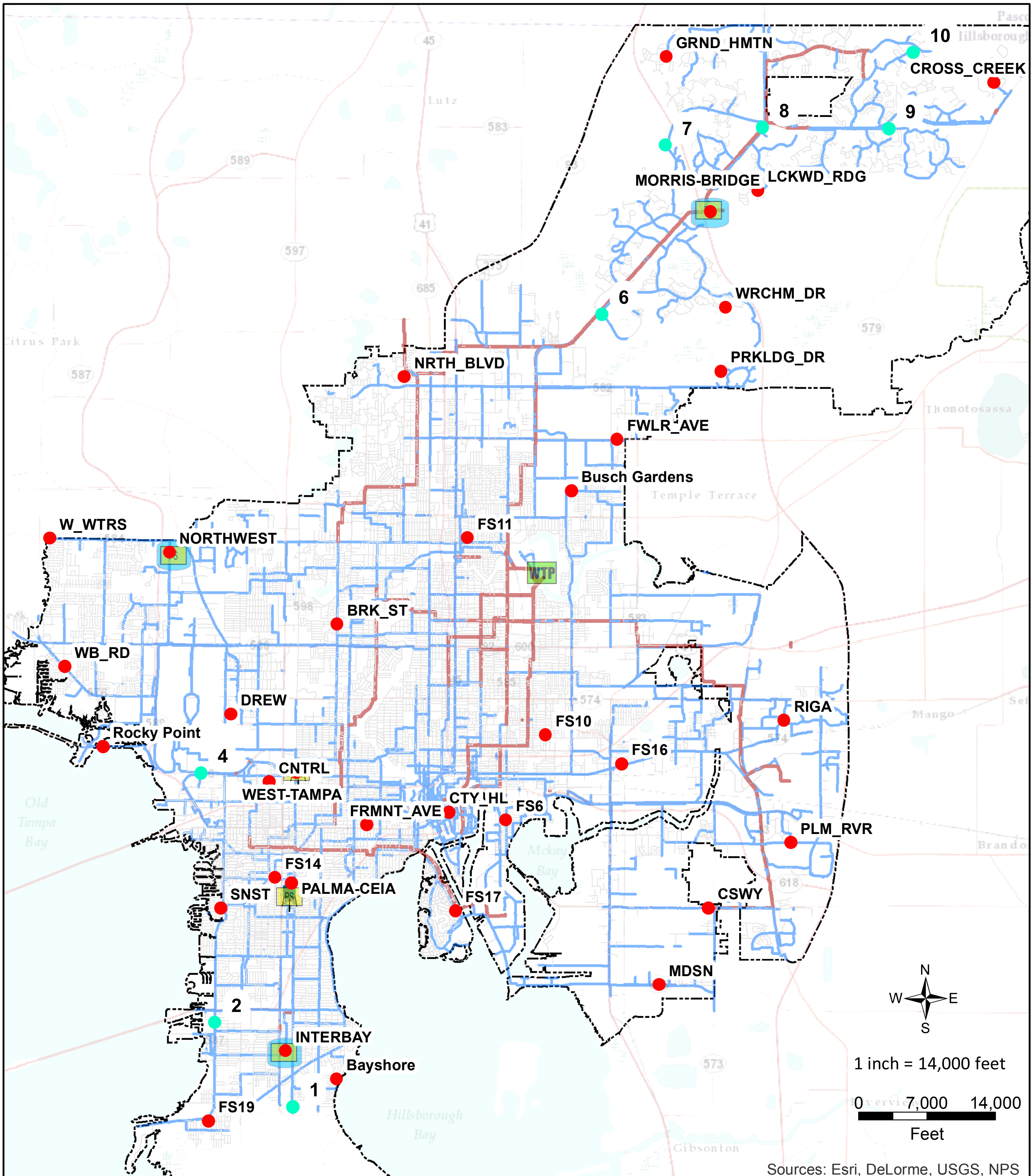
The City of Tampa Water Department (TWD) maintains a hydraulic model of its potable water distribution system to conduct various analyses on the capabilities and capacities of the system. As part of the City's 2015 Potable Water Master Plan Update, Black & Veatch updated the City's hydraulic model with updated water demand information and prepared the model for extended period simulations (EPS). A 24-hour EPS is the preferred calibration methodology and provides a clear indication of the ability of the hydraulic model to simulate system operating conditions under a number of settings. In addition, Black & Veatch completed a model calibration process to compare and validate the updated hydraulic model results with actual system operating data that was collected by the City. Most of the facilities and water mains in the distribution system had previously undergone a steady-state calibration process. To further refine the correlation between the system conditions and the hydraulic model, the calibration efforts presented in this report built upon the results of the previous calibration. The following presents the steps which were followed to complete the calibration process of the City's Hydraulic Model.

2. Available Field Data

The City records and maintains Supervisory Controls and Data Acquisition (SCADA) data at each of the major system facilities including the five repump stations (RPS) and several permanent pressure loggers. The availability of this data allowed Black & Veatch to conduct an EPS model calibration of the distribution system. **Table 1** summarizes the available SCADA data. Data from 28 permanent SCADA pressure loggers and 9 temporary hydrant pressure loggers was also available for the calibration effort. **Figure 1** illustrates the location of each logger and **Table 2** illustrates the 10 facility calibration points.

Table 1 Available SCADA Data

PUMP STATION, TANK OR LOGGER	PUMP STATUS	PUMP SPEED	TOTAL FLOW	INDIVIDUAL PUMP FLOW	DISCHARGE PRESSURE	TANK LEVEL
D.L. Tippin WTF	Limited (missing data on 6, 7, & 8)	Limited (missing data on 5, 7, & 8)	Yes	-	Yes	N/A
Interbay RPS	Limited (lots of "Bad" readings)	Limited (lots of "Bad" readings, missing jockey pumps)	Yes (had a few "Bad" reading which were assumed to be zero)	-	Yes	Yes
Morris Bridge RPS	Yes (looks like there is an error with 3 & 4, assumed off)	No	Yes	No	Yes	Yes
Northwest RPS	No	N/A	Yes	No	Yes	Yes
Palma Ceia RPS	No	N/A	No	No	Yes	Yes
West Tampa RPS	Yes	N/A	No	No	Yes	Yes
North Boulevard Connection	Yes	No	Yes	No	Yes	N/A
Aquifer Storage Recovery (ASR) Recharge Flow	No	N/A	No	Yes	No	N/A



City of Tampa

BLACK & VEATCH
Building a world of difference.

Temporary Hydrant Loggers
Permanent SCADA Points
WTP
Pump_Stations
Ground Storage Tank
Elevated Storage Tank

Diameter
Less than 12-inch
12 - 24-inch
Greater than 24-inch
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 1

Recalibration Pressure Logger Location

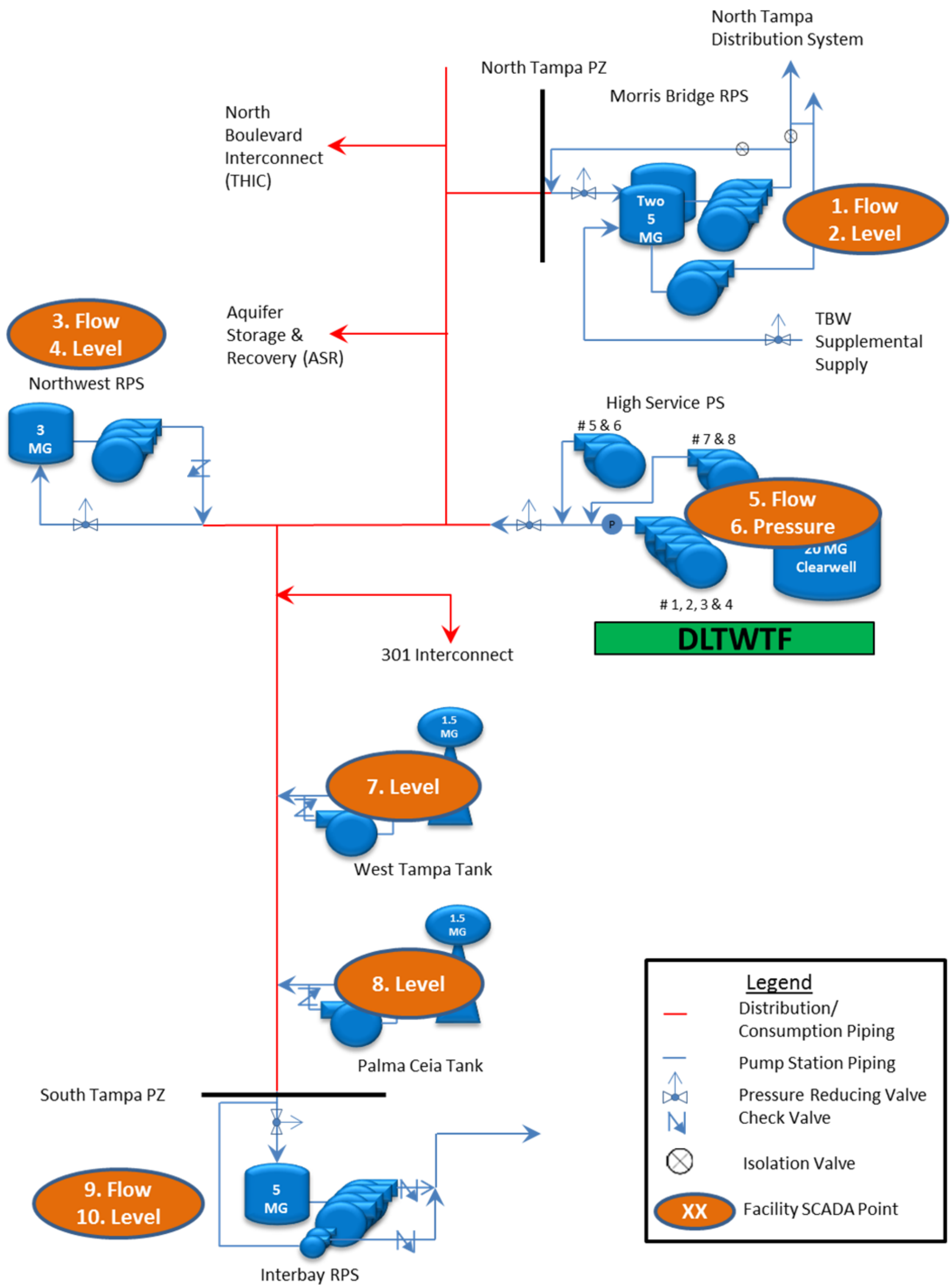


Figure 2 Facility SCADA Calibration Points

3. Model Setup

3.1 CALIBRATION VERIFICATION DAY

The City approved the calibration plan and installed the temporary hydrant pressure loggers in August 2017. Data was collected from August 23 through September 7, 2017. The SCADA data and pressure logger data were reviewed and September 5, 2017 (Tuesday) was the date selected for the EPS calibration of the model. Selection of this date included reviewing the data for consistency and data gaps. September 5th had the fewest data gaps from SCADA, was a weekday which includes irrigation and a more normalized diurnal pattern, and was one of the highest demand days from the available data. Based on the tank and pumping records for September 5th the total demand that day was 75.1 million gallons per day (MGD).

3.2 DIURNAL DEMAND CURVE DEVELOPMENT

In order to conduct a 24-hour EPS calibration of the updated model, it was necessary to calculate changes in the system demands at regular intervals throughout the 24 hour period. This was accomplished through a mass balance calculation utilizing the available SCADA data to relate pump station flows and changing tank levels (converted to flow rates) to specific demands. The locations of the SCADA data used for this calculation are illustrated in Figure 3 to Figure 5.

DLT Pressure Zone:

Demand = Volume Produced (total pumped x time increment) ± Change in Volume (NW, WT, PC) – Wholesale – ASR – Flow to MBBS – Flow to IB RPS
Volume Produced = DLTWTF + US301 Interconnect
Volume Stored (NW, WT, PC) = Volume Into Tanks – Volume Out of Tanks
Wholesale = Interconnections monitored on SCADA (THIC)[1]
Flow to MBBS = MB RPS Flow + Change in Volume – TBW Flow
Flow to IB RPS = IB RPS Flow + Change in Volume

North Tampa Pressure Zone:

Demand = Volume Produced (total pumped x time increment)
Volume Produced = Morris Bridge RPS Flow
Volume Stored = 0

South Tampa Pressure Zone:

Demand = Volume Produced (total pumped x time increment)
Volume Produced = Interbay RPS Flow – MacDill AFB Demand
Volume Stored = 0

1. Other wholesale accounts with master meters not connected to SCADA are not included and have the diurnal pattern assigned to the demand.

Future Demand Curve:

DLT Pressure Zone:

Demand = Volume Produced (total pumped x time increment) ± Change in Volume (NW, WT, PC) – Wholesale – ASR – Flow to MBBS – Flow to IB RPS + Flow from MBBS(P1-4)
Volume Produced = DLTWTF + US301 Interconnect + Flow from MBBS (P1-4)
Volume Stored (NW, WT, PC) = Volume Into Tanks – Volume Out of Tanks

$$\textit{Flow to MBBS} = \textit{MB RPS Flow} + \textit{Change in Volume} - \textit{TBW Flow}$$
$$\textit{Flow to IB RPS} = \textit{IB RPS Flow} + \textit{Change in Volume}$$

North Tampa Pressure Zone:

$$\textit{Demand} = \textit{Volume Produced (total pumped x time increment)} - \textit{Flow from MBBS(P1-4)}$$
$$\textit{Volume Produced} = \textit{Morris Bridge RPS Flow} - \textit{Flow from MBBS(P1-4)}$$
$$\textit{Volume Stored} = 0$$

Based on the mass balance calculations above, time-specific demands were calculated for each time increment during the calibration day. The results of this calculation were then divided by the average demand on that day in order to generate a normalized diurnal demand curve. The 1 min SCADA was provided by the City and using formulas in Microsoft Excel the data was sampled at the beginning of every 5 min interval to generate a 5 min data. The diurnal pattern was calculated using the 5 minute SCADA data records. For the purpose of this calibration effort, the SCADA data was averaged each hour to develop an hourly average pattern to input into the hydraulic model. This was done to increase stability and mitigate the accuracy errors in the level transducers at such small time increments. The hourly pattern has the same general shape as the 5 minute pattern shown above without the sudden drops and peaks. This hourly pattern was used for calibration and is shown in **Figure 6** through **Figure 8**. The same process will be used for the system analysis, but will use SCADA data from a maximum demand period in 2017.

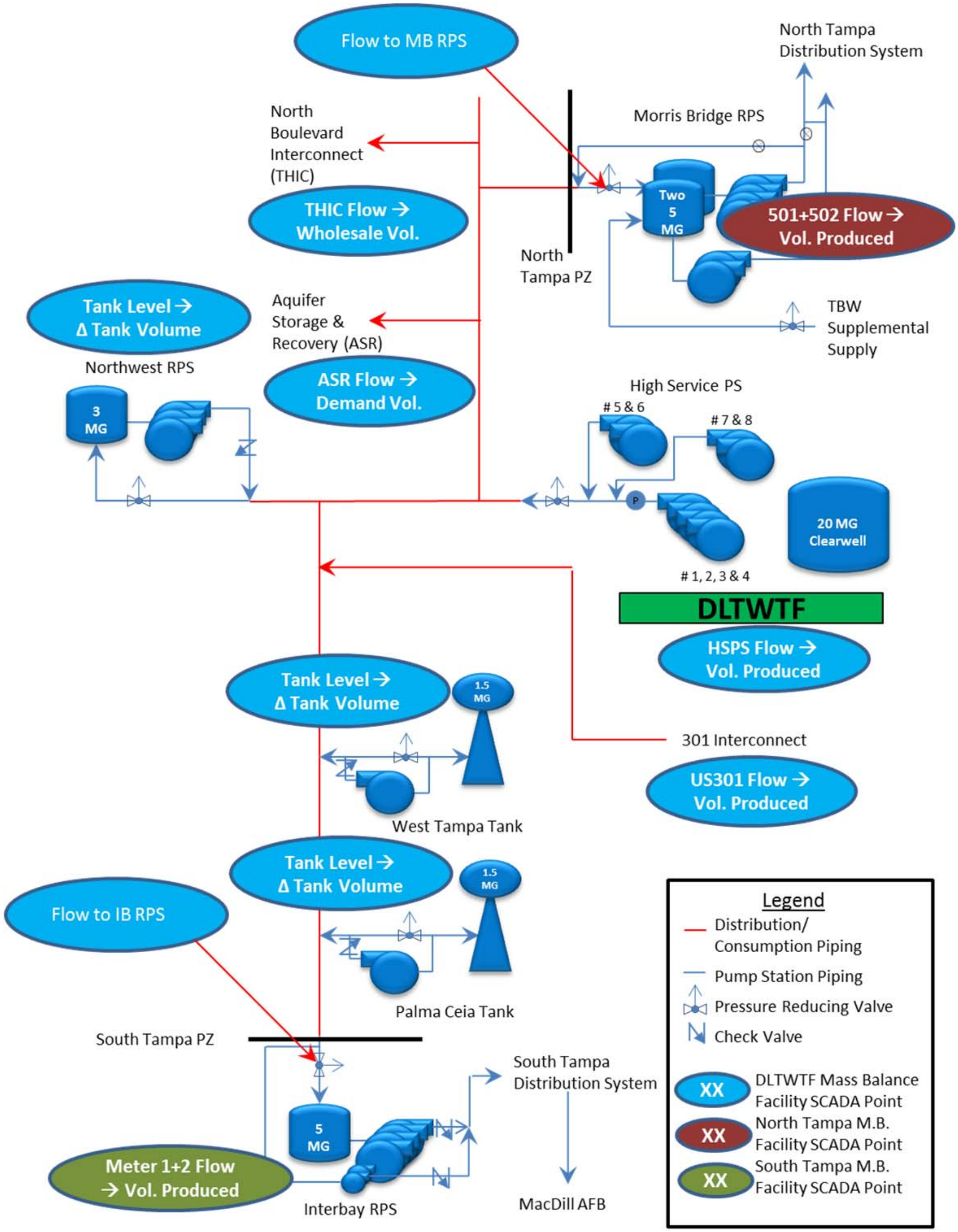
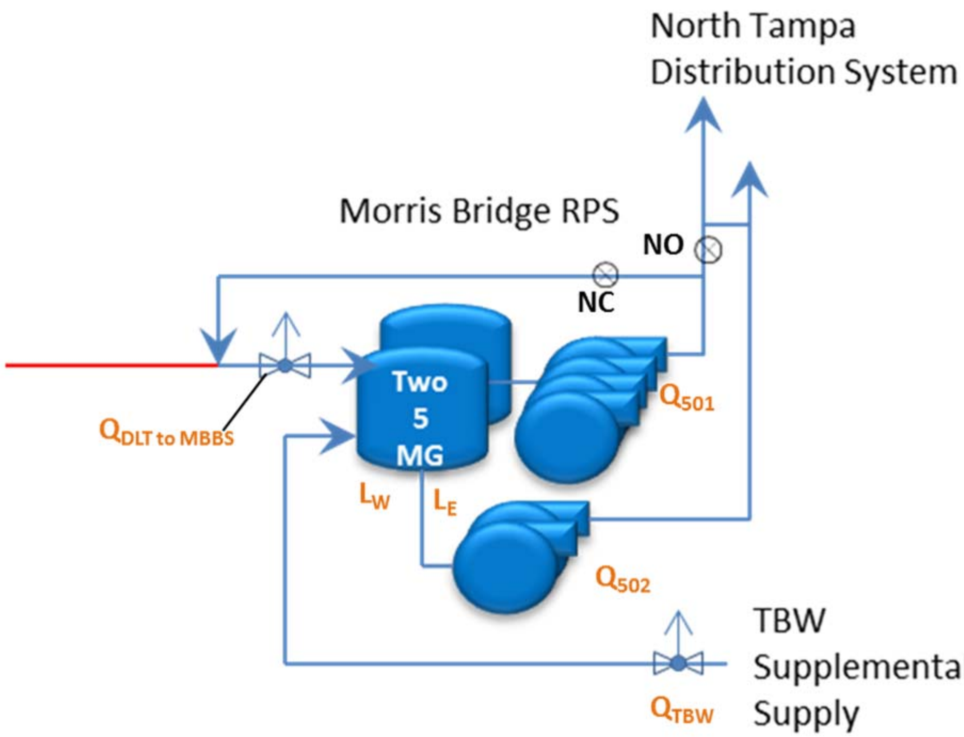


Figure 3 – Facility Mass Balance Locations

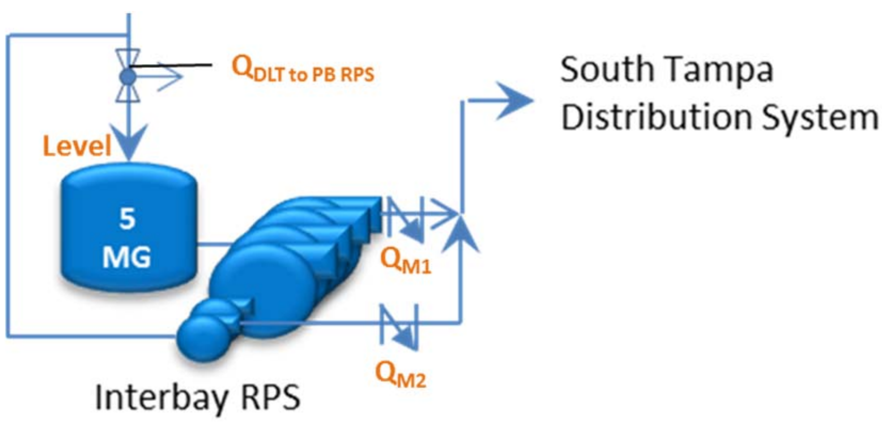


Flow Out = Flow IN

$Q_{501} + Q_{502} + \Delta V_E + \Delta V_W = Q_{DLT\ to\ MBBS} + Q_{TBW}$

$\Delta V = 0.25\pi(D^2)(L_{T1} - L_{T0})*7.48/Time$; Where "+" is filling and "-" is draining

Figure 4 Flow From DLT to MB RPS Calculation



Flow Out = Flow IN

$Q_{M1} + Q_{M2} + \Delta V = Q_{DLT\ to\ IB\ RPS}$

$\Delta V = 0.25\pi(D^2)(L_{T1} - L_{T0})*7.48/Time$; Where "+" is filling and "-" is draining

Figure 5 Flow From DLT to IB RPS Calculation

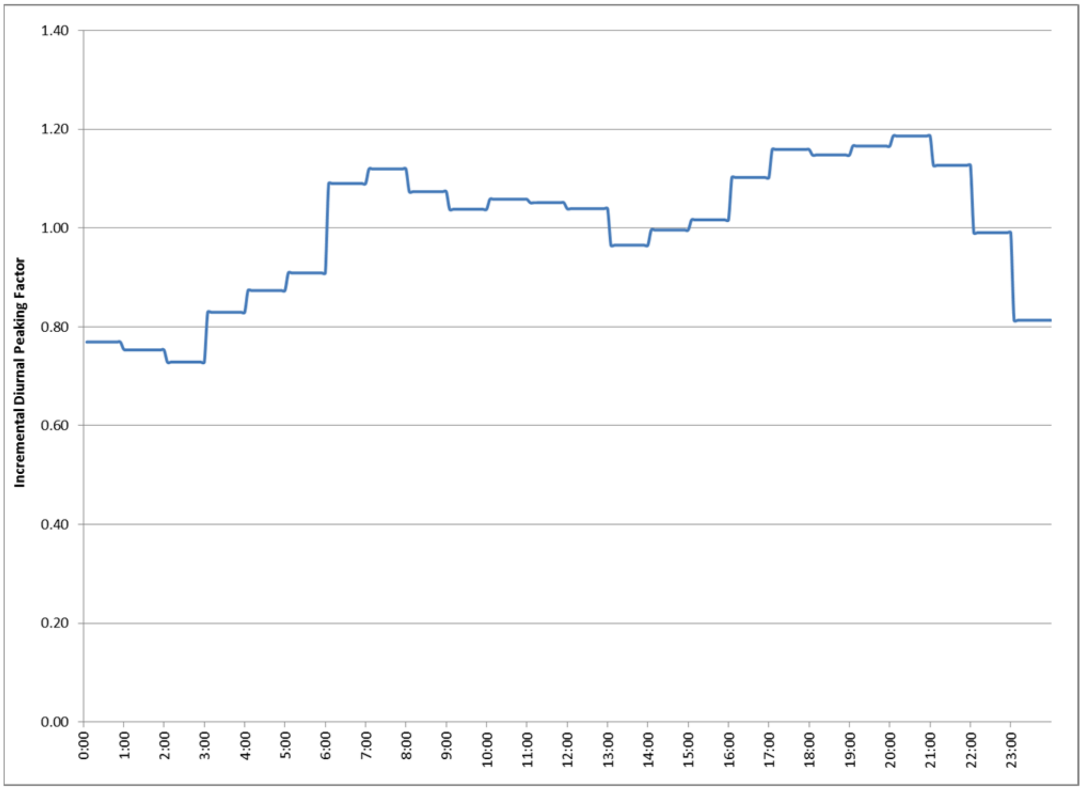


Figure 6 DLT Zone Hourly Calibration Pattern

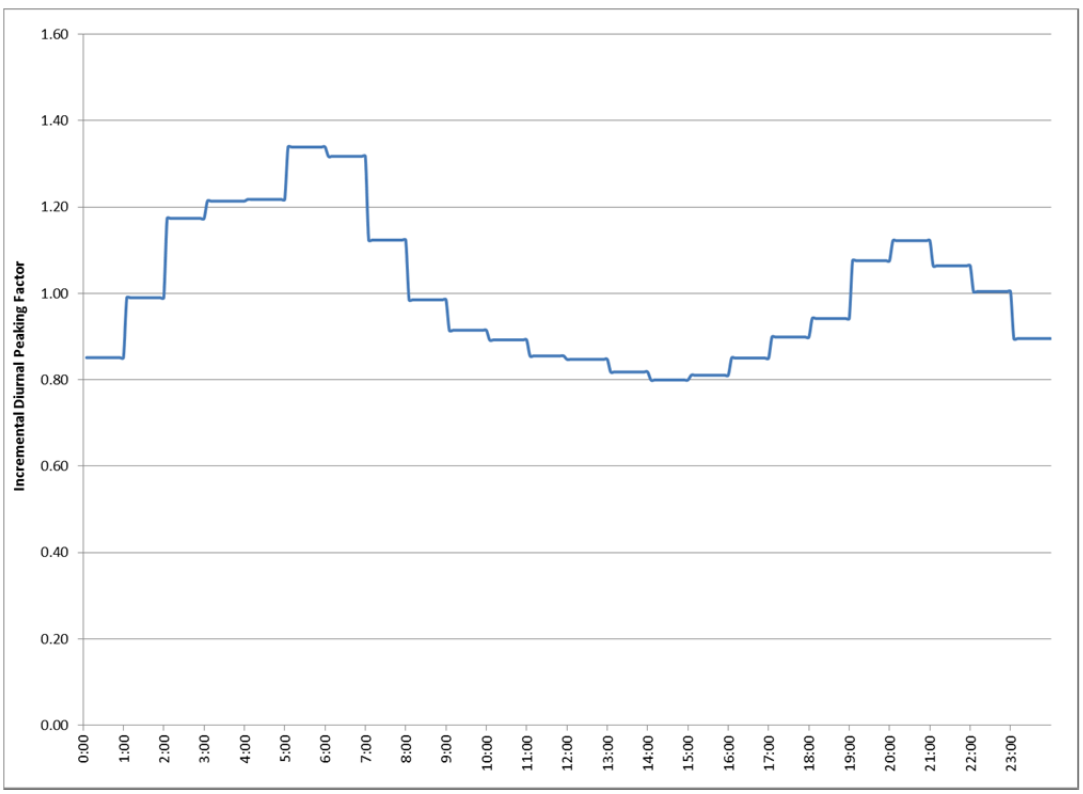


Figure 7 North Tampa Zone Hourly Calibration Pattern

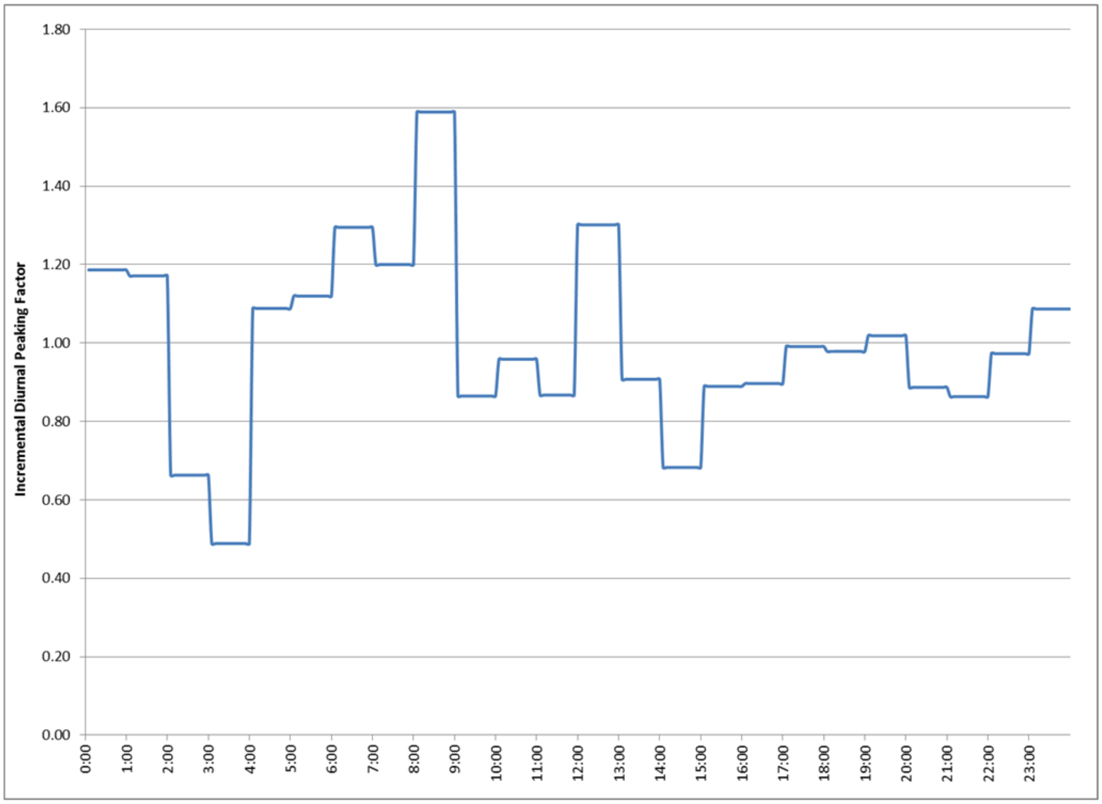


Figure 8 South Tampa Zone Hourly Calibration Pattern

3.3 CONTROLS

Valve and pump controls were added to the model to replicate the actual operation of the distribution system on the selected calibration day. Details on the calibration controls are summarized below. All of the system controls, with the exception of the variable frequency drive (VFD) pumps at the High Service Pump Station (HSPS), Interbay RPS and Morris Bridge RPS, are operator controlled. Operators work in three shifts and the shifts are described as follows: First – 11:00 PM to 7:00 AM; Second – 7:00 AM to 3:00 PM; Third –3:00 PM to 11:00 PM.

3.3.1 Tank Fill Valve Controls

The fill valves located at tank sites are opened remotely by operations staff at the system operations console at the David L. Tippin Water Treatment Facility (DLTWTF) to fill the tanks. There are no automated controls associated with the valves. An operator must manually control the filling process, and typically this occurs during the First operator shift (night). The valves are not flow control or percent open valves, but rather are either open or closed with a low pressure safety set at 35 psi where the valve would throttle to ensure system pressure remain above 35 psi.

The Northwest tank is filled first, then followed by the West Tampa elevated tank, and finally the Palma Ceia elevated tank. The valves were modeled as "Throttle Control Valves" (TCV). The individual controls were based on decreasing the minor loss of the valve during filling to simulate when the valve was set to open, and increasing the minor loss when the valve was closed. This method was used to mimic how the same valves do not completely close and allow a small flow to divert into the tanks. This occurrence is illustrated in **Figure 9** below. Additionally, the tank valve controls are summarized in **Table 2** below.

The tank valves at Interbay RPS and Morris Bridge RPS are always open, but the percent they are open is operator controlled to try to maintain sufficient fire protection in each tank.

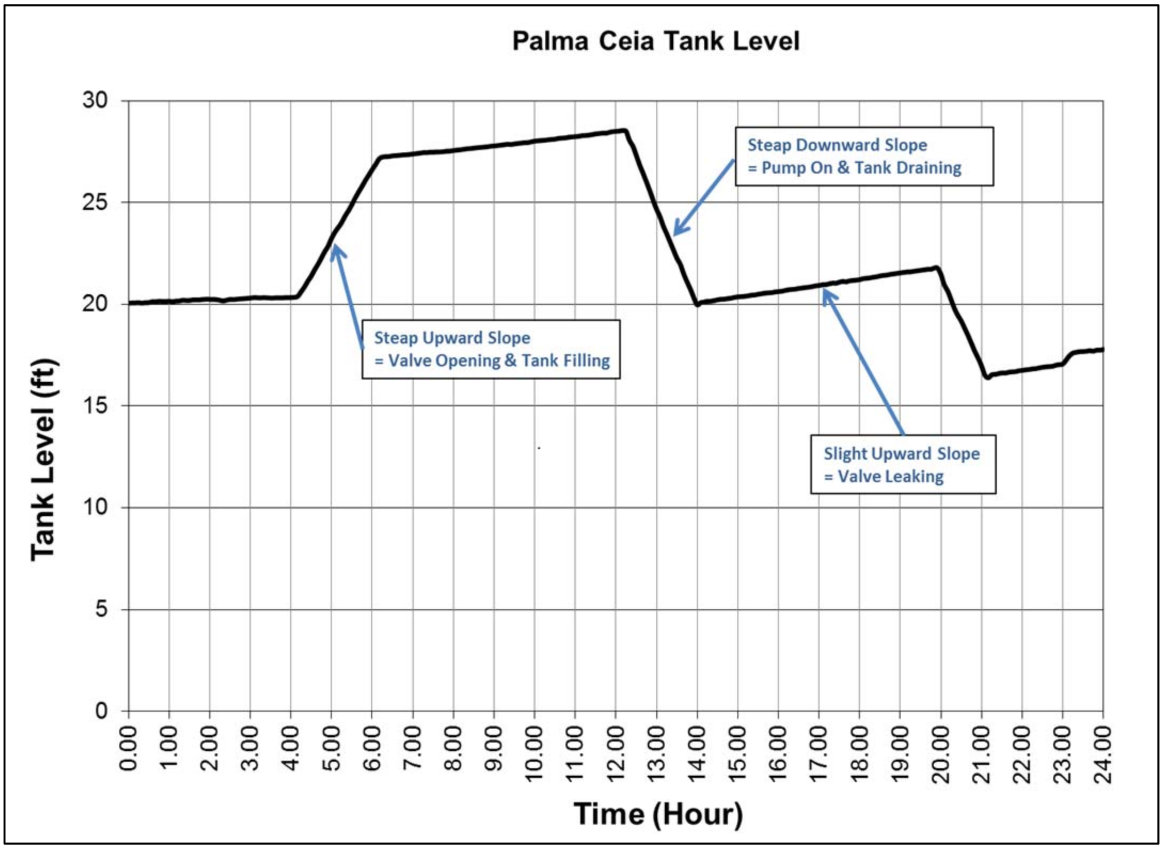


Figure 9 Valve Leaking Occurrence

Table 2 Valve Controls for Calibration.

TANK VALVE	INITIAL STATUS	TANK LEVEL TO CLOSE (FT)	TIME STAMP / MINOR LOSS 1	TIME STAMP / MINOR LOSS 2	TIME STAMP / MINOR LOSS 3
Interbay RPS	Open	Valve opened & closed by operator to try to maintain between 15 & 30 ft.			
Morris Bridge RPS	Open	Valve opened & closed by operator to try to maintain between 15 & 30 ft.			
Northwest RPS	Closed	28	0:00 / 75 (OPEN)	0:55 (CLOSED)	22:35 / 75 (OPEN)
Palma Ceia RPS	Closed	27	0:00 (CLOSED)	1:00 / 25 (OPEN)	4:35 / 100,000 (CLOSED)
West Tampa RPS	Closed	29	0:00 / 100 (OPEN)	1:10 (CLSOED)	22:25 / 50 (OPEN)

3.3.2 Pump Controls

As with the tank valves, the NW, WT and PC pumps are remotely turned on and off by operations staff to manage tank levels / tank turnover, and maintain system pressures. Typically each shift will turn on pumps to drawdown the tanks by 5 to 6 feet to allow for at least a third tank turn over each day. The Northwest tanks pumped first, followed by the West Tampa tank, and finally the Palma Ceia tank. The Morris Bridge and Interbay tanks are pumped into separate pressure zones and are discharge pressure controlled to maintain a discharge pressure between 70 and 65 psi. **Table 3** below summarizes the pump controls for the calibration day.

Table 3 Pump Controls for Calibration.

<table>
<tr><th>PUMP STATION</th><th>NO.</th><th>TIME STAMP / OPERATION 1</th><th>TIME STAMP / OPERATION 2</th><th>TIME STAMP / OPERATION 3</th><th>TIME STAMP / OPERATION 4</th><th>TIME STAMP / OPERATION 5</th></tr>
<tr><td rowspan="6">Interbay RPS</td><td>1</td><td>0:00 / CLOSED</td><td rowspan="4" colspan="4">DISCHARGE PRESSURE = 65 PSI</td></tr>
<tr><td>2</td><td>0:00 / CLOSED</td></tr>
<tr><td>3</td><td>0:00 / CLOSED</td></tr>
<tr><td>4</td><td>0:00 / CLOSED</td></tr>
<tr><td>5</td><td>0:00 / CLOSED</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>6</td><td>0:00 / CLOSED</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="6">Morris Bridge RPS</td><td>1</td><td>0:00 / CLOSED</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2</td><td>0:00 / CLOSED</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3</td><td>0:00 / CLOSED</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>4</td><td>0:00 / CLOSED</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>5</td><td>0:00 / CLOSED</td><td rowspan="2" colspan="4">DISCHARGE PRESSURE = 65 PSI</td></tr>
<tr><td>6</td><td>0:00 / CLOSED</td></tr>
<tr><td rowspan="3">Northwest RPS</td><td>1</td><td>0:00 / CLOSED</td><td>16:40 / OPEN</td><td>20:40 / CLOSED</td><td>-</td><td>-</td></tr>
<tr><td>2</td><td>0:00 / CLOSED</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>3</td><td>0:00 / CLOSED</td><td>11:10 / OPEN</td><td>13:45 / CLOSED</td><td>-</td><td>-</td></tr>
<tr><td>Palma Ceia RPS</td><td>1</td><td>0:00 / CLOSED</td><td>6:20 / OPEN</td><td>7:00 / CLOSED</td><td>8:35 / OPEN
20:00 / OPEN</td><td>9:52 / CLOSED
20.45 / COSED</td></tr>
<tr><td>West Tampa RPS</td><td>1</td><td>0:00 / CLOSED</td><td>13:40 / OPEN</td><td>14:45 / CLOSED</td><td>18:15 / OPEN</td><td>19:05 / CLOSED</td></tr>
</table>

4. Calibration Verification Results

The hydraulic model was setup to simulate the distribution system conditions on September 5th in order to compare the results to the field data and verify if the model was calibrated. Based on the availability of SCADA data summarized in **Table 1**, there were a total of 10 facility points of calibration (flow & tank level) and 35 points of calibration at the permanent and temporary pressure loggers over 288 different time steps. **Table 4** summarizes the calibration goals and limits. The calibration goal represents the desired tolerance in the hydraulic model results compared to the field data which should be achieved overall systemwide. There are no set industry standard calibration goals, but the goals listed below are typical throughout the industry and were agreed to by the TWD during the calibration review meeting as appropriate for the City's distribution system.

Table 4 Calibration Goals.

CALIBRATION POINT TYPE	LOCATION	CALIBRATION GOAL
Tank Level	Interbay, Morris Bridge, Northwest, Palma Ceia and West Tampa	+/- 3 ft.
Flow	DLTWTF, Interbay, Morris Bridge, Northwest, ASR Recharge	+/- 10%
Pressures	See Figure 1	+/- 3 psi

As a comparison, the following two tables present calibration goals recommended by several water modeling groups and goals used for calibration at other utilities.

Table 5 Recommended Calibration Goals by Purpose.

PURPOSE / USE	PRIMARY GOAL	% OF MATCHING POINTS	SOURCE
Master Planning	± 10 ft. ~ ± 5 psi	100%	AWWA M32 (2012)
	± 5 psi	100%	AWWA ECAC (1999)
	± 10 ft. ~ ± 5 psi	100%	Advanced Water Distribution Modeling and Management (2003)
Water Quality	± 3 psi	70%	AWWA ECAC (1999)
Detailed Design / Operations	± 5 ft. ~ ± 2 psi	100%	AWWA M32 (2012)
	± 2 psi	90%	AWWA ECAC (1999)
	± 5 ft. ~ ± 2 psi	100%	Advanced Water Distribution Modeling and Management (2003)

Table 6 Sample Utility Calibration Goals.

UTILITY	PRIMARY GOAL	% OF MATCHING POINTS
Charlotte, NC	± 5 psi (11.5 ft.)	85%
Kansas City, MO	± 6 psi ± 4 psi ± 2 psi	84% (actuals) 67% (actuals) 38% (actuals)
Paulding, GA	± 10%	100%
Region of Peel, ON, CA	± 3 psi (6.9 ft.)	85%* (of reliable readings)
Region of York, ON, CA	± 3 psi (6.9 ft.) for SCADA ± 5 psi (11.5 ft.) for temporary monitors	90%
Tempe, AZ	± 5 psi (11.5 ft.)	75%
Toronto, ON, CA	± 3 psi (6.9 ft.) for SCADA ± 5 psi (11.5 ft.) for temporary monitors	90%

4.1 CALIBRATION PROCESS & OBSERVATIONS

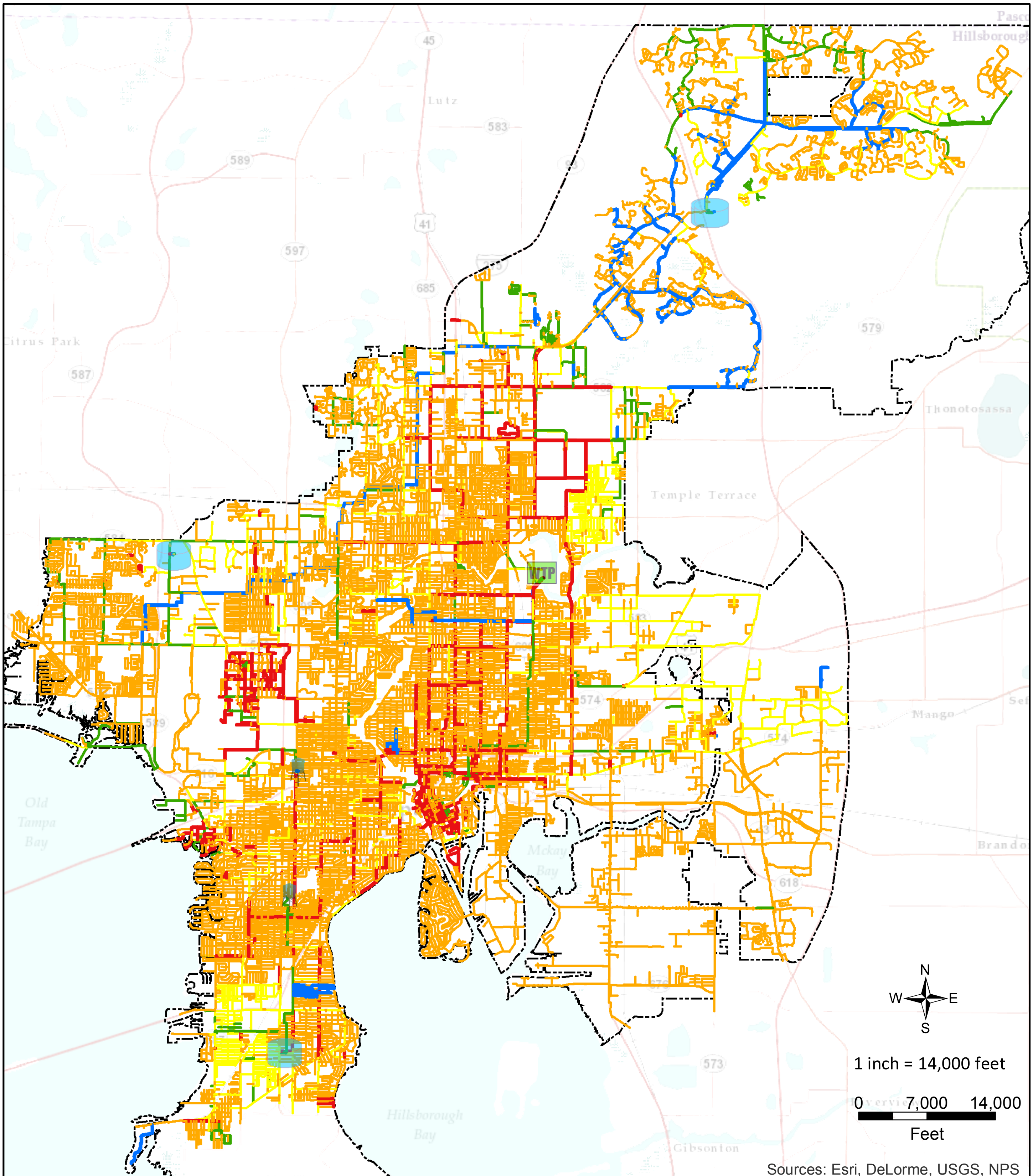
The following is a brief summary of the calibration process used.

4.1.1 Hydraulic Gradeline / Tank Levels:

The process was started by calibrating the hydraulic gradeline (HGL) with no pump curves or controls by using negative demand junctions to simulate the correct amount of flow from each pump station at the correct time. This allowed for the tanks to be balanced, closed valves to be found and verified, C-factors to be adjusted, and possible restrictions (like partially closed valves) to be identified.

Observations:

- The altitude valves filling IB RPS and MBBS were modeled as flow control valves matching the inflow calculated from the diurnal patterns because the use of throttle controls valves were causing increased pressures in the DLT Zone.
- Once the flow control settings were modeled the HGL and tank levels came into calibration.
- No additional adjustments were required to meet the HGL / Tank Level criteria.



WTP

Ground Storage Tank

Elevated Storage Tank

Service Area

ROUGHNESS

Less than 100

100 to 110

110 to 120

120 to 130

Greater than 130

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Figure 10

C-Factor Summary

4.1.2 Hydraulic Gradeline / Pressure Loggers Observations

Once the tank levels were calibrated, the pressure logger HGLs were analyzed and calibrated.

- Most of the model results at the pressure logger locations readily matched the corresponding field data within the calibration goals. A few of the junction elevations were adjusted to better match the 1 ft. contours provided by the TWD and then to match the field pressure data. Elevations were only adjusted for junctions where the pattern of the model results matched the pattern of the field data. Matching patterns indicate that the friction losses and demands are accurately represented and that the static pressure is inaccurate, thus the change in elevation. **Table 7** summarizes the elevation changes.

Table 7 Pressure Logger Elevation Changes.

#	LOGGER / SCADA POINT NAME	INITIAL JUNCTION ELEVATION (FT)	CONTOUR ELEVATION (FT)	UPDATED JUNCTION ELVATION (FT)	DIFFERENCE (UPDATED – INITIAL) (FT)
1	PC[1]	16.92	18	9.5	7.5
2	IB[1]	10	12	6	4
3	FS19	5	5	0.5	4.5
4	Morris Bridge	40	44	44	4
5	1679506	54.03	52	50	4
6	GRND_HMPTN	47.96	26	45	3
7	Temp #7	45	43	43	2
8	BRK_ST	40	42	45	5
9	RIGA	22.84	30	28	5
10	Northwest	20	23	27	7
11	FRMNT_AVE	20	18	18	2
12	Temp #2	5	5	1	4
13	Temp #1	10	unkn	6	4

- **MacDill AFB:** MacDill Air Force Base (AFB) is a large user within the City of Tampa. The AFB receives water from the distribution through a few connections in the South Tampa pressure zone to fill the onsite storage tank; MacDill Ave, Himes Ave and MacDill Ave. A diurnal pattern was created from SCADA data provided by the AFB during the previous calibration and system assessment. The AFB lost the historian data for this specific calibration time period. **Figure 11** illustrates the average diurnal pattern created to fill AFB the tanks.

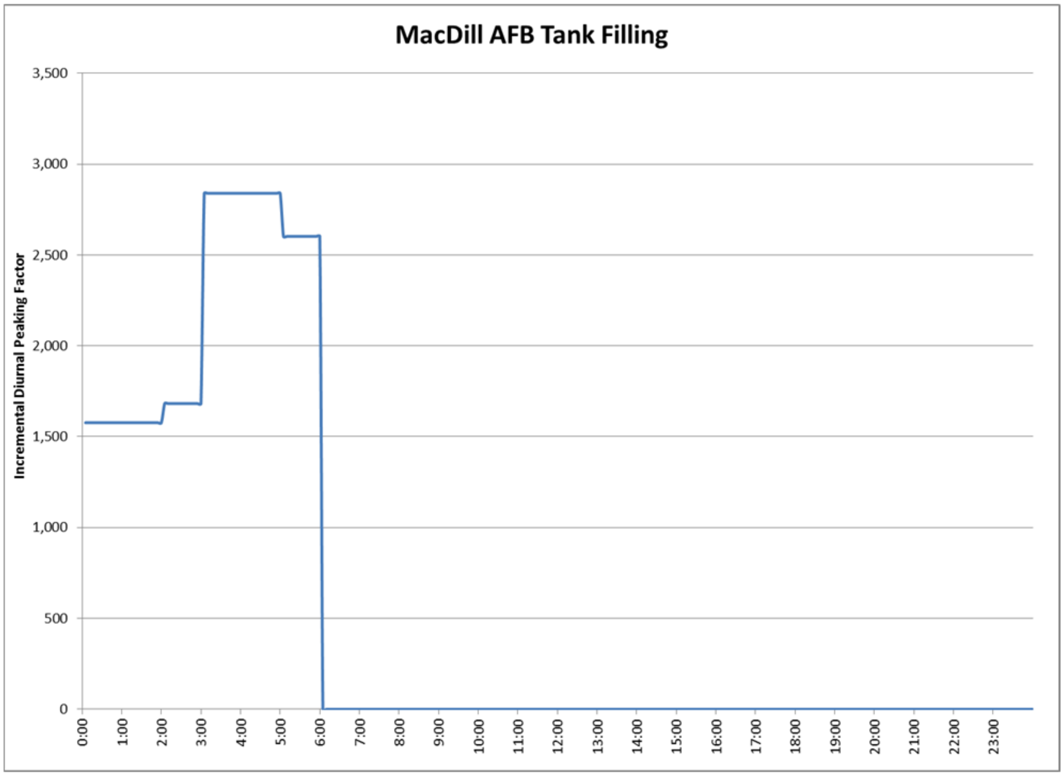

Figure 11 MacDill Calibration Diurnal Demand Pattern

4.1.3 Pump Flows / Curves:

Once the HGL was calibrated, the pump curves were modeled with time-based controls. The manufacturer curves were a fit for most of the pump stations.

- **DLTWTF**: Since a number of the tags for the high service pump station (HSPS) were missing, it was difficult to simulate the correct combination of pumps. Therefore a reservoir with variable head was modeled in place of the pumps for calibration. The reservoir head pattern was set to match the HSPS discharge pressure and the total flows from the WTF were monitored to verify the validity of the reservoir. The average percent error between the SCADA data and model results was very good at 3%. This caused the modeled pressure at one of the SCADA loggers (HSP) to exactly match the field data.

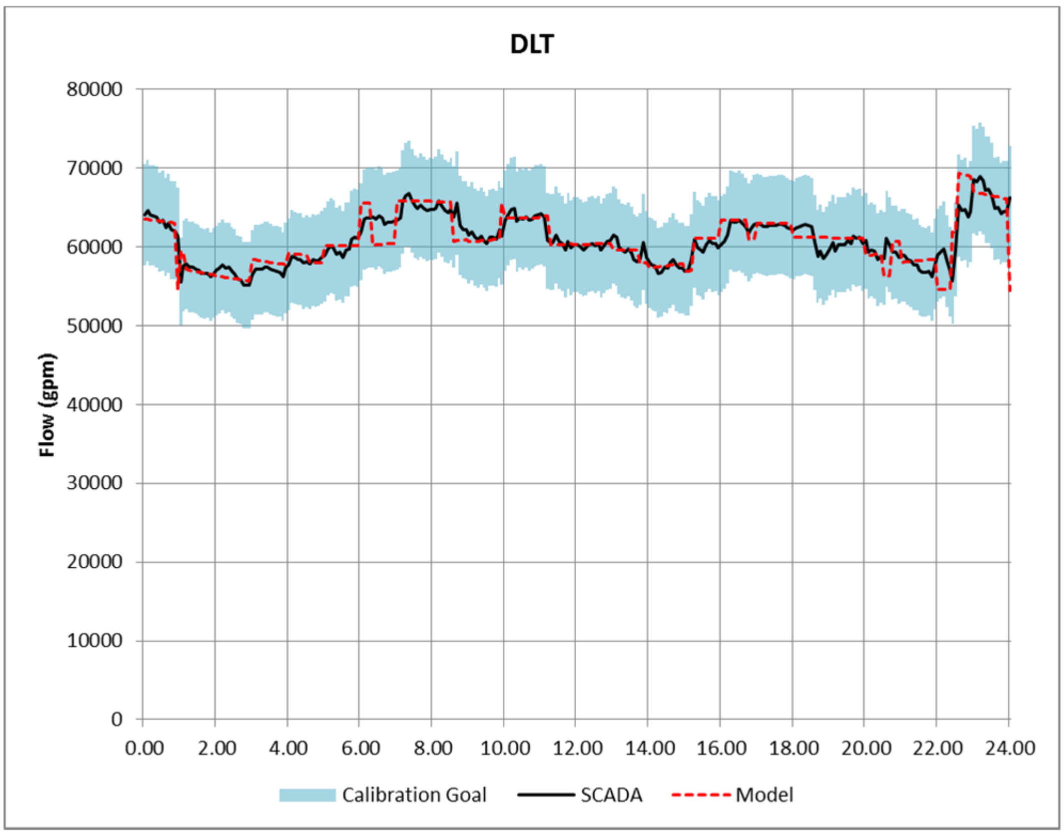

Figure 12 DLTWTF/ HSPS Discharge Flow Comparison

- **Interbay RPS and Morris Bridge RPS**: Due to the limited information available on pump status and speed at the Interbay RPS and Morris Bridge RPS the exact configuration of the pump stations were not known during calibration. The pumps were controlled to best match discharge flow and tank levels, but discharge pressure did not match as closely.

4.2 RESULTS AND CONCLUSIONS

The results of calibration show a very high correlation between the field SCADA data and the tank levels and pumped flows. One hundred percent of the 2880 data points covering all of the facility locations were within the calibration goals. Likewise, the calibration results of the pressure points also had a good correlation with closely matching daily patterns and **95% of the 12,427 data points within the calibration goal**.

4.2.1 Pump Stations

As was mentioned above, there was a high correlation between the field data and model results for the pumped flows. One hundred percent of the modeled pumped flows were within the calibration goal. The largest degree of uncertainty is around the Interbay RPS and Morris Bridge RPS due to the lack of SCADA data regarding the pump status and speed; thus the pump VFD discharge pressure control was used to best match the discharge flow. The time-series flow plots for each pump station are included in Attachment 1.

4.2.2 Tank Levels

As was mentioned above, there was a high correlation between the field data and model results for the tank levels. One hundred percent of the modeled tank levels were within the calibration goal with the largest difference between the field data. The time-series level plots for each tank are included in Attachment 1.

4.2.3 Pressure Points

There was a total of 12,427 pressure data points analyzed during calibration covering 43 permanent and temporary pressure loggers. Ninety-five percent of those data points met or exceeded the calibration goal resulting in a well calibrated pressure model. **Table 8** below summarizes the results of the pressure point calibration based on seven different areas of the City. **Figure 13** and **Figure 14** illustrate the results per logger systemwide. The time-series level plots for each pressure point are included in Attachment 1.

Table 8 Pressure Logger Results Summary.

#	AREA	LOGGERS INCLUDED	% MET GOAL		
			AVE.	BEST LOGGER	WORST LOGGER
1	Downtown	CTY_HL; FRMNT_AVE; FS17; FS6; PC; FS14	93%	100%	81%
2	East Tampa	FS16; MDSN; PLM_RVR; RIGA	99%	100%	97%
3	North Tampa	NRTH_BLVD; PRKLDG_DR; WRCHM_DR; BG_PMP_STA; FWLR_AVE; 1679899	97%	100%	91%
4	New Tampa	1678275; 1678943; 1679506; 2814356; GRND_HMTN; LCKWD_RDG_NEW; MB_HS502_PSI ; MB_HS_501_PSI;	97%	100%	90%
5	South Tampa	1683316; 2869168; FS19; IB; IB Tank Inlet; BAYSHORE;	90%	100%	57%
6	Central Tampa	SNST_LN; CROSS_CREEK; CNTRL; FS10; FS11; BRK_ST;	94%	100%	82%
7	West Tampa	Rocky Point; 1673512; DREW; NW_EFF; W_WTRS; WB_RD; WT	93%	97%	85%

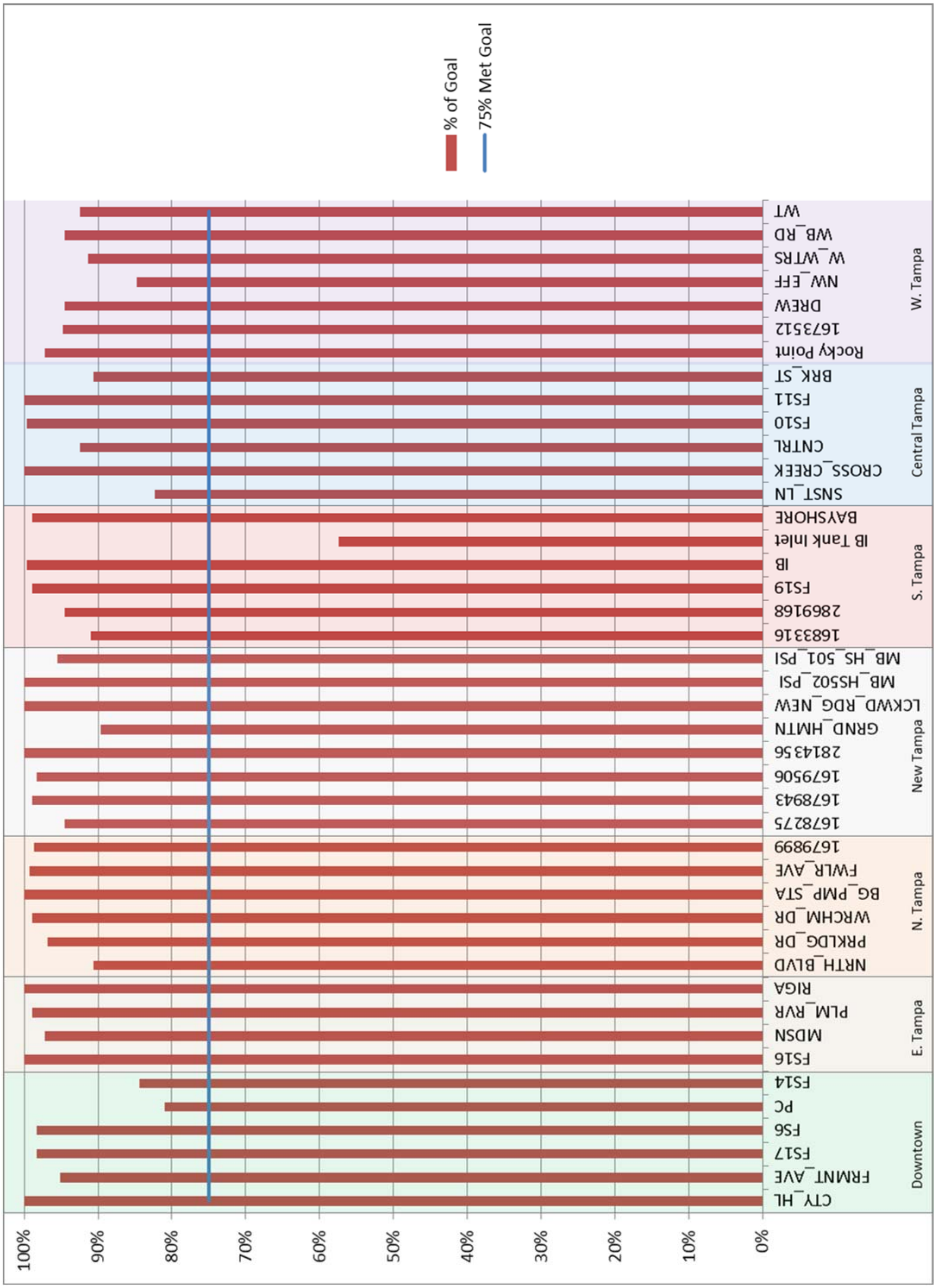

Figure 13 Pressure Logger % of Goal Results

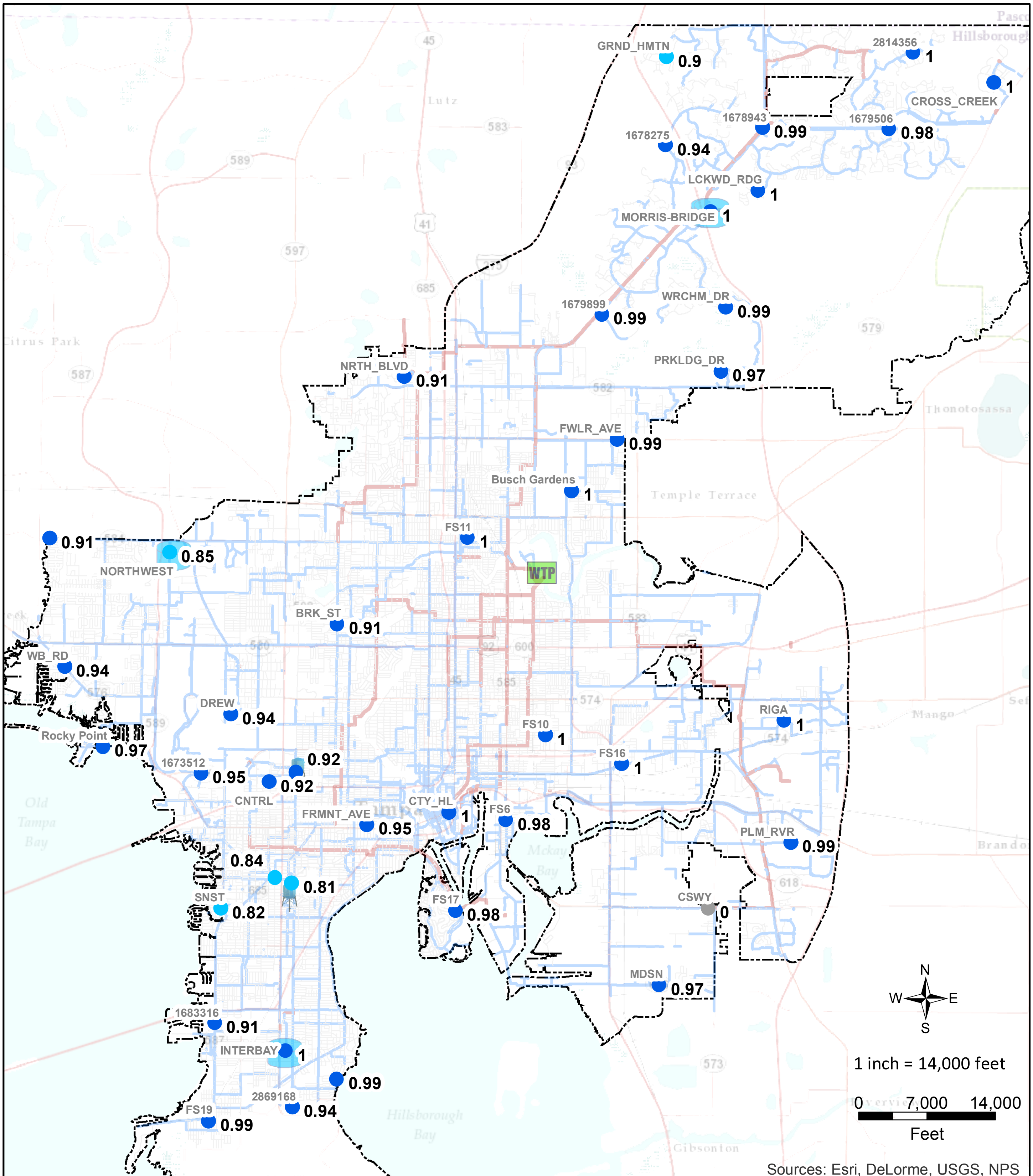

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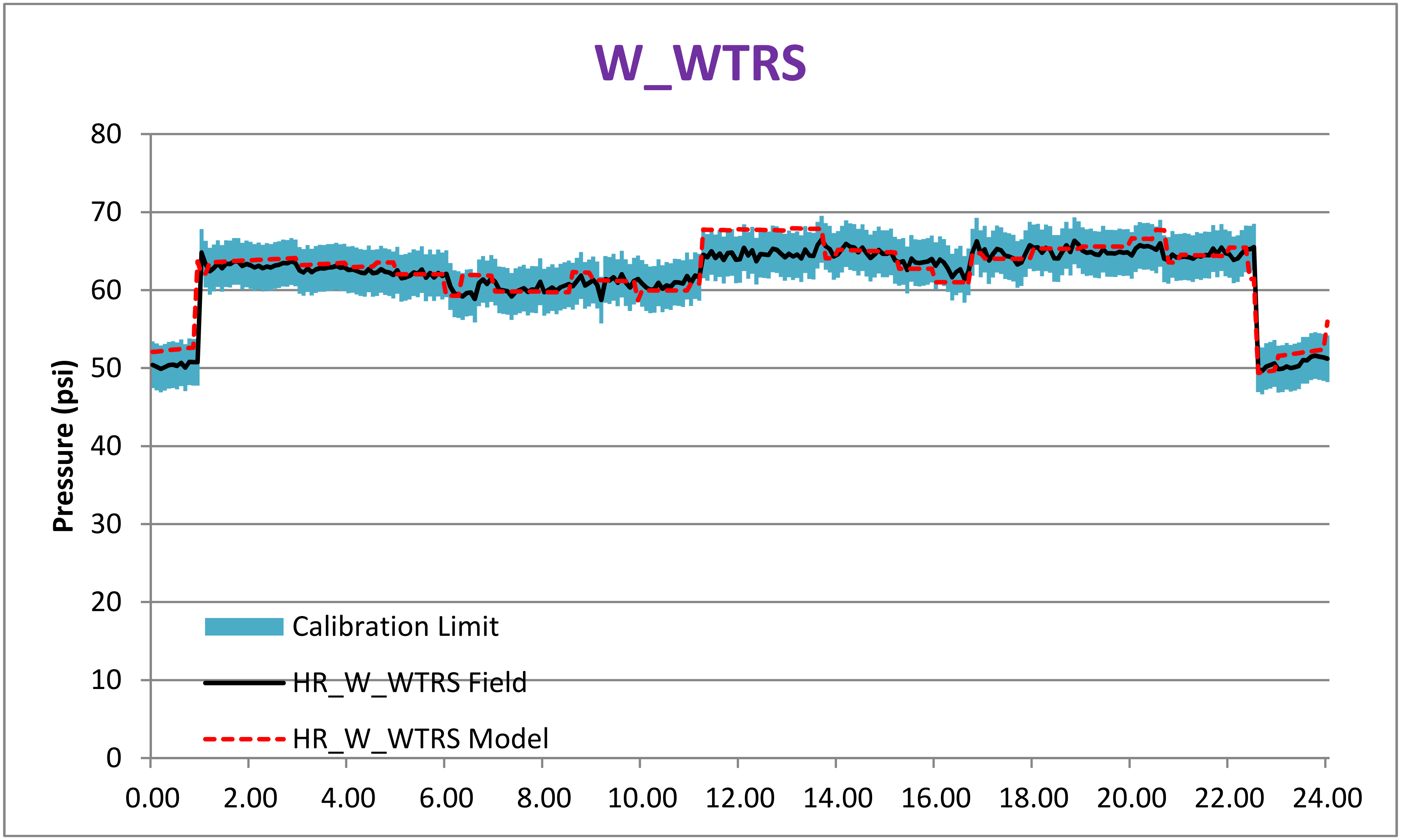
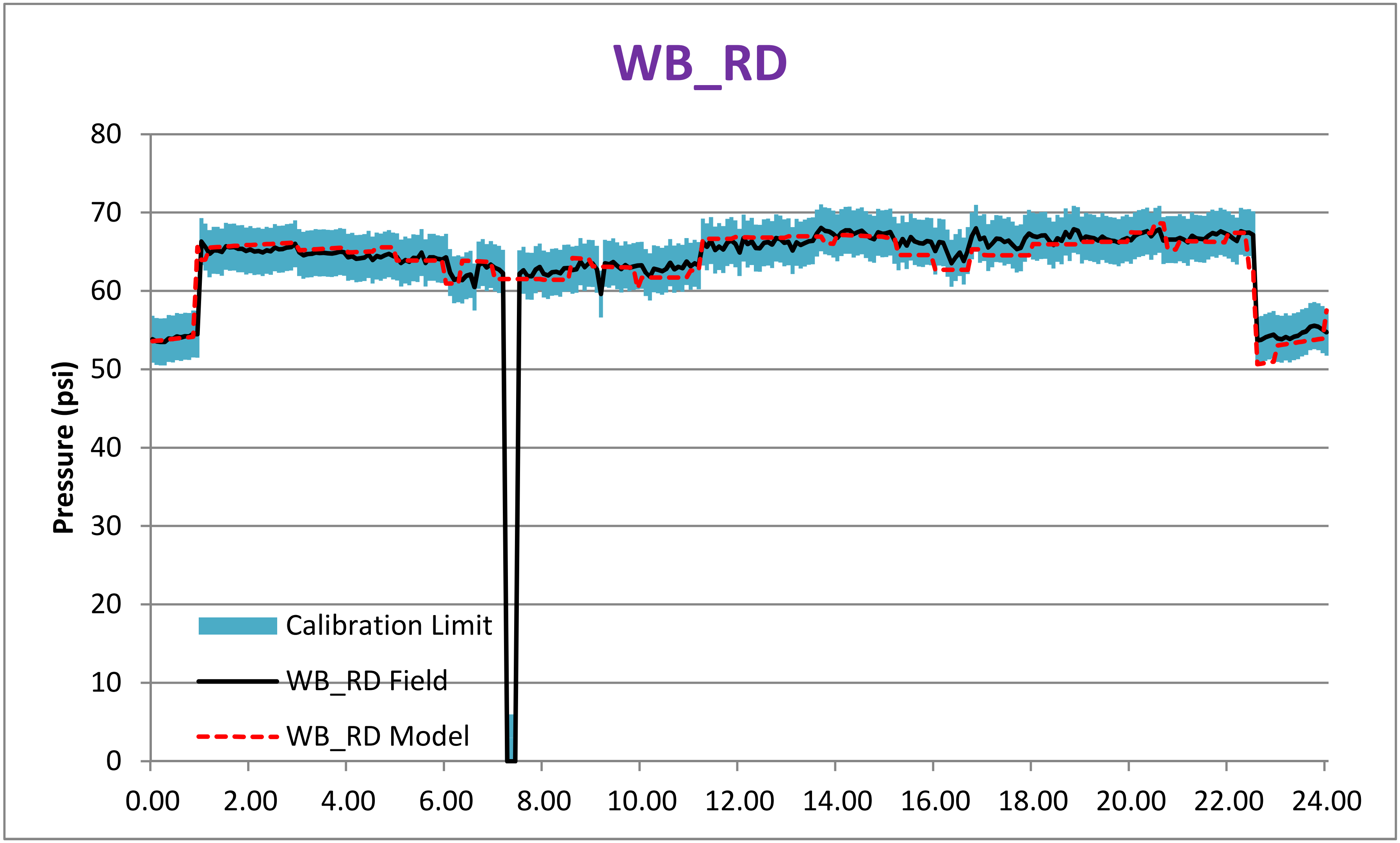
Figure 14

Calibration Results Summary

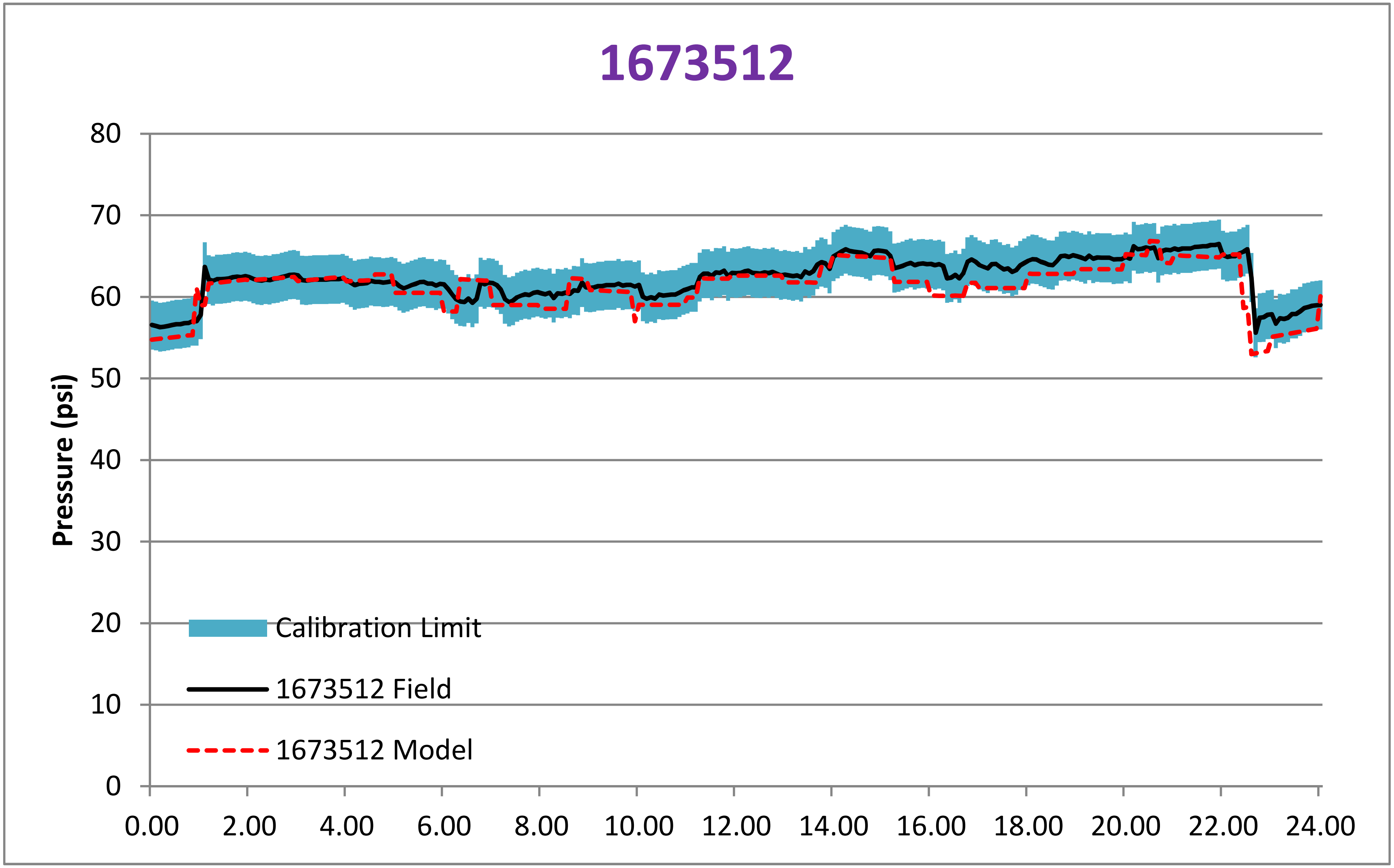
Attachment 1 – Calibration Plots

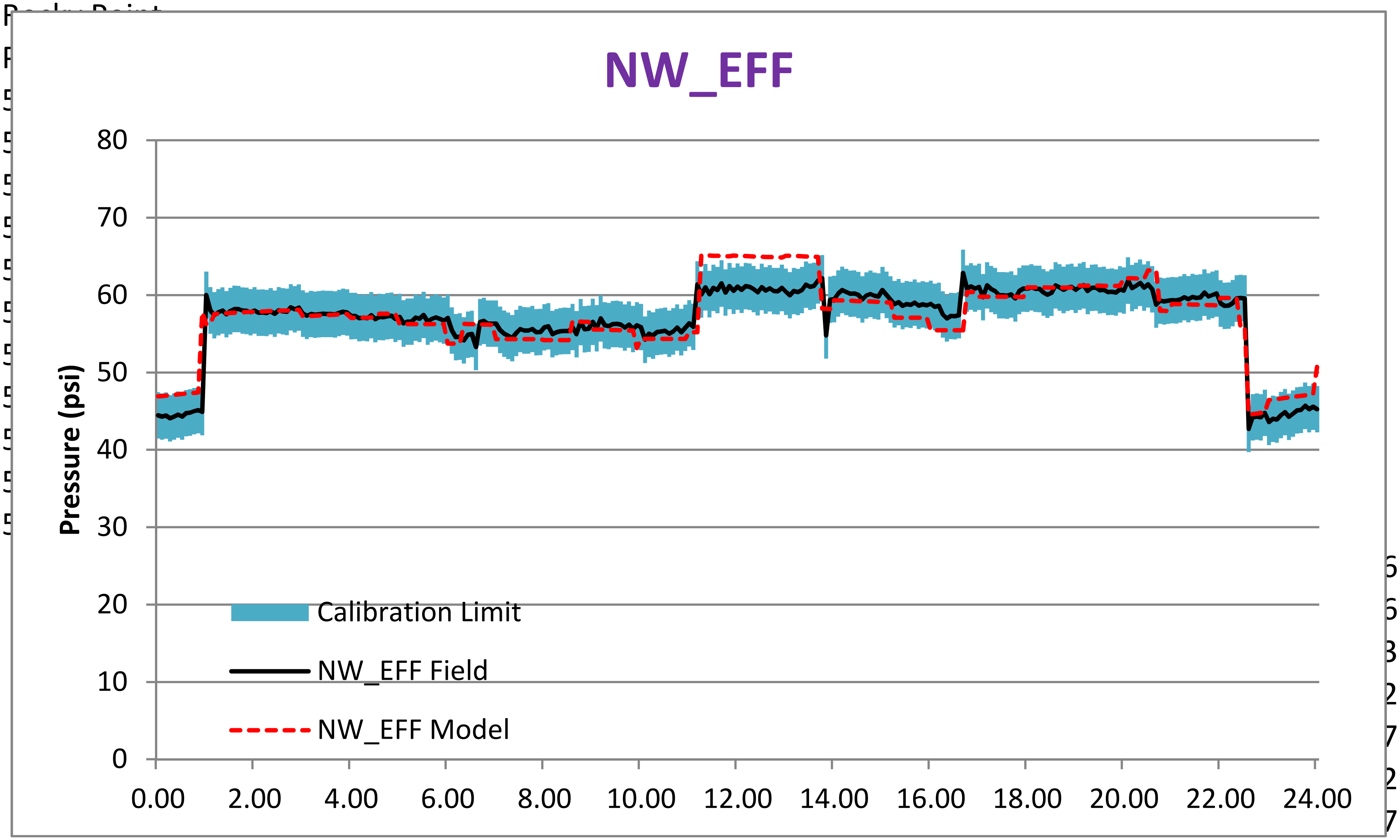


W_WTRS
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
HR_W_WTRS Field
HR_W_WTRS Model

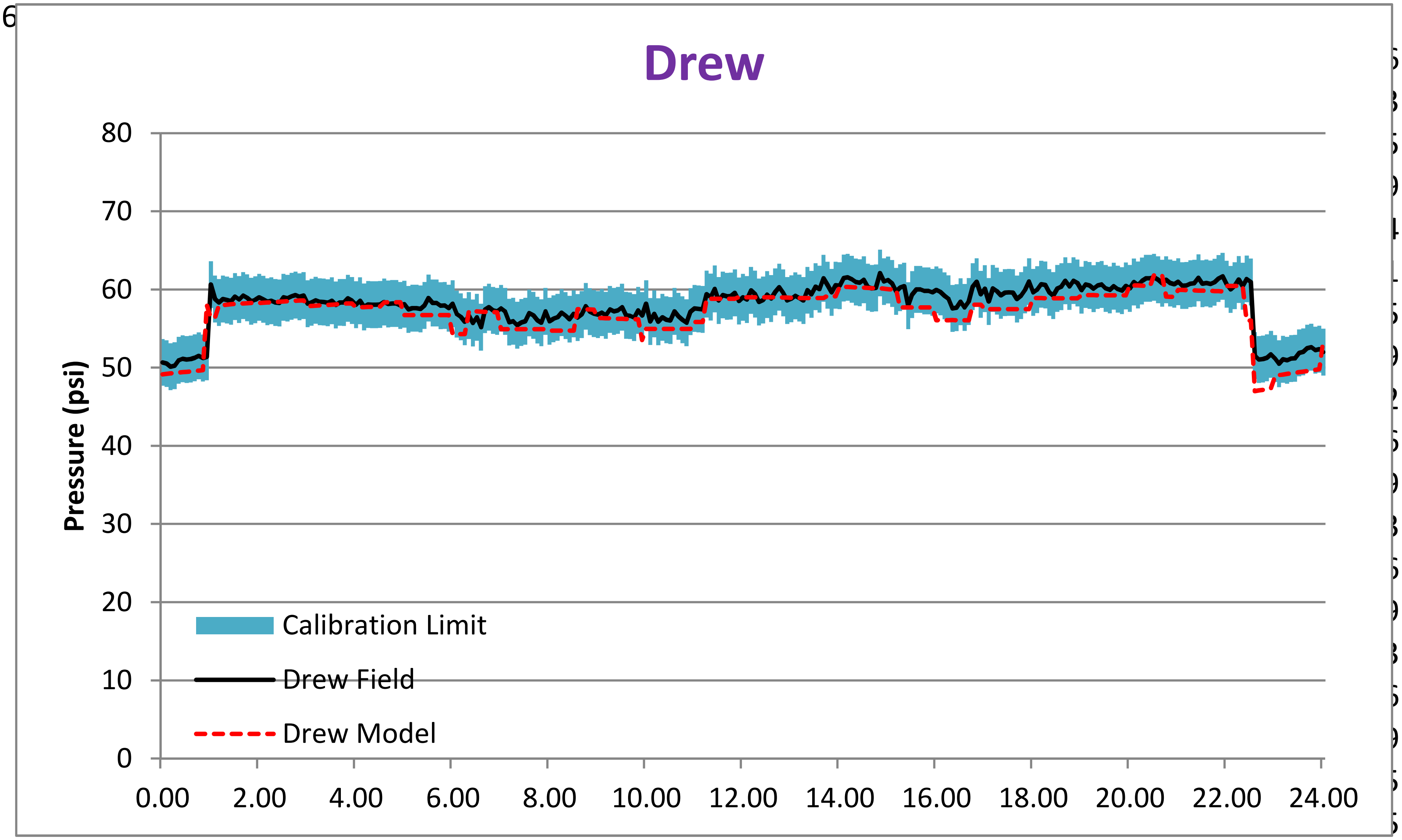


WB_RD
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
WB_RD Field
WB_RD Model

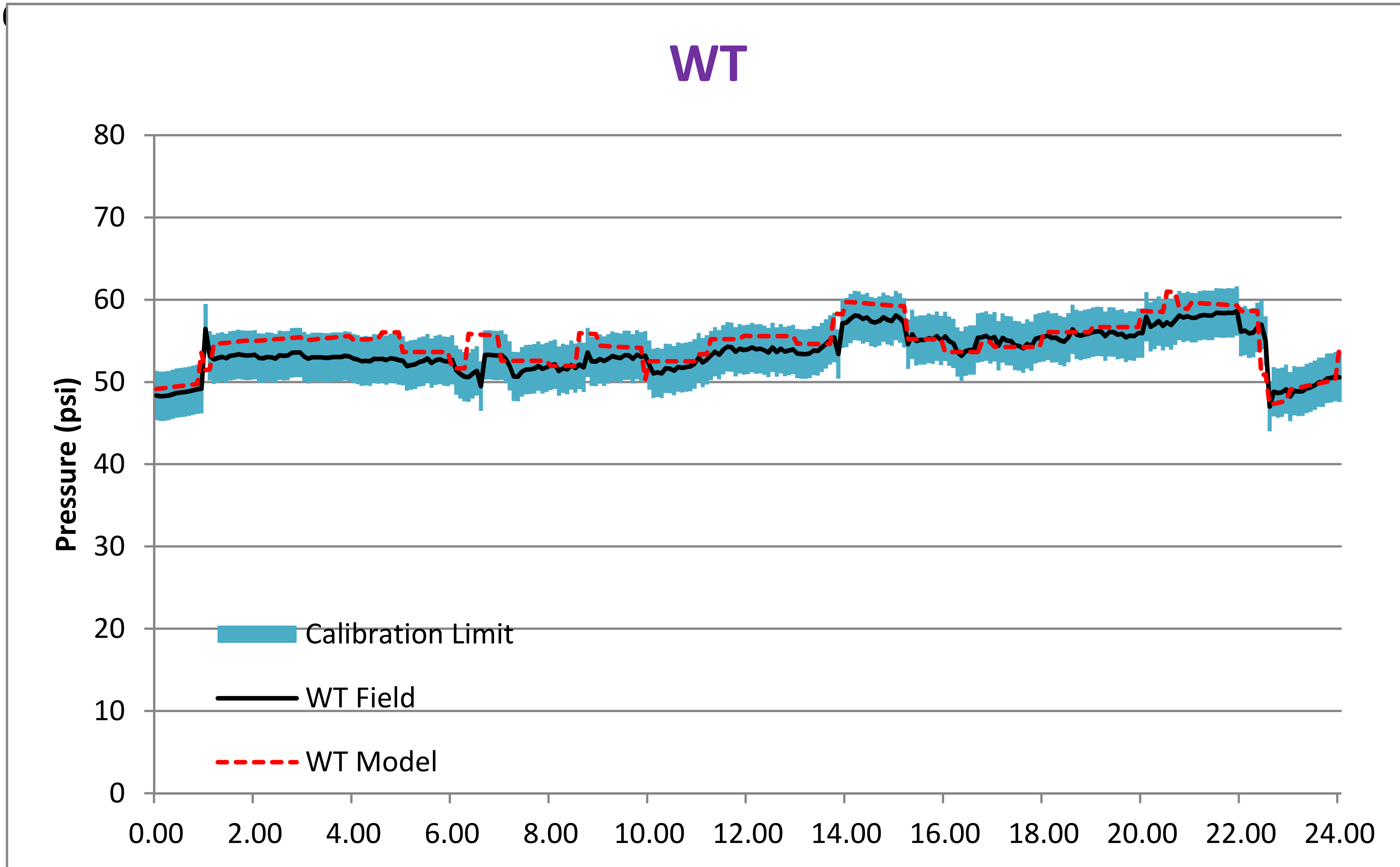

1673512
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1673512 Field
1673512 Model



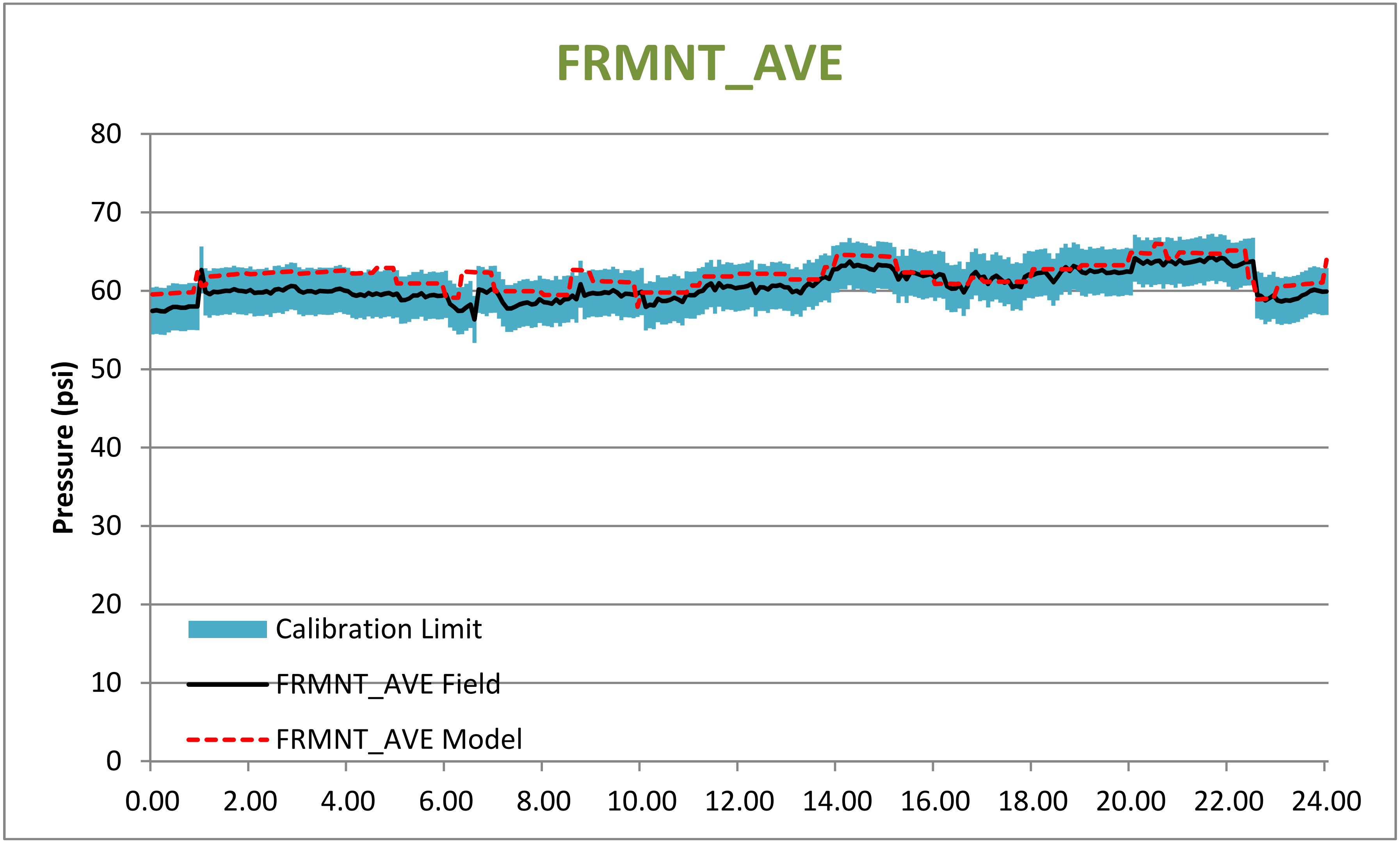
NW_EFF
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
NW_EFF Field
NW_EFF Model

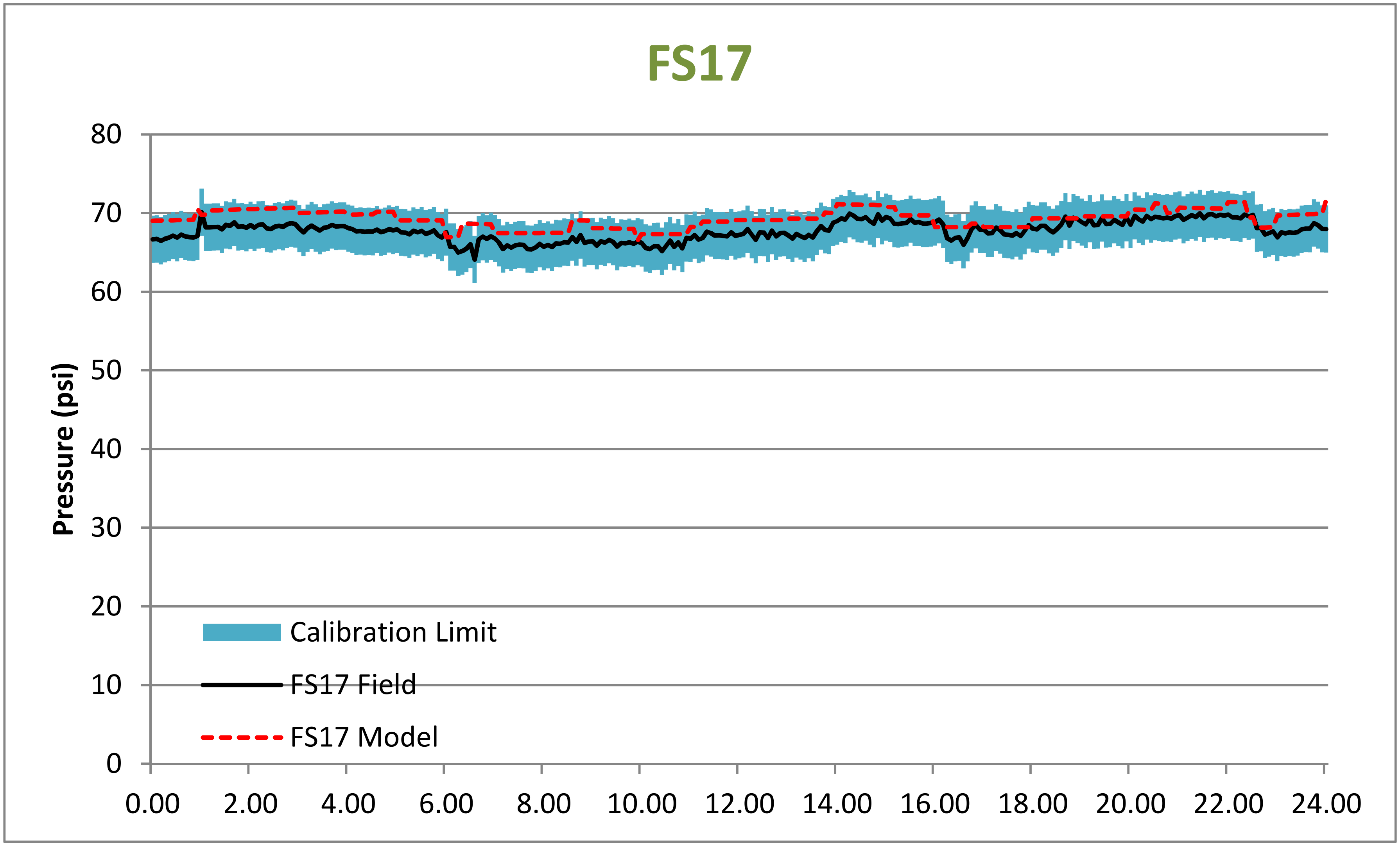


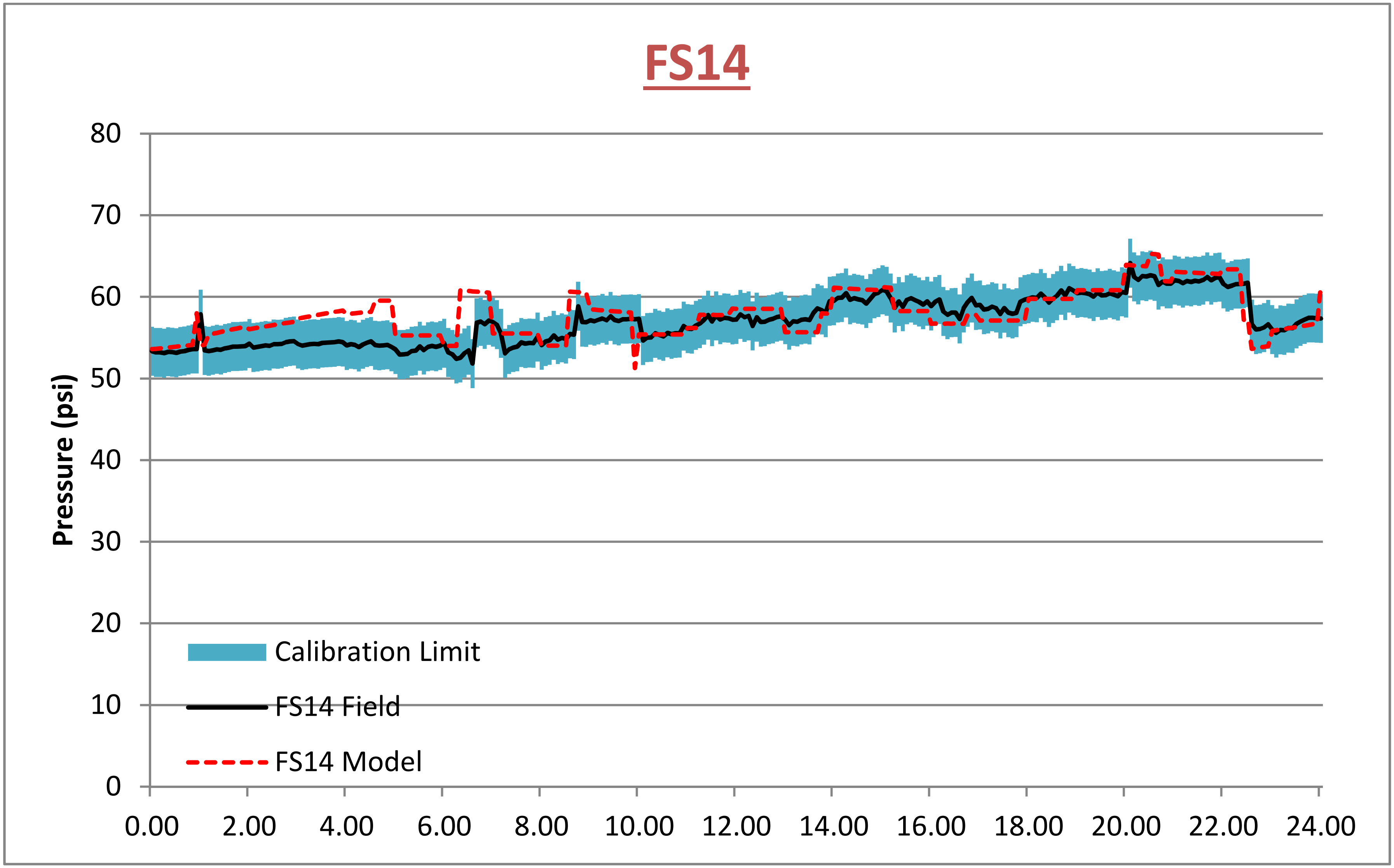
Drew
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
Drew Field
Drew Model

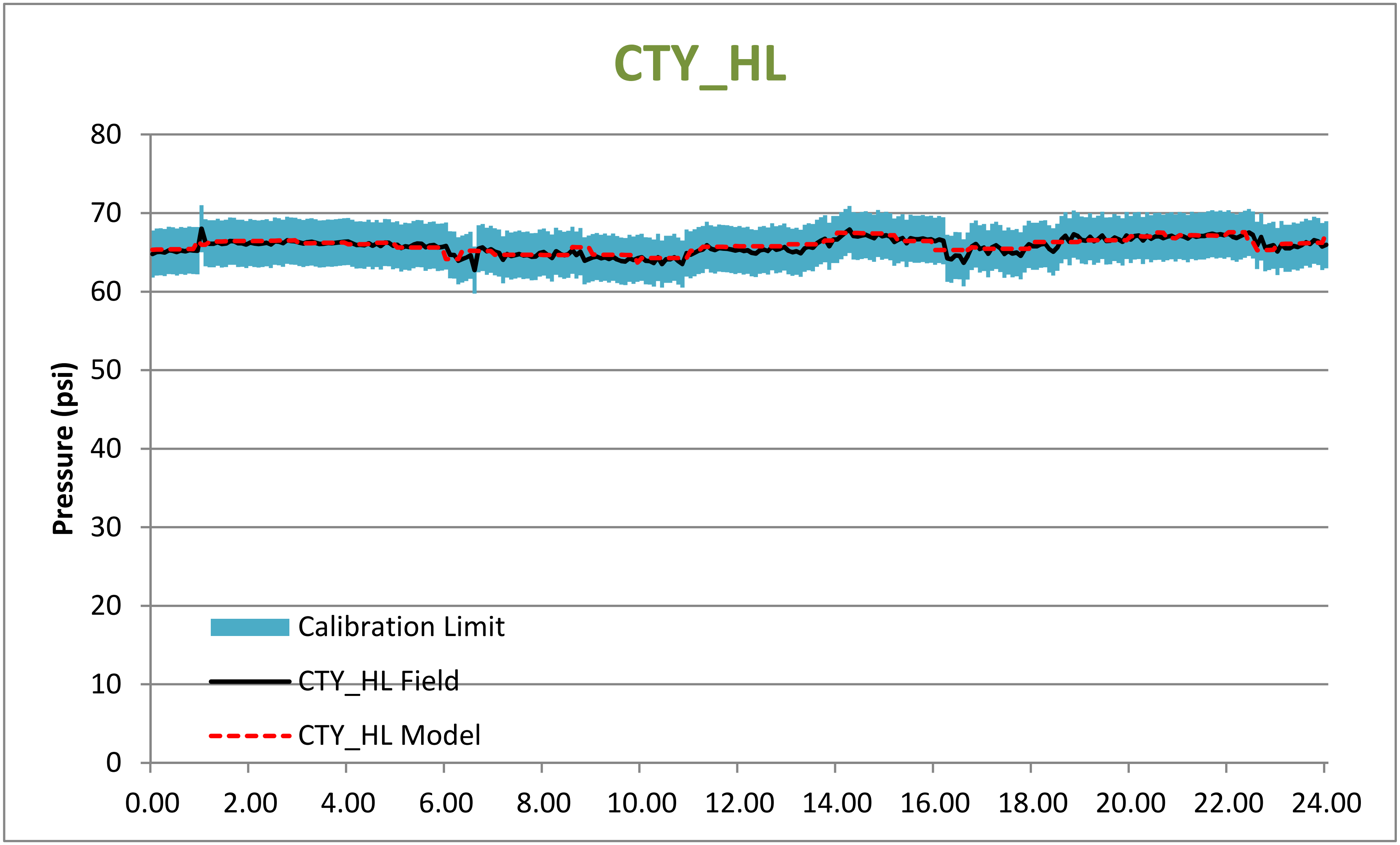


3
8
2
6
3
4
9
3
7
7
9
1
3
6
8
5
6
6
6

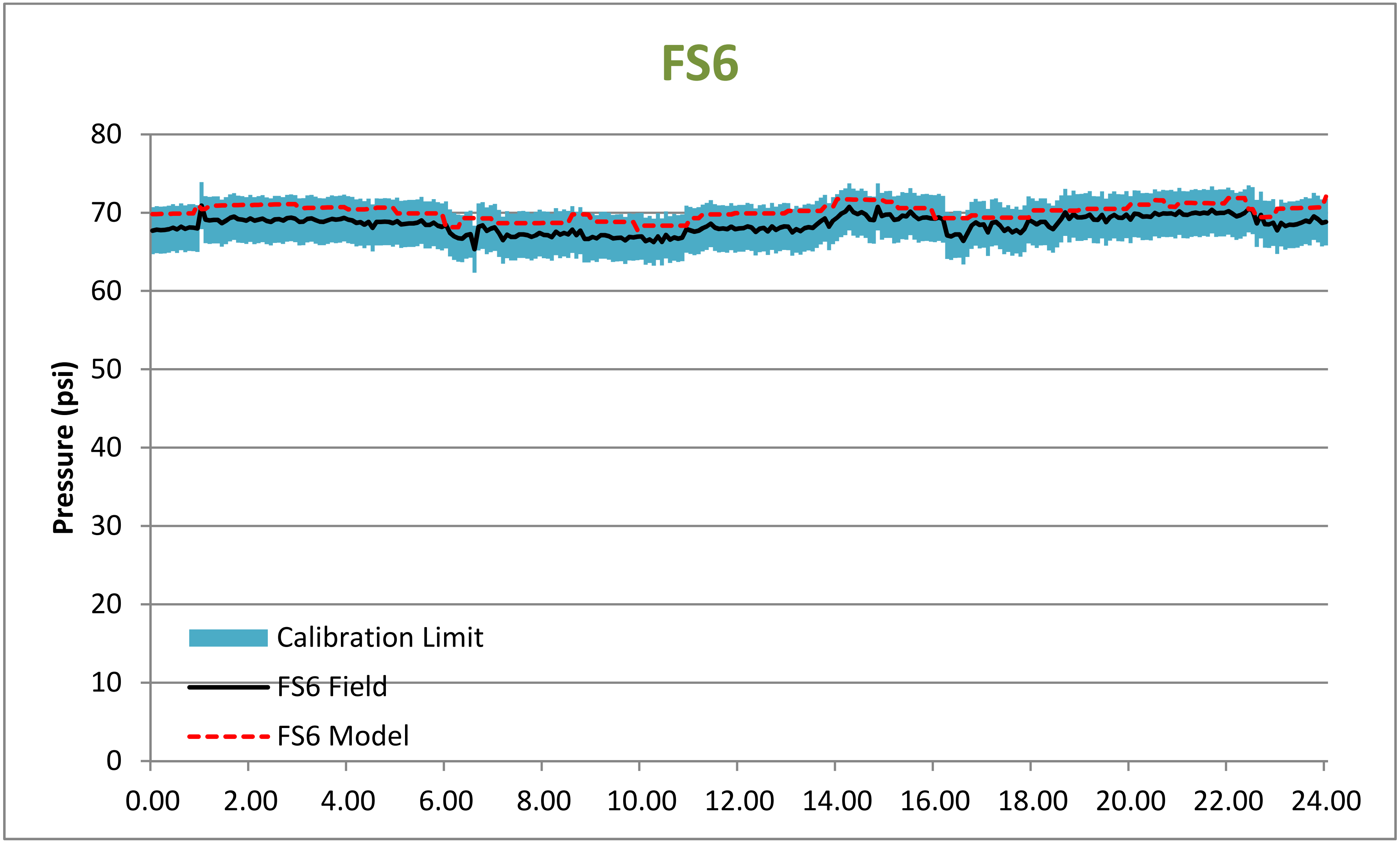

FRMNT_AVE
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FRMNT_AVE Field
FRMNT_AVE Model


FS17
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS17 Field
FS17 Model

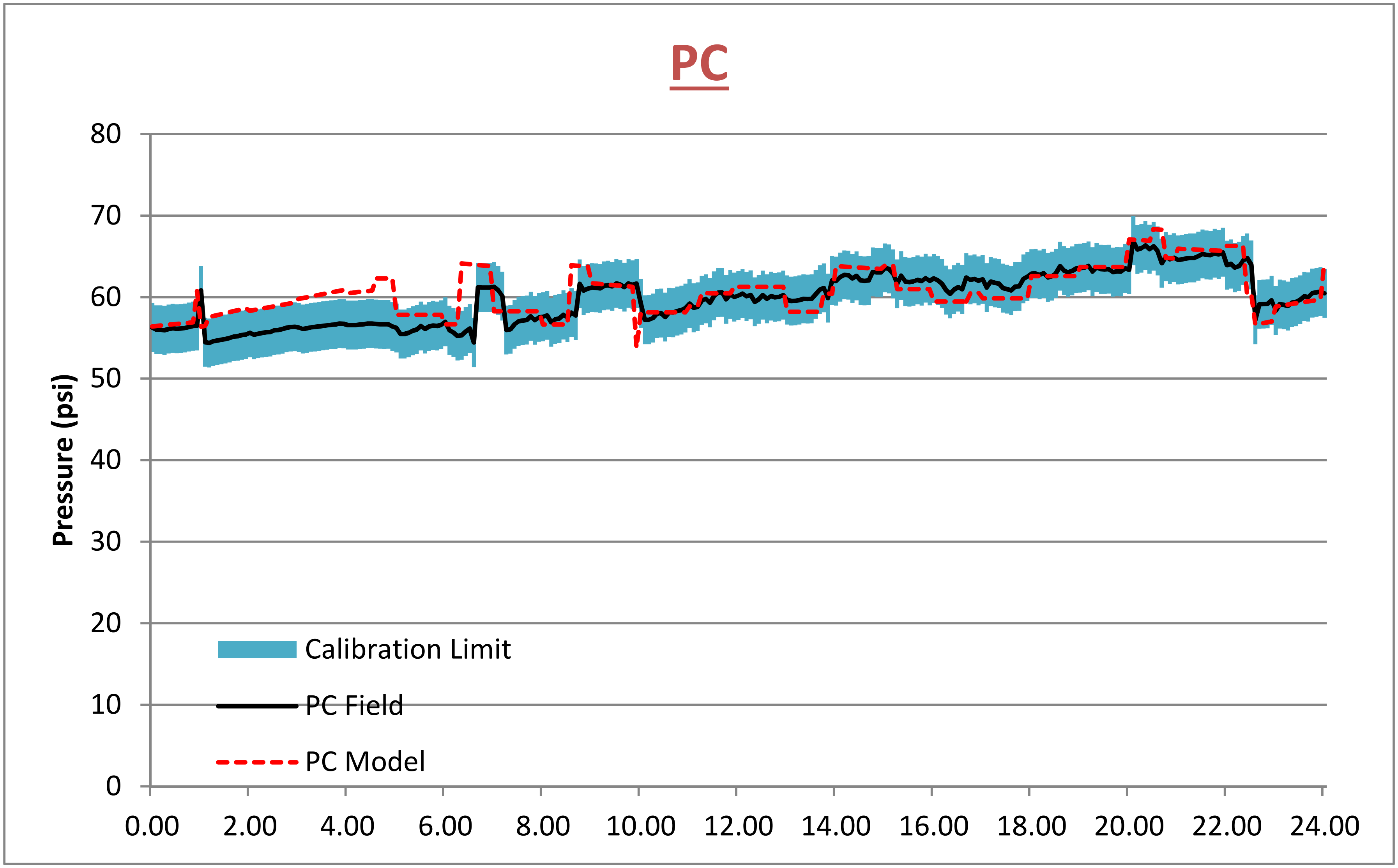

FS14
80
70
60
50
40
30
20
10
0
Pressure (psi)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS14 Field
FS14 Model



CTY_HL
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
CTY_HL Field
CTY_HL Model



FS6
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS6 Field
FS6 Model


PC
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
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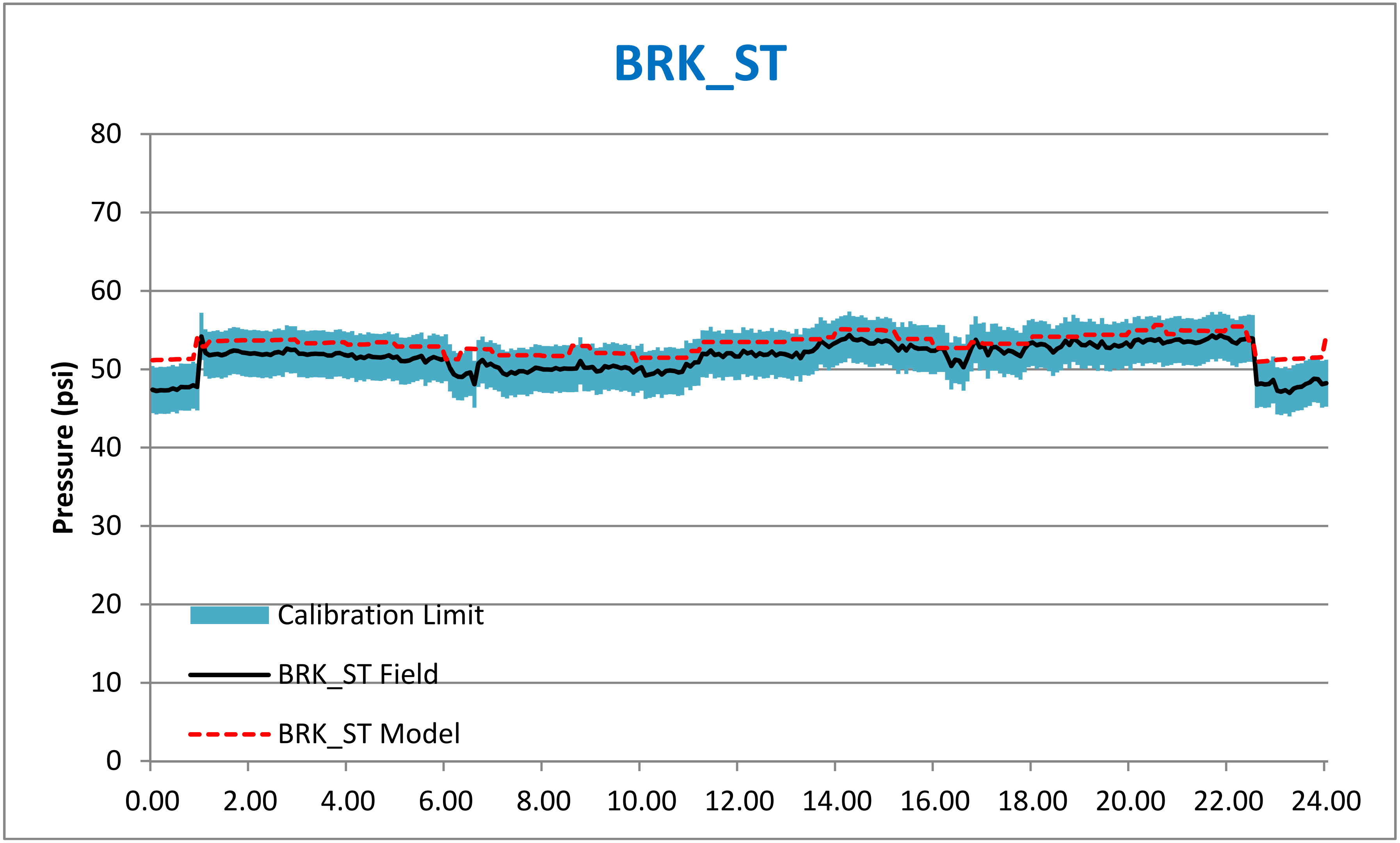
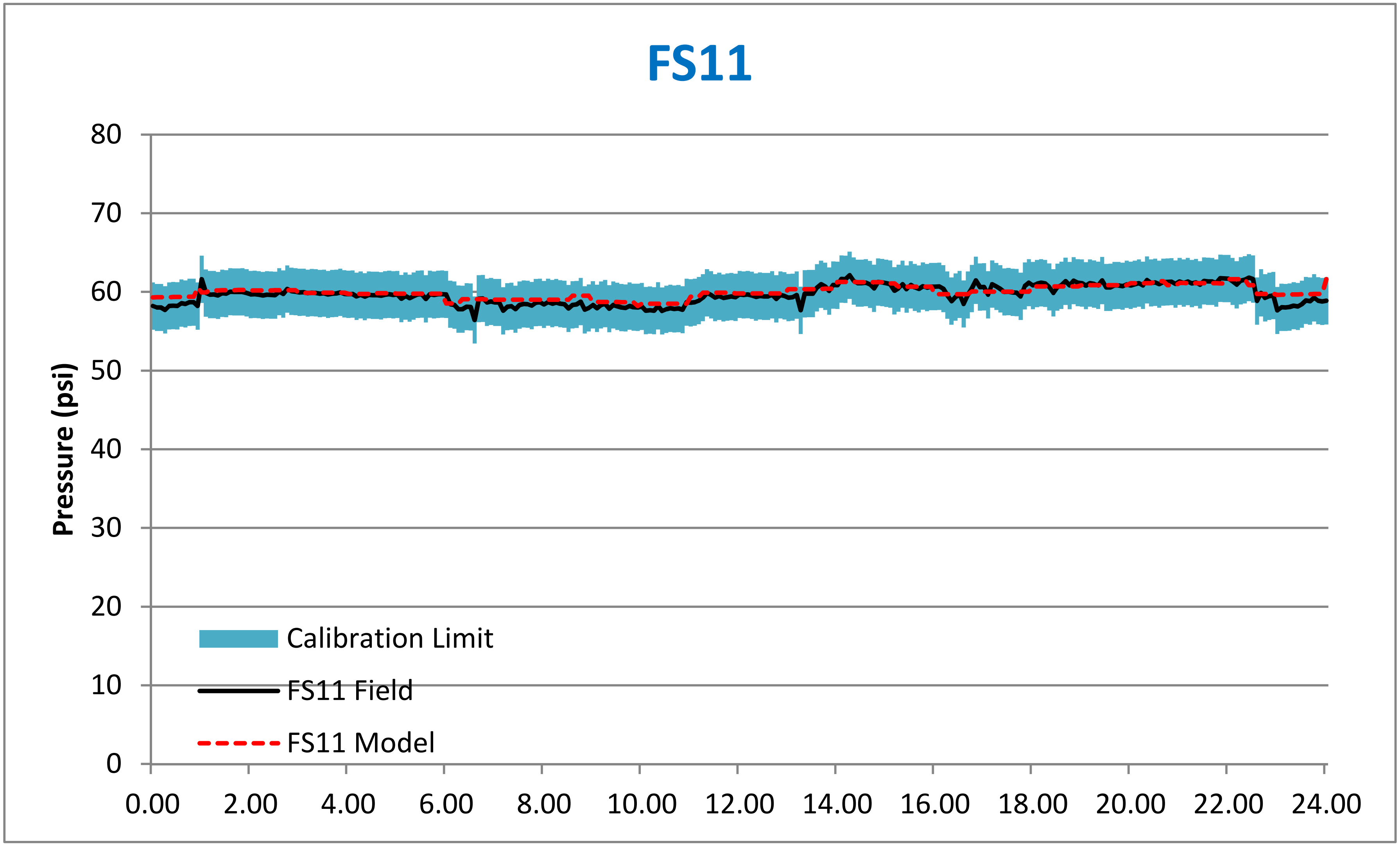
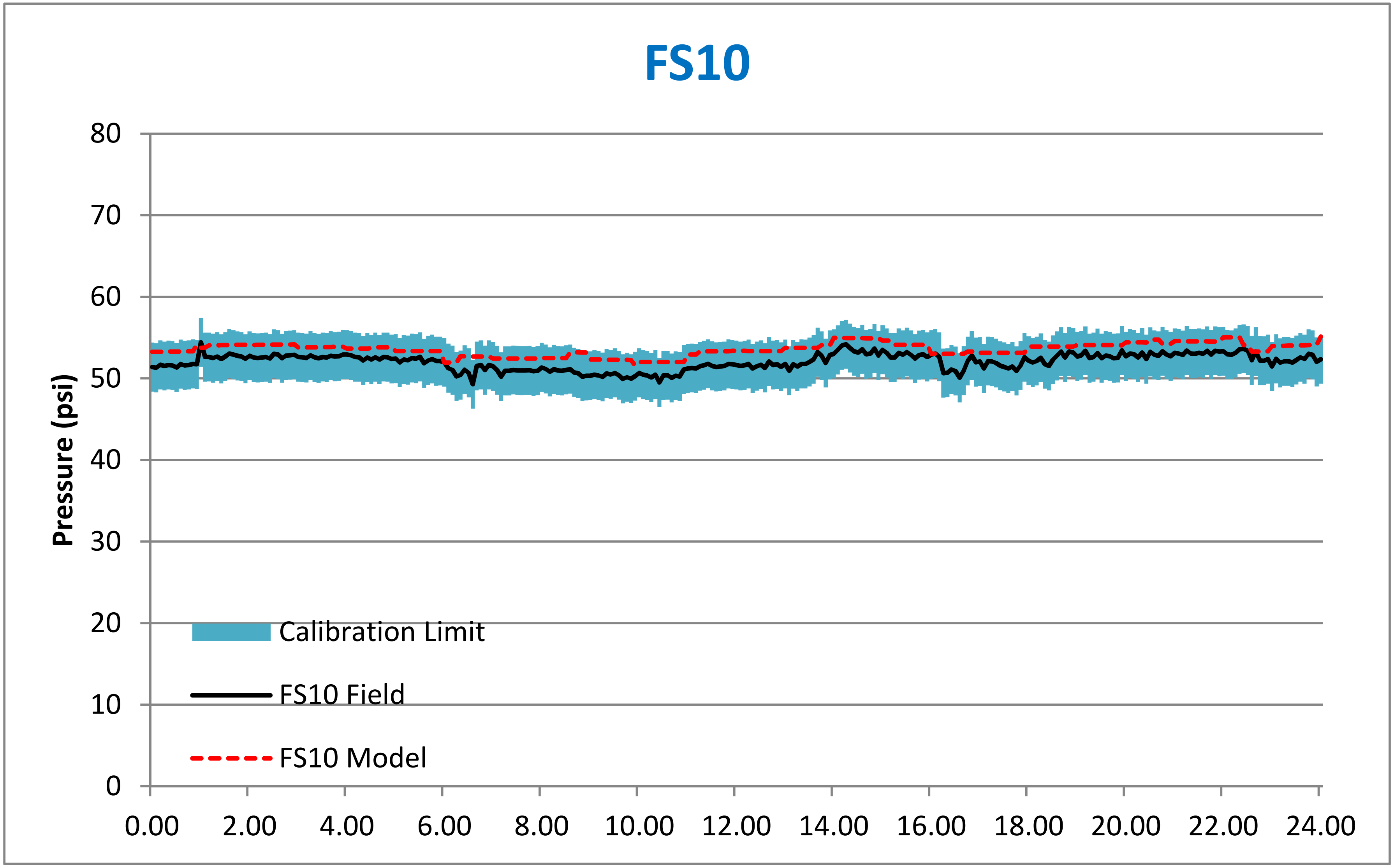
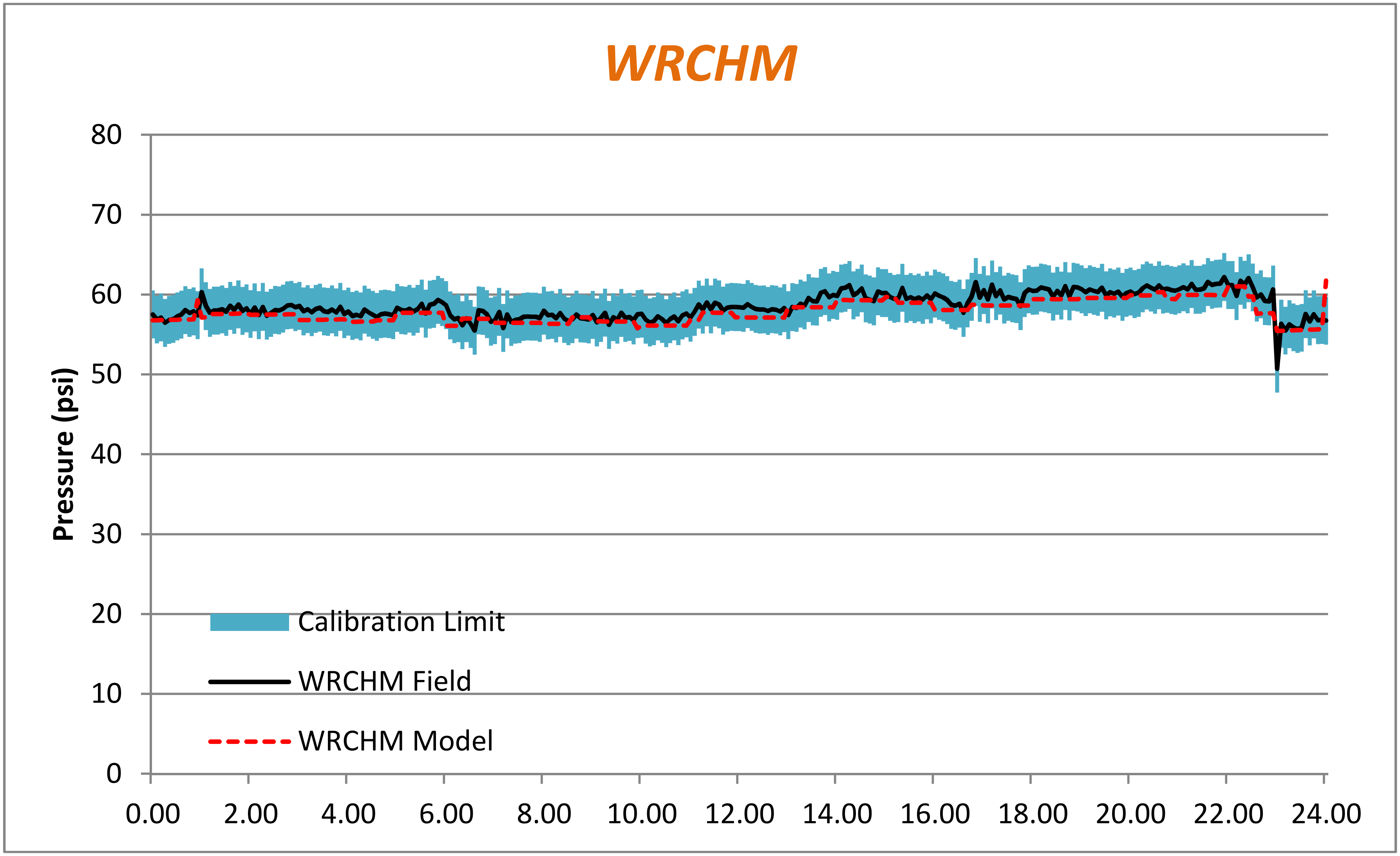
24.00
Calibration Limit
PC Field
PC Model


BRK_ST
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
BRK_ST Field
BRK_ST Model

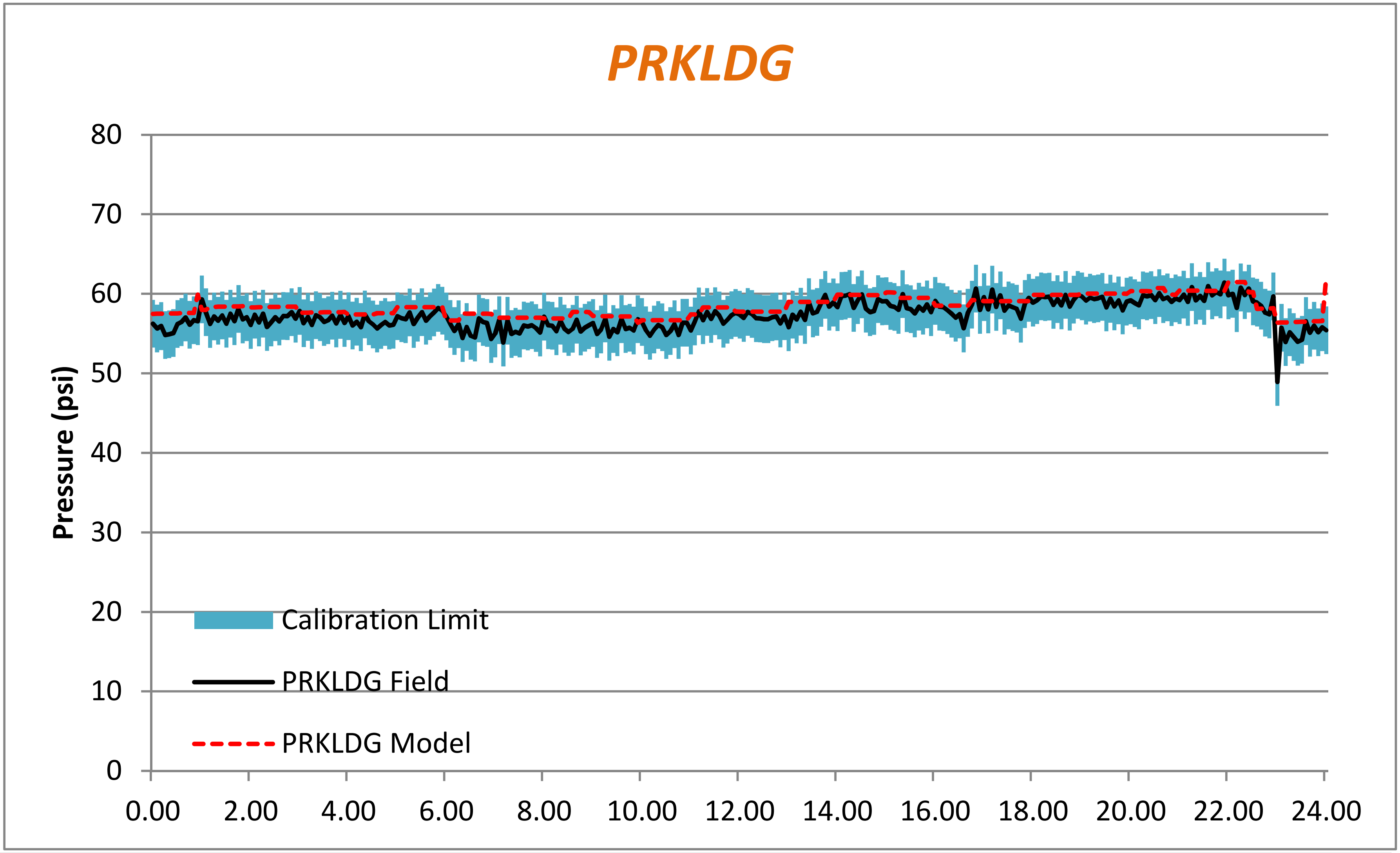


FS11
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS11 Field
FS11 Model

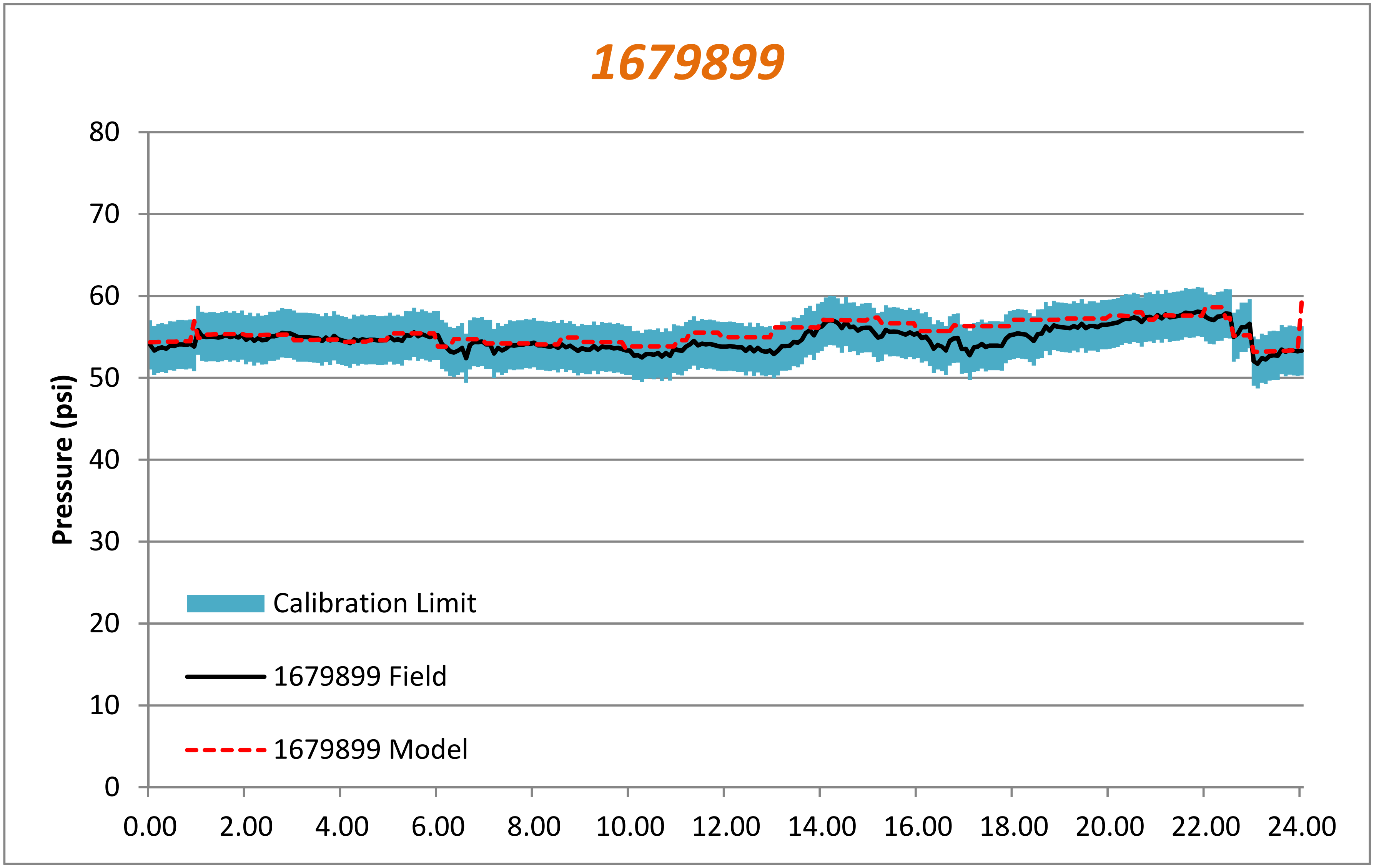

FS10
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS10 Field
FS10 Model



WRCHM
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
WRCHM Field
WRCHM Model



PRKLDG
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
PRKLDG Field
PRKLDG Model



1679899
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
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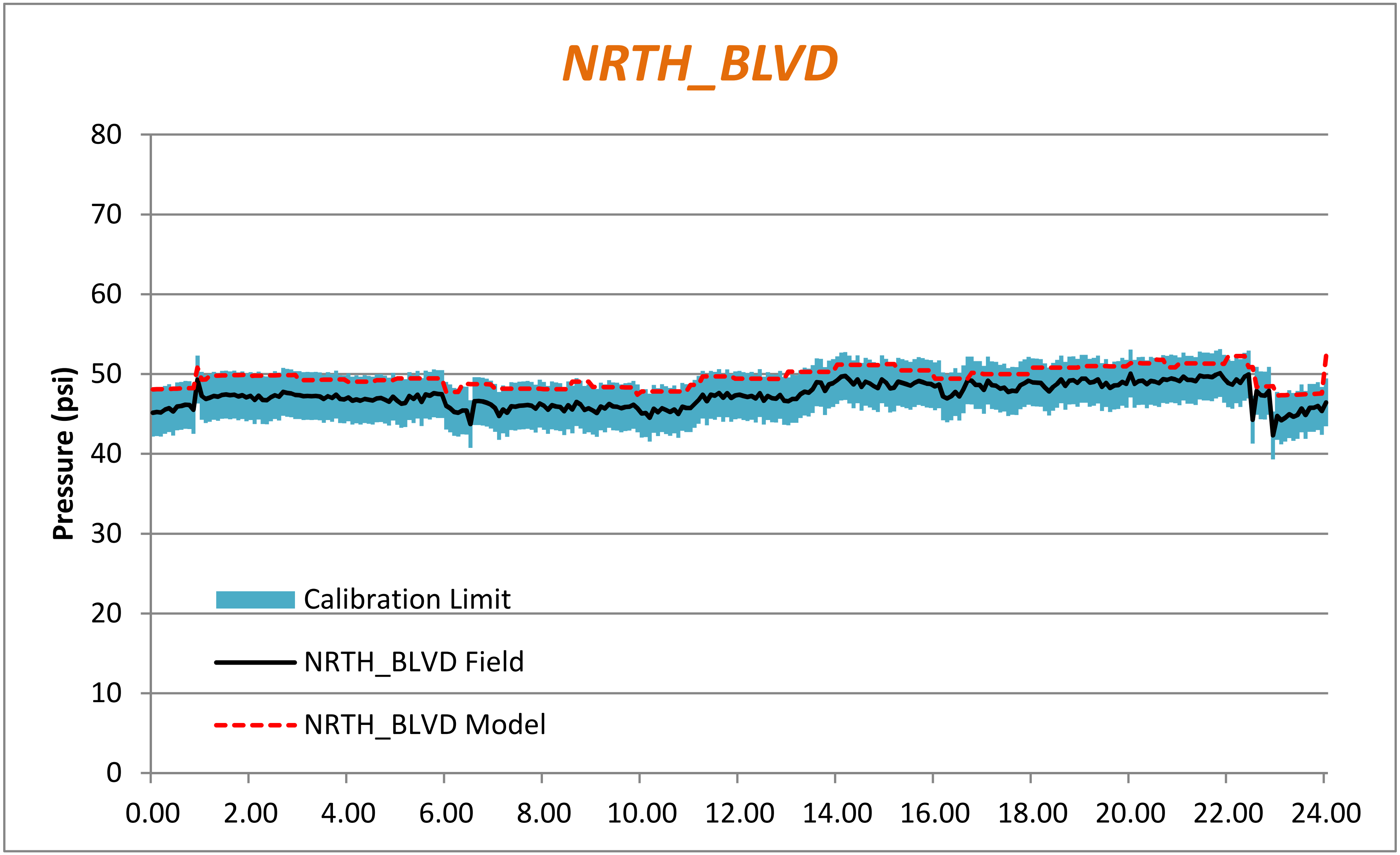
20.00
22.00
24.00
Calibration Limit
1679899 Field
1679899 Model


NRTH_BLVD
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
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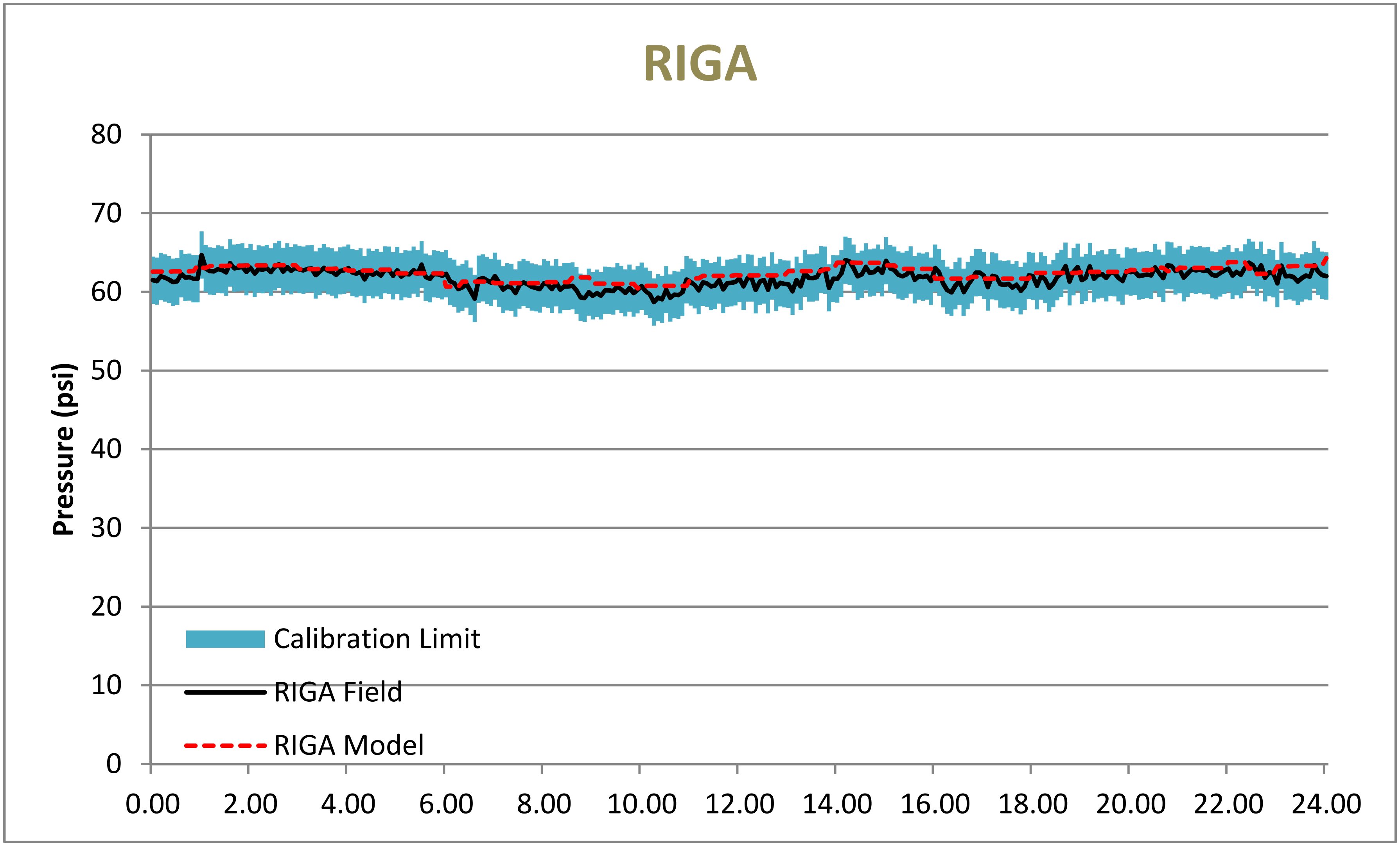
16.00
18.00
20.00
22.00
24.00
Calibration Limit
NRTH_BLVD Field
NRTH_BLVD Model


RIGA
Pressure (psi)
80
70
60
50
40
30
20
10
0
Calibration Limit
RIGA Field
RIGA Model
0.00
2.00
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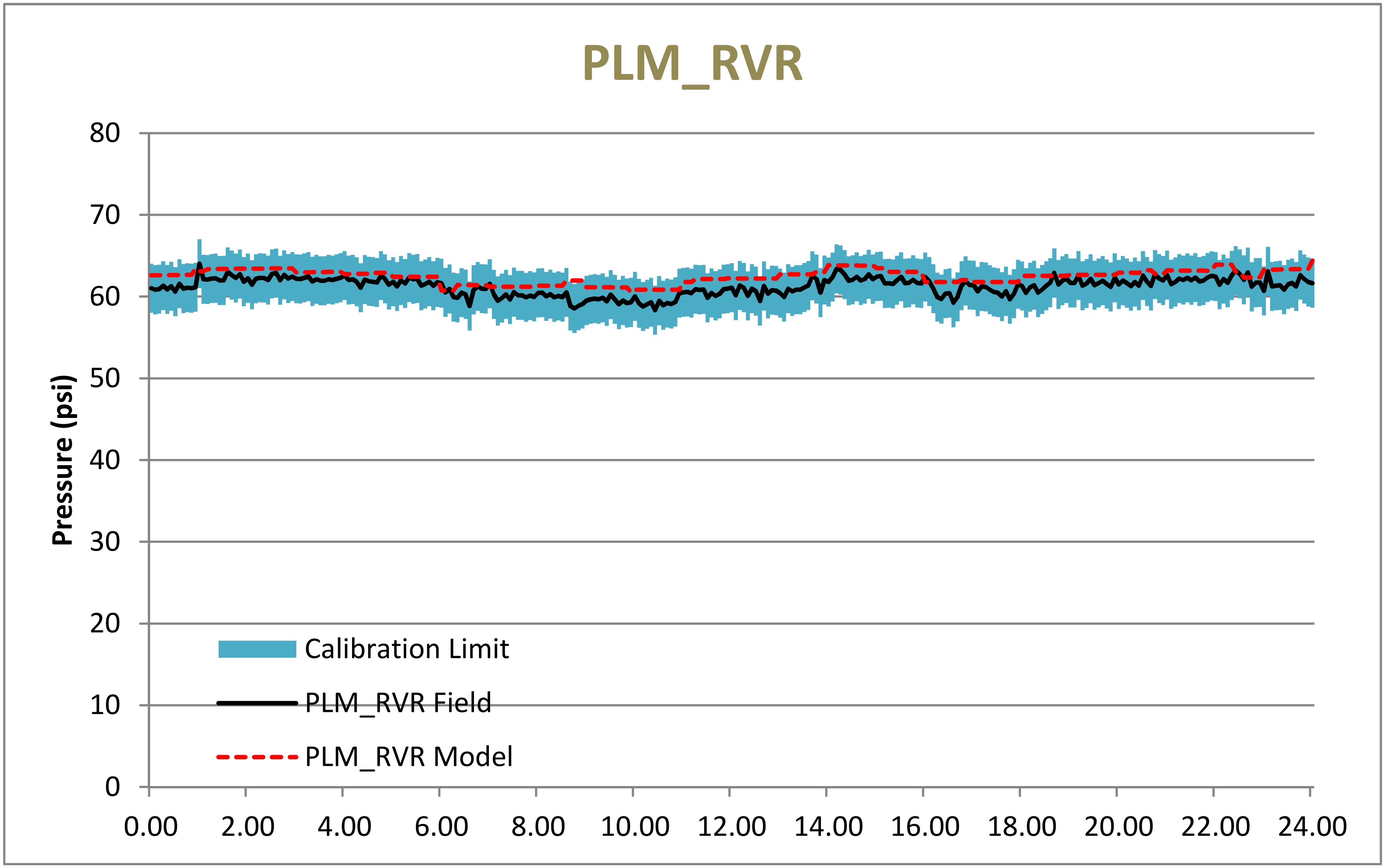
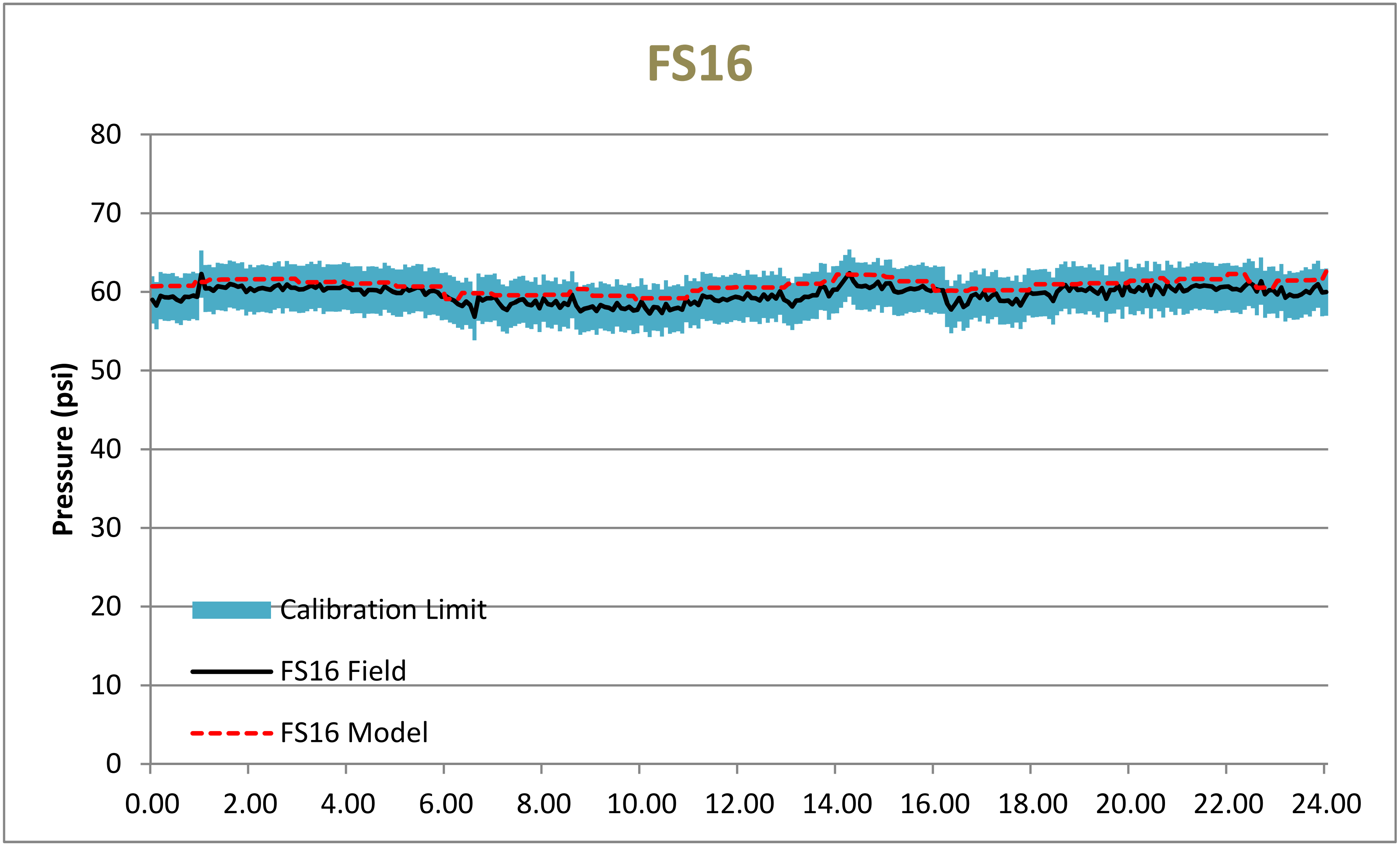
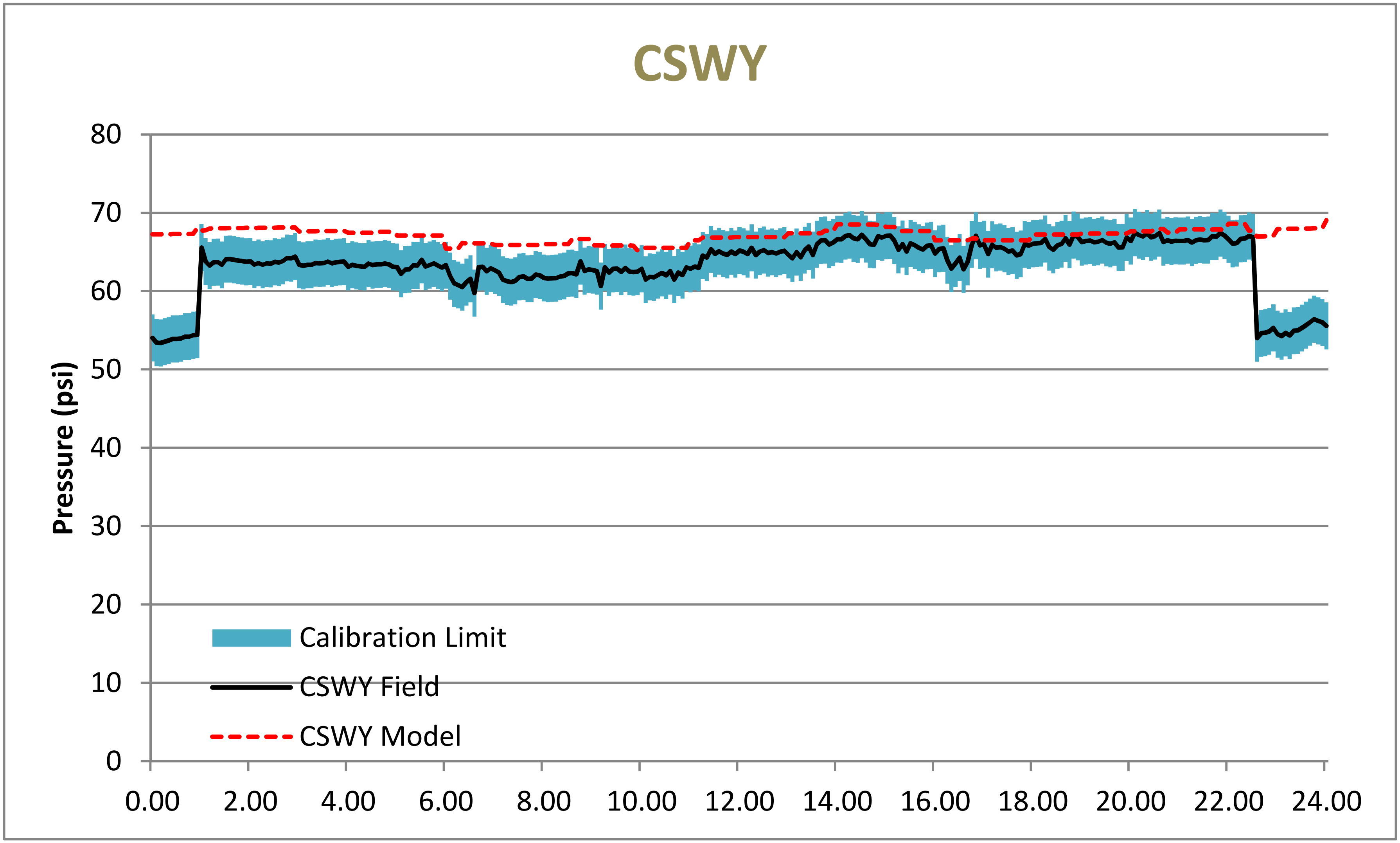
20.00
22.00
24.00

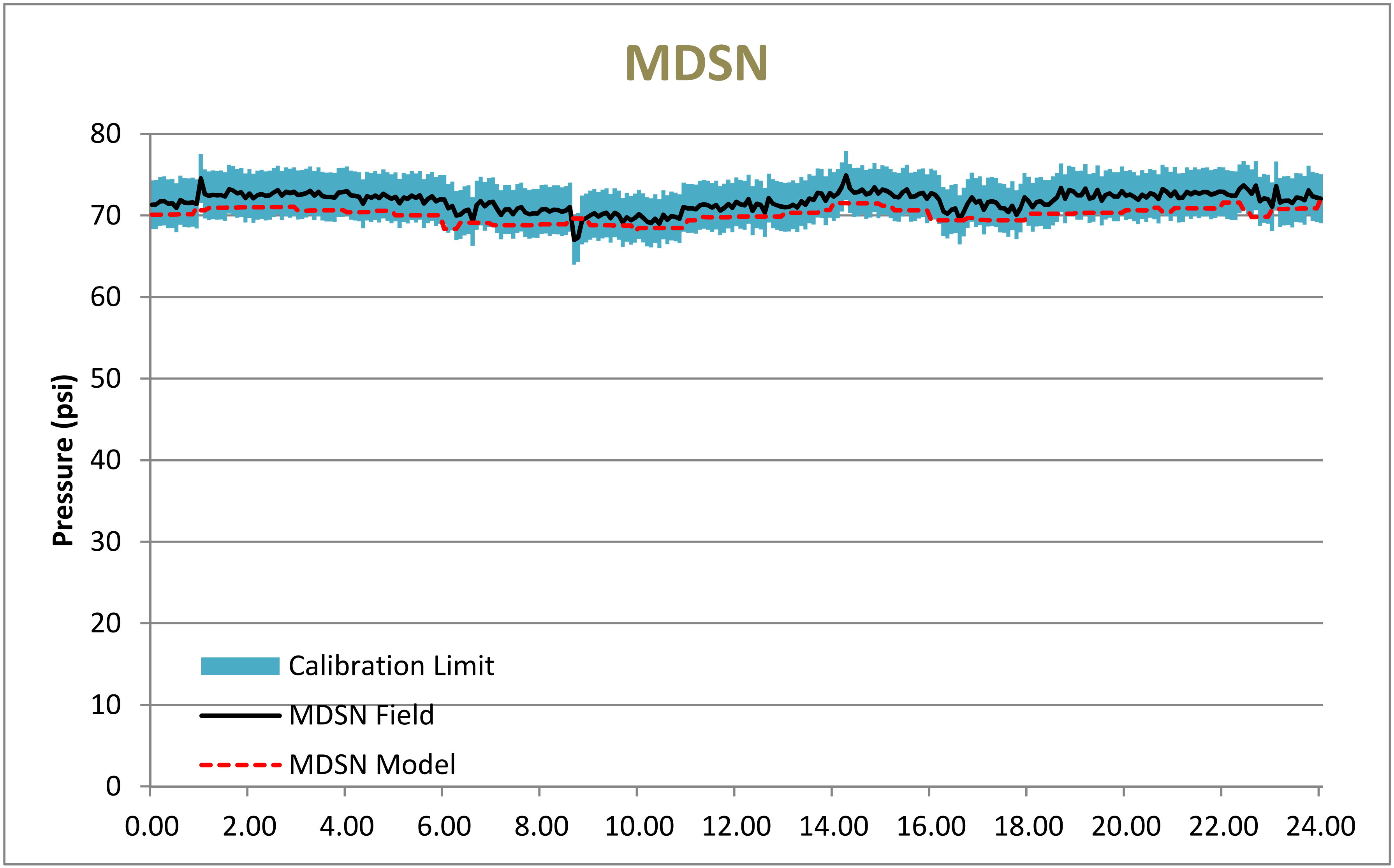

PLM_RVR
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
PLM_RVR Field
PLM_RVR Model

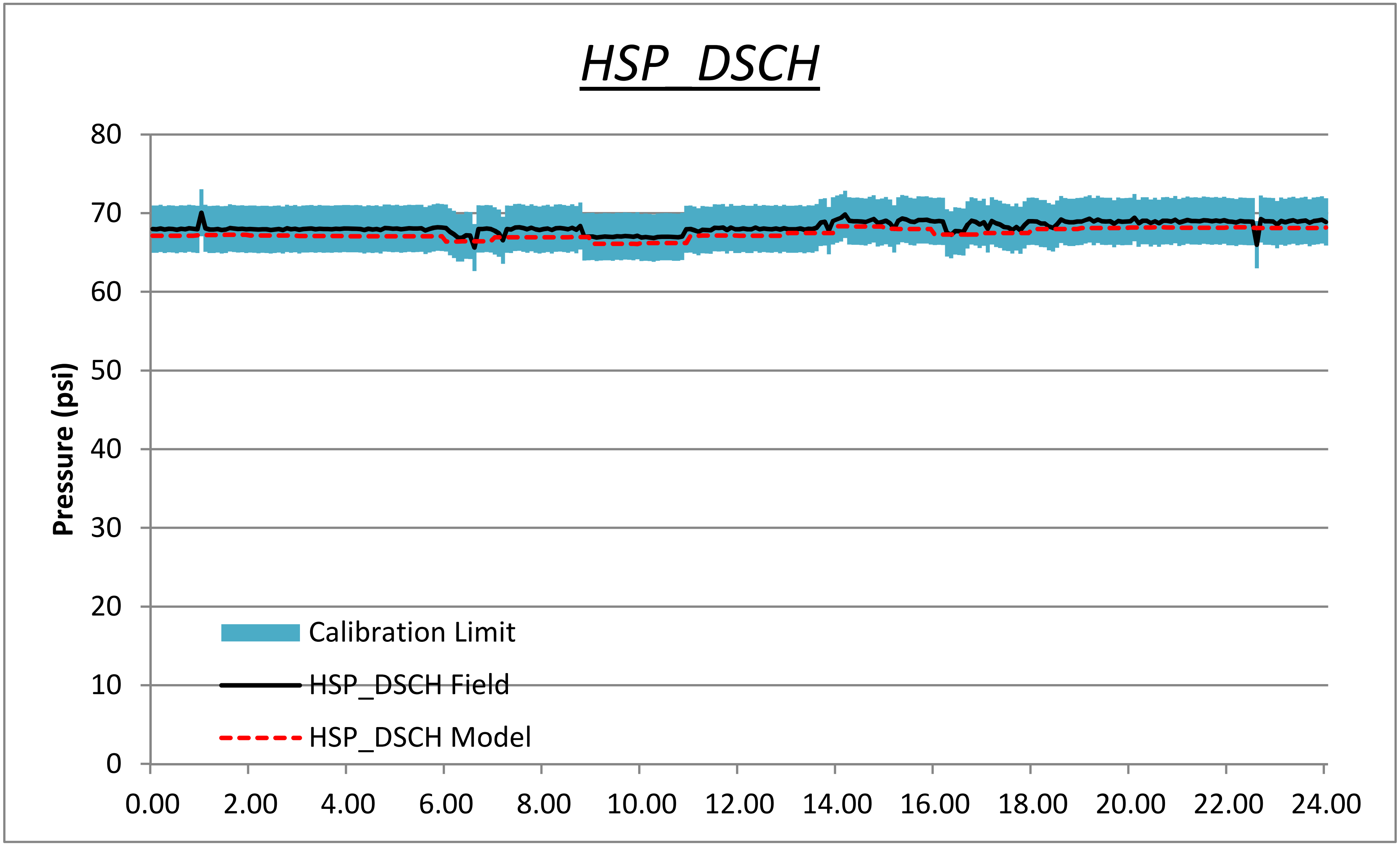


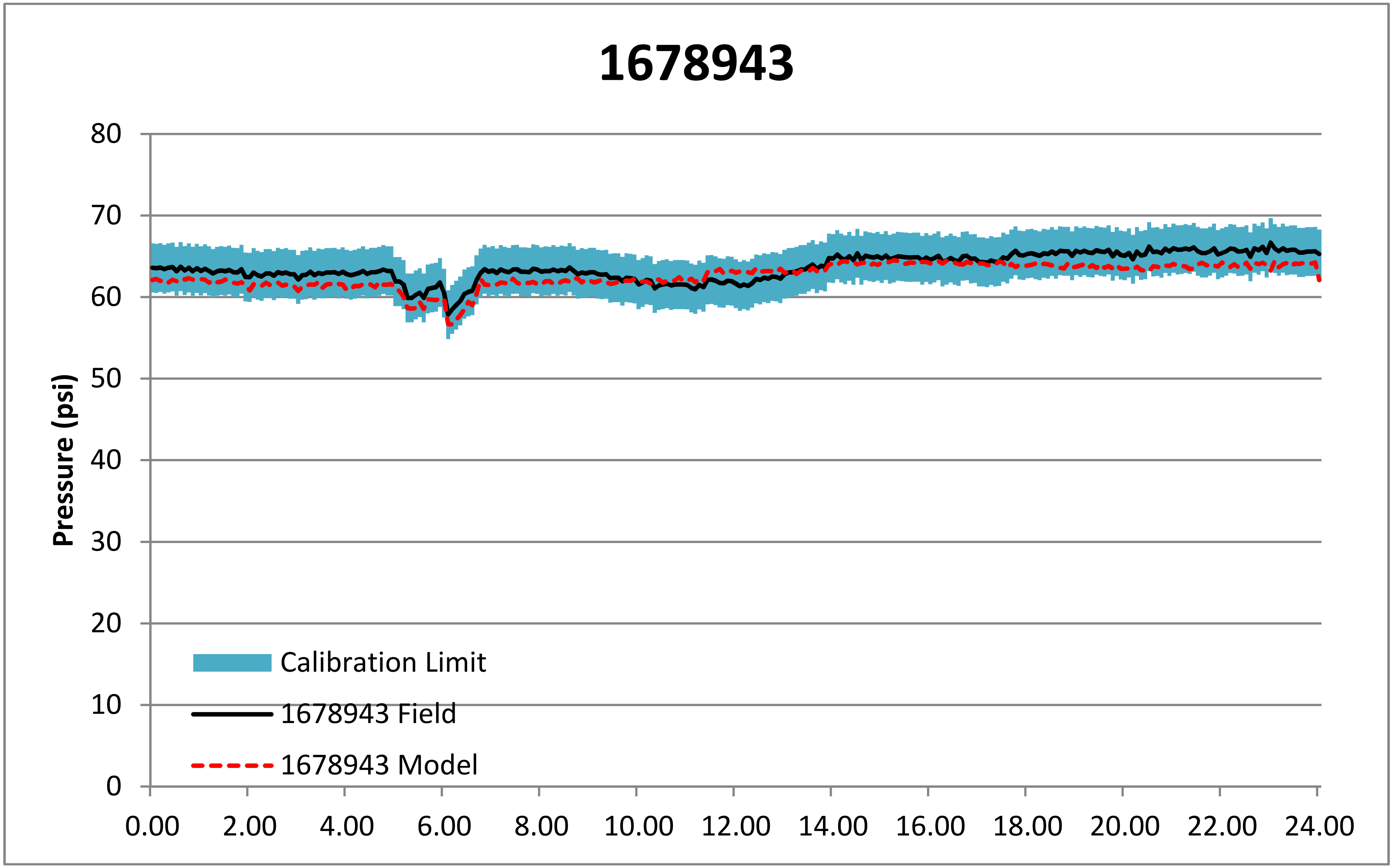
FS16
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS16 Field
FS16 Model



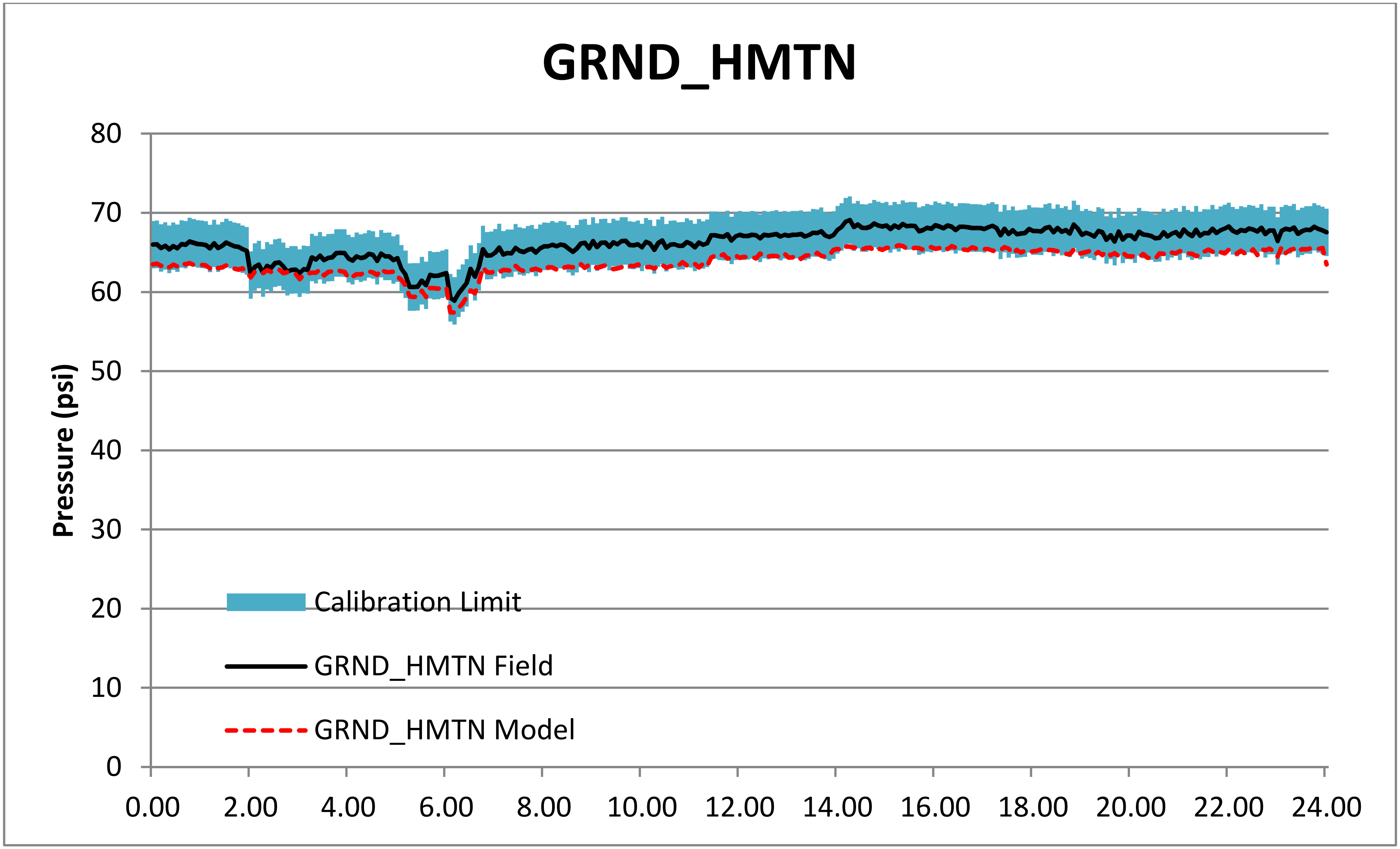
CSWY
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
CSWY Field
CSWY Model


MDSN
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
MDSN Field
MDSN Model

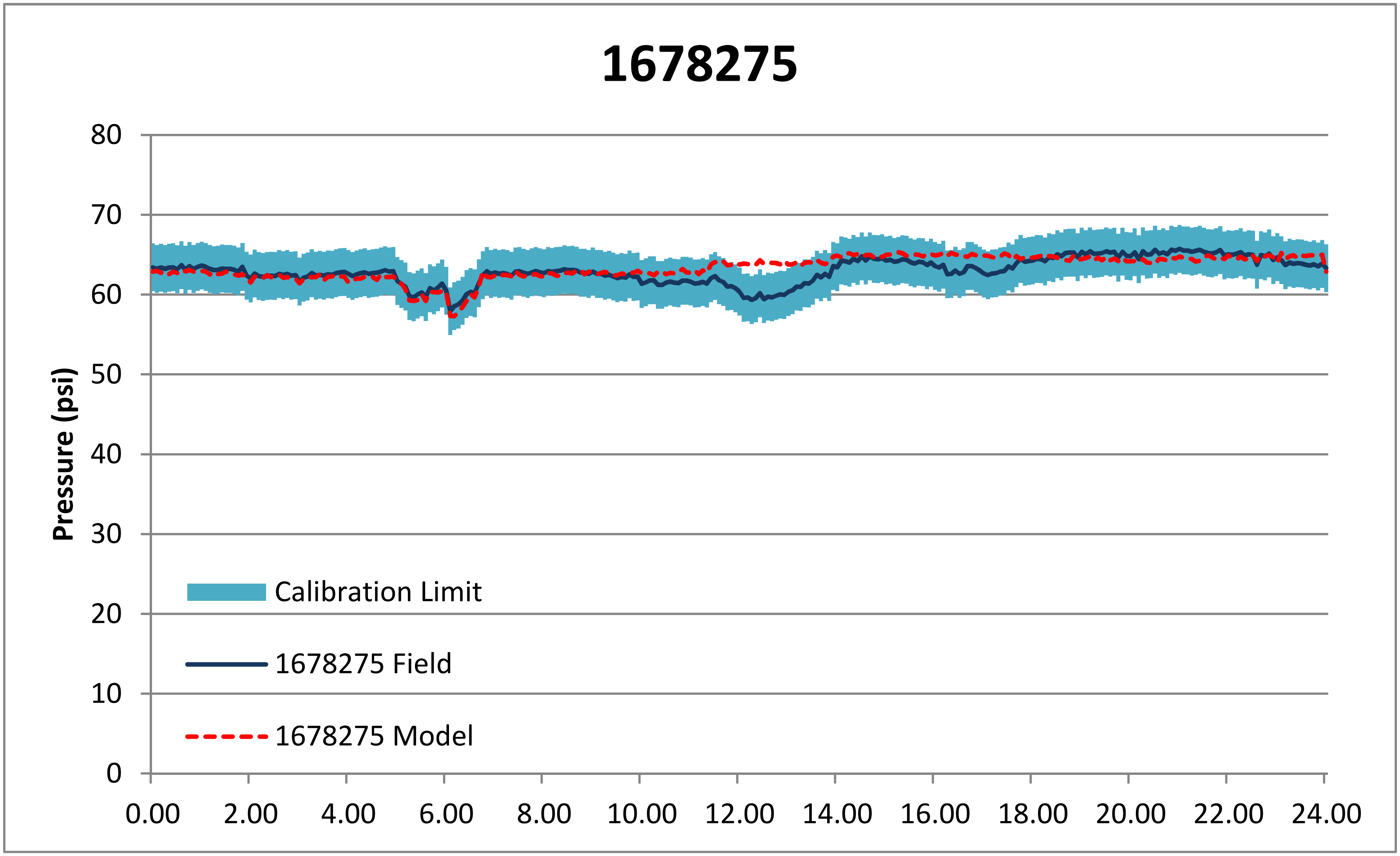

HSP_DSCH
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
HSP_DSCH Field
HSP_DSCH Model



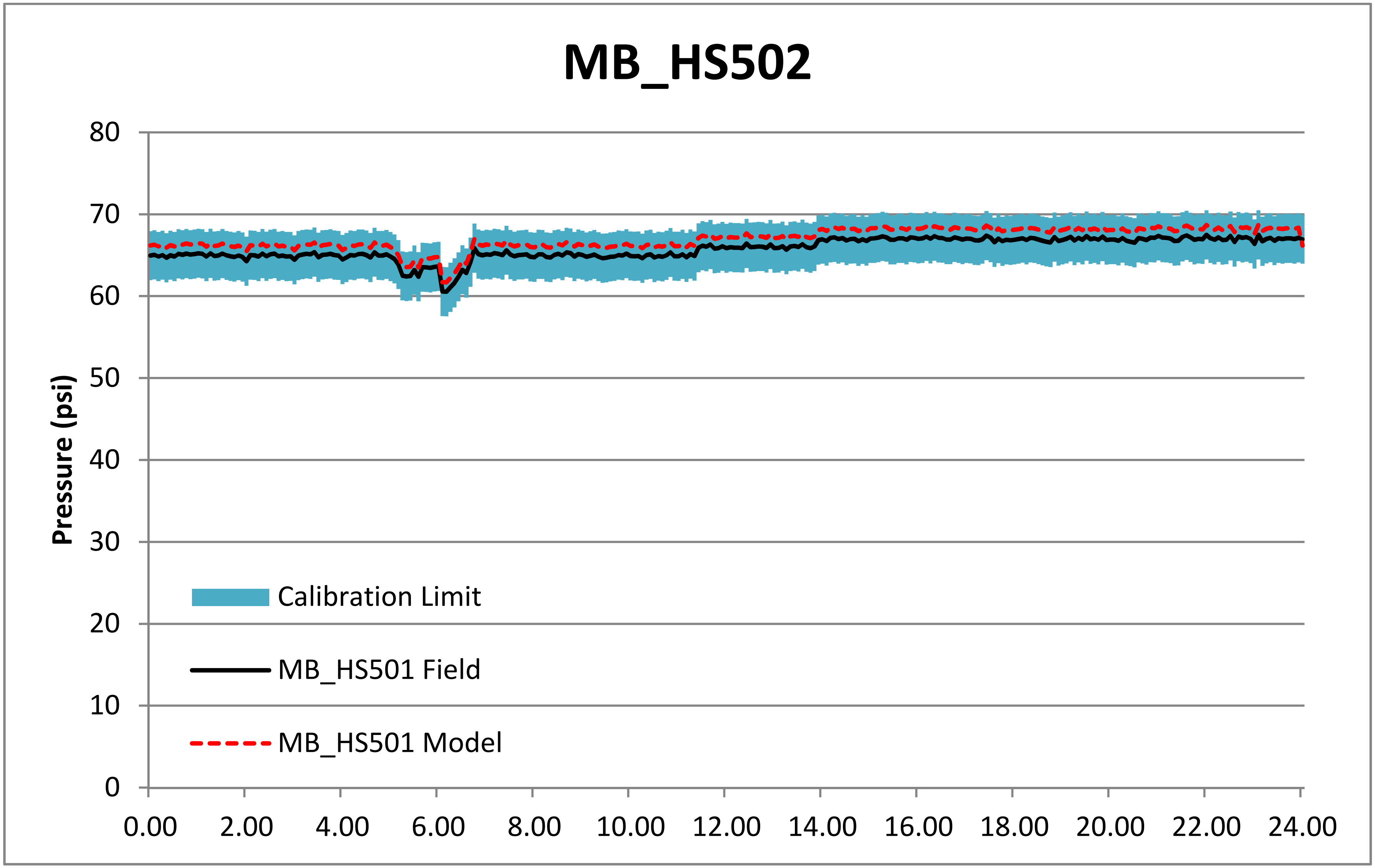
1678943
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1678943 Field
1678943 Model

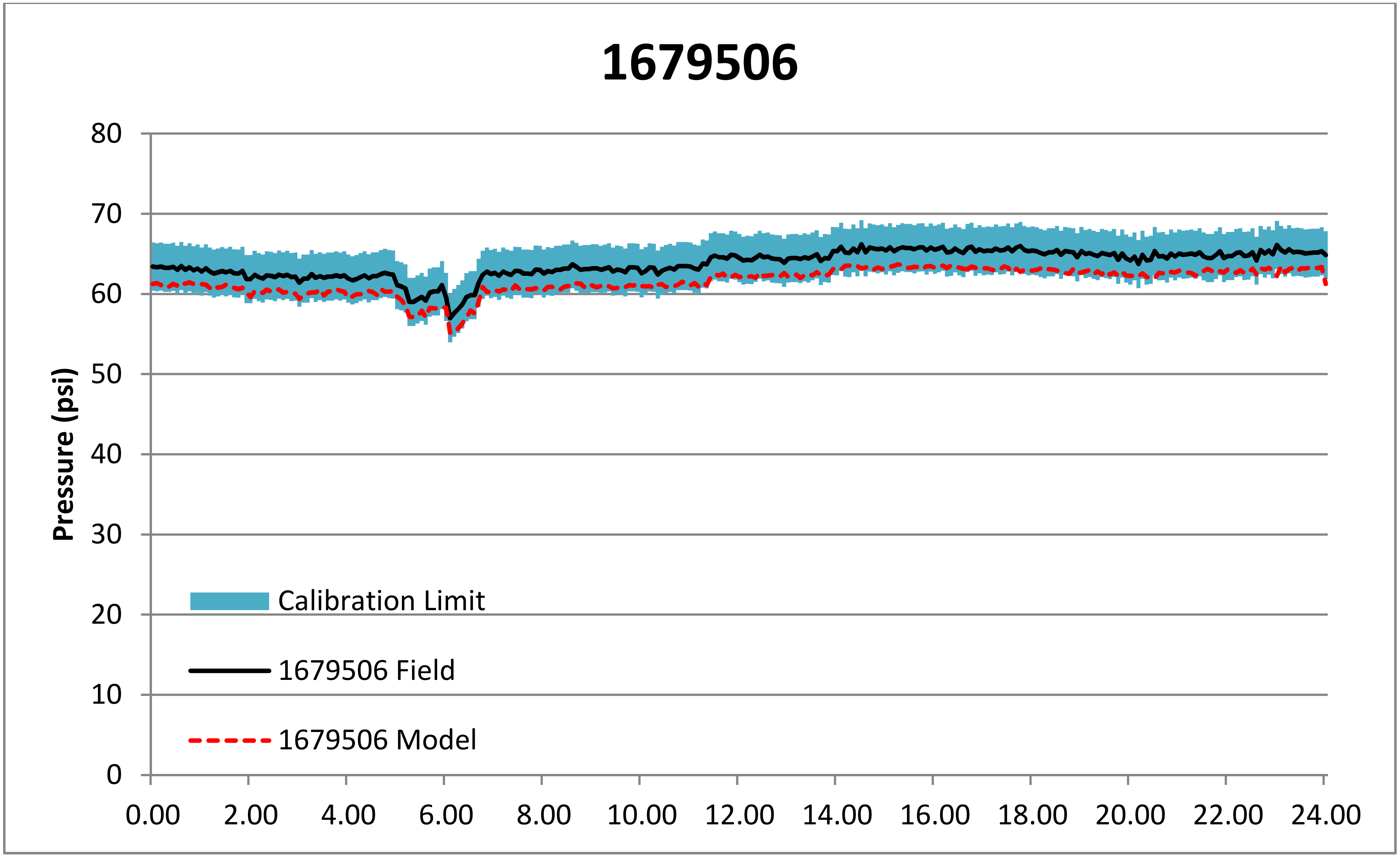


GRND_HMTN
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
GRND_HMTN Field
GRND_HMTN Model

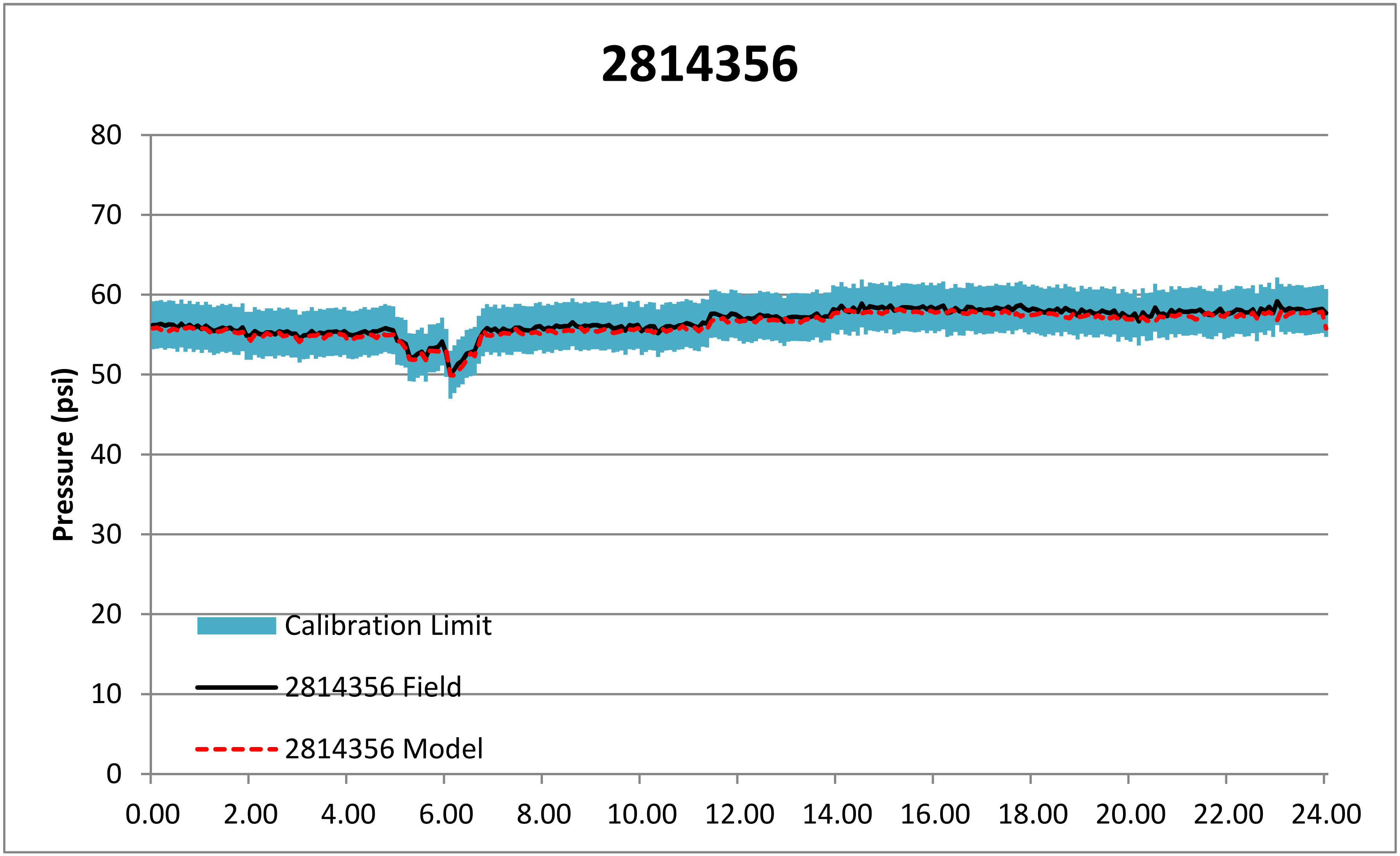


1678275
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1678275 Field
1678275 Model

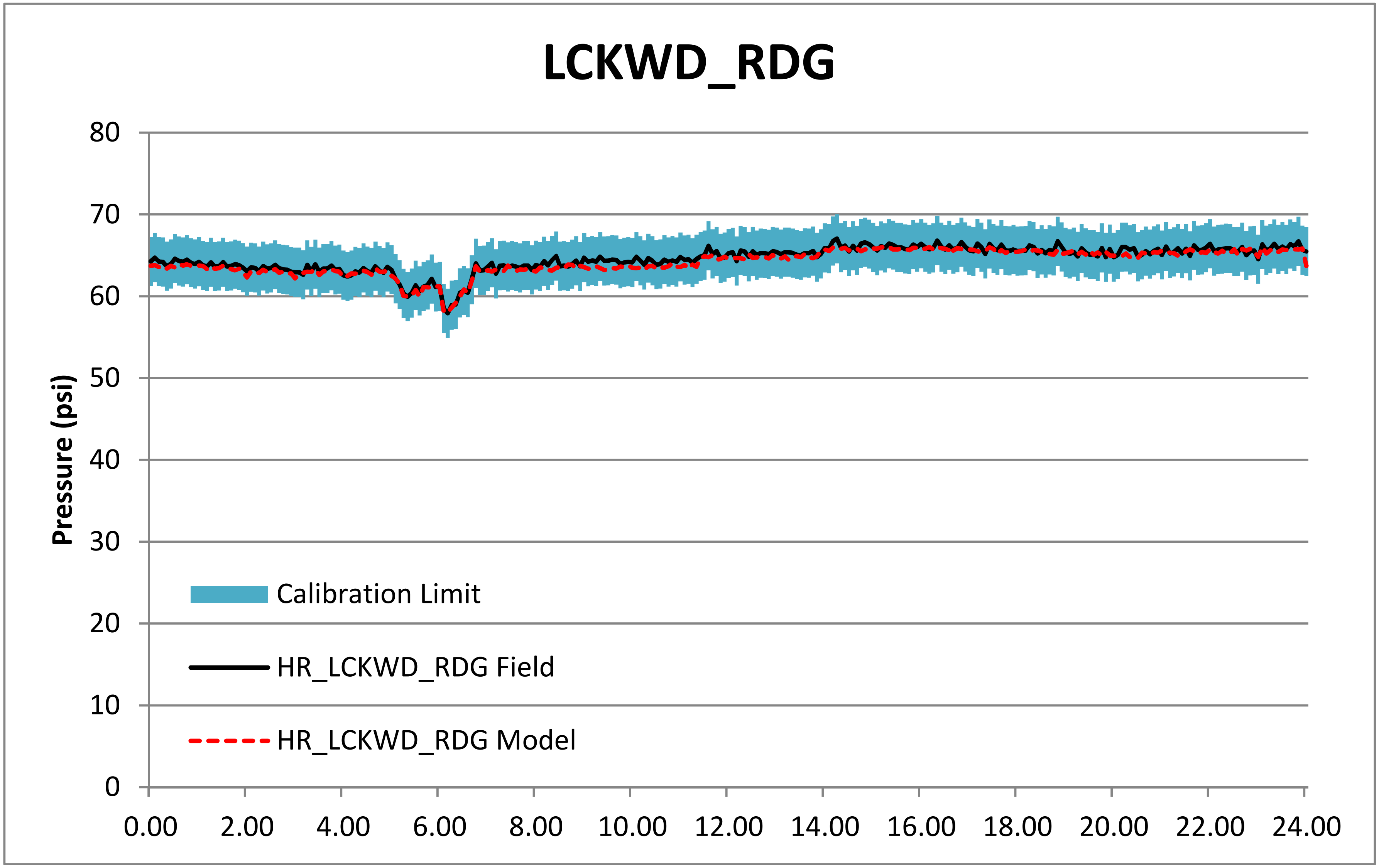

MB_HS502
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
MB_HS501 Field
MB_HS501 Model



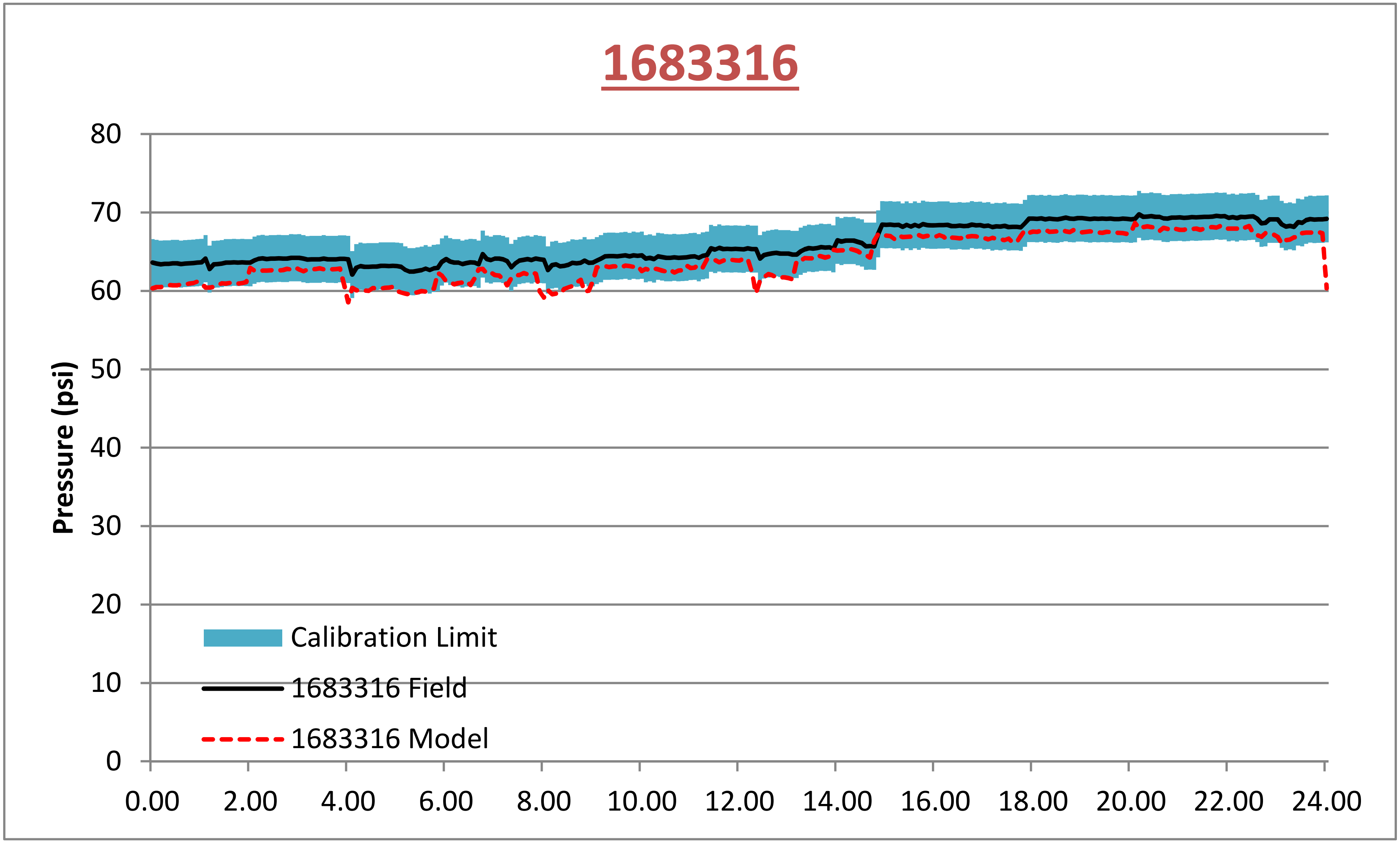
1679506
Pressure (psi)
80
70
60
50
40
30
20
10
0
Calibration Limit
1679506 Field
1679506 Model
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00



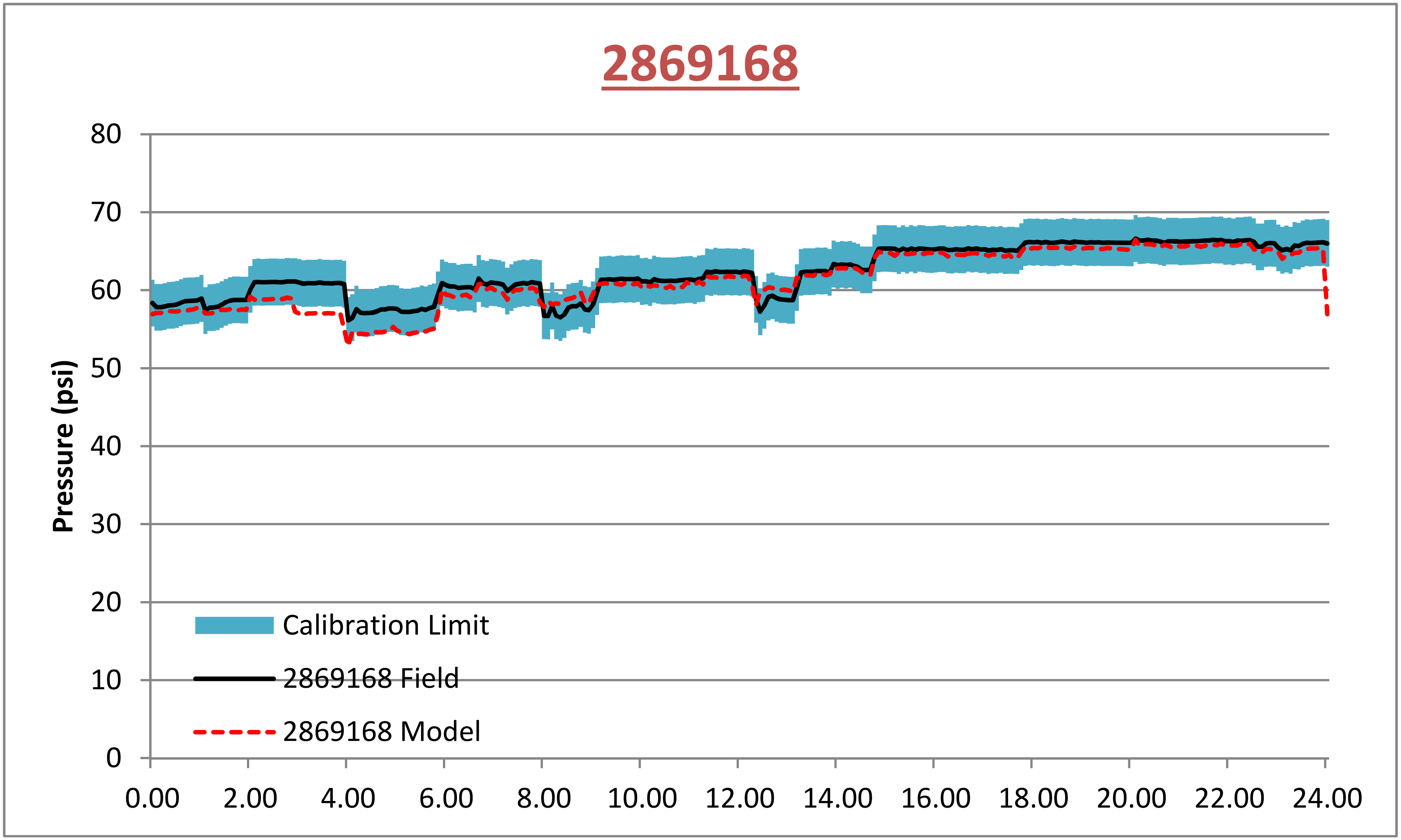
2814356
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
2814356 Field
2814356 Model



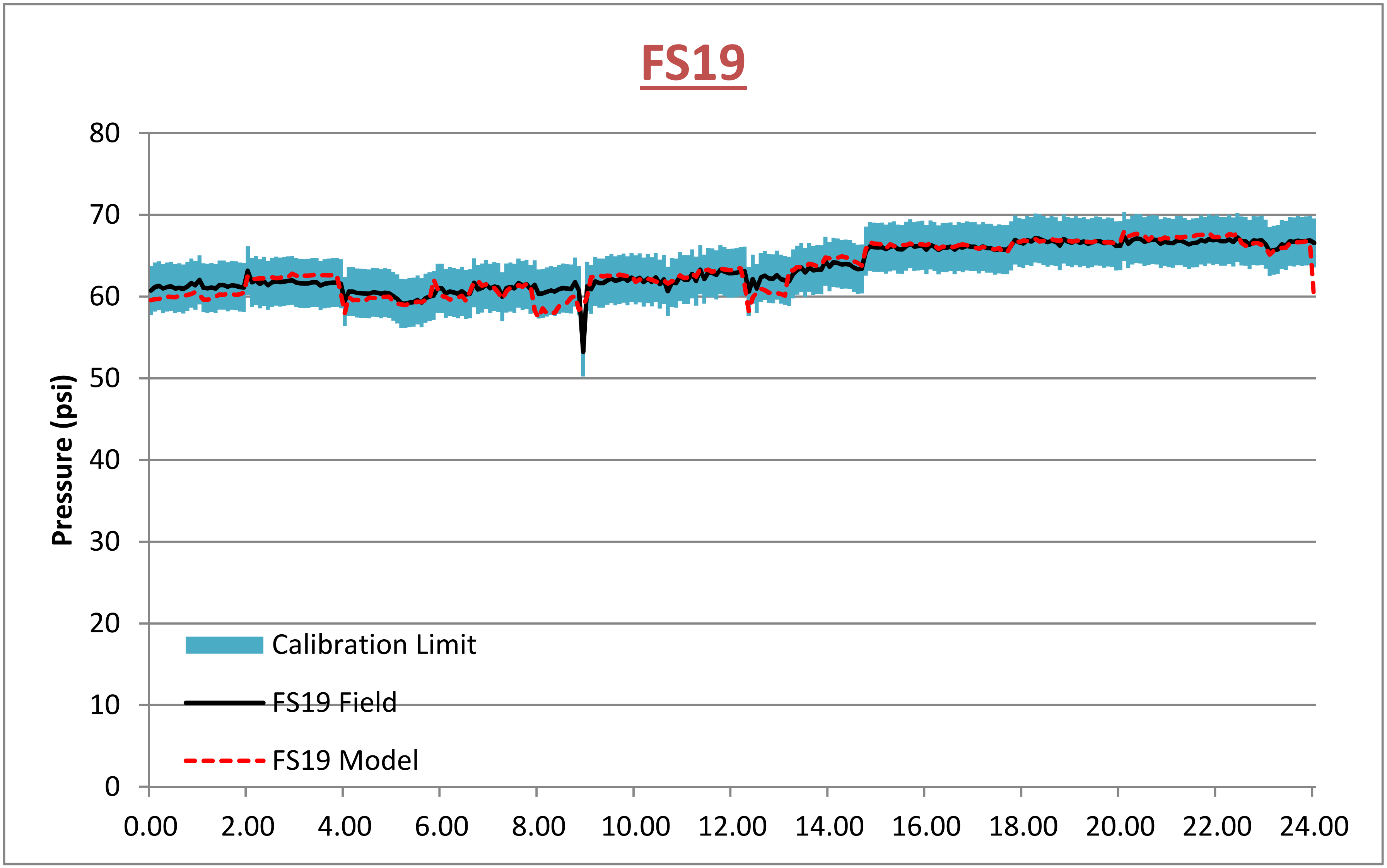
LCKWD_RDG
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
HR_LCKWD_RDG Field
HR_LCKWD_RDG Model

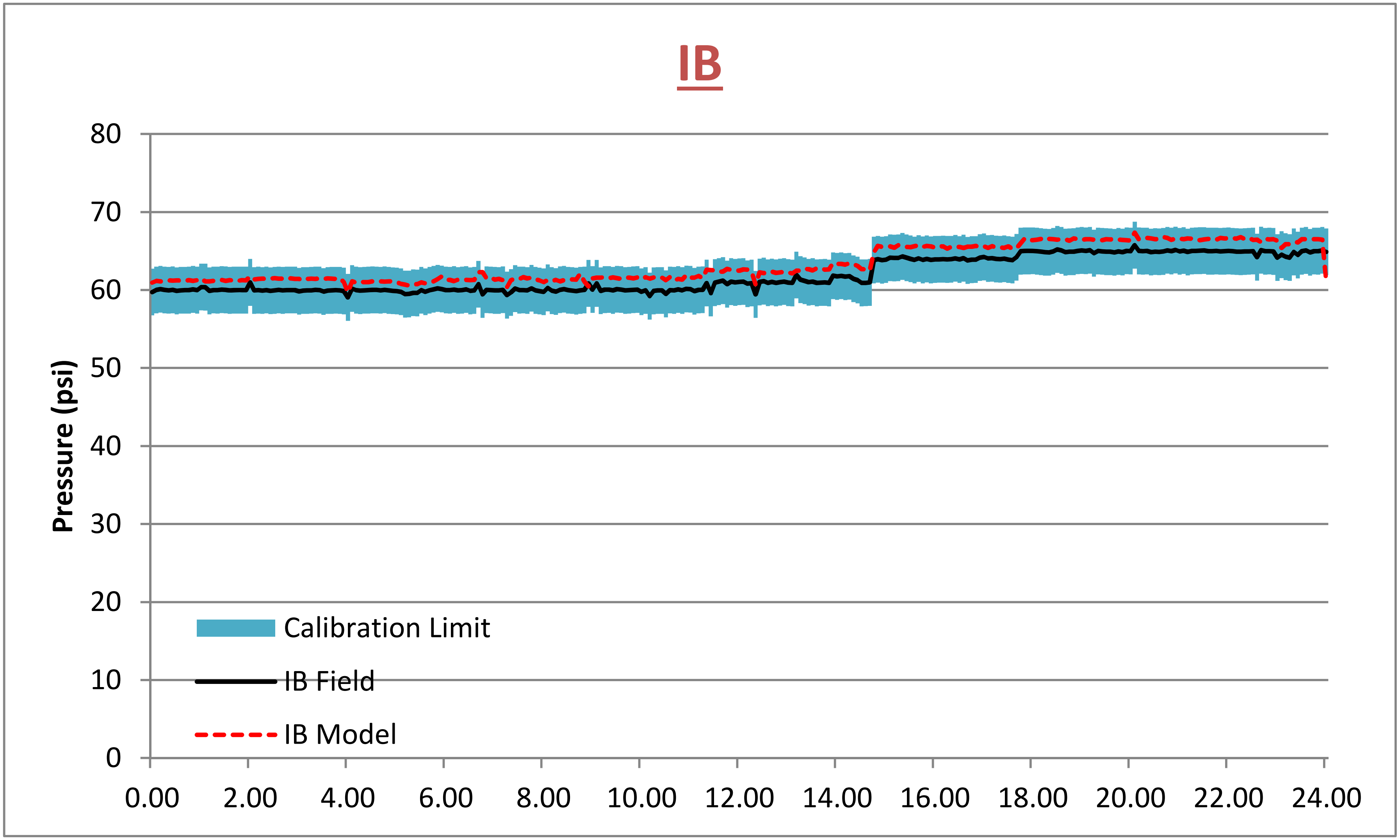


1683316
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
1683316 Field
1683316 Model

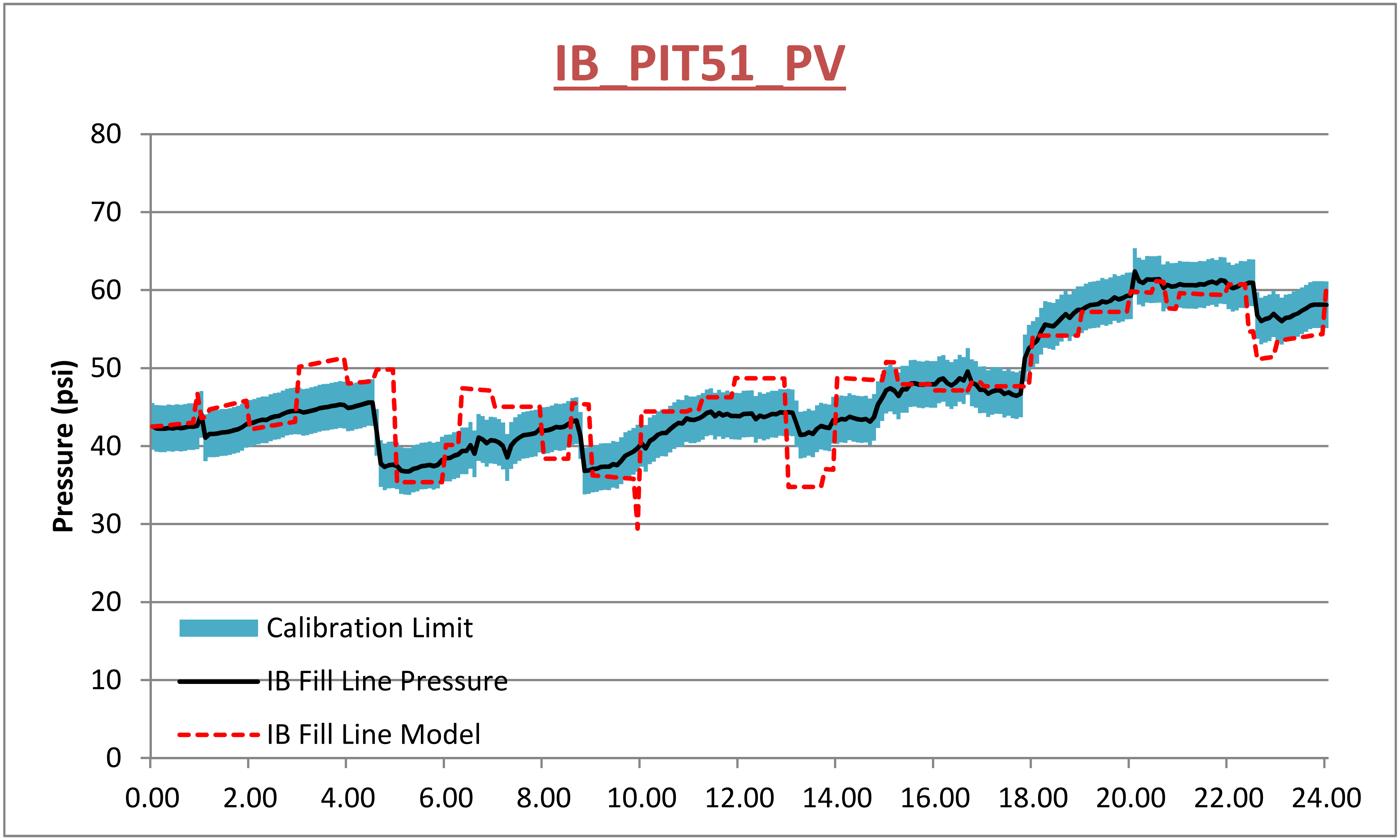


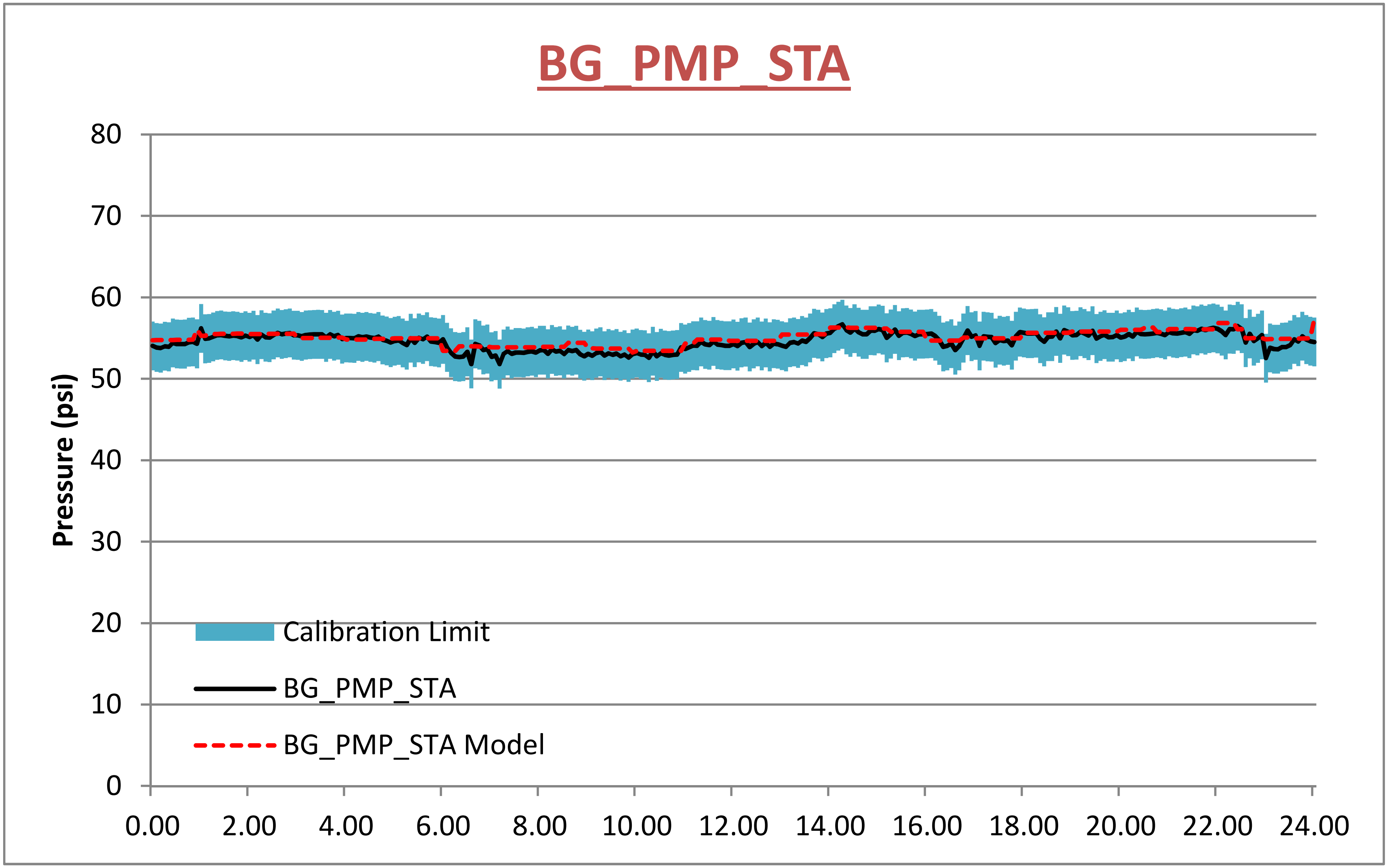
2869168
80
70
60
50
40
30
20
10
0
Pressure (psi)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
2869168 Field
2869168 Model

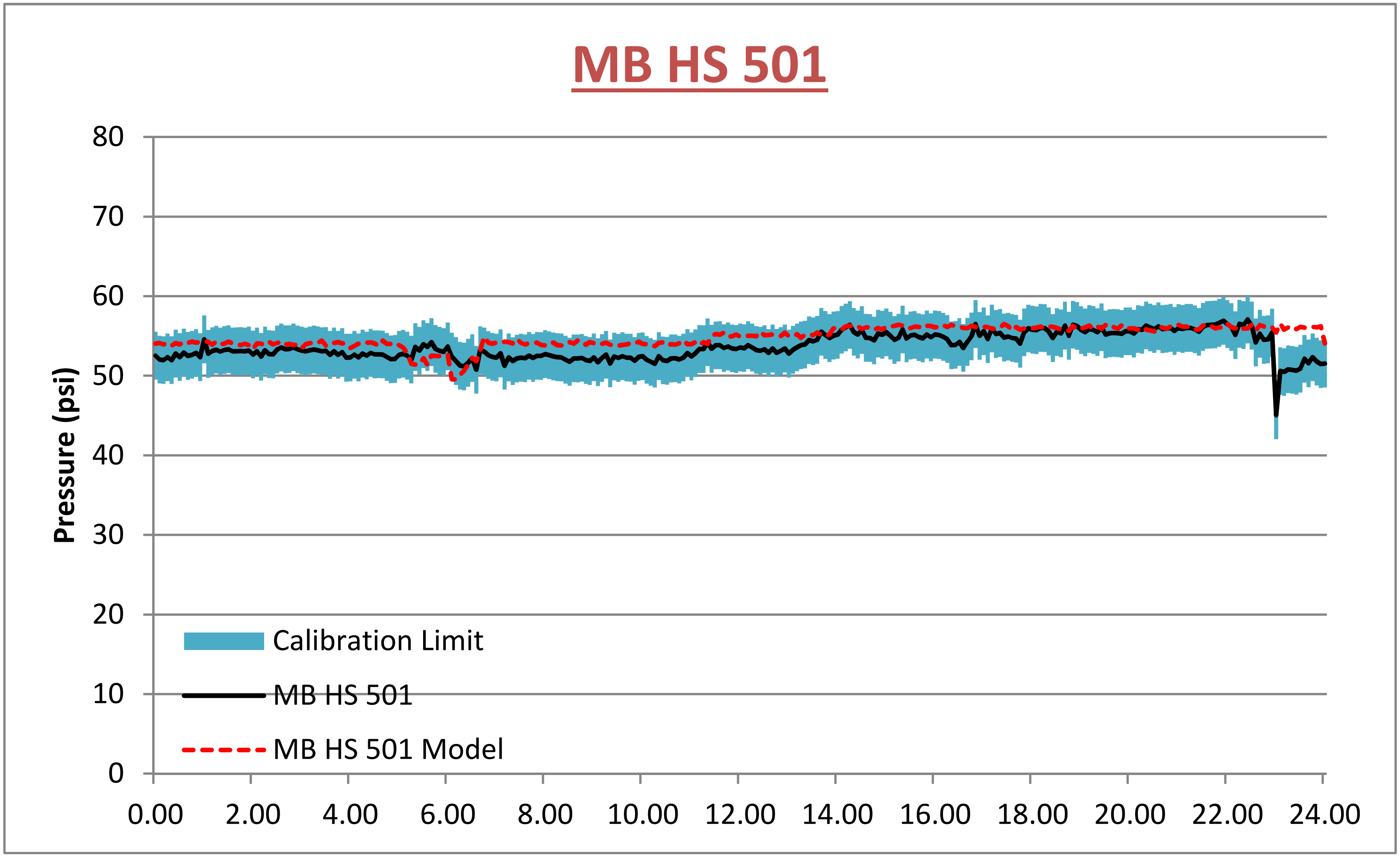

FS19
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
FS19 Field
FS19 Model

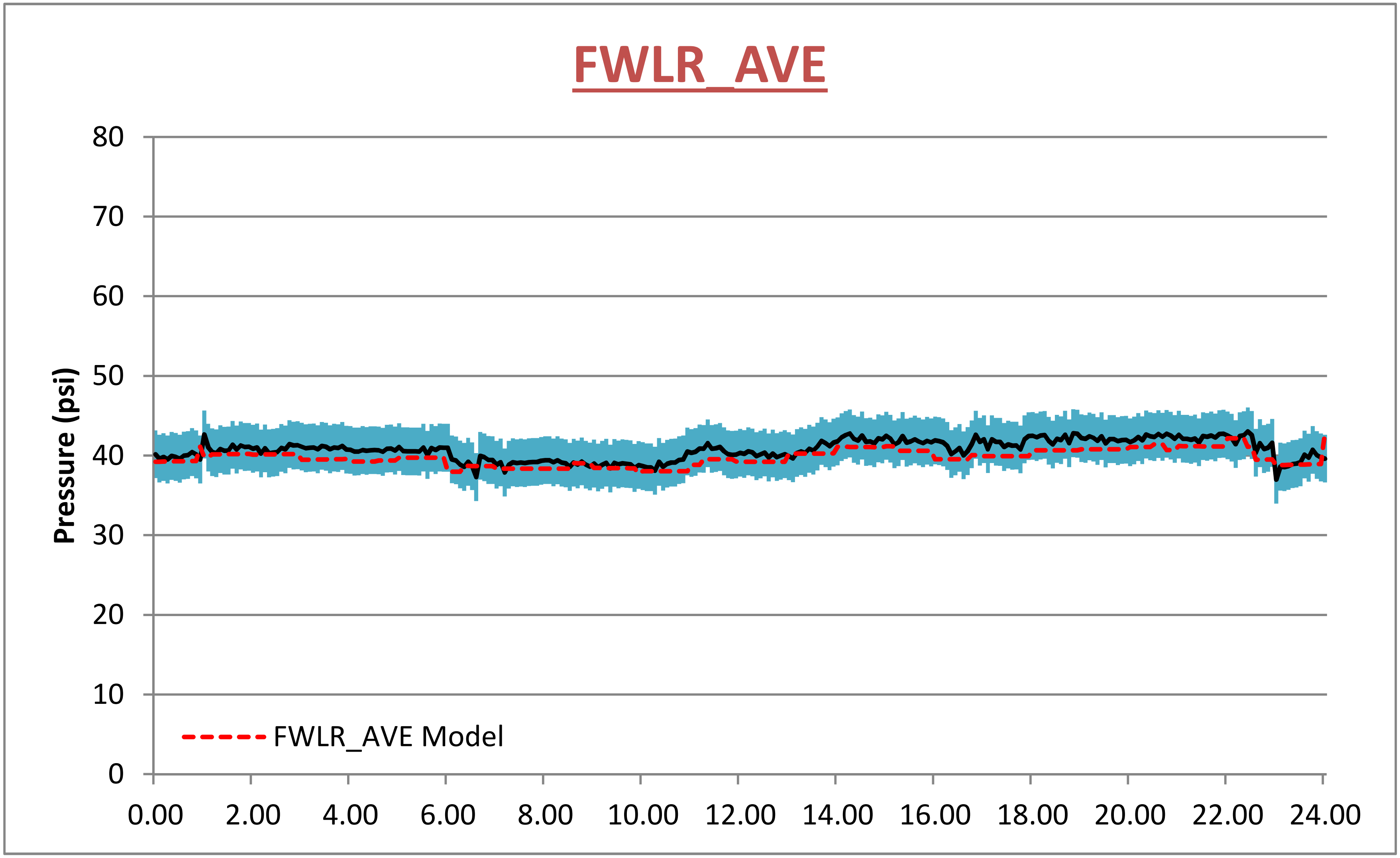


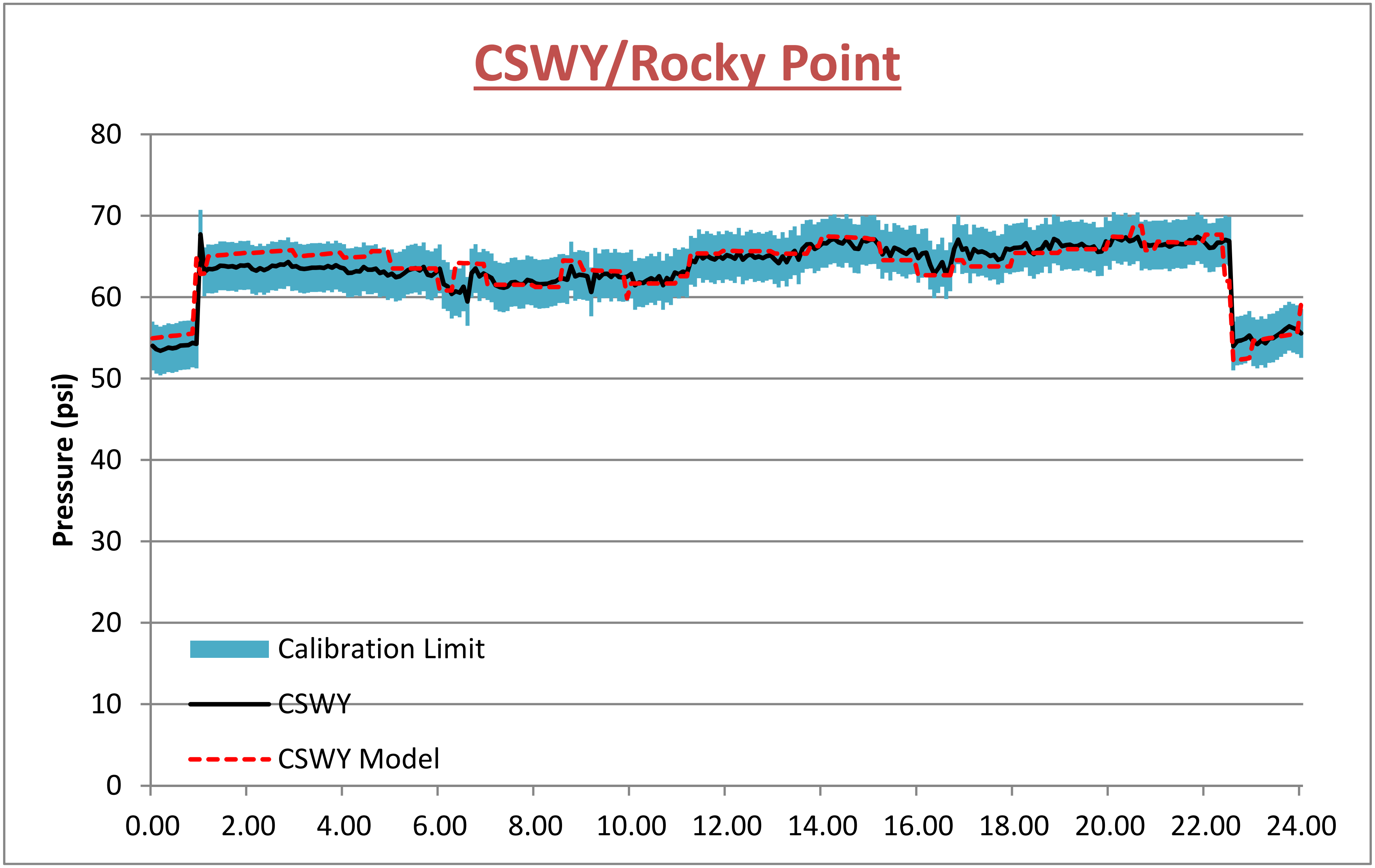
IB
80
70
60
50
40
30
20
10
0
Pressure (psi)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
IB Field
IB Model

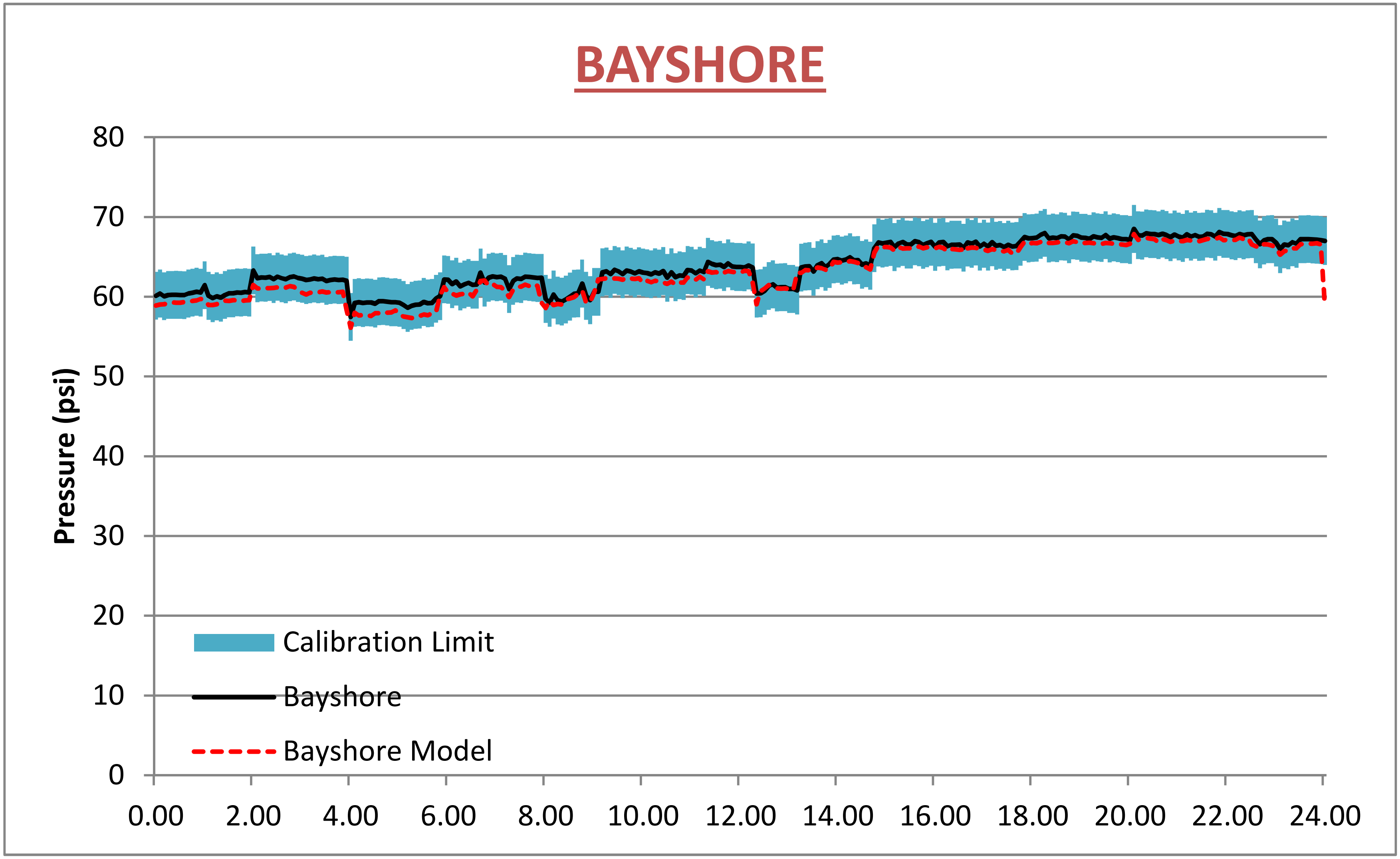

IB_PIT51_PV
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
IB Fill Line Pressure
IB Fill Line Model

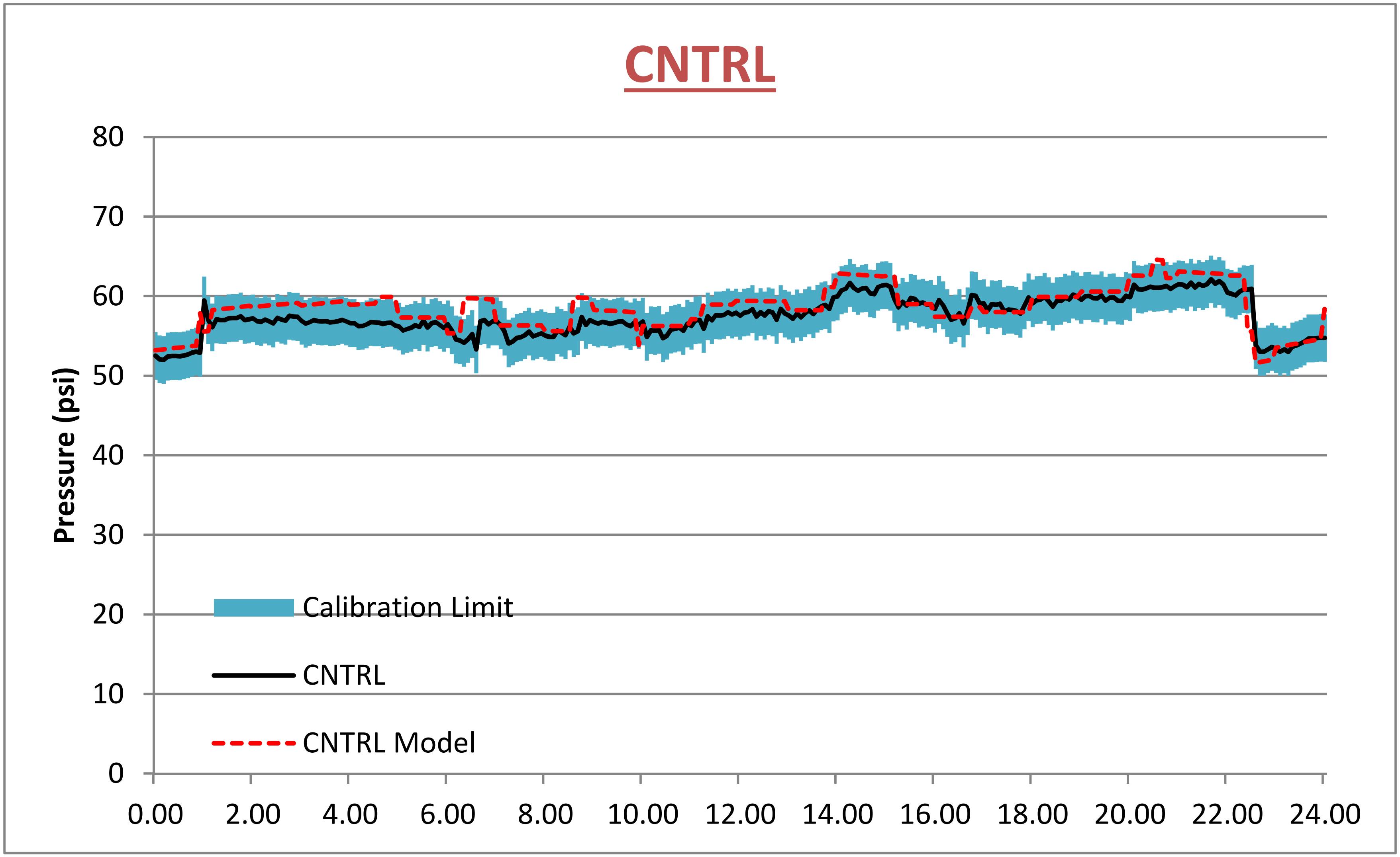

BG_PMP_STA
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
BG_PMP_STA
BG_PMP_STA Model


MB HS 501
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
MB HS 501
MB HS 501 Model

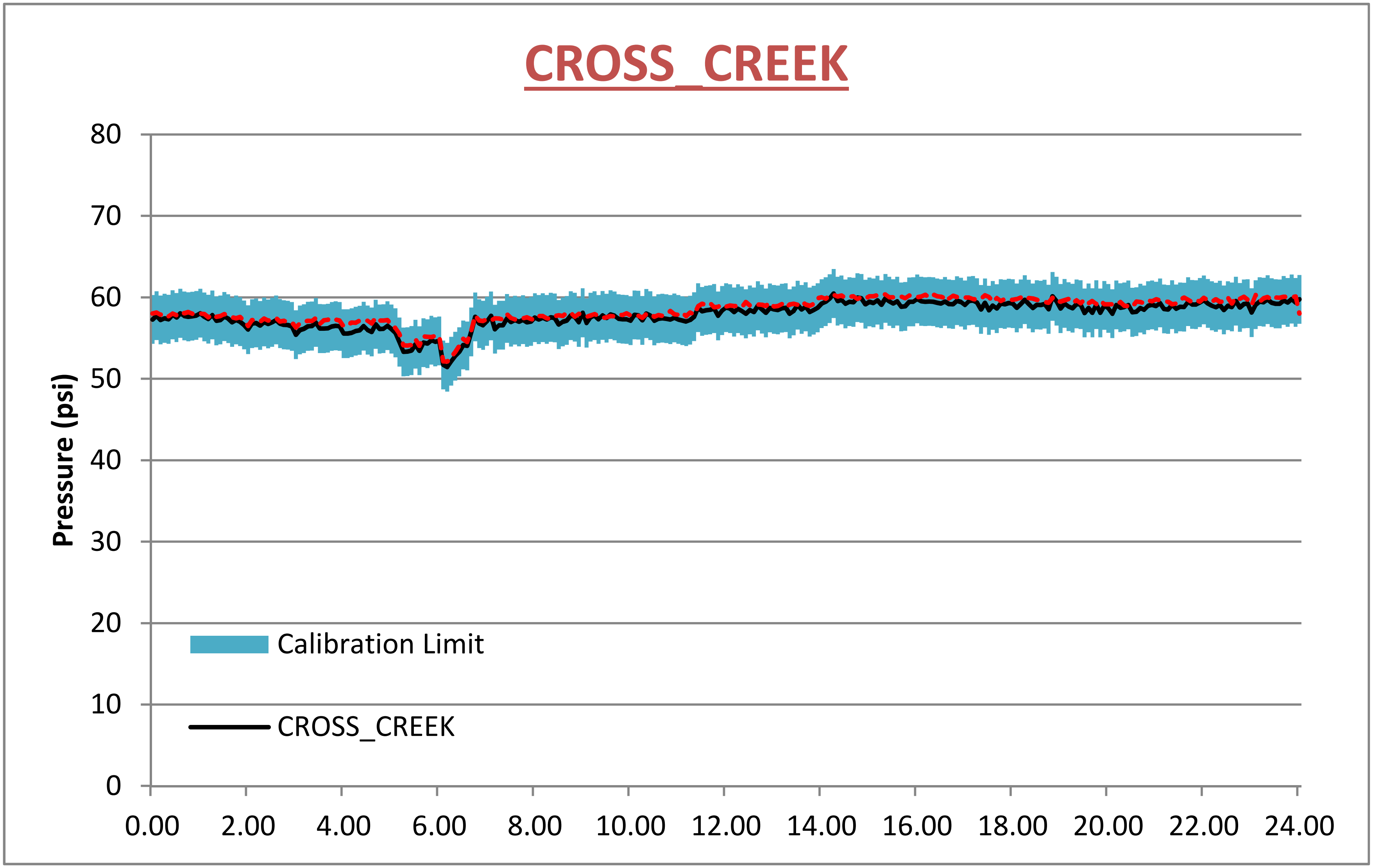

FWLR_AVE
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
FWLR_AVE Model


CSWY/Rocky Point
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
CSWY
CSWY Model

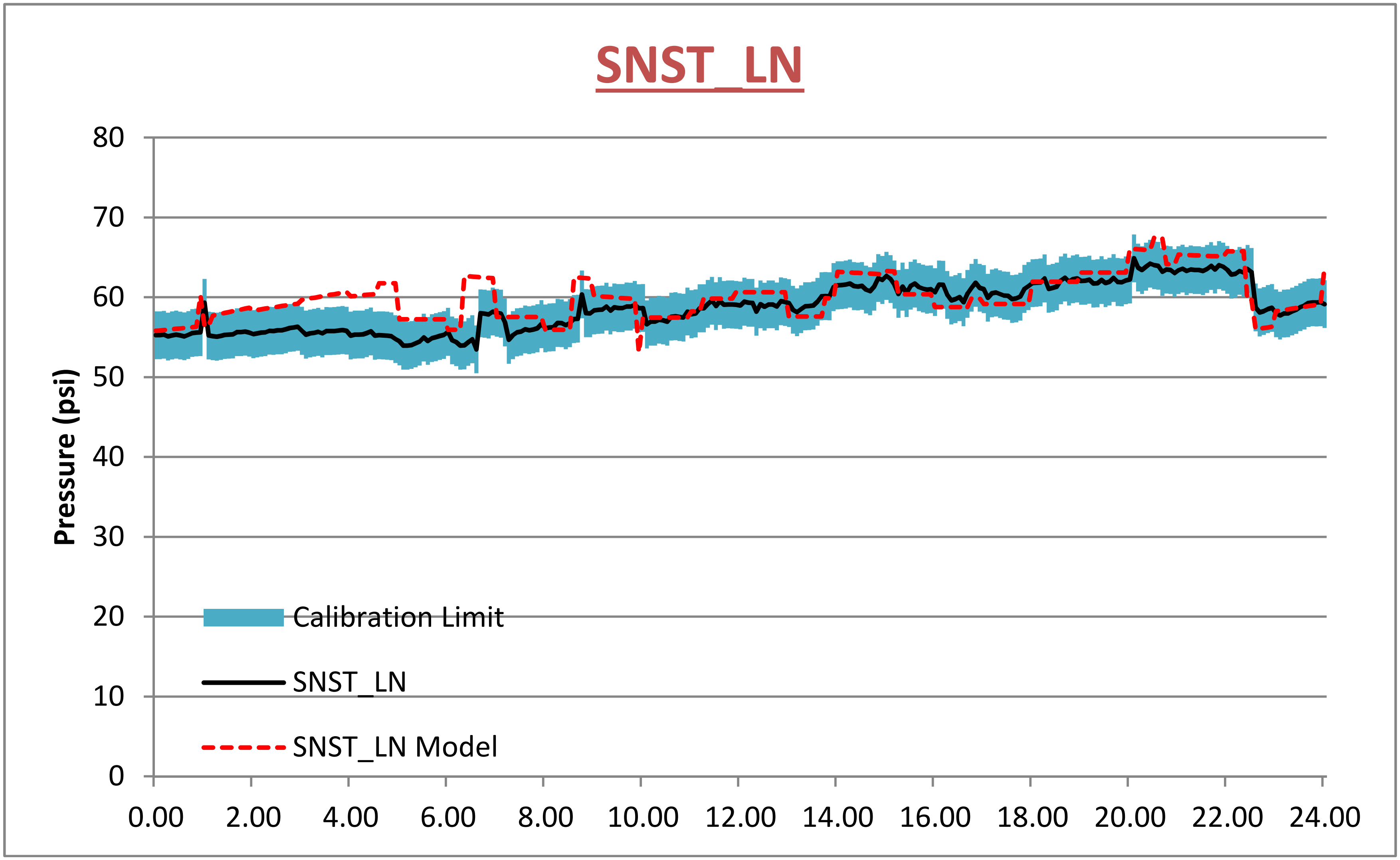

BAYSHORE
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
Bayshore
Bayshore Model



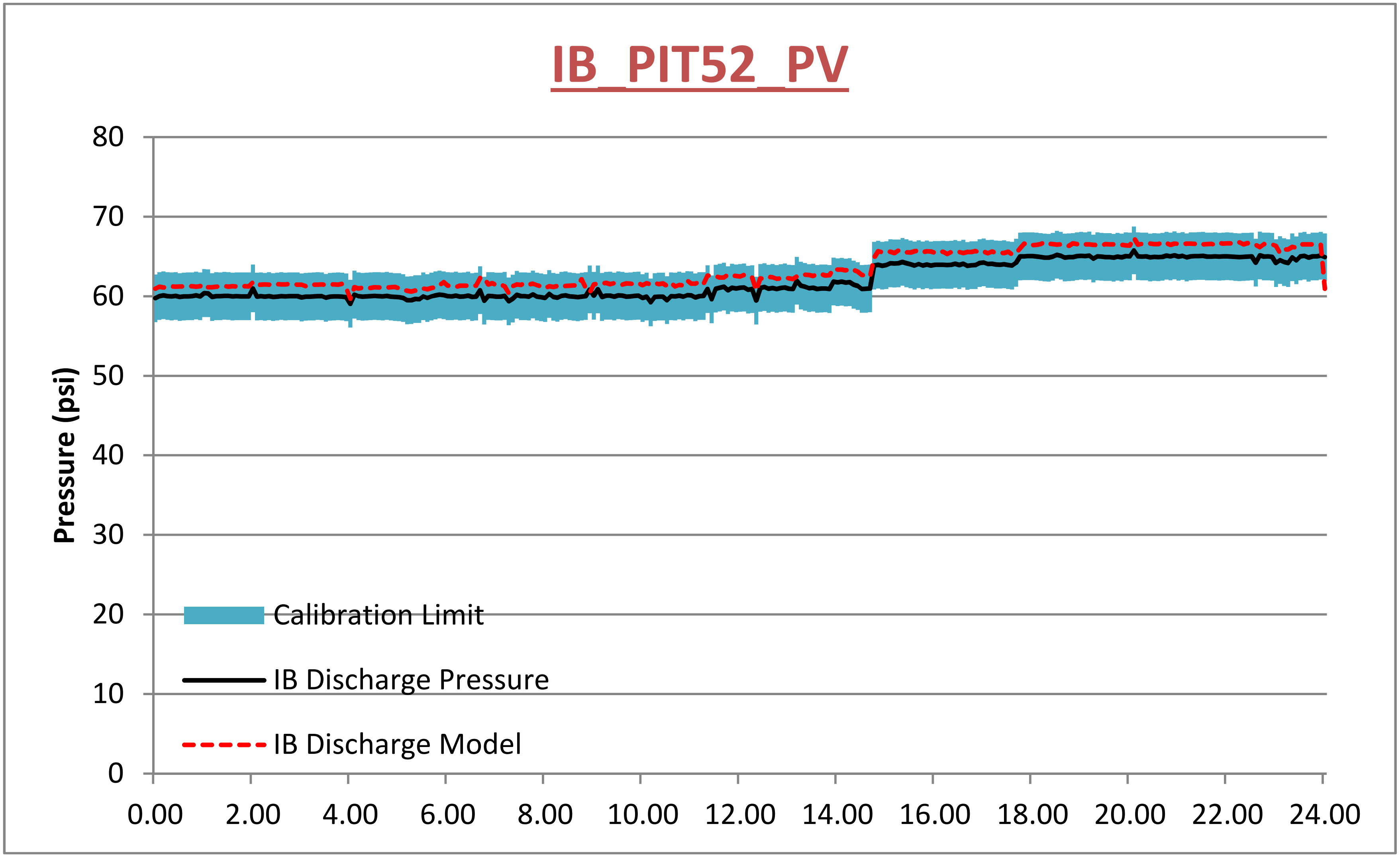
CNTRL
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
CNTRL
CNTRL Model



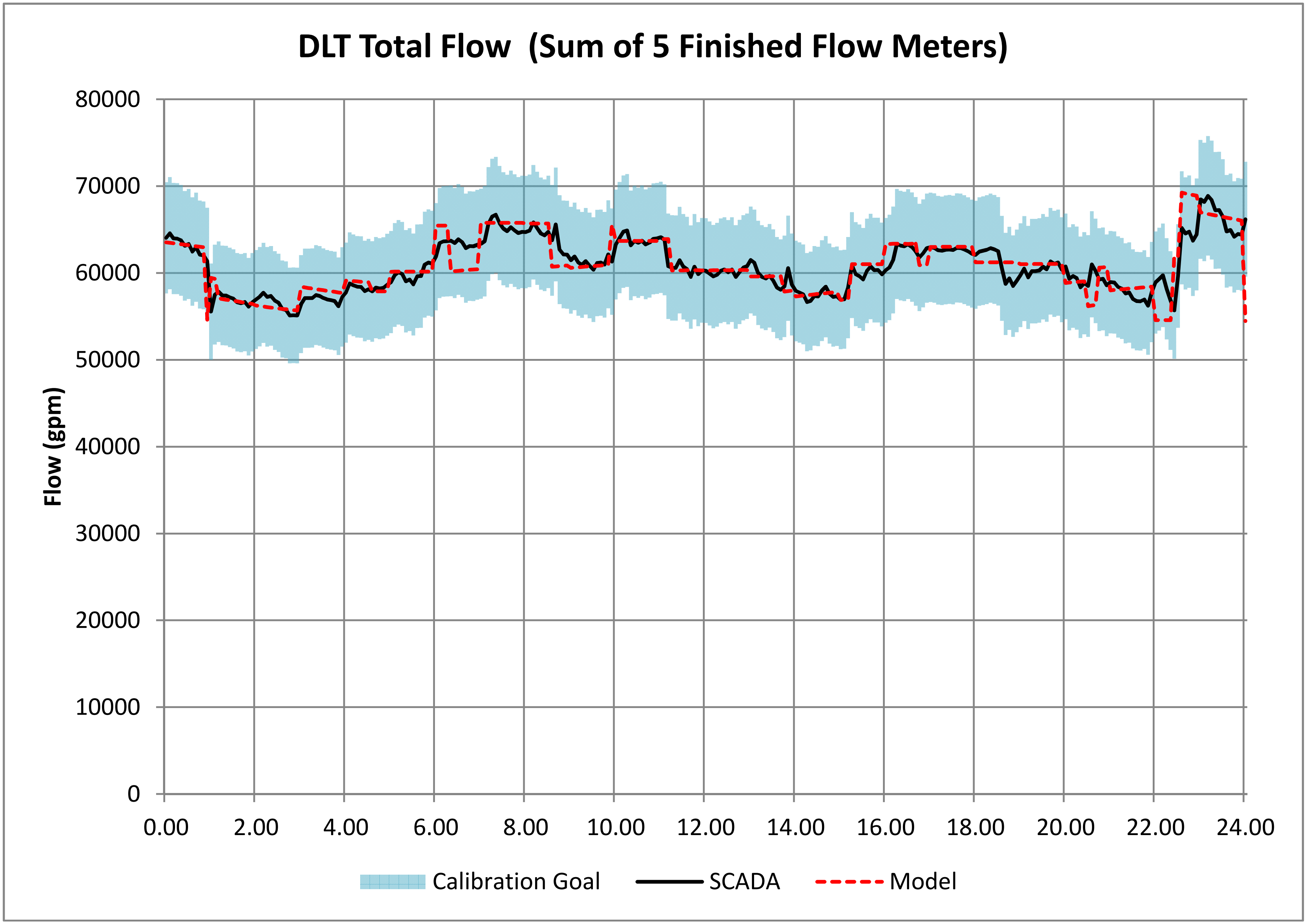
CROSS_CREEK
80
70
60
50
40
30
20
10
0
Pressure (psi)
Calibration Limit
CROSS_CREEK
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00

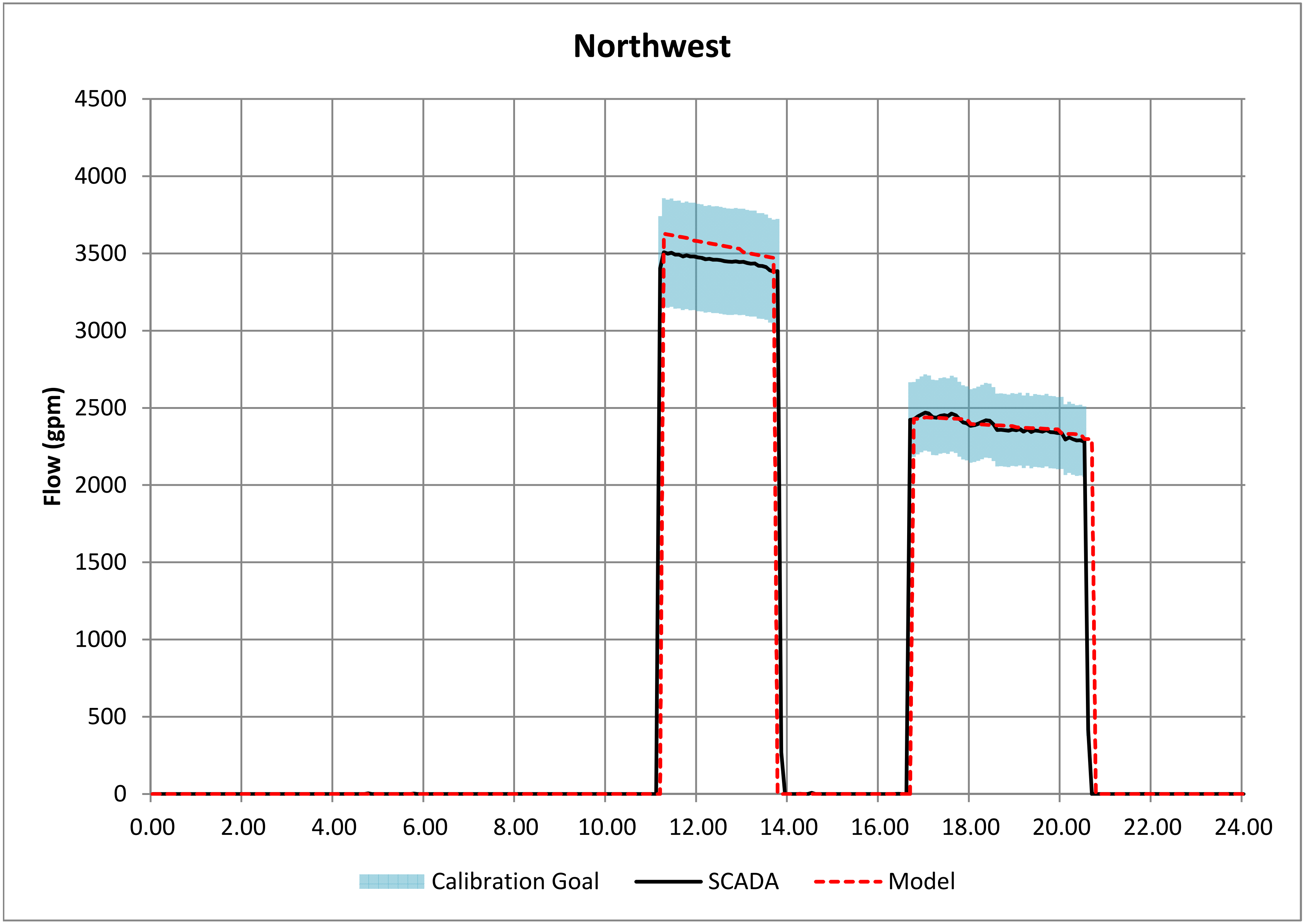


SNST_LN
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
SNST_LN
SNST_LN Model

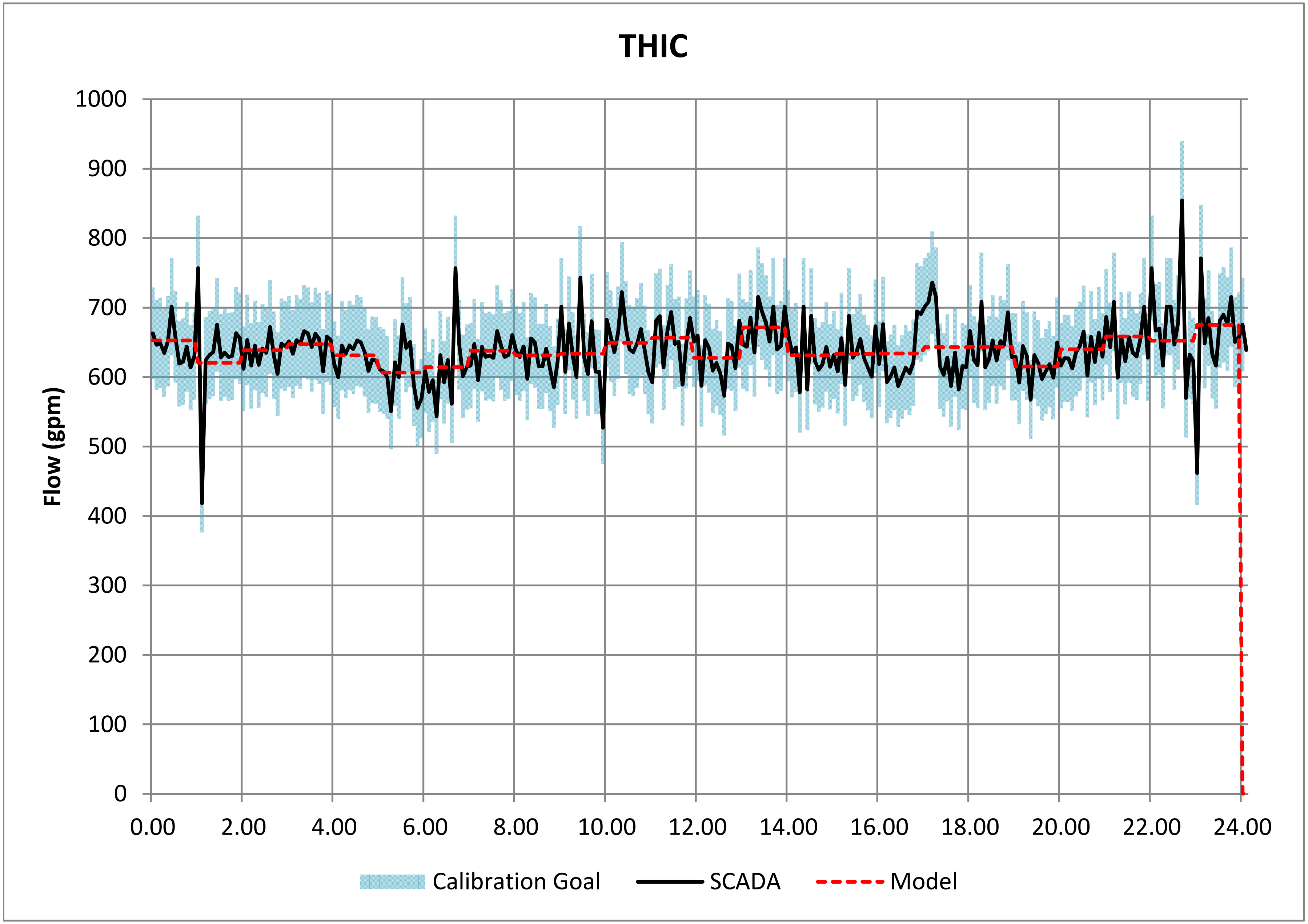


IB_PIT52_PV
Pressure (psi)
80
70
60
50
40
30
20
10
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Limit
IB Discharge Pressure
IB Discharge Model

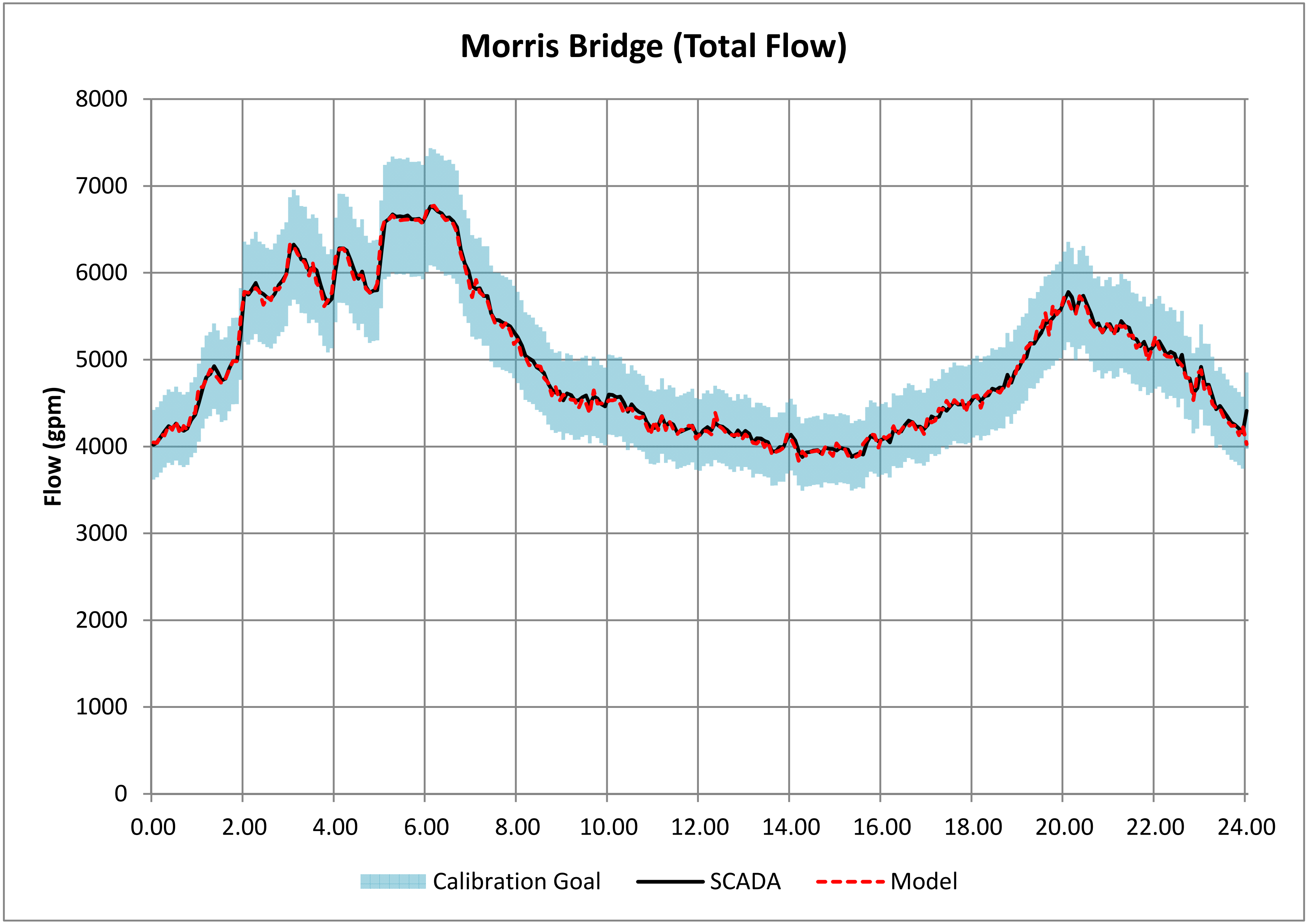

DLT Total Flow (Sum of 5 Finished Flow Meters)
Flow (gpm)
80000
70000
60000
50000
40000
30000
20000
10000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



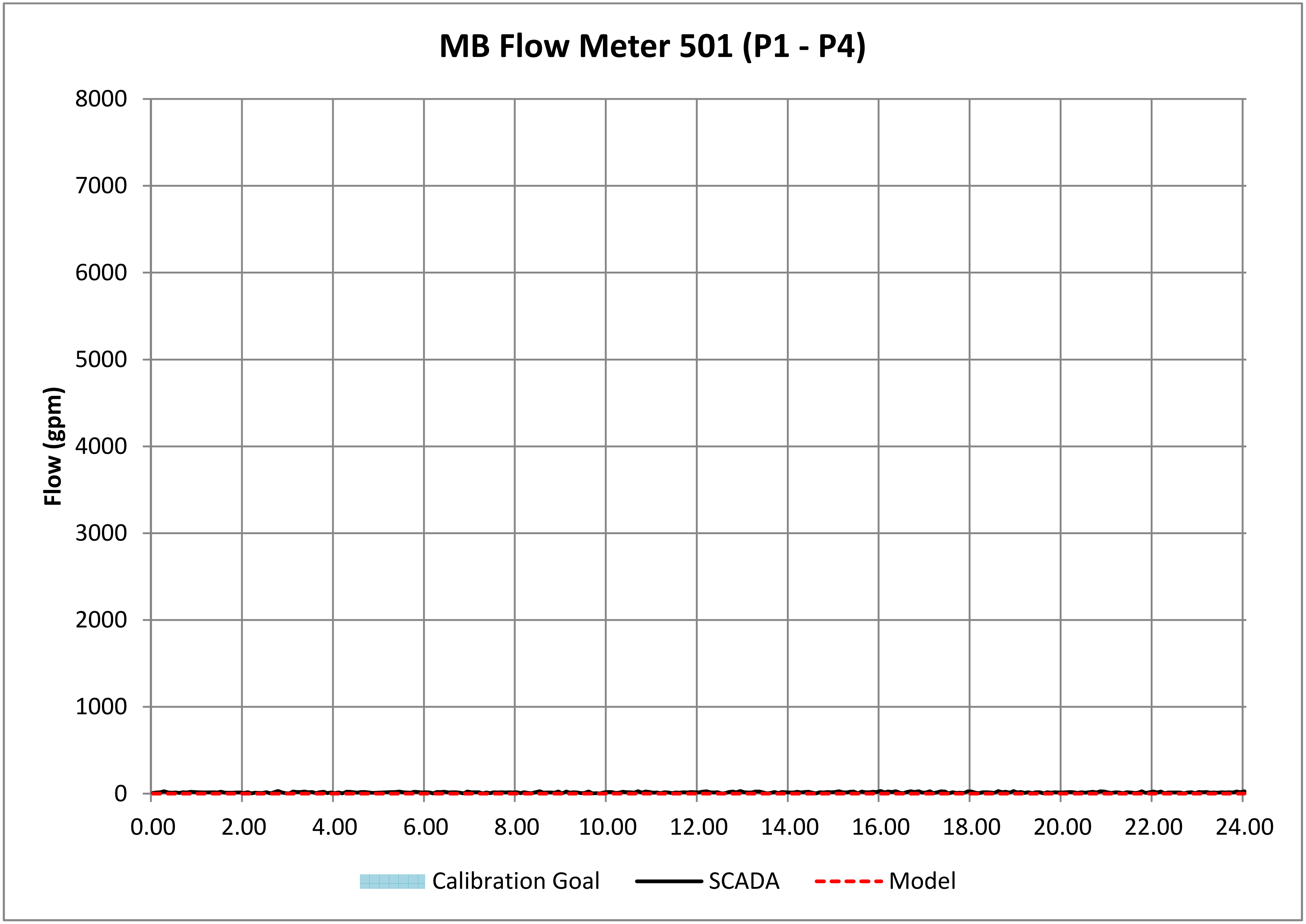
Northwest
Flow (gpm)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

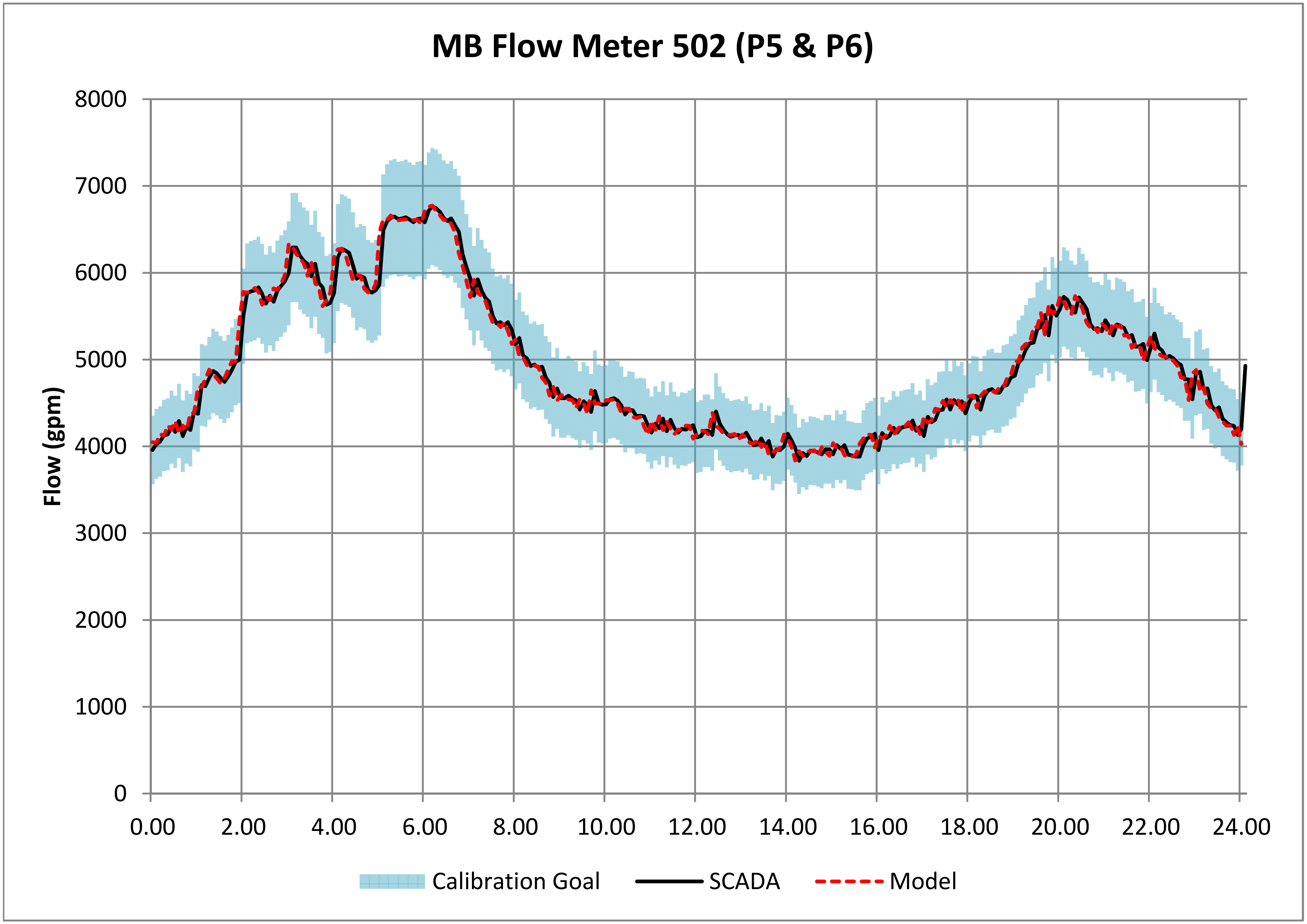


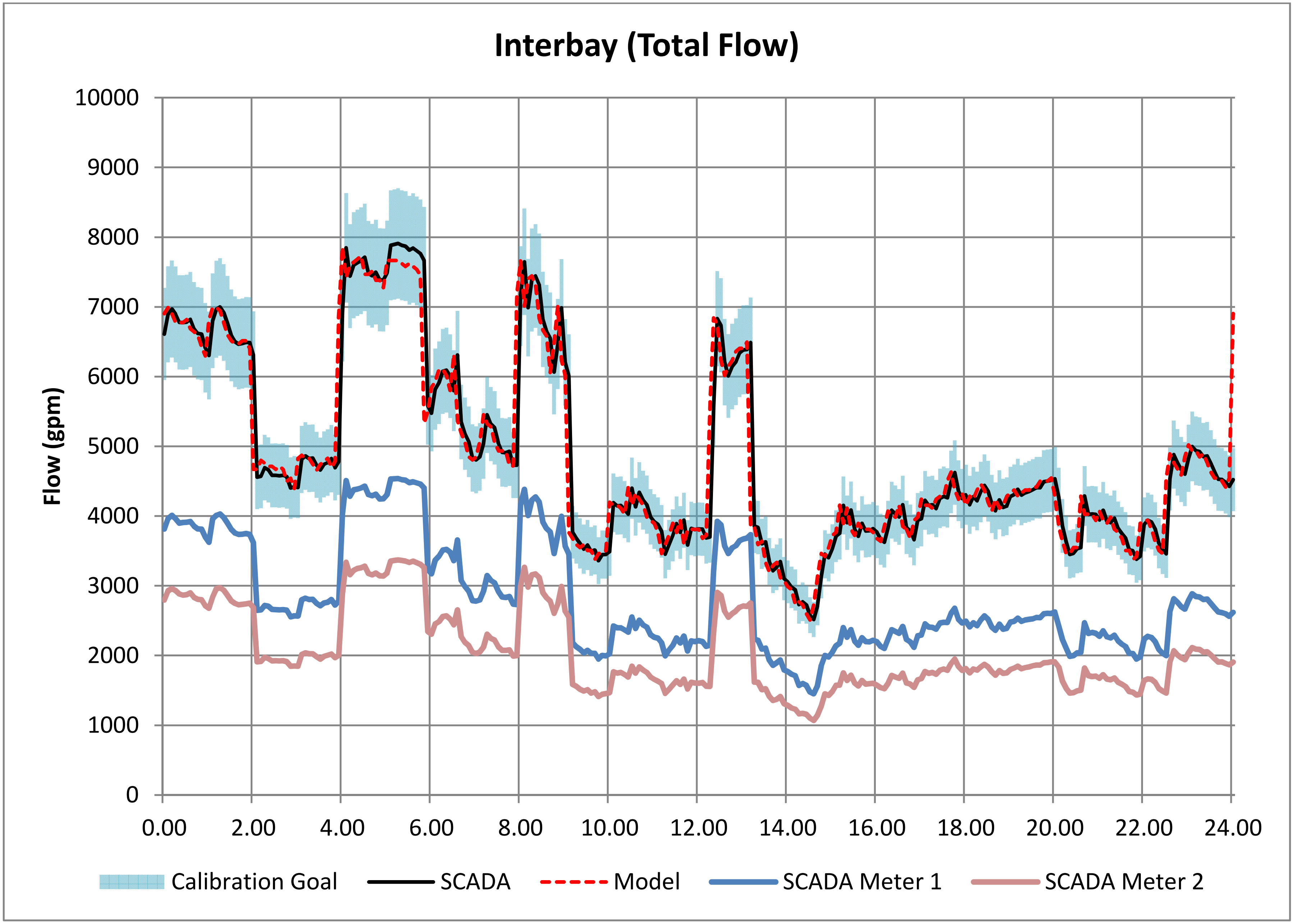
THIC
Flow (gpm)
1000
900
800
700
600
500
400
300
200
100
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



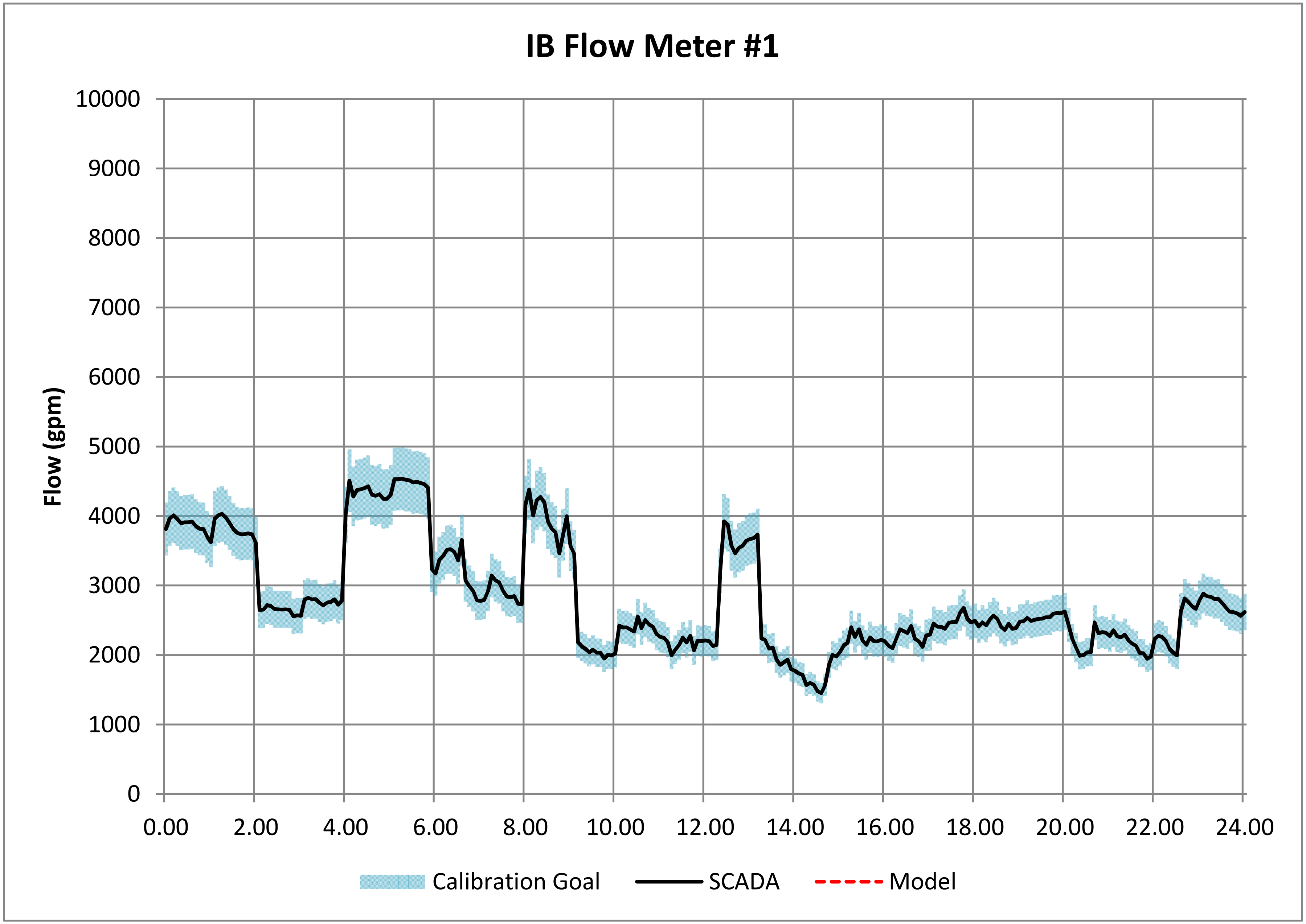
Morris Bridge (Total Flow)
Flow (gpm)
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model


MB Flow Meter 501 (P1 - P4)
Flow (gpm)
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

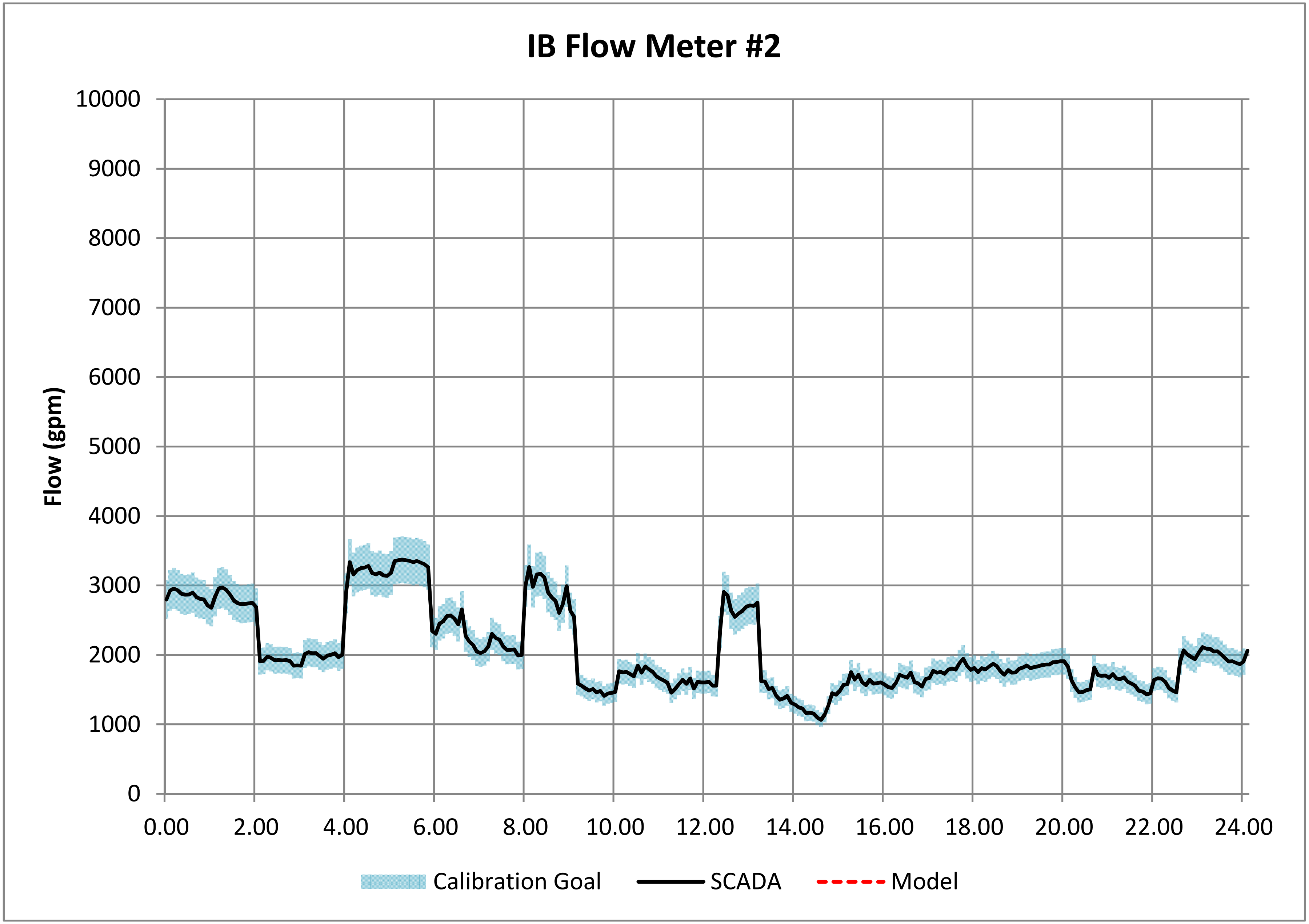

MB Flow Meter 502 (P5 & P6)
Flow (gpm)
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

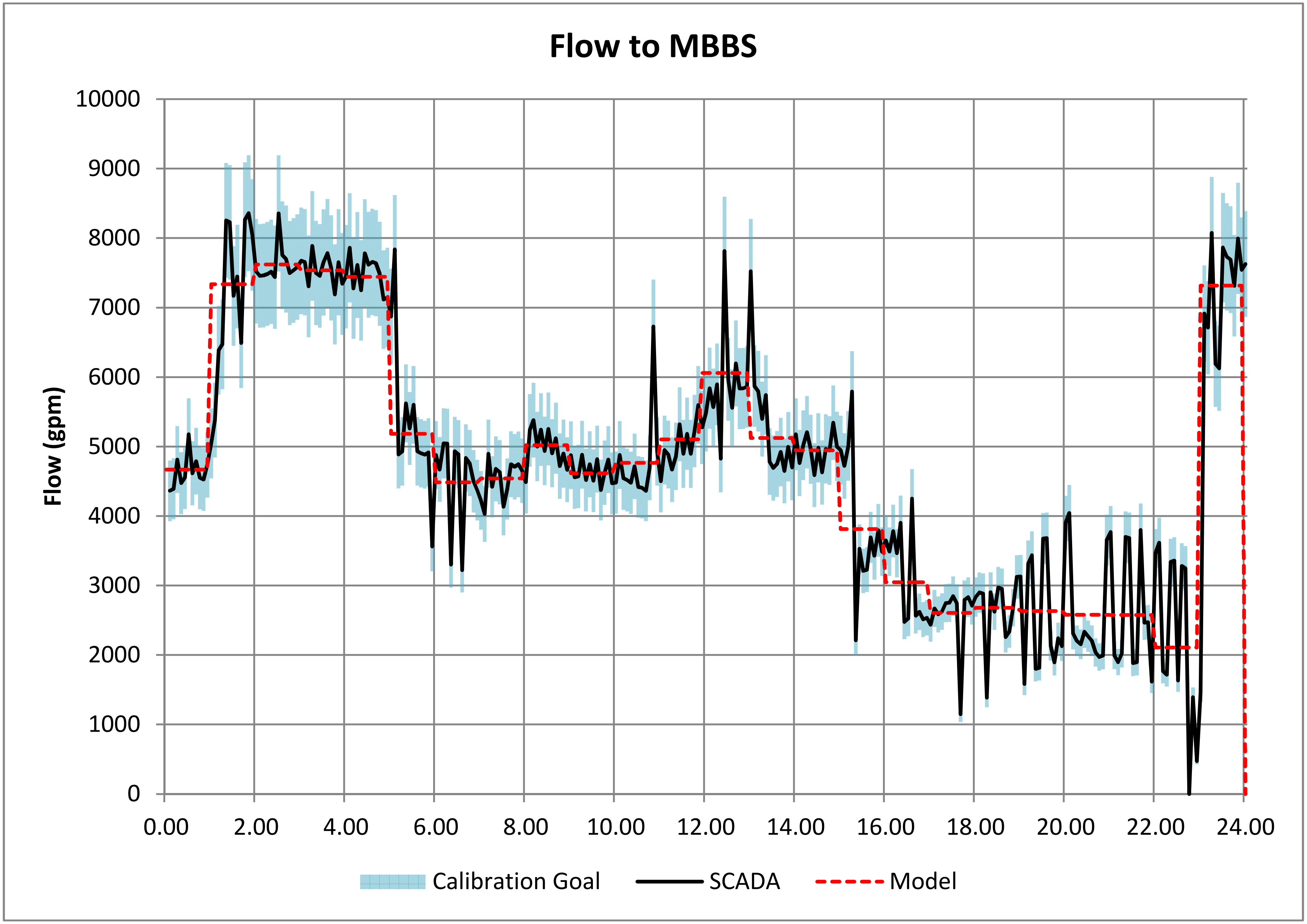


Interbay (Total Flow)
Flow (gpm)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model
SCADA Meter 1
SCADA Meter 2

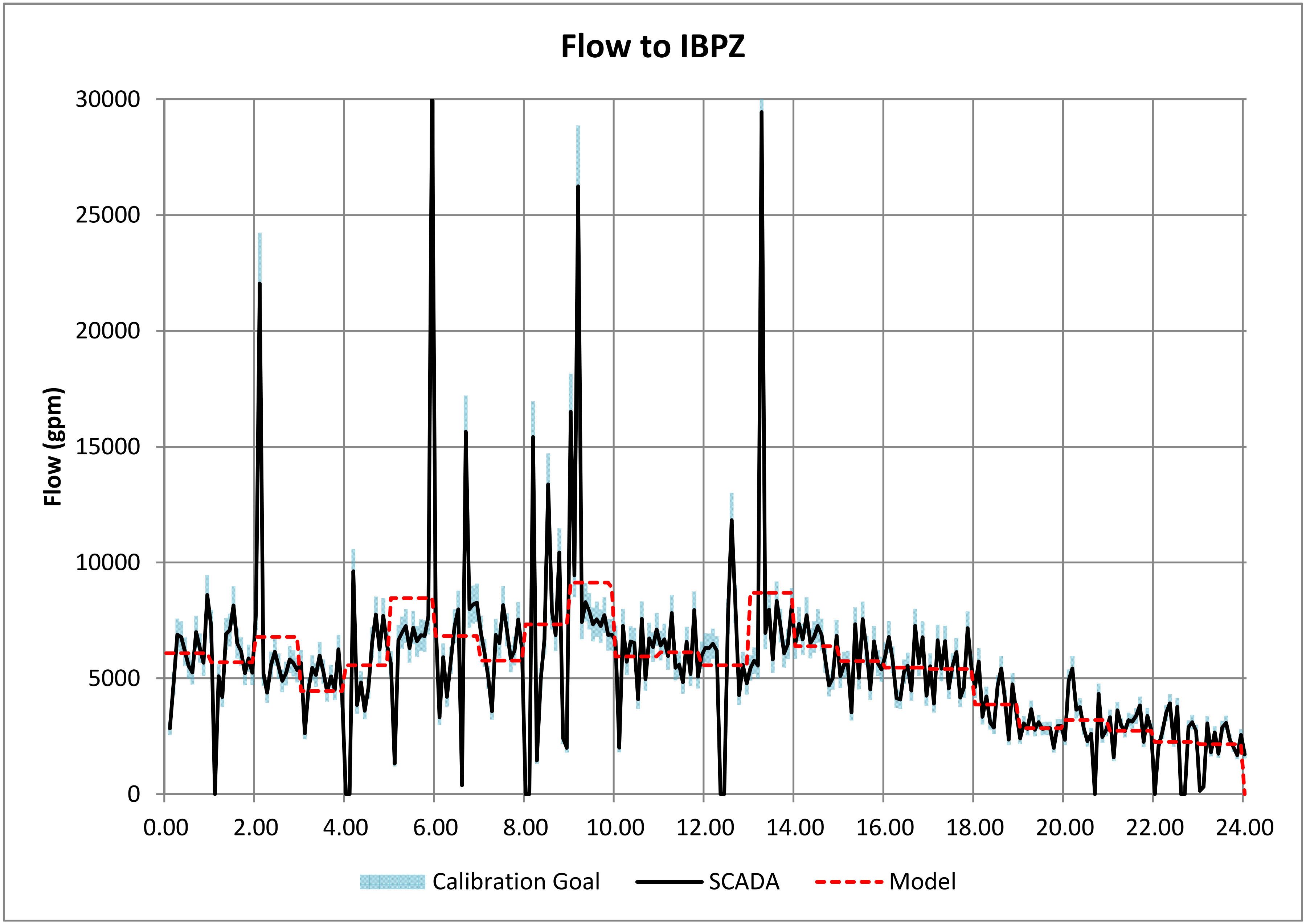


IB Flow Meter #1
Flow (gpm)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

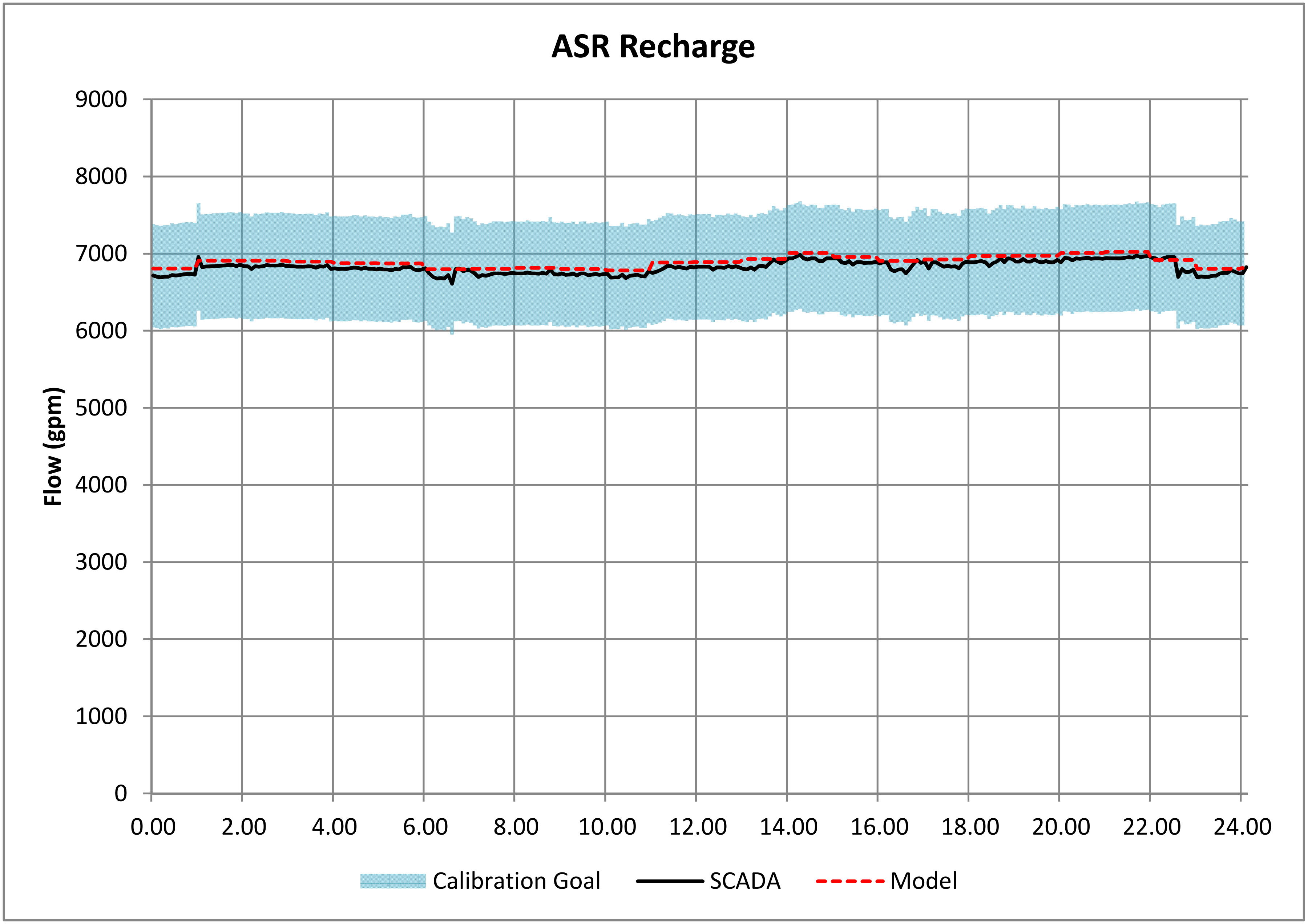

IB Flow Meter #2
Flow (gpm)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

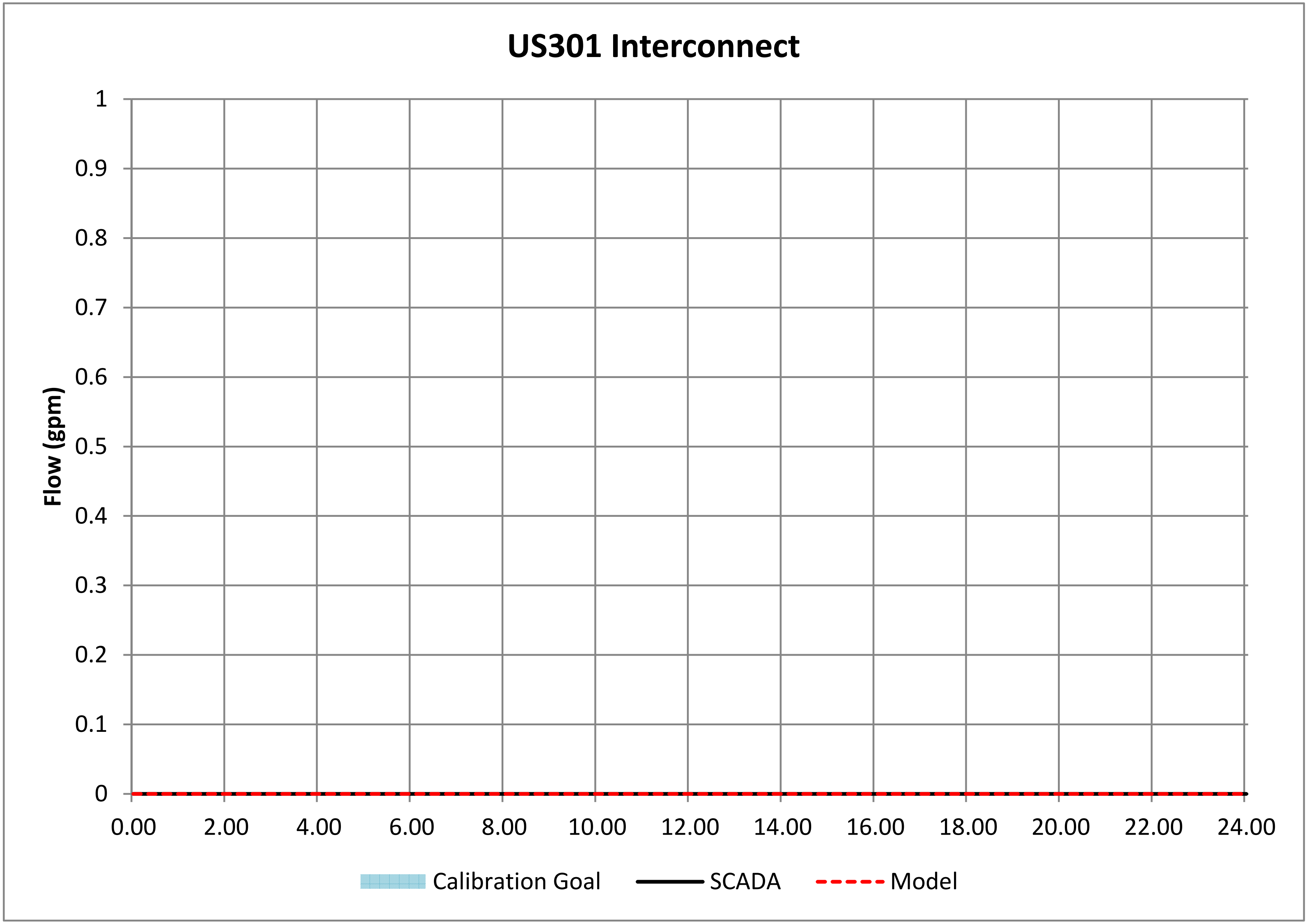


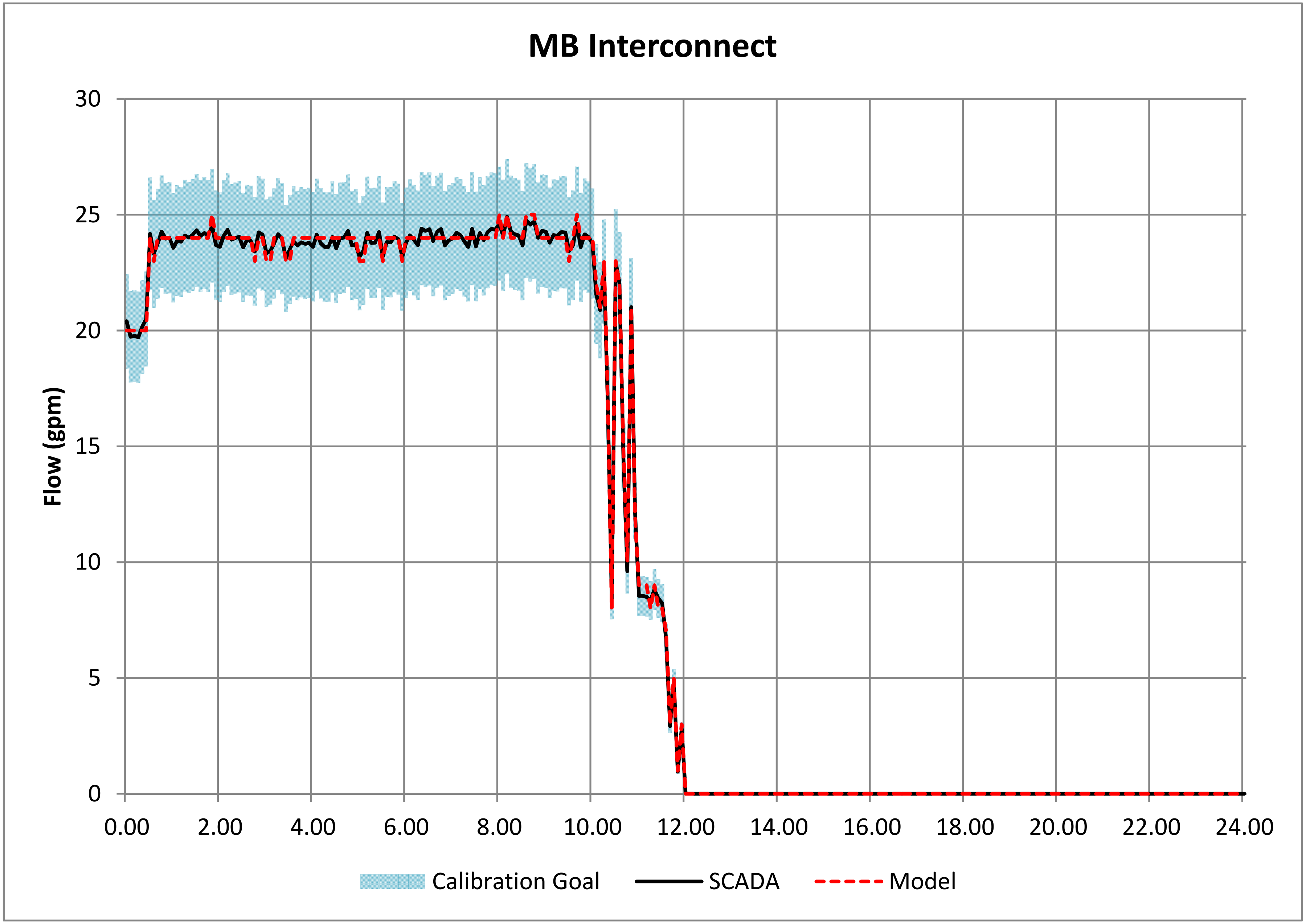
Flow to MBBS
Flow (gpm)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



Flow to IBPZ
Flow (gpm)
30000
25000
20000
15000
10000
5000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model


ASR Recharge
Flow (gpm)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model


US301 Interconnect
Flow (gpm)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model


MB Interconnect
Flow (gpm)
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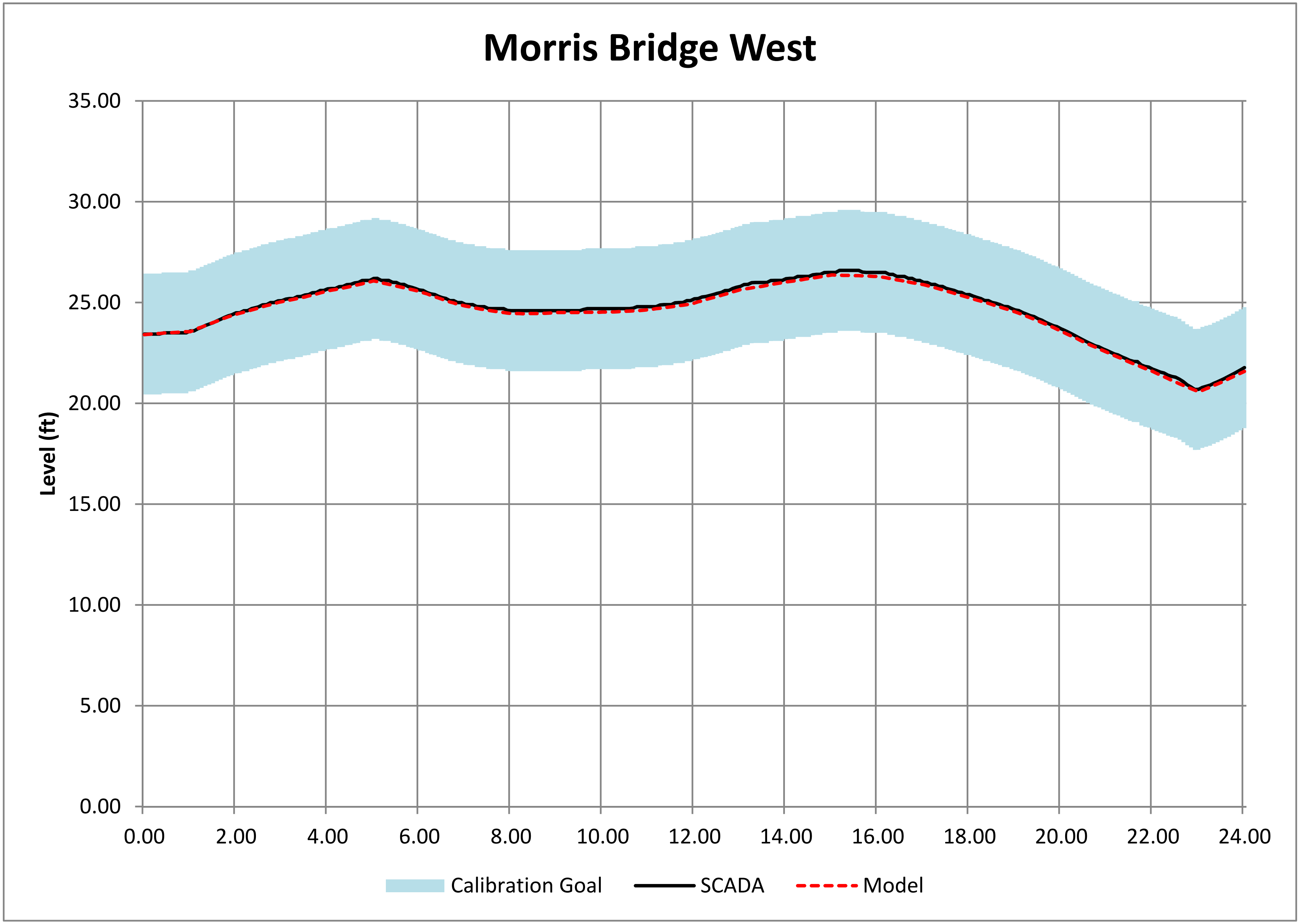
25
20
15
10
5
0
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



Morris Bridge West
Level (ft)
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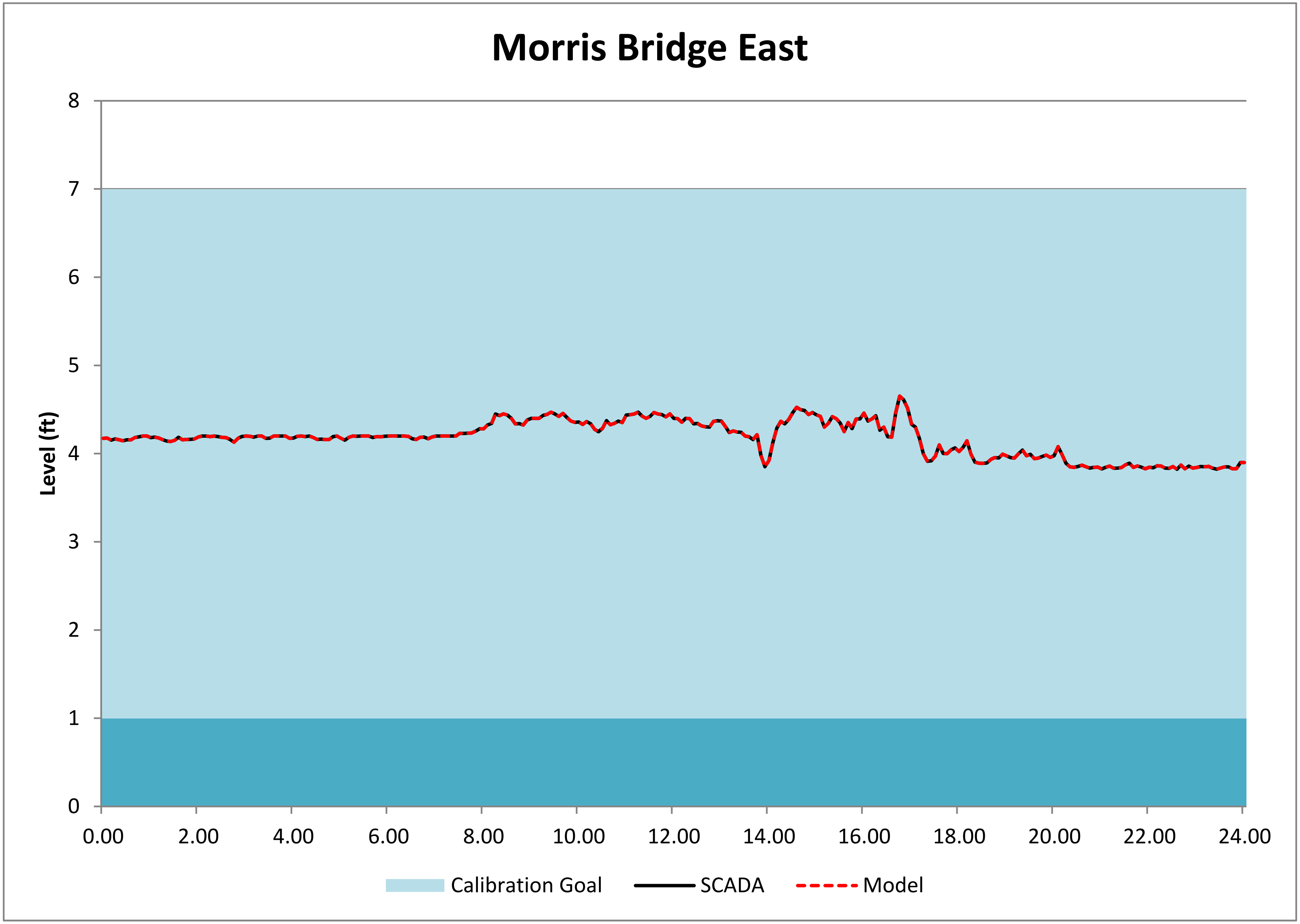
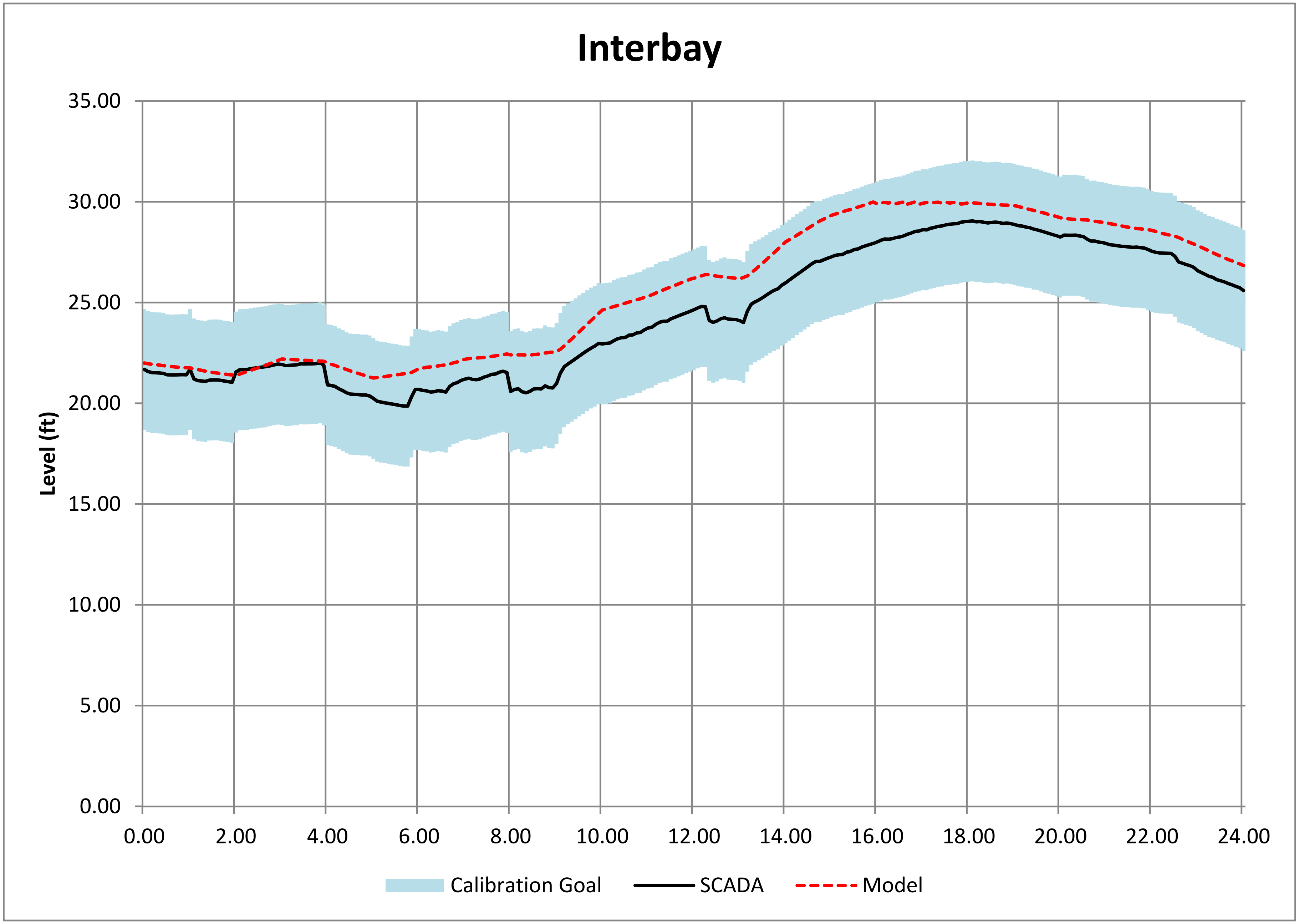
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



Morris Bridge East
Level (ft)
0
1
2
3
4
5
6
7
8
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model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Level (ft)
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15.00
10.00
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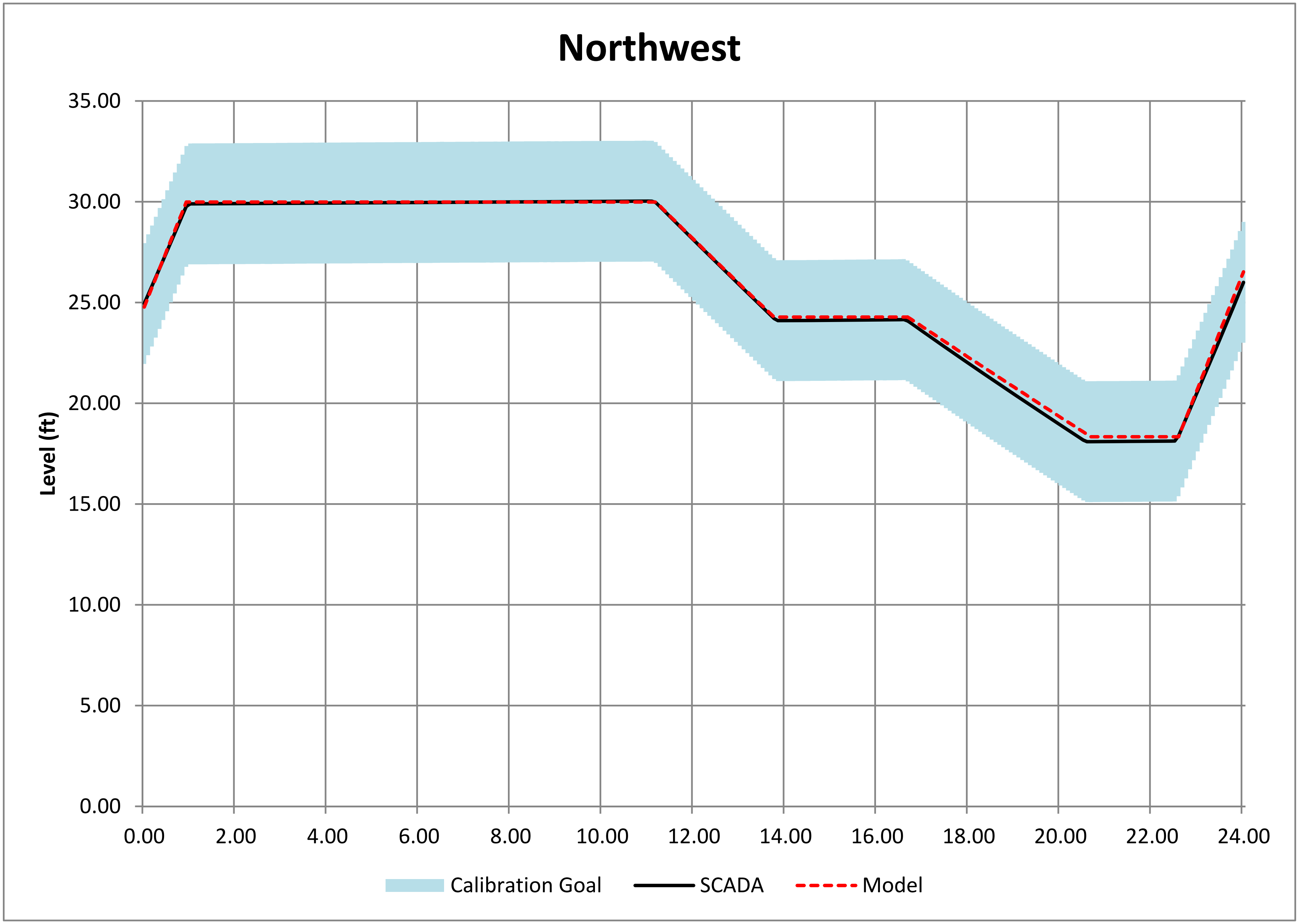
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model


Northwest
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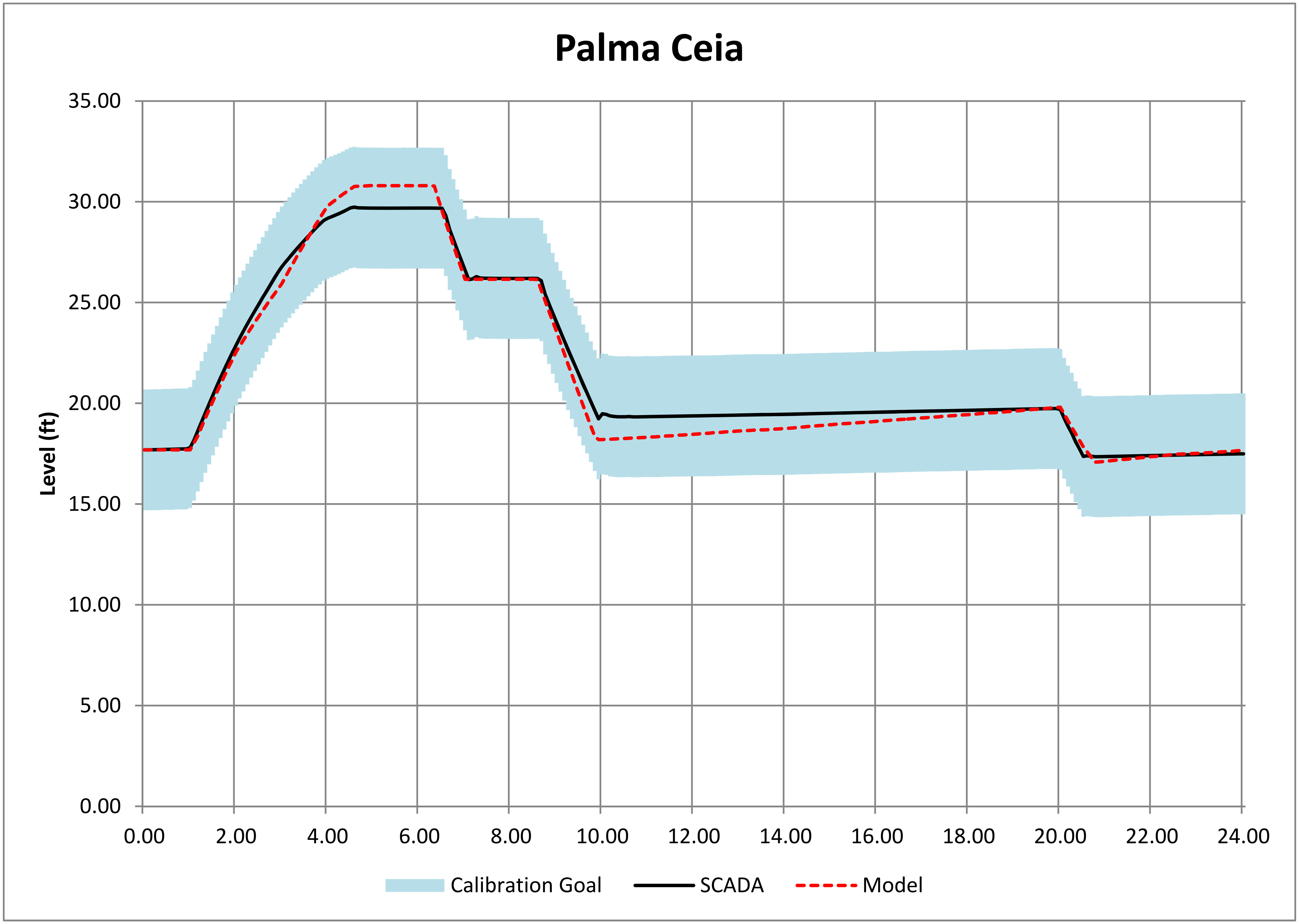
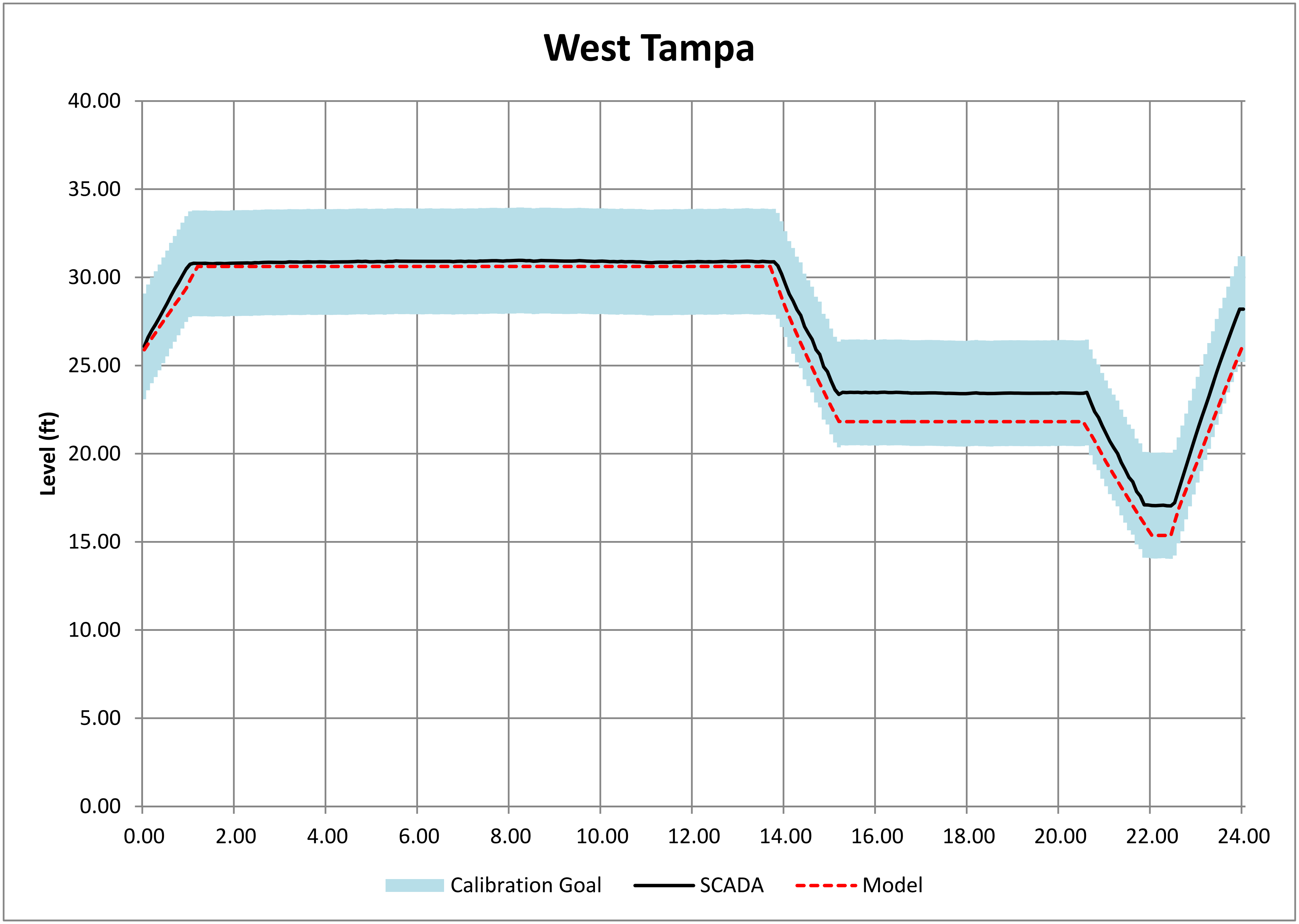
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model



Palma Ceia
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Level (ft)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model


West Tampa
Level (ft)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
24.00
Calibration Goal
SCADA
Model

Appendix D

Distribution System Assessment Technical Memorandum

FINAL

DISTRIBUTION SYSTEM ASSESSMENT

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

16 DECEMBER 2016

Table of Contents

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LIST OF FIGURES

LIST OF ATTACHMENTS

1. Introduction

As part of the City's 2015 Potable Water Master Plan Update, Black & Veatch has calculated the City's demand projections and updated and calibrated the City's hydraulic model as documented in the Population & Demand Projections TM (June 2016) and Hydraulic Calibration Report (July 2016), respectively. Using the demand projection information and the calibrated hydraulic model, Black & Veatch has performed a distribution system analysis of the base year (2015) and three future planning years (2020, 2025 and 2035) based on the existing system configuration. The system analysis evaluates the adequacy of the existing distribution system and highlights areas requiring improvements to meet the system performance criteria established by the Tampa Water Department (TWD). The following technical memorandum presents the steps which were followed to complete the system analysis and the observations and conclusions stemming from the analysis.

Technical Memorandum Update

After the submittal of the draft Distribution System Assessment Technical Memorandum, the TWD elected to test the ability of the existing pumps at the Morris Bridge Repump Station (MBRPS) to supply flow to the future North Tampa pressure zone by isolating the portion of the system east of Interstate 75. During the exercise it was discovered that there was a closed valve on the 36-inch water main downstream of the MBRPS which was restricting flow and causing low system pressure in North Tampa.

The discovery of the close valve may explain some of the observations and issues during calibration within the New Tampa area and will alter not only the system calibration, but the subsequent distribution system assessment. The model will be recalibrated during the next phase of the project and the subsequent updated demands and system operation will be used to identify system improvements, but has not been reflected in this report.

The closed valve may affect the system analysis results and recommendation in this technical memorandum including:

- Peak Hour Demand and irrigation demand in North Tampa → Firm Capacity requirements of the MBRPS and DLTWTF
- Diurnal Pattern for North Tampa and the rest of the system
- Operational controls used during the system analysis
- Fire Flow Coverage in North Tampa
- Transmission capacity to MBRPS

2. System Conditions

The existing system conditions include infrastructure installed before January 2016 as illustrated on the system map in **Figure 1** and the flow diagram shown in **Figure 2**. The system includes one water treatment facility (WTF) and five repump stations (RPS). These five RPS pump from four above ground storage tanks and two elevated storage tanks. The elevation of these elevated storage tanks places them below the normal hydraulic grade line (HGL) of the system, which causes them to operate similar to ground storage tanks. There are two supply interconnections with Tampa Bay Water; one at Morris Bridge RPS and an emergency connection at US301. As shown in **Figure 3** with the other interconnections, there is one wholesale interconnection with Tampa Bay Water serving Hillsborough County at the Tampa-Hillsborough Interconnect (THIC) which is also known as the North Boulevard Interconnect. The other interconnections are much smaller and act as development master meters.

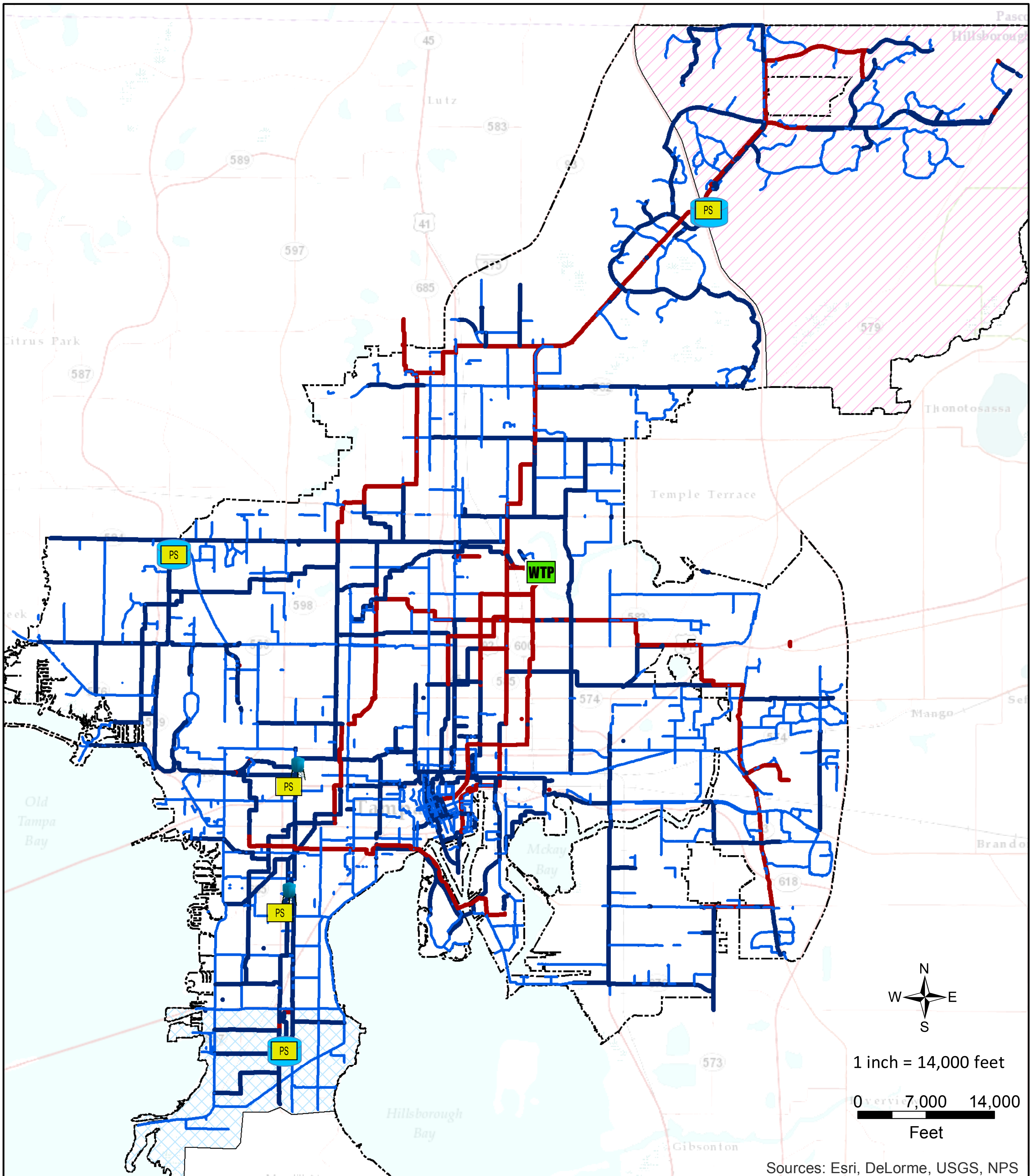
Since the collection of the model calibration data, the existing system configuration has changed and now includes two pressure zones with plans for a future third zone:

- North Tampa – the northeast portion of the distribution system fed by the Morris Bridge RPS; east of Interstate 75 (I-75) and north of Bruce B. Downs Blvd. (Future planned zone)
- South Tampa – the southern portion of the distribution system fed by the Interbay RPS; south of Gandy Blvd.
- DLTWTF – the central part of the distribution system fed by the D.L. Tippin WTF.

Table 1 summarizes the existing pump capacities for the DLTWTF high service pump station and the various repump stations that serve the distribution system.

- Maximum Capacity – the maximum flow a pump is capable of under low pressure conditions (conditions on the far right side of the pump curve)
- Rated Capacity – the flow/head conditions at which the pump was designed to operate
- Pump Station Firm Capacity (rated) – the rated pump station capacity with the largest pump out of service
- Pump Station Firm Capacity (modeled) – the model results of the pump station capacity with the largest pump out of service under peak hour conditions. NOTE: Firm capacity per pressure zone is calculated slightly different and is the capacity with the largest pump in the pressure zone out of service.

Figure 4 illustrates two planned improvements (CIAC & KBar) schedule to be implemented prior to the planning year 2020; thus not included in the base year assessment, but included for all others.



City of Tampa Florida

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WTP WTP

PS Pump_Stations

Ground Storage Tank

Elevated Storage Tank

Service Area

Pressure_Zones

South Tampa

New Tampa

Diameter

Less than 12-inch

12 - 16-inch

16 - 24-inch

Greater than 24-inch

CITY OF TAMPA

Potable Water Master Plan

Figure 1

Base Year
Existing System

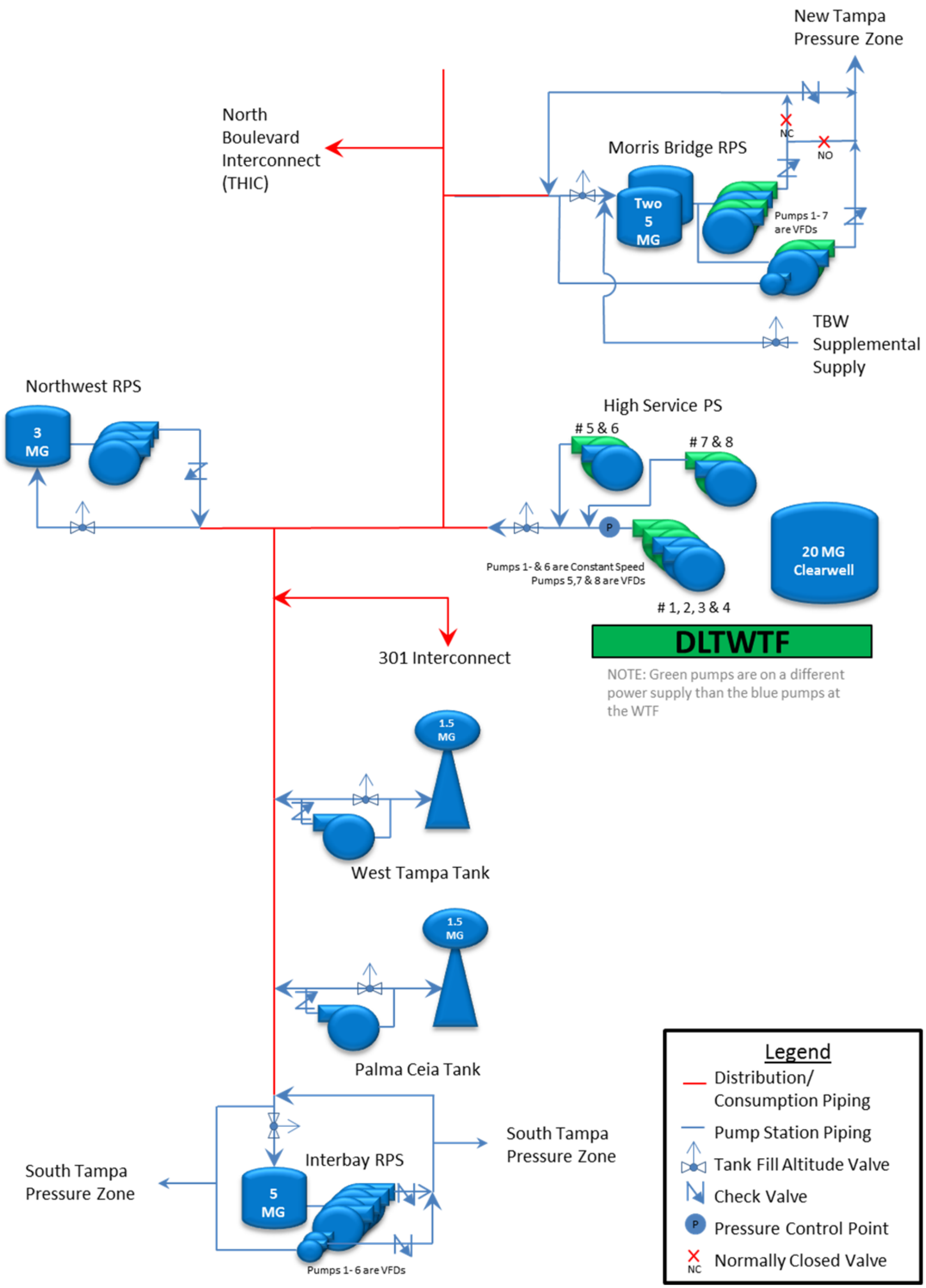
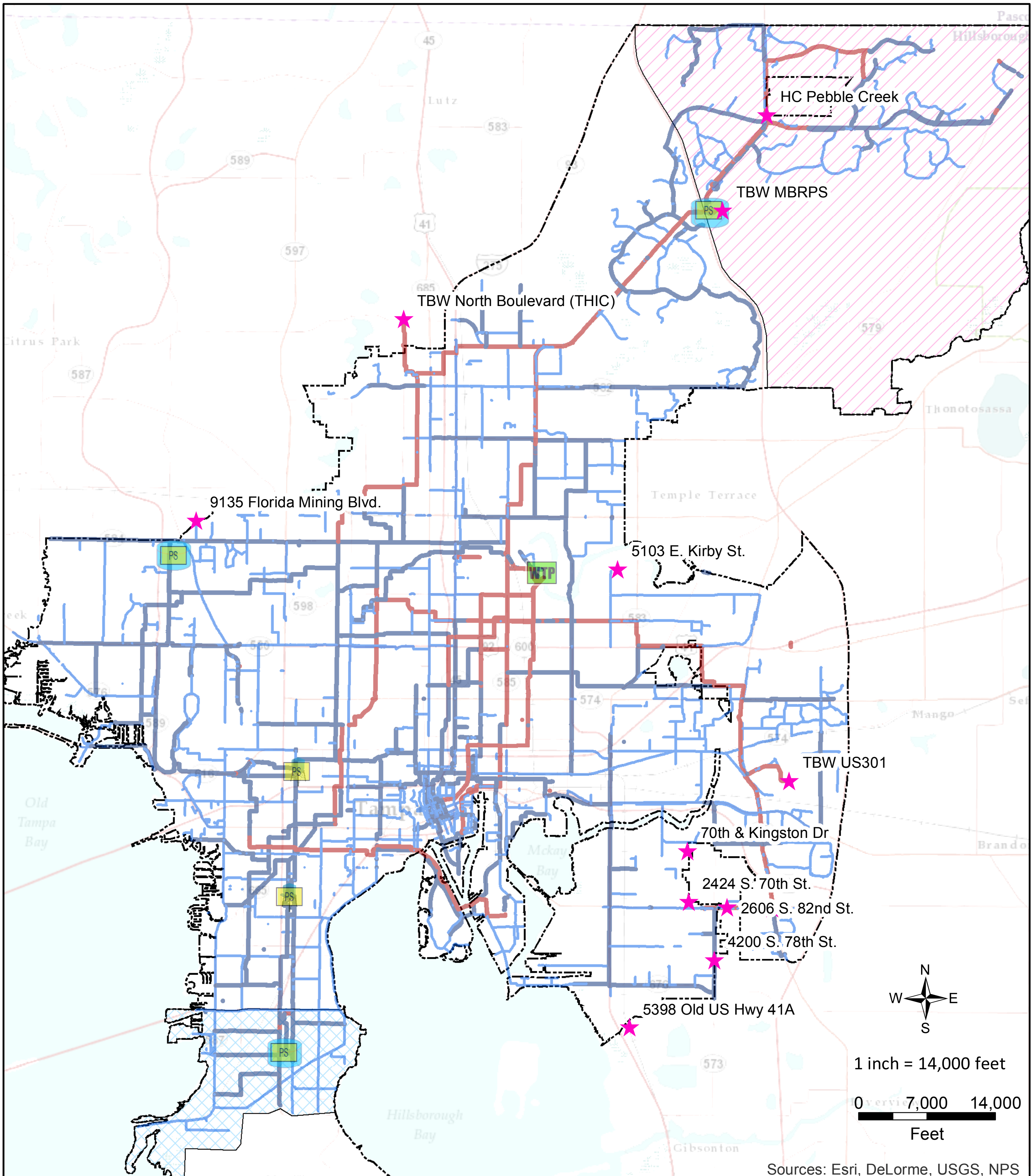


Figure 2 Existing System Flow Diagram

Table 1 Existing Pump Capacities

Pump Station	#	Maximum Capacity		Rated Capacity		Rated TDH	Motor	Typical & Standby Power Capability	Total Pump Station Capacity			
									Max	Rated	Firm (MGD)	
(Install Year)		(gpm)	(MGD)	(gpm)	(MGD)	(ft)	(Type)		(MGD)	(MGD)	Rated	Modeled
D.L. Tippin WTP - High Service Pump Station #1-6, 1984, Dietzgen Pumps, #7-8, 1999, Ingersoll-Dresser 34KKL	1	13,900	20	8,000	12	210	Constant	2 Utility Feeds & Generators	164	99	82	114
	2	8,150	12	5,000	7	255	Constant					
	3	7,850	11	6,000	9	240	Constant					
	4	11,200	16	6,600	10	236	Constant					
	5	15,800	23	9,000	13	240	VFD					
	6	18,125	26	10,000	14	235	Constant					
	7	18,350	26	12,000	17	230	VFD					
	8	20,750	30	12,000	17	230	VFD					
Morris Bridge Repump Station #1-4, 1973, Goulds Pumps 3420 #5, 1996, BW/IP Pump 17HQ #6, 1996, BW/IP Pump 20HQO #7, Proposed	1	14,000	20	11,100	16	152	VFD	2 Utility Feeds & Generators	101	78	62	66
	2	14,000	20	11,100	16	152	VFD					
	3	14,000	20	11,100	16	152	VFD					
	4	14,000	20	11,100	16	152	VFD					
	5	4,161	6	2,200	3	150	VFD					
	6	7,000	10	5,850	8	188	VFD					
	7	3,500	5	2,000	3	188	VFD					
Northwest Repump Station 1987	1	2,600	4	2,100	3	150	Constant	1 Utility Feed & Generator	15	12	6	8
	2	2,600	4	2,100	3	150	Constant					
	3	5,000	7	4,000	6	150	Constant					
Interbay Repump Station #1-4, 1998, Ingersoll-Dresser 8LR-14A *NOTE: #5&6 cannot operate with #1-4*	1	5,000	7	3,000	4	150	VFD	1 Utility Feed & Generator	30	16	12	15
	2	5,000	7	3,000	4	150	VFD					
	3	5,000	7	3,000	4	150	VFD					
	4	5,000	7	3,000	4	150	VFD					
	5	1,000	1	1,000	1	35	VFD					
	6	1,000	1	1,000	1	35	VFD					
West Tampa Repump 1991, Aurora Pump 90-12258	1	7,000	10	5000	7.2	50	Constant	1 Utility Feed	10	7	0	0
Palma Ceia Repump 2000, Aurora Pump 410-HSC-1200	1	6,500	9	5000	7.2	45	Constant	1 Utility Feed	9	7	0	0

1. Rated capacity of the DLTWTF pumps is unclear on the pump curves and are assumed values in this table.



WTP

Pump_Stations

Ground Storage Tank

Elevated Storage Tank

Diameter

Less than 12-inch

12 - 16-inch

16 - 24-inch

Greater than 24-inch

South Tampa

New Tampa

Service Area

Interconnections

City of Tampa Florida

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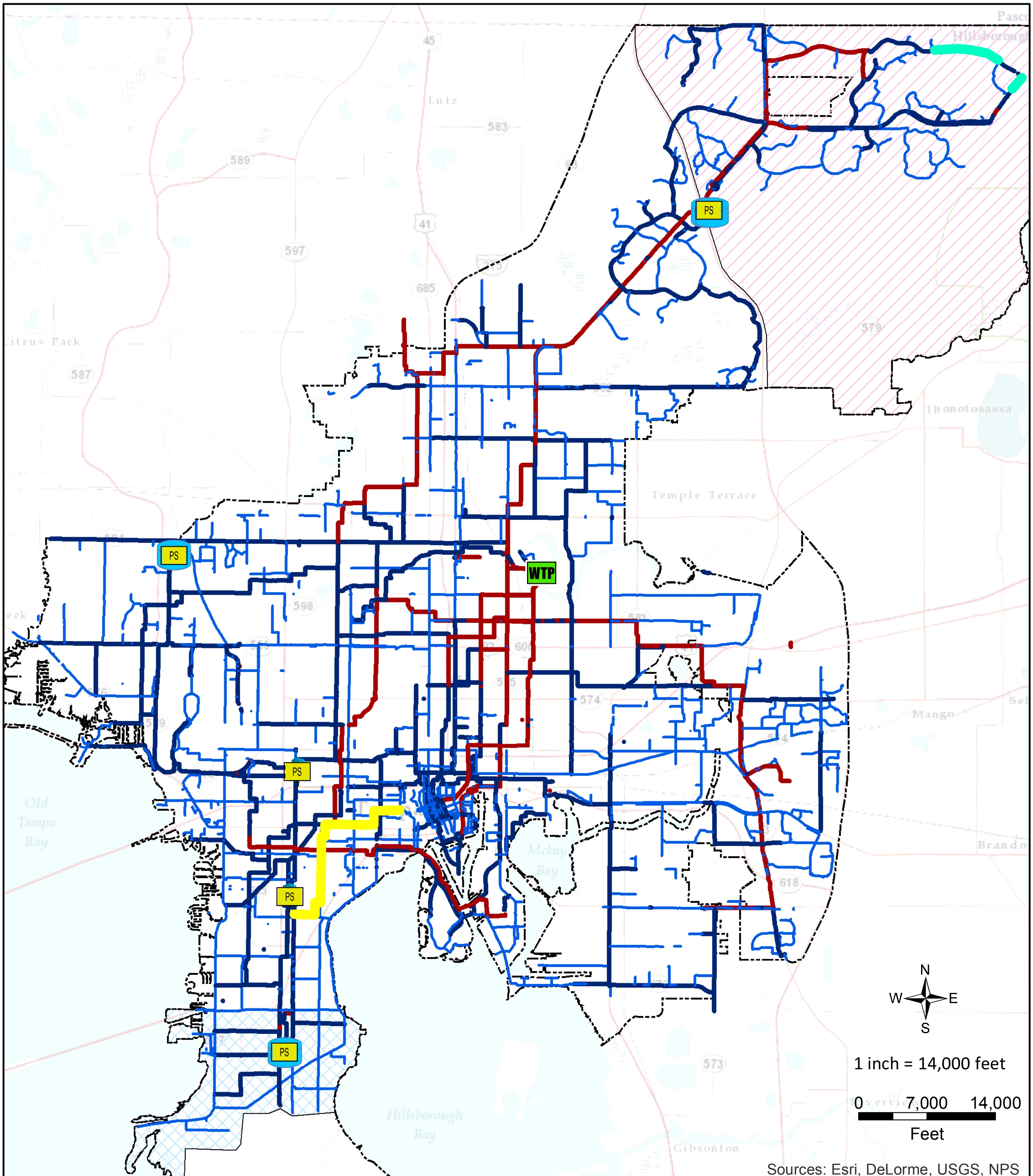
CITY OF TAMPA

Potable Water Master Plan

Figure 3

Wholesale & Interconnections



City of Tampa Florida

BLACK & VEATCH
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WTP
Pump_Stations
Ground Storage Tank
Elevated Storage Tank

Diameter

Less than 12-inch
12 - 16-inch
16 - 24-inch
Greater than 24-inch
KBar Improvements
CIAC Improvements

South Tampa
New Tampa
Service Area

CITY OF TAMPA

Potable Water Master Plan

Figure 4

Planned Improvements (prior to 2020)

2.1 SYSTEM DEMANDS

Average Daily Demand (ADD) systemwide demands were calculated and allocated to appropriate model nodes per the Population & Demand Projections TM (June 2016). After the submittals of the demand projections tech memo, the TWD elected to base maximum day demand (MDD) and peak hour demand (PHD) on the following criteria which provides a conservative but not excessive basis for analyzing the distribution system. **Table 2** summarizes the data used to calculate the peaking factors used during the analysis. **Table 3** summarizes the systemwide demands and demands per pressure zone.

- MDD : ADD Peaking factor (PF) – Calculated at the 95th percentile of twelve years of historic data
- PHD : MDD PF – Calculated at the 95th percentile of five years of historic data

Table 2 MDD and PHD Peaking Factors.

FY	ADD	MDD[1]	PHD[1]	MDD[1]:ADD	PHD[1]:MDD[1]	PHD[1]:ADD
	Line 33	Line 22	Line 23			
'04	77.8	112.0	NA	1.44	NA	NA
'05	79.8	101.7	NA	1.27	NA	NA
'06	81.0	112.7	NA	1.39	NA	NA
'07	82.0	106.7	NA	1.30	NA	NA
'08	77.6	109.4	NA	1.41	NA	NA
'09	69.5	118.5	NA	1.70	NA	NA
'10	68.6	90.4	NA	1.32	NA	NA
'11	71.3	94.7	117.2	1.33	1.24	1.64
'12	70.8	94.4	132.3	1.33	1.40	1.87
'13	67.6	87.2	104.7	1.29	1.20	1.55
'14	68.3	87.6	106.7	1.28	1.22	1.56
'15	68.4	90.4	113.8	1.32	1.26	1.66
Percentile (95th)				**1.56**	**1.37**	**1.83**
Average (not used for analysis)				1.37	1.26	1.66

1. Indicates MDD & PHD flows specifically without ASR Recharge
2. Data source = Monthly Operating Reports

Table 3 System Demands

PRESSURE ZONE	YEAR											
	2015			2020			2025			2035		
	ADD	MDD[1]	PHD[2]	ADD	MDD[1]	PHD[2]	ADD	MDD[1]	PHD[2]	ADD	MDD[1]	PHD[2]
Systemwide	68.9	107.5	126.1	77.3	120.6	141.5	81.0	126.4	148.2	88.0	137.3	161.0
North Tampa[3]	4.8	7.4	16.6	6.1	9.5	21.4	7.0	10.8	24.3	8.3	13.0	29.2
South Tampa	4.6	7.2	8.4	5.1	7.9	9.3	5.2	8.1	9.5	5.4	8.4	9.8
DLTWTF	59.6	93.0	109.1	66.1	103.2	121.0	68.8	107.3	125.8	74.3	115.9	136.0

1. MDD : ADD PF = 1.56
2. PHD : ADD PF = 1.83 systemwide and occurs @ 9:00 PM
3. PHD : ADD PF for New Tampa = 3.5 based on calibration and occurs @ 3:20 AM

2.2 DIURNAL PATTERNS

System demands are constantly changing and in order to conduct a 24-hour extended period simulation (EPS) analysis it was necessary to determine a diurnal demand pattern which represented the existing system demand patterns as close as possible. This was accomplished for both the maximum day demands (MDD) and average day demands (ADD) through a mass balance calculation utilizing the available SCADA data to relate pump station flows and changing tank levels (converted to flow rates) to specific demands:

Demand = Volume Produced ± Change in Storage Volume
– Wholesale – ASR Recharge – New Tampa – South Tampa Irrigation - MacDill AFB

Volume Produced = Total pumped x time increment = DLTWTF + US301 Interconnect + Morris Bridge Interconnect

Change in Storage Volume = Volume Into Tanks – Volume Out of Tanks

NOTE: Additional information was provided by the TWD after calibration was completed regarding the time of day the MacDill AFB fill onsite tanks. The new data shows that MacDill AFB typically fills their tanks in the evening. The demand assumed to be from the MacDill AFB during calibration is now assumed to be due to irrigation in South Tampa during the morning hours.

2.2.1 MDD Diurnal Pattern

The MDD diurnal pattern analysis was based off of the 2015 MDD. One week of SCADA data was collected before and after the 2015 MDD (May 11, 2015) and a diurnal pattern was calculated for each day during this 15 day period. Then a “typical” system diurnal pattern was fit to match the average of the 15 patterns. The peaks and troughs were adjusted to match the PHD:MDD PF as described above but still follow the typical pattern of the system. **Figure 5** illustrates the selected MDD analysis pattern. **Figure 6** illustrates the New Tampa diurnal pattern, **Figure 7** illustrates the South Tampa irrigation pattern and **Figure 8** illustrates the MacDill AFB diurnal pattern both of which were based on the model calibration tech memo. The systemwide pattern was assigned to the model node demands everywhere except for the North Tampa zone and the MacDill AFB connections.

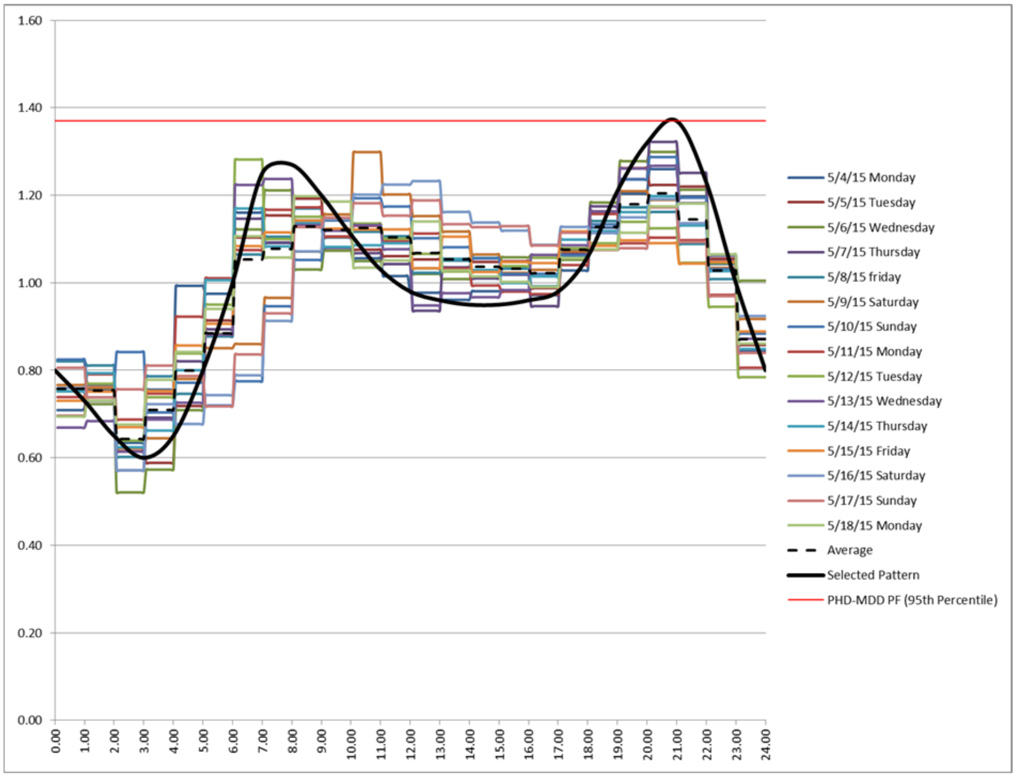


Figure 5 Systemwide MDD Analysis Diurnal Pattern

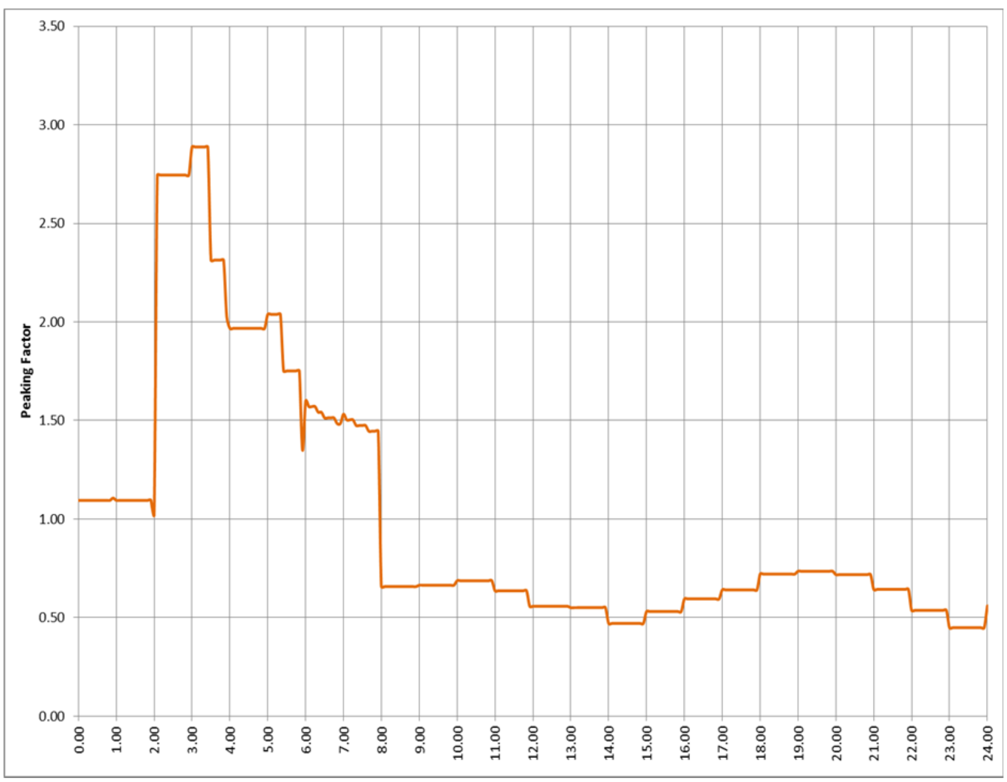


Figure 6 New Tampa Diurnal Pattern

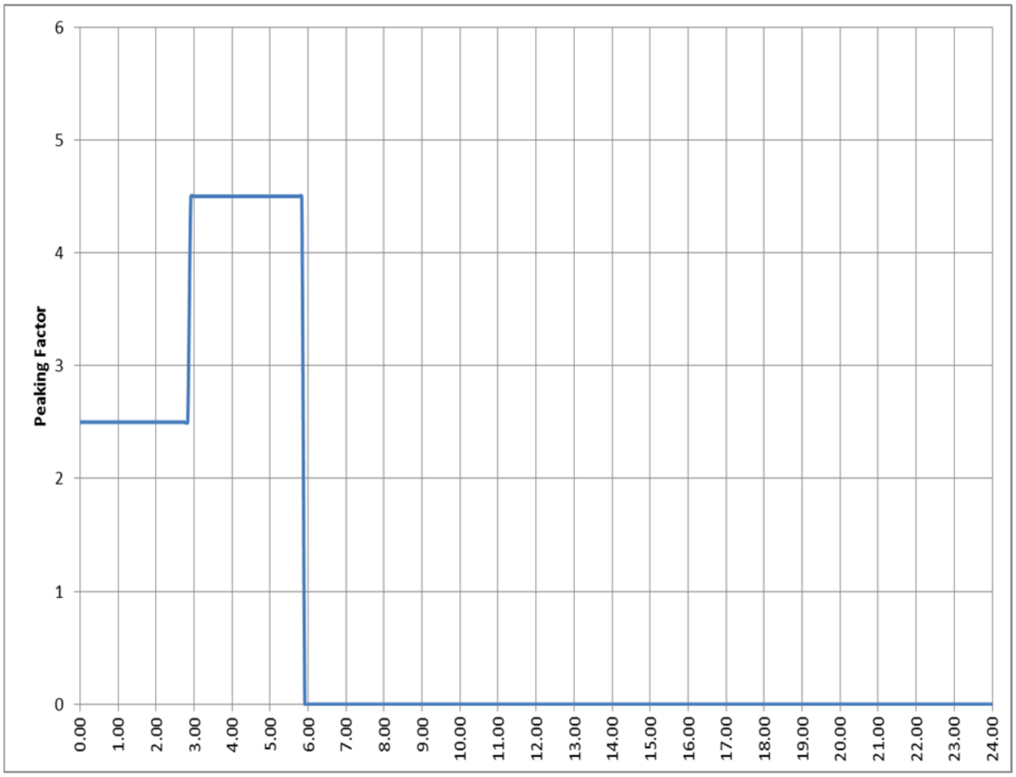


Figure 7 South Tampa Irrigation Pattern

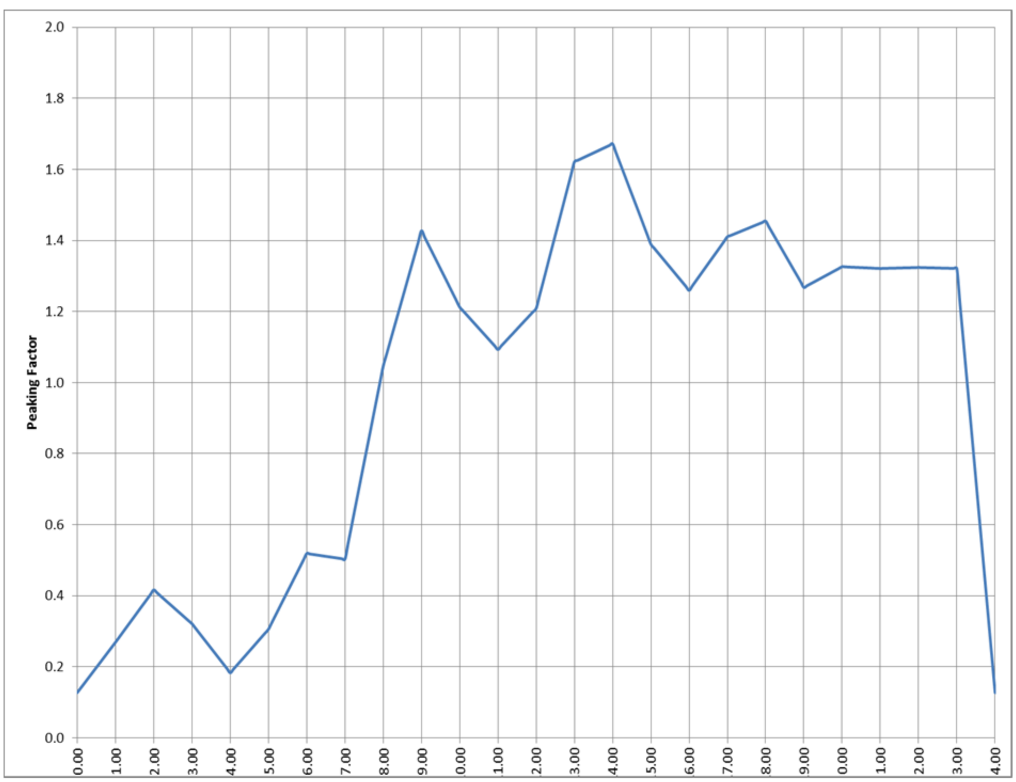


Figure 8 MacDill Diurnal Pattern

2.2.1 ADD Diurnal Pattern

The ADD diurnal pattern analysis was based off of the 2015 minimum month; March 2015. Thirty days of SCADA data was collected for the month and a diurnal pattern was calculated for each day. Then the average system analysis pattern was selected for the typical ADD pattern. **Figure 9** illustrates the selected ADD analysis pattern.

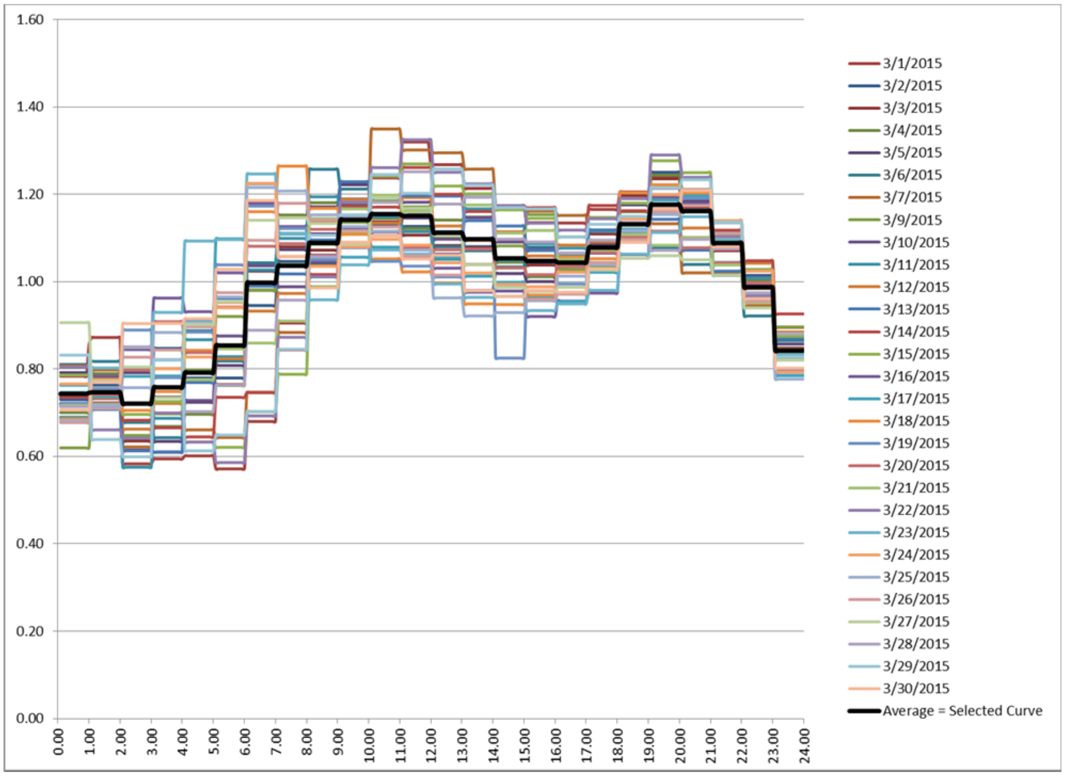


Figure 9 Systemwide ADD Analysis Diurnal Pattern

2.2.1 Non-Irrigation Day Diurnal Pattern

As described in the Population & Demands Projection TM, irrigation in the City is controlled by street address (0, 1, 2, 3 = M/TH, 4, 5, 6 = TU/F and 7, 8, 9 = W/SA) and is allowed every day of the week except for Sundays. To understand the system diurnal pattern without the influence of irrigation, analysis of the SCADA data from Sundays only is required. **Figure 10** illustrates the systemwide diurnal pattern (including New Tampa) on non-irrigation near MDD demands. Likewise **Figure 11** illustrates the ADD systemwide non-irrigation diurnal pattern. As expected, the most significant difference between non-irrigation days and normal days occurs in the early morning before 8 AM which is when most customers tend to irrigate.

For system analysis purposes and based on discussion with TWD, the diurnal patterns which included irrigation were used to simulate the MDD and ADD demand conditions.

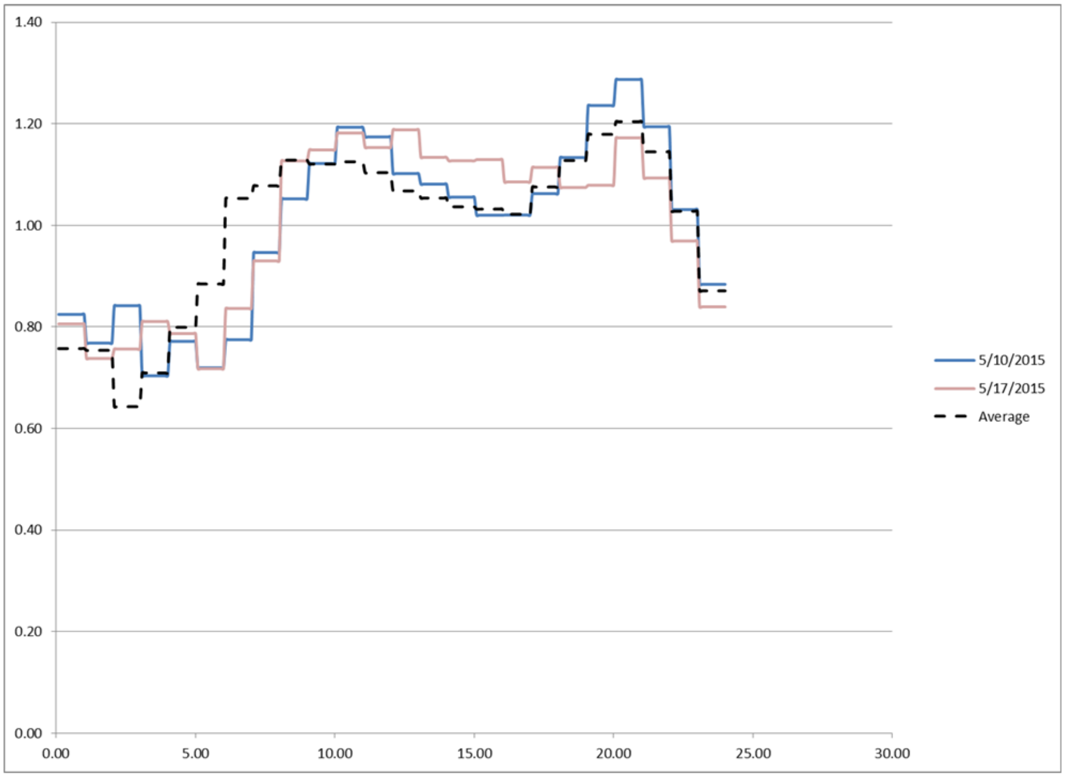


Figure 10 Systemwide Non-Irrigation MDD Pattern

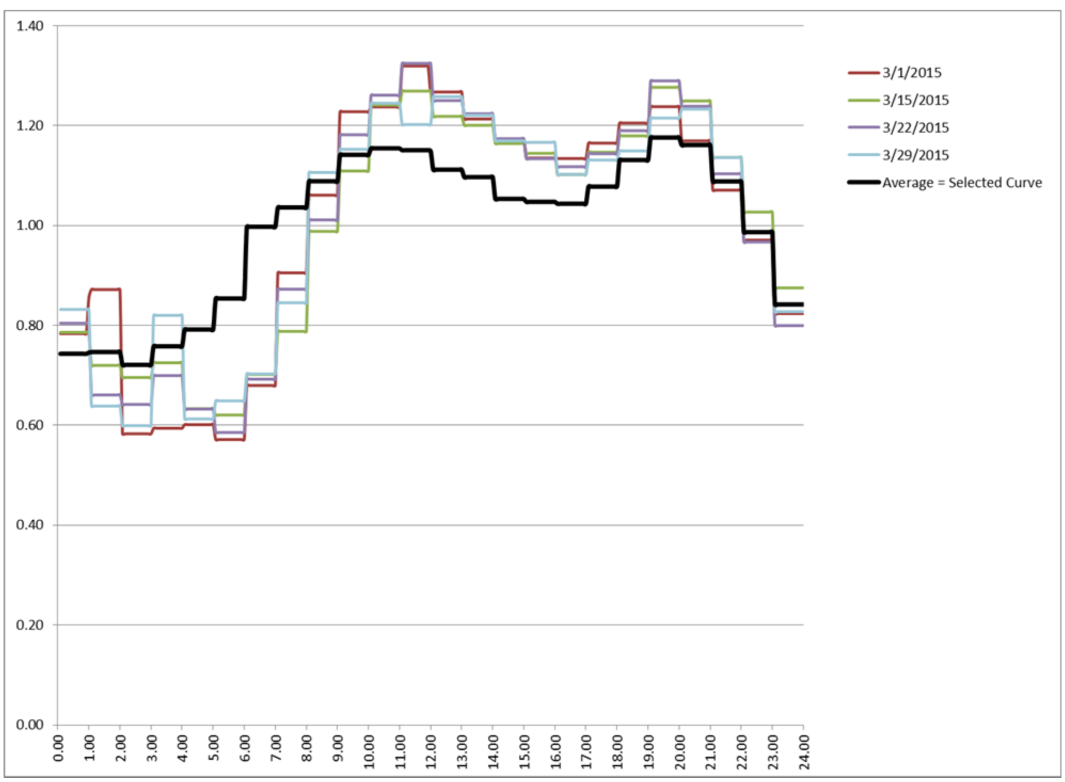


Figure 11 Systemwide Non-Irrigation ADD Pattern

2.3 VALVE AND PUMP CONTROLS

With the addition of the North Tampa and South Tampa pressure zones, the valve and pump operations and controls used for model calibration no longer fully apply to the system. Therefore, the controls were updated for the system analyses to reflect the new controls for Interbay RPS and the proposed controls for Morris Bridge RPS.

2.3.1 Tank Fill Valve Controls

The fill valves located at tank sites are opened remotely by operations staff at the system operations console at the DLTWTF to fill the tanks based on their discretion and system operating experience. There are no automated controls for the valves. Therefore, valve control settings have been loaded to the model to mimic how system operators typically control the valves. The valves are controlled to either an open or closed position and include an adjustable back-pressure sustaining feature that will automatically throttle the valve position if and when system pressure drops to the control setting. This feature helps to ensure adequate pressures are maintained in the system during tank filling operations. The new tank fill controls are summarized in **Table 4**.

Table 4 Tank Fill Valve Controls with new Pressure Zones

STORAGE TANK	OPERATION	CONTROL TYPE	CONTROL LOCATION	CONTROL SETTING	BACK-PRESSURE SETTING (PRESURE / HGL)
Interbay Ground Tank T= T-IB; V= V-IB	OPEN	Level Based	Interbay Tank	18.0 ft	35 psi / 92 ft
	CLOSED	Level Based	Interbay Tank	20.0 ft	
Morris Bridge Ground Tank T= T-MB-W; V= V-MB	OPEN	Level Based	Morris Bridge Tank	19.0 ft	50 psi / 155.5 ft
	CLOSED	Level Based	Morris Bridge Tank	29.0 ft	
Northwest Ground Tank T= T-NW; V= V-NW	OPEN	Time Based	NA	0:00 AM	45 psi / 123 ft
	CLOSED	Level Based	Northwest Tank	31.0 ft	
	OPEN	Time Based	NA	11:00 PM	
West Tampa Elevated Tank T= T-WT; V= V-WT	OPEN	Level Based	Northwest Tank	31.0 ft	35 psi / 117 ft
	CLOSED	Level Based	West Tampa Tank	33.0 ft	
Palma Ceia Elevated Tank T= T-PC; V= V-PC	OPEN	Level Based	West Tampa Tank	33.0 ft	40 psi / 112 ft
	CLOSED	Level Based	Palma Ceia Tank	33.0 ft	

2.3.2 Pump Controls

As with the tank valves, the pumps are remotely turned on and off by operations staff to manage tank levels / tank turnover, and maintain system pressures. Typically, each operator shift will turn on pumps to drawdown the tanks by 5 to 6 feet to force at least a third of the tank volume to turn over each day. However, with the new pressure zones in service, both the Morris Bridge and Interbay pump variable frequency drives (VFD) are now controlled to maintain a constant discharge pressure setting. During increased demand periods, the Morris Bridge pumps are also operated to maintain pressures in the New Tampa area and may operate for longer periods. **Table 5** below summarizes the new pump controls.

Table 5 Pump Operation Average Day Demands

PUMP STATION	OPERATION	# OF PUMPS	CONTROLTYPE	CONTROL LOCATION	CONTROL SETTING
DLTWTF High Service	ON	1-4 & 6 Constant 5, 7 & 8 VFD	Discharge Pressure	High Service Pump Station	65 psi → 80 psi
Morris Bridge	>8,000 gpm	1-4 VFD	Discharge Pressure	Morris Bridge RPS	70 psi
	8,000 – 3,500 gpm	5-6 VFD			
	<3,500 gpm	7 VFD			
Interbay	ON	1-6 VFD	Discharge Pressure	Interbay RPS	65 psi
Northwest PMP-NW1 PMP-NW2 PMP-NW3	ON	1	Time Based	NA	7:00 AM
	OFF		Level Based	Northwest Tank	26.00 ft
	ON		Time Based	NA	7:30 PM
	OFF		Level Based	Northwest Tank	20.0 ft
West Tampa WT_Pump	ON	1	Level Based	Northwest Tank	26.5 ft
	OFF		Level Based	West Tampa Tank	28.5 ft
	ON		Level Based	Northwest Tank	20.5 ft
	OFF		Level Based	West Tampa Tank	23.0 ft
Palma Ceia PCBooster	ON	1	Level Based	West Tampa Tank	28.5 ft
	OFF		Level Based	Palma Ceia Tank	28.5 ft
	ON		Level Based	West Tampa Tank	23.0 ft
	OFF		Level Based	Palma Ceia Tank	23.0 ft

2.3.3 Proposed Morris Bridge Controls

The proposed Morris Bridge RPS reconfiguration is currently under design by a third party and should be constructed within the next year. As such, the proposed design was used during the system analysis. This section of the TM combined with **Figure 12** summarizes the current design and control strategy. The proposed configuration for Morris Bridge RPS allows for three flow schemes; 1. Flow below 3,500 gpm (5 MGD), 2. Flow between 3,500 gpm and 11,000 gpm (5 – 15.8 MGD), 3. Flow above 11,000 gpm (15.8 MGD).

The first configuration allows for the suction of the proposed pump #7 to bypass the ground storage tanks and pull supply from the DLTWTF zone. The pump was sized for minimum and average day flows to the North Tampa zone which are below 3,500 gpm. The pump has a VFD and will be controlled to maintain a discharge pressure of 70 psi.

The second configuration allows for pump #5 and #6 to be used to meet MDD in the North Tampa Zone. As with pump #7, pumps #5&6 will be controlled with VFDs to maintain a discharge pressure of 70 psi. However, the suction for pumps #5&6 will be supplied from the ground storage tanks. No piping or valve changes are required to switch from using pump #7 to pumps #5&6.

The third configuration is currently reserved for emergency purposes such as losing supply from the DLTWTF, and is not included in the proposed normal operation of the Morris Bridge RPS.

During an emergency the design allows for the motor actuated valve between the discharge pipes of pumps #1-4 and pumps #5&6 to be opened and allow flow from pumps #1-4 to flow to New Tampa.

During the system analysis, it was observed that the first and second configurations did not have sufficient capacity to provide the morning demands for New Tampa which can reach upwards of 10,000 gpm and include a high irrigation demand. The use of the emergency pumps #1-4 was required to meet demands. NOTE: the capacity of pumps #5&6 is as follows:

- Maximum (per definition in Table 1): 11,000 gpm (#5 is 4,161 gpm @ 83 ft and #6 is 7,000 gpm @ 150 ft)
- At 70 psi discharge pressure setting: 8,300 gpm at full speed with low tank levels (#5 is 1,950 gpm @ 162 ft and #6 is 6,350 gpm @ 162 ft)

To meet the high morning demands of New Tampa and the Florida Administrative Code for pump station capacity as referenced in the next section, Black & Veatch suggests that the City should change the operation of pumps #1-4 such that pumps #1-4 are operated from midnight to 8AM to meet irrigation demands and pressures. After 8AM pumps #5&6 will be used to meet MDD. In conjunction with this change in operation, B&V also recommends adding a motor actuated valve such that when pumps #1-4 are operated to meet peak demands during irrigation periods in New Tampa, this new valve can automatically be closed to prevent flow from entering the DLTWTF zone.

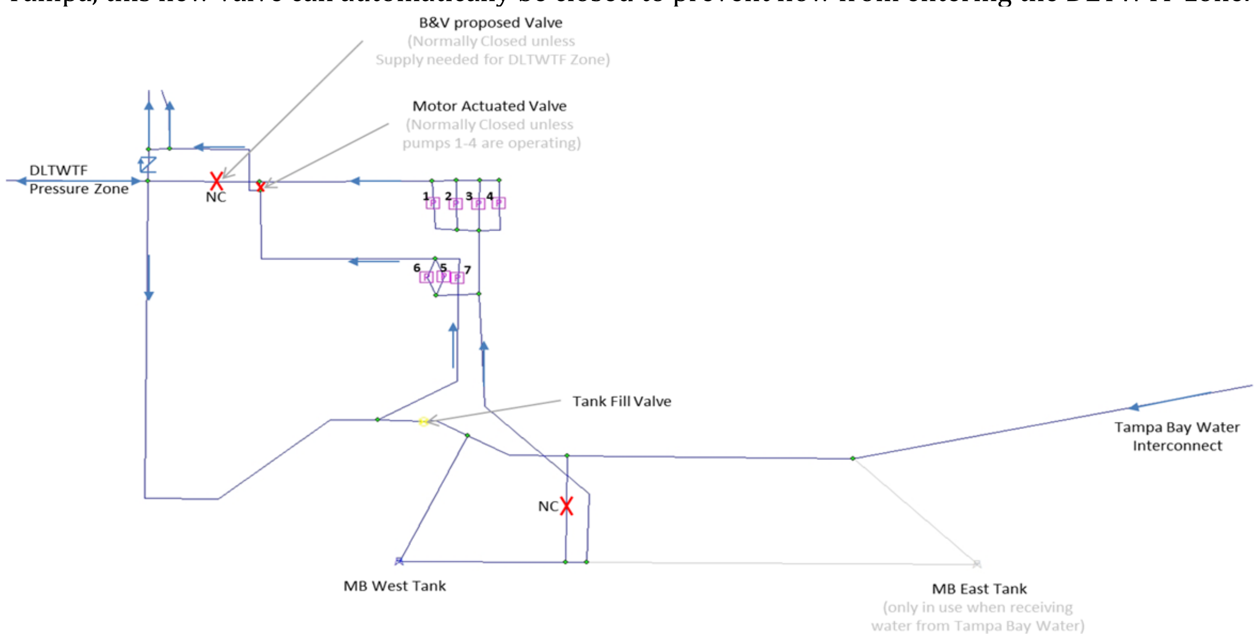


Figure 12 Morris Bridge RPS Configuration

3. Performance Criteria

Black & Veatch met with the TWD to develop the desired system performance criteria which will be used to determine what improvements are needed in the distribution system. Collectively, the group established the basic assumptions and system performance goals that were used to identify system performance deficiencies that require improvement. The criteria are based on various water system design guidelines and consider references such as existing and proposed regulations (i.e. FDEP).

Table 6 Distribution System Performance Criteria Table.

Parameter	Criteria / Description	Performance Goal	Comments
1. Demand Peaking Factor	MDD : ADD	**95th confidence interval (only exceeded 1 year out of 20 years)** [B&V]	- Ratio to be calculated based on actual system data from 2004 - 2015. - PHD:MDD data is not available for the period and will be based on 95th Percentile of 5 years (2011-2015)
	# Years of Historic Data	**12**	- 12 years were selected to include the last drought conditions in 2007.
2. Pump Station Capacity	Supply + Remote Pump Stations (**w/out** elevated storage)	**Firm Capacity > PHD + Fire Flow (per service area)** **[F.A.C 62-555.320(15)(a)]**	- Firm Capacity > PHD + Fire Demand, unless elevated finished drinking water storage is provided [F.A.C. 62-555.320 (15)(a)] - Firm Capacity + useful elevated storage capacity > greater of PHD for 4 hours or MDD+FF [F.A.C 62-555.320(15)(b)] - Firm capacity per pressure zone is the capacity with the largest pump out of service per pressure zone. • North Tampa Zone, South Tampa (Interbay) and DLT Zone - Existing Elevated tanks cannot be counted for F.A.C 62-555.320(15)(a) as they do not float on the system. - If elevated tank improvements were made to allow the tanks to float on the system, the criterion may be reduced to meet F.A.C. 62-555.320(15)(b). This can be evaluated as a potential improvement option.
	Supply + Remote Pump Stations (**w/**elevated storage)	**Firm Capacity > MDD + Fire Flow (per service area)** **[F.A.C 62-555.320(16)(b)]**	
3. Storage Volume	Total Storage (per pressure zone)	**> 25% of the System's MDD + Fire Flow (Reserve)** **[F.A.C. 62-555.320 (19)(a)]**	- Unless a demonstration showing that the useful finished water storage capacity (minus fire protection) is sufficient for operational equalization [F.A.C. 62-555.320(19)(b)1] - Unless a demonstration showing that the water system's total useful finished water storage capacity (minus fire protection) is sufficient to meet the water systems PHD for 4 consecutive hours [F.A.C. 62-555.320(19)(b)2] - Equalization storage should be 15-20% of max daily use. [Lindeburg] - Per discussion with the City, total storage does not include additional emergency storage due to existing WQ concerns.
	Fire Reserve	**3,500 gpm for 3 hours (per service area)**	- Minimum fire flow = 1,000 gpm for 1 hour [Florida Fire Code, Table 18.4.5.1.2] - Fire Flow between 1,500 gpm & 2,750 gpm = a duration of 2 hours; 3,000 & 3,750 gpm = a duration of 3 hours [Florida Fire Code]
4. Pressure	Minimum Pressure – Peak hour demand conditions. (Non-Fire, Non-Emergency)	**> 50 psi Transmission** **> 40 psi Distribution** **> 25 psi Metered Discharge** **[TWD Tech Manual, 3.2.A.2]**	- > 20 psi [F.A.C. 62-555.320 (15)(b)] - Minimum pressure at the tap should be 25 psi. Minimum pressures at fire hydrants should be 60 psi, possibly higher in commercial and industrial districts [Lindeburg] - Metered discharge pressure is on the private side of the customer meter and is not represented in the model
	Maximum Pressure	**< 75 psi**	- Florida 2010 Plumbing Code requires a service line PRV if the pressures within the building exceeds 80 psi.
5. Fire Flow	System Demand/Supply	**MDD**	- If fire protection is being provided the design capacity should be fire flow plus maximum day demand. MDD+FF [F.A.C. 62-555.320(15)(a)] - PHD+FF was not selected due to existing WQ concerns which would increase with oversized water mains.
	Minimum Flow	**1,000 gpm (residential)** **3,500 gpm for 3 hours (commercial & Industrial)** **[exceeds TWD Tech Manual, 3.2.A.3.c]**	- Residential fire flow can be reduced to 500 gpm if building has automatic sprinkler systems and greater than 30ft separation between buildings [18.4.5.1.23, Florida Fire Code] - 1,000 gpm for 1 hour (residential) & 3,000 gpm for 3 hours (commercial & industrial)[TWD Tech Manual, 3.2.A.3.c]
	Maximum Flow	**3,500gpm for 3 hours** **[ISO & AWWA M31]**	The maximum flow is the maximum fire flow required from the TWD system. For system customers with fire flow requirements greater than what can be provided by the TWD system, it is assumed that those customers will construct private fire protection systems as needed to meet their own fire service needs.
	Minimum Residual Pressure	**> 25 psi [TWD Tech Manual, 3.2]**	Minimum residual pressures = 20 psi. [F.A.C. 62-555.320 (15)(a)]
6. Pipe Capacity	Maximum Velocity	**< 5 ft./sec at peak hour demands (normal, non-fire conditions)** **< 10 ft./sec at MDD+FF demands** **[TWD Tech Manual, 3.2]**	- This parameter is used to identify pipes that may be contributing to pressure and/or flow deficiencies. - Considered a secondary criteria to trigger consideration for improvement, but not automatically triggering an improvement
	Maximum Head loss (HL) per 1,000 Feet	**< 3ft (Mains >=16-inch diameter)** **< 5ft (Mains <16-inch diameter)**	- This parameter is used to identify pipes that may be contributing to pressure and/or flow deficiencies. - Considered a secondary criteria to trigger consideration for improvement, but not automatically triggering an improvement

4. Distribution System Assessments

Black & Veatch analyzed the existing distribution system for the purpose of identifying system capacity, operational, resiliency and reliability needs. This section documents the analysis approach, observations and conclusions of the system analysis.

4.1 ANALYSIS CONDITIONS

Twenty-five scenarios were selected to analyze the distribution system as summarized in **Table 7**.

Table 7 System Analysis Scenarios

#	SCENARIO NAME	DEMAND	SIMULATION TYPE	PURPOSE
1	Base MDD Analysis	2015 MDD	EPS - 24 hrs	Analyze the capacity and operation of the distribution system including tank cycling.
1.1	Base MDD Analysis + ASR Recharge	2015 MDD	EPS - 24 hrs	
2	2020 MDD Analysis	2020 MDD	EPS -	
3	2025 MDD Analysis	2025 MDD	EPS - 24 hrs	
4	2035 MDD Analysis	2035 MDD	EPS - 24 hrs	
4.1	2035 MDD Analysis + ASR Recharge	2035 MDD	EPS - 24 hrs	
5	Base MDD+FF Analysis	2015 MDD	EPS - 24 hrs	Analyze the ability of the system to meet fire flow demands.
6	2020 MDD+FF Analysis	2020 MDD	EPS - 24 hrs	
7	2025 MDD+FF Analysis	2025 MDD	EPS - 24 hrs	
8	2035 MDD+FF Analysis	2035 MDD	EPS - 24 hrs	
9	Base Water Quality Analysis	2015 ADD	EPS - Min 72 hrs	Create a baseline for WA to compare to future years
10	Base PHD Analysis	2015 PHF	NA (Steady State)	Document conditions
11	Base ADD Analysis	2015 ADF	NA (Steady State)	Document conditions
12	DLTWTF Failure	2015 MDD	EPS - 24 hrs	Analyze the criticality of pumping/storage facilities.
13	DLTWTF Failure	2035 MDD	EPS - 24 hrs	
14	Morris Bridge WTP Failure	2015 MDD	EPS - 24 hrs	
15	Morris Bridge WTP Failure	2035 MDD	EPS - 24 hrs	
16	Interbay Repump Station Failure	2015 MDD	EPS - 24 hrs	
17	Interbay Repump Station Failure	2035 MDD	EPS - 24 hrs	
18	Northwest Repump Station Failure	2015 MDD	EPS - 24 hrs	
19	Northwest Repump Station Failure	2035 MDD	EPS - 24 hrs	
20	Palma Ceia Elevated Tank Failure	2015 MDD	EPS - 24 hrs	
21	Palma Ceia Elevated Tank Failure	2035 MDD	EPS - 24 hrs	
22	West Elevated Tank Failure	2015 MDD	EPS - 24 hrs	
23	West Elevated Tank Failure	2035 MDD	EPS - 24 hrs	
24	Failure of top 10 most critical pipe/valve	2015 MDD	EPS - 24 hrs	
25	Failure of top 10 most critical pipe/valve	2035 MDD	EPS - 24 hrs	

4.2 POTABLE WATER STORAGE AND PUMPING FACILITY CAPACITIES

The capacity of the pump stations and storage facilities were analyzed for each planning year to evaluate the adequacy of the existing facilities and to identify any deficiencies in capacity based on the performance criteria. **Table 8** summarizes the capacity assessment results. NOTE: hydraulic limitations were assessed using the model and summarized later in the technical memorandum.

Table 8 Pump Station and Storage Facility Capacity Analysis.

Pump Station Capacity

PRESSURE ZONE	PUMPING FACILITY	MAX CAPACITY (MGD)	M. FIRM CAPACITY (MGD)	PERFORMANCE CRITERIA (MGD) PHD + Fire Flow[4]				MEETS CRITERIA (Y/N)				DEFICIENT CAPACITY (MGD)	YEAR IMPROVEMENT REQUIRED
				2015	2020	2025	2035	2015	2020	2025	2035		
New Tampa[1]	Morris Bridge RPS Pumps #1-4 (w/ valve)	80	66.0	21.7	26.4	29.4	34.2	Y	Y	Y	Y	N/A	N/A
	Morris Bridge RPS Pumps #5&6 (only)	16	6					N	N	N	N	28.2	2015
South Tampa	Interbay RPS[2]	28	15.0	13.5	14.3	14.5	14.8	Y	Y	Y	Y	N/A	N/A
DLTWTF[3]	DLTWTF Total	183.8	136.0	114.2	126.1	130.9	141.0	Y	Y	Y	N	5.0	2035
	High Service	*164*											
	Northwest	*0*											
	West Tampa	*10*											
	Palma Ceia	*9*											

1. Pumps #1-4 and Pumps #5&6 cannot operate at the same time and are thus compared separately. Pumps #1-4 are required to meet regulations
2. Interbay firm capacity exclude the two small jockey pumps due to pump station configuration. Also the RPS is currently frequently running all 4 pumps, but not at full speed.
3. DLTWTF firm capacity is based upon the largest pump at the DLTWTF being out of service. The remainder of the pumps within this pressure zone ar operational.
4. PHD + Fire Flow for each Plan Year is the PHD in MGD plus the Fire Flow of 3,500 gpm converted to MGD or 5.0 MGD

Storage Capacity

PRESSURE ZONE	STORAGE FACILITY	TOTAL VOLUME (MG)	EFFECTIVE VOLUME (MG)	PERFORMANCE CRITERIA (MG) 25% of MDD + Fire Reserve[1]				MEETS CRITERIA (Y/N)				DEFICIENT VOLUME (MG)	YEAR IMPROVEMENT REQUIRED
				2015	2020	2025	2035	2015	2020	2025	2035		
New Tampa	Morris Bridge RPS	10.0	7.5	2.5	3.0	3.3	3.9	Y	Y	Y	Y	N/A	N/A
South Tampa	Interbay RPS	5.0	5.0	2.4	2.6	2.7	2.7	Y	Y	Y	Y	N/A	N/A
DLTWTF	DLTWTF Total	26.0	18.5	23.9	26.4	27.4	29.6	N	N	N	N	11.1	2016
	Clearwell	*20.0*	*12.5*										
	Northwest	*3.0*	*3.0*										
	West Tampa	*1.5*	*1.5*										
	Palma Ceia	*1.5*	*1.5*										

1. Fire Reserve storage required is 3500 gpm for 3 hours or 0.63 MG
2. The total system storage is 41.0 MG.
3. There is a 40 MGD interconnection with Tampa Bay Water at the MBRPS.
4. MBRPS has the ability to supply the DLTWTF pressure zone and some storage might be able to be counted to that zone.

4.3 DISTRIBUTION SYSTEM ANALYSIS

This section provides a description of the distribution system analyses and conclusions. Figures showing pressure, velocity, flows and tanks levels are located in **Attachment 2**.

4.3.1 System Configuration Updates

The overall diurnal pattern for the distribution system follows a typical pattern for potable water distribution systems including decreased nighttime demands with morning and evening peak hours corresponding to residential customers waking up and preparing for work/school and then again returning from work/school for their evening meal and household activities. Even though there are portions of the system with increased nighttime flows due to irrigation demands, the overall system demand pattern provides the opportunity for the repump station tanks to be refilled during the nighttime hours when domestic demands are lower which allows these tanks to again supply the system during daytime peak hours.

However, the new pressure zone configuration isolates two areas of the distribution system with high nighttime irrigation demands requiring the tanks supplying those zones to be full and available during the nighttime hours when the peak demands occur in those zones. Ultimately, this requires the tanks to be filled during other times of the day when the system-wide demands are higher and the domestic demand requirements for the high service pump station is the greatest.

The hydraulic model results showed that the current normal discharge pressure setting for the high service pump station at DLTWTF is not sufficient to supply the system-wide PHD while concurrently filling the Morris Bridge and Interbay tanks. In order to produce a valid model run that would permit refill of these tanks during daytime hours, the discharge pressure setting at the DLTWTF was increased from 65 psi to 80 psi. This is not a preferred operating condition for a number of reasons including the potential for increased pipe breaks/leaks and water loss, but it was used as a temporary operation change to provide results in which to begin discussions on appropriate improvements to consider. For reference, **Table 9** summarizes the imported water assumed to be purchased from Tampa Bay Water (TBW) for the various planning years.

Table 9 Assumed TBW Supplemental Supply

#	SCENARIO NAME	DEMAND CONDITIONS	DLTWTF SUPPLY @ PHD	TBW SUPPLEMENTAL SUPPLY
1	Base MDD Analysis	107.5 MGD	136 MGD	0 MGD
2	2020 MDD Analysis	120.6 MGD	145 MGD	5 MGD
3	2025 MDD Analysis	126.4 MGD	149 MGD	8 MGD
4	2035 MDD Analysis	137.3 MGD	158 MGD	12 MGD

The change in system configuration to include two new pressure zones, while improving low pressure and disinfection residual issues within the new zones, will likely come with the need for additional system improvements to help convey water supply to the re-pump storage tanks for the new zones during daytime system demand conditions. Based on discussions with the TWD, system improvements to consider in order of attractiveness to the TWD are as follows: operational changes (pump operation and scheduling of tank refill operations), capital improvement projects (i.e. transmission mains), and then finally, DLTWTF discharge pressure increases.

4.3.2 System Capacity and Operation

The system capacity analysis showed that most of the distribution system maintains adequate minimum pressures and does not excessively exceed maximum pressure criteria. The lowest pressures in the system are located in the southern portion of the system between Kennedy Blvd and Gandy Blvd as well as in the western portion of the system around the Northwest RPS. The southern system pressures, however, are greatly increased with the addition of the final CIAC improvements which are shown in **Figure 3**. System improvements to increase pressures in the western portion of the system should be considered.

Table 10 Percent of the System Meeting Pressure Criteria

#	SCENARIO NAME	MINIMUM PRESSURES			MAX. PRESSURES	
		> 30 psi	> 40 psi	> 50 psi	> 75 psi	> 85 psi
1	Base MDD Analysis	98.6%	91.5%	67.7%	15.6%	0.0%
2	2020 MDD Analysis	99.6%	94.3%	69.8%	17.6%	0.0%
3	2025 MDD Analysis	99.5%	93.2%	65.0%	16.4%	0.0%
4	2035 MDD Analysis	98.5%	88.9%	52.3%	9.8%	0.0%

The water main maximum velocities throughout the system are within the performance criteria limits. However, additional transmission mains may be needed to address the tank refill requirements discussed in the previous subsection. Maximum velocities between 2.5 and 5 fps are observed in the transmission mains supplying the Northwest and Morris Bridge tanks and between 5 and 10 fps are observed in the transmission main supplying the Interbay tank.

4.3.3 Fire Flow Results

In general, the residential fire flow goal of 1,000 gpm during MDD while maintaining a minimum residual pressure of at least 25 psi was met for each planning year. However, the system cannot meet the commercial and industrial fire flow goals in all parts of the system. **Table 11** summarizes the percentage of the system that met the fire flow goals. TWD will need to consider where investments in capital improvements are needed to improve available fire flows. For areas of the system that include fire flow requirements in excess of 3,500 gpm, it was previously discussed with TWD that those customers should be responsible for providing those fire flow requirement via their own fire protection system (i.e. storage tank with fire pumps).

Table 11 Percent of the System Meeting Fire Flow Goals

#	SCENARIO NAME	RESIDENTIAL (1,000 GPM)	COMMERCIAL / INDUSTRAL (3,500 GPM)
1	Base MDD+FF Analysis	95%	61%
2	2020 MDD+FF Analysis	97%	62%
3	2025 MDD+FF Analysis	91%	51%
4	2035 MDD+FF Analysis	87%	50%

NOTE: increased coverage is due to the addition of the planned CIAC & KBar pipelines.

4.3.4 Water Age Analysis

A water age analysis for the base year (2015) was performed as part of the distribution system analyses to set a baseline for comparing to water ages for future year water age analyses. Additionally, tank mixing model parameters were assumed based on tank volume and inlet/outlet configuration and assigned to storage tanks as summarized in **Table 12**.

Table 12 Tank Mixing Models

#	TANK	MIXNG MODEL	COMMENTS
1	Morris Bridge	First in / First Out	This models the flow through the tank similar to "plug flow" with no mixing where the first water to enter the tank is the first to leave the tank. This was selected because each of the ground storage tanks have separated inlet and outlet pipes.
2	Interbay	First in / First Out	
3	Northwest	First in / First Out	
4	West Tampa	Complete Mix	This models a completely mixed tank where all water that enters the tank is subsequently and completely mixed with the water already in the tank. This option was selected due to the relatively small size of the tank and the high flowrate at which these tanks typically fill.
5	Palma Ceia	Complete Mix	

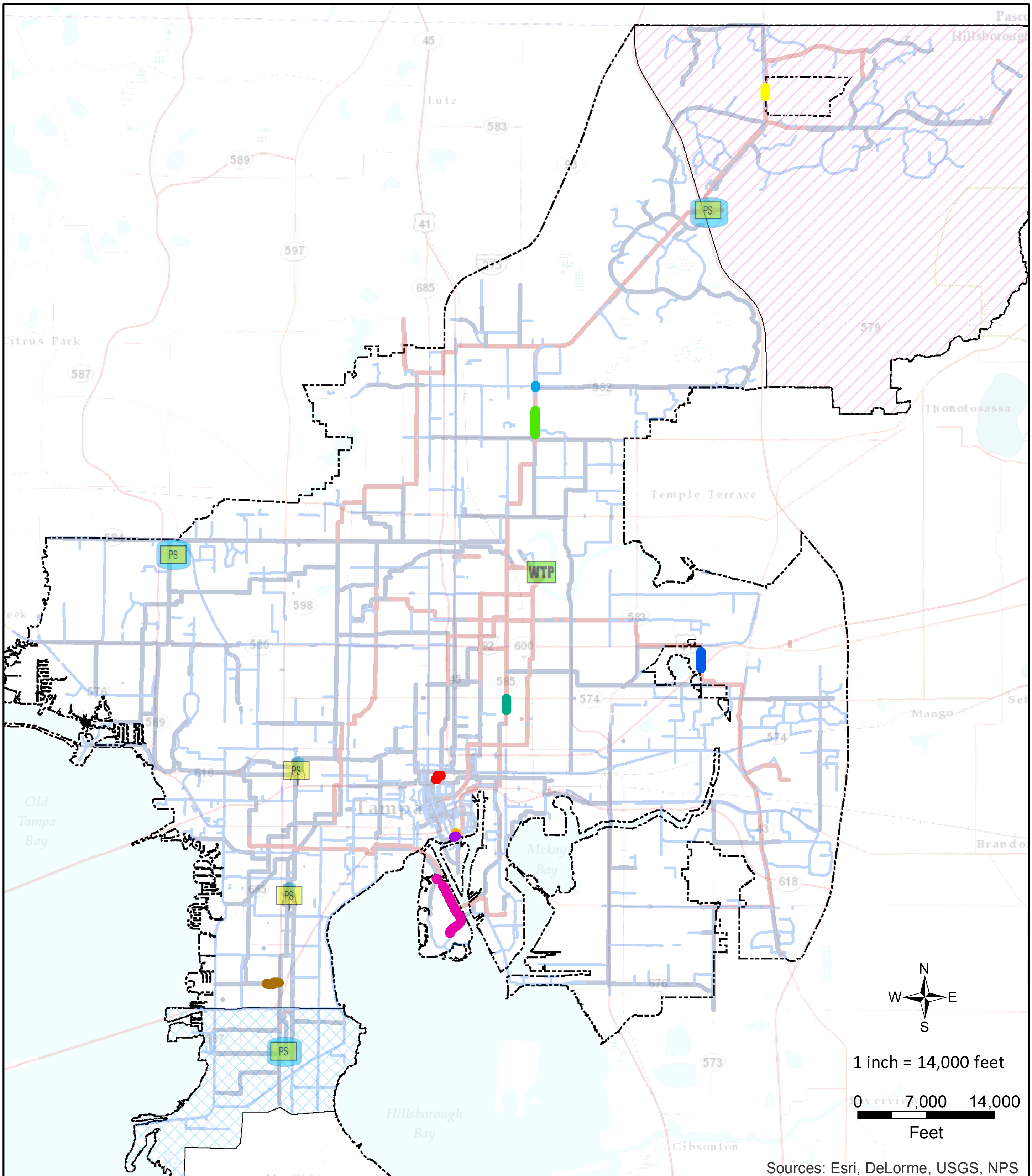
Generally, the model results show that the water age of the system is less than 5 days with small pockets around the tanks with ages up to 10 days. Additionally, the water age in each of the small pressure zones is in the 5 to 10 day range. This is attributed to all of the supply to these small zones going through the ground storage tanks.

4.3.5 Valve/Pipe Criticality

Under the Potable Water Master Plan Phase 700 tasks, the InfoMaster valve criticality extension was used in conjunction with other consequence of failure (COF) criteria developed with the TWD to determine pipe criticality. **Figure 13** illustrates the location of the top 10 critical pipes as defined by the consequence of failure score. **Table 13** summarizes the criteria and weightings used in the analysis.

Table 13 COF Criteria Summary

CATEGORY	CRITERIA	PRELIMINARY SCORING WEIGHT	FINAL SCORING WEIGHT
Social / Political / Health / Safety	Critical Customer Impact	15%	10%
	Population Density	10%	10%
	Repeatable Breaks on Individual Pipe Segments	5%	5%
	Contaminated Soil	10%	5%
	Additional Fire Hydrants	5%	5%
	Modeled Velocity/High Head Loss	0%	10%
	Available Fire Flow	0%	10%
	Service Main Replacements	0%	5%
Economical	Right-of-Way (ROW)/Crossings	10%	5%
	Water Demand	15%	10%
	Diameter	15%	10%
	Interconnect Location	10%	10%
	2015 Planned Paving Projects	5%	5%



CITY OF TAMPA

Potable Water Master Plan

Figure 13

Top 10 Consequence of Failure Pipes

4.3.6 Resiliency and Reliability

Asset Failure Analysis

A hydraulic analysis was performed under base year (2015) and planning year 2035 MDD conditions to assess the criticality of the DLTWTF and each of the Repump Stations. MDD conditions were selected to represent a conservative scenario, but typically the TWD can ask residents to eliminate irrigation demands in emergency cases. This analysis resulted in a ranking of infrastructure criticality or "importance" to the distribution system and provided insight into the need for additional infrastructure. **Table 14** summarizes the asset failure observation and ranks the infrastructure in order of significance.

Critical Customers

Under the Potable Water Master Plan Phase 700 tasks, the following list of critical customer types was identified. Within the risk based prioritization pipe serving critical customers were given a score of 5 and weighted at 15%. For more details on the customer selection and risk score reference the March 2016 Risk Based Pipeline Prioritization Technical Memorandum. These customers should have more than one connection to the distribution system and protect against service disruptions due to main breaks.

- Top 20 users based on FY2015 water demand
- Airports
- Hospitals
- Jails
- MacDill Airforce Base
- Port of Tampa
- Schools/University of South Florida
- EOC-ERC Facilities (2015 Critical Facilities) –
  - Main Crossings,
  - Adult Day Care Center,
  - Adult Family Care Home,
  - Ambulatory Surgical Center,
  - Assisted Living Facility,
  - Com Center,
  - Crisis Stabilization Unit/ Short Term Residential Treatment Facility,
  - Dam / Operation Shelter,
  - Data Center,
  - Elevated Water Tank,
  - EOC,
  - Fire Station,
  - Hospital,
  - Nursing Home,
  - Police Department,
  - Residential Treatment Facility,
  - Shelter,
  - W Pump Station,
  - W Storage Tank,
  - Water Treatment Plant & Storage,
  - WW Treatment Plant
- Tourist Attractions –
  - Art Museums,
  - Cruise Terminals,
  - Performing Arts Center,
  - Sports Arenas,
  - Busch Gardens Tampa Bay,
  - The Florida Aquarium,
  - Adventure Island,
  - Glazer Children's Museum,
  - Lowry Park Zoo

Table 14 Facility Criticality Assessment

#	ASSET FAILURE LOCATION	COMPLETE REDUNDANCY	COMMENTS / NOTES	POTENTIAL IMPROVEMENTS
1	DLTWTF	N	• There is no full supply option available, only 70 MGD total is available from TBW through the Morris Bridge and US301 connections • All tanks drain trying to meet demands & pressures, WT & PC drain before 8AM. • Cannot refill tanks • Minimum pressures occur at peak hour • Maximum pressures occur during min hours due to elevation of MBRPS. • Need more than 40 MGD @ MBRPS	• Bi-Directional interconnect @ THIC/North Boulevard • New RPS with new interconnect to address redundancy and required additional storage in **Table 8**.
2	Morris Bridge RPS	N	• Cannot get supplemental flow from TBW from MBRPS • DLTWTF serving New Tampa through check valves • DLTWTF does not have enough capacity to serve system causing low pressure during peak demands • IB tank has trouble refilling causing low pressure problems in South Tampa	• Bi-Directional interconnect @ THIC/North Boulevard • New RPS with new interconnect to address redundancy and required additional storage in **Table 8**. • Add a bypass around the MBRPS to allow Tampa Bay Water interconnect to discharge to distribution system
3	Interbay RPS	Y	• Minimum pressures occur at peak hour while trying to refill MB tank. • Cannot fill Palma Ceia tank.	• Will need operational changes to meet demands and to open all closed valves along pressure zone boundary. Check valves will need to be installed at select closed valve locations. • Additional redundancy of key IBRPS equipment should be considered.
4	Northwest RPS	Y – 2015 N – 2035	• NWRPS needed to meet demands during peak hour • West Tampa and Palma Ceia tanks drain before 10AM to meet morning high demands	New RPS with new interconnect to address redundancy and required additional storage in **Table 8**.
5	Palma Ceia RPS	Y – 2015 N – 2035	• PCRPS needed to meet demands during peak hour in 2035	New RPS with new interconnect to address redundancy and required additional storage in **Table 8**.
6	West Tampa RPS	Y – 2015 N – 2035	• WTRPS needed to meet demands during peak hour in 2035	New RPS with new interconnect to address redundancy and required additional storage in **Table 8**.

Overall System Reliability

In general, the distribution system pipeline network is well looped, the repump stations are located in areas of the system with higher demands, and the critical repump stations have multiple pumps and more than sufficient firm capacity to meet demands through 2035. However, additional pumping capacity is required at the DLTWTF before 2035. Also, two areas were identified which could benefit from improved pipeline looping:

- The western portion of the system near the Northwest RPS
- Transmission mains to the Morris Bridge RPS

Additional transmission mains could be added to the western portion of the system to complete looping from Waters Ave. along Sheldon Rd to Hillsborough Ave. This project may also reduce water age by allowing lower water age water to reach this area, increase fire flows, as well as improve system reliability.

More importantly, demands in the New Tampa pressure zone are about 20% of the total system demand but are supplied only by one transmission main. Consideration should be given to installing an additional transmission main from the DLTWTF to supply the Morris Bridge RPS to increase redundancy and to increase the ability of the system to refill the tanks during daytime hours.

4.4 CONCLUSIONS AND RECOMMENDATIONS

The distribution system analyses and resiliency/reliability evaluations show that some system improvements will be needed to meet existing and future demands. Improvements which should be further considered and evaluated during the next task phase are as follows.

4.4.1 Short-Term Recommendations

- Additional high service pump station capacity at the DLTWTF; includes pumping and potentially clearwell capacity to meet regulations and the pump and storage performance criteria referenced in **Table 6**
- The Interbay demands are very close to the modeled firm capacity of the pump station, 90% capacity, and should be monitored. Once the flow are frequently at 95% of the firm capacity, plans for additional pump capacity should be considered
- The change in system configuration to include two new pressure zones, while improving low pressure and disinfection residual issues within the new zones, will likely come with the need for additional system improvements to help convey water supply to the re-pump storage tanks for the new zones during daytime system demand conditions.
- Additional transmission mains may be needed to address the tank refill requirements.

4.4.2 Long term Recommendations

- Increasing transmission capacity to the Morris Bridge and Interbay tanks to allow the tanks to refill during daytime hours; operational and infrastructure improvements
- Improvement to available fire flow in select commercial/industrial and residential parts of the system
- Pipeline looping in the western portion of the system.
- Pipeline looping to the North Tampa pressure zone / MBRPS.
- Additional interconnections incorporated with a new repump station to address reliability should the DLTWTF fail and additional storage per the performance criteria referenced in **Table 6**

Appendix E

TPA and TIA Master Meter Technical Memorandum

FINAL

PORT TAMPA BAY AND TAMPA INTERNATIONAL AIRPORT MASTER METER PRELIMINARY FEASIBILITY ANALYSIS

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

20 SEPTEMBER 2018

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Introduction

The City of Tampa Water Department (TWD) is responsible for supplying water throughout the City of Tampa (City) and portions of Hillsborough County including the Port Tampa Bay (PTB) and Tampa International Airport (TIA).

The water mains are constructed in the PTB and TIA properties within non-exclusive utility easements. As a result, the City does not have control over landscaping, paving and other construction activities by others within these easements, which could negatively affect the pipeline by imparting additional loads or obstructing access for maintenance and repairs. Both of these sites have high security requirements, which limit the speed of access for maintenance crews and City contractors. Limited or obstructed access can increase the costs for repair and maintenance since specialized equipment and/or hand work may be required to perform these activities.

To address the feasibility of improving access and reducing maintenance costs, Black & Veatch performed a conceptual analysis to determine how to transition from the existing multiple water supply mains at the TIA and PTB areas into single (or a reduced number of) master meters, and eliminating or reducing City-owned distribution piping infrastructure within the TIA and PTB properties while still maintaining the desired level of service throughout the distribution system through the 2035 planning horizon.

Water mains identified for ownership transfer as a part of this analysis are listed in **Exhibit A** for Port Tampa Bay and **Exhibit B** for Tampa International Airport.

Water System Improvements at Port Tampa Bay

Within the property of PTB, the City of Tampa owns and maintains multiple water mains. Port security and water system protection and maintenance are concerns as described in the Introduction; therefore, the City has requested an evaluation to determine potential modifications required for delegating ownership of a part of the system to Port Tampa Bay. **Figure 1** illustrates the area.

The City system includes a 20-inch water main, with an as-built date of May 13, 1957, that crosses the channel from Davis Islands to Hooker's Point. A part of the 20-inch main was cleaned and lined in 1976. The 20-inch main connects to a looping system (**Figure 1, Location A)** that follows Maritime Boulevard and Guy N. Verger Boulevard, the main thoroughfares within Hooker's Point. The water system also serves to loop the water system on Davis Islands with the eastern portion of the City's water system. The main that crosses the channel from the vicinity of the Peter O. Knight Airport on Davis Islands (**Figure 1, Location B)** continues to the intersection of Maritime Boulevard and South 20th Street **(Figure 1, Location C)**, then turns south and follows Guy N. Verger Boulevard to the south end of Hooker's Point. The City will maintain ownership of the main from the crossing to the area in the vicinity of 2520 Guy N. Verger Boulevard **(Figure 1, Location D)** in order to provide service to the Howard F. Curren Advanced Wastewater Treatment Facility. The system to the south of **Locations A** and **D** would be transferred to Port Tampa Bay ownership. **Exhibit A** lists the mains considered for ownership transference and includes the anticipated remaining life for each main.

As ownership of the southern portion of the system on Hooker's Point changes, two master meter locations have been identified and are described within **Table 1**. In addition to the Hooker's Point area, PTB has facilities on US Highway 41 at Pendola Point Road. The City owns and operates the mains within this area as well. A master meter system, installed within the right-of-way of US Highway 41, would be installed with transference of ownership from the downstream side of the meter to Port Tampa Bay. Reduced Pressure Zone (RPZ) Backflow Prevention devices are available in a limited number of sizes, with 10-inch diameter units being the largest. Two 12-inch master metering assemblies would be installed in parallel with 10-inch diameter RPZ devices on the existing 16-inch main to provide water service to this area without a reduction in water capacity to the area.

Figure 2 illustrates proposed master meter locations (**1**, **2**, and **3**). Existing appurtenances, such as fire hydrants, blow-off assemblies, air release assemblies, etc., and smaller diameter water mains (less than 6-inches in diameter), are not considered within this evaluation.

Table 1: Proposed Master Meters

NO.	DIAMETER, IN	MATERIAL	AS-BUILT DATA	FACILITY ID	LOCATION
1.	12	PVC	11/1/2011	2832713	2520 Guy N Verger Blvd vicinity
2.	12	CAS	10/4/65	1860311	SW corner of Barton Road
3.	16*	DIP	10/10/01	3010852	US HWY 41 at Pendola Point Rd

* Due to the size of the main, two 12-inch services would be required to provide an appropriate cross-sectional area approximating one 16-inch main (the cross-sectional area, XA, of 16-inch is 1.4 SF, XA of one 12-inch is 0.8 SF, where the XA of two 12-inch mains would be greater than 1.4 SF).

The Howard F. Curren Advanced Wastewater Treatment Facility, which is owned and operated by the City, is encapsulated within the Port Tampa Bay property. The facility would remain on the City-owned water system with service feeds from both the west and the east.

The mains from **Location A** to **Location C** provide system resiliency to the east service area for the City, as well as Davis Island. Davis Island has one feed from the north and the main to Hooker's Point providing a looped system. By remaining under the ownership of the City, water service capacity is provided in the event of a main break in the eastern portion of the system.

Figure 3 illustrates the modeling results for the Port Tampa Bay property. The modeling results indicate no change in pressures throughout the PTB area including the portions transferred to the PTB which have increased headloss due to the meters and backflow prevention devices. These were model as check valves on the water mains with an assigned headloss.

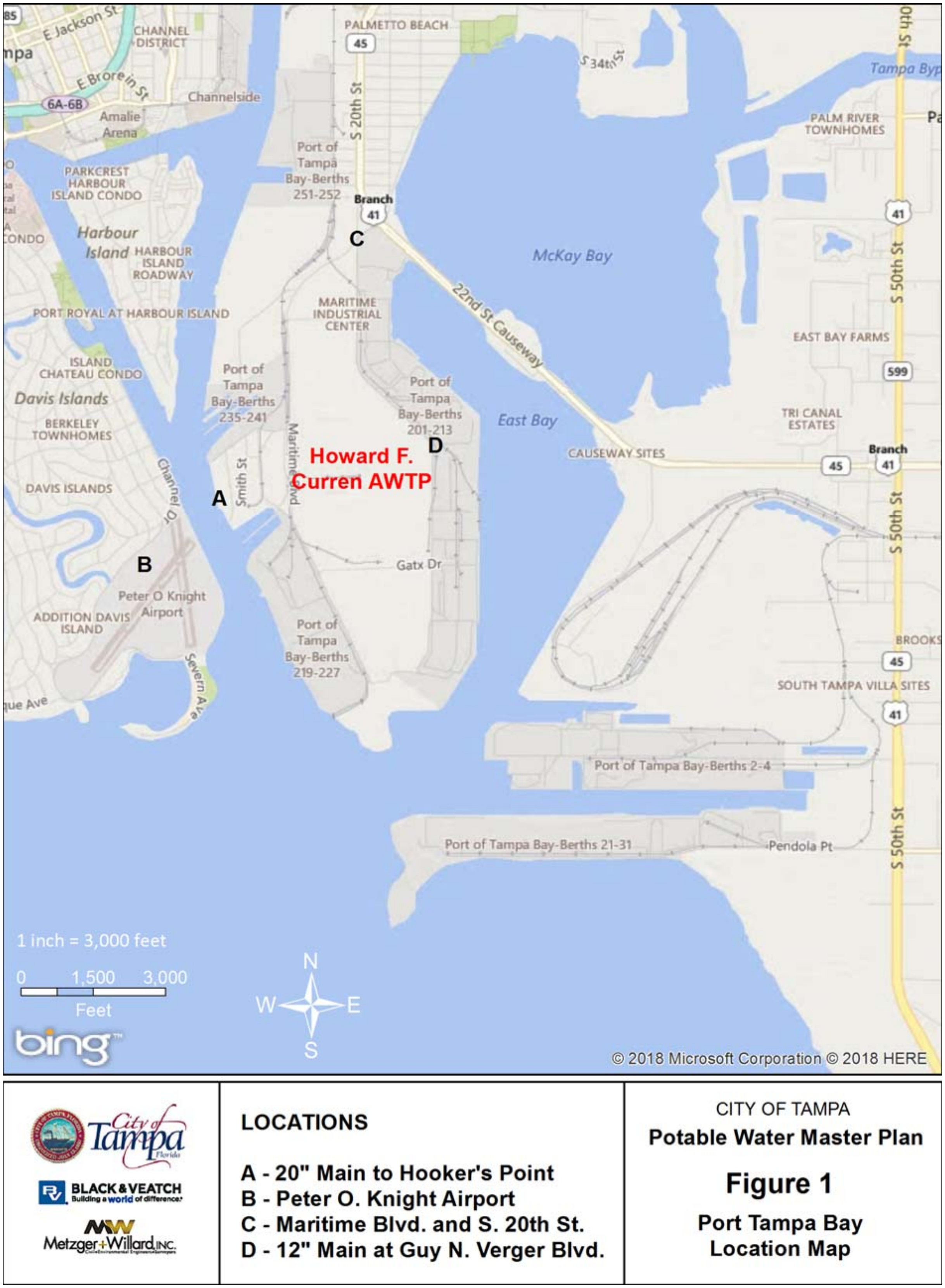

Figure 1: PTB Location Map

Figure 2: PTB Water Mains to Transfer

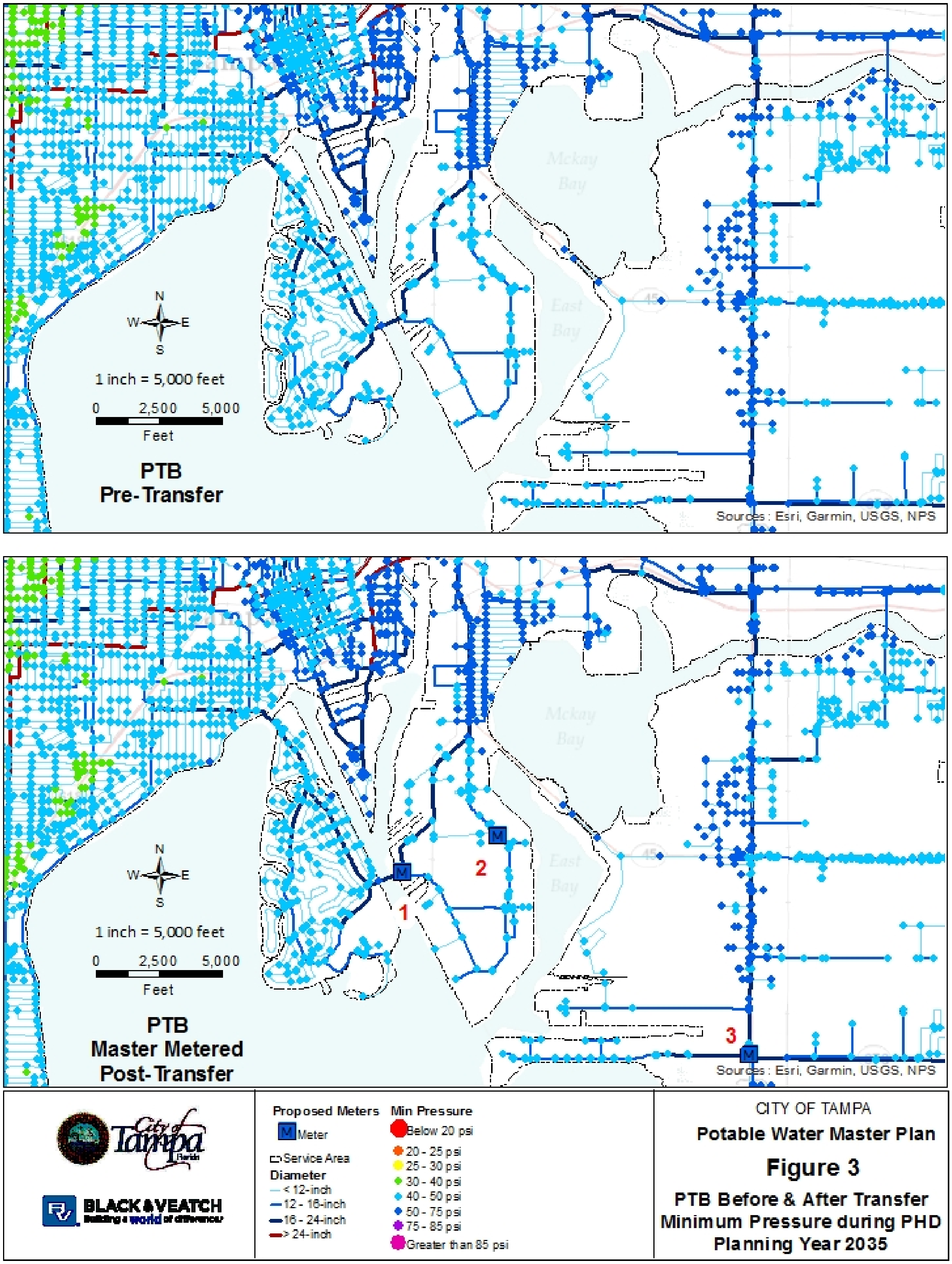

Figure 3: PTB Minimum Pressures with and without Master Meters

PORT TAMPA BAY OPINION OF COST

For purposes of establishing an opinion of cost, which is summarized in **Table 2**, the following assumptions are included:

- Each meter assembly will require approximately 30 feet of main in the size of the main
- The meter and backflow assembly are not included in the linear foot rates
- Meters will be installed in the public right-of-way, where possible and utility easements if required
- Separation of fire lines and potable water mains are not considered
- No new water customers; impact fees are not considered
- A detailed breakdown of the opinion of cost is provided in **Exhibit C**

Table 2: PTB Proposed Master Meters Costs

NO.	DIAMETER, IN	EXTENDED COST, $
1.	12	$48,780.00
2.	12	48,780.00
3.	16*/12	97,560.00
TOTAL		**$195,120.00**

* Provide two 12-inch metering assemblies with RPZ backflow prevention assemblies in parallel. Assume 60 feet of main is required to install.

Water System Improvements at Tampa International Airport

Within the property of TIA, the City of Tampa owns and maintains multiple water mains. Airport security is a concern and access for City personnel and City contractors for critical repairs may not be possible during peak airport periods. Another major concern is the protection of the water system installed in easements where the water main corridor cannot be controlled by the City for future onsite improvements. As a result, costs associated with the repair and/or lost water costs may be unacceptably high. The City has requested an evaluation to determine any potential modifications required to meter the piping into the property and so that ownership of portions of the water system may be delegated to the Hillsborough County Aviation Authority. The TIA location is indicated in **Figure 4.**

As ownership of the water mains within TIA changes, master meter locations have been identified and are described within **Table 3**. A list of water mains identified for transference of ownership is provided in **Exhibit B** and illustrated in **Figure 5. Exhibit B** also indicates the remaining life for each water main. **Figure 5** also illustrates proposed master meter locations. To maintain resilience and looping, the 16-inch and 20-inch water main along W Spruce St and Memorial Hwy at the Entrance to the Airport west crossing Fisheater Creek should remain under the ownership of the City.

The water system in the area of the airport was modeled to determine if the area relies upon airport piping to meet pressure and demand needs, with the results illustrated in **Figure 6**. The meters were model as check valves on the water mains with an assigned headloss.

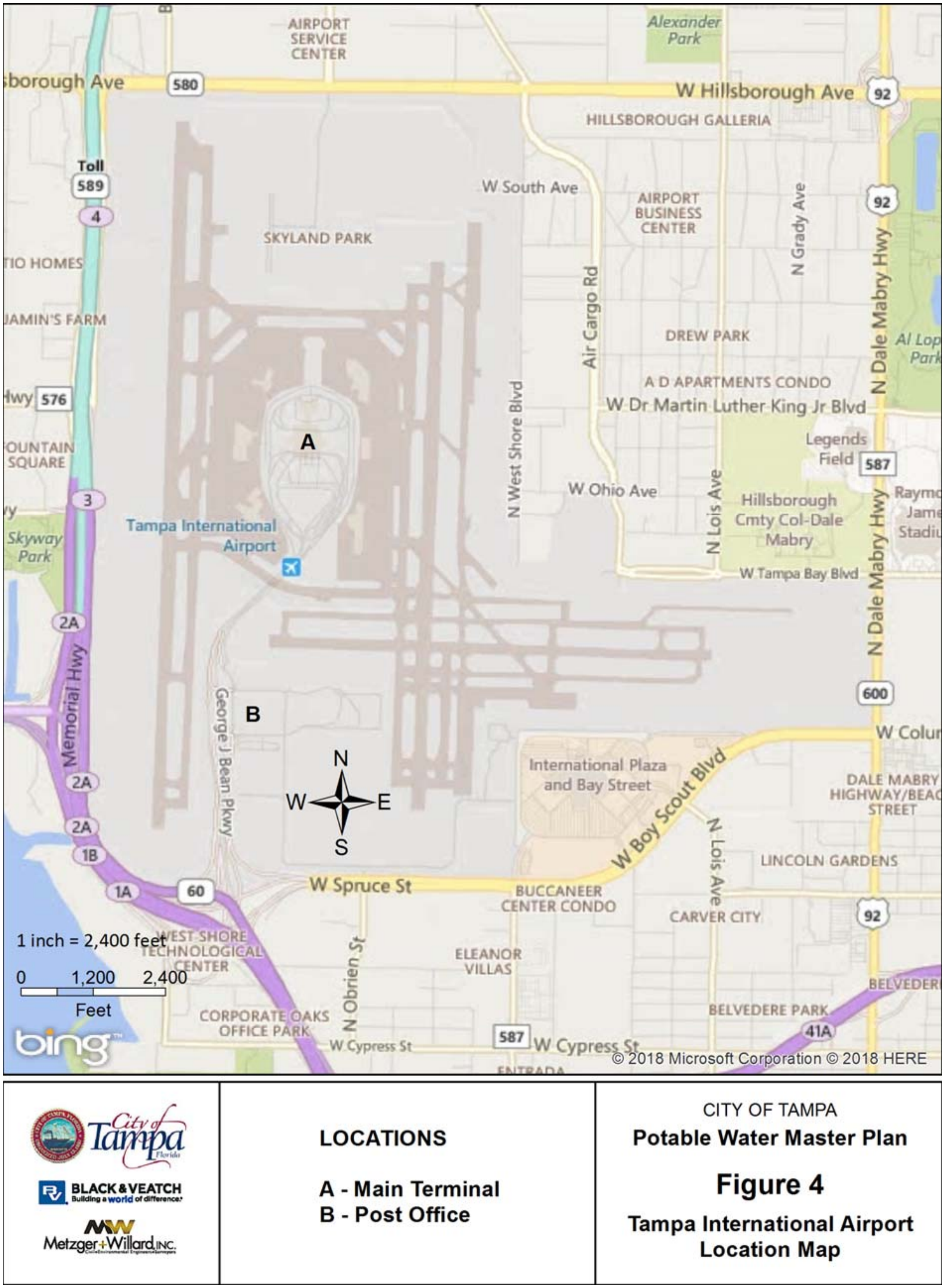

Figure 4: TIA Location Map

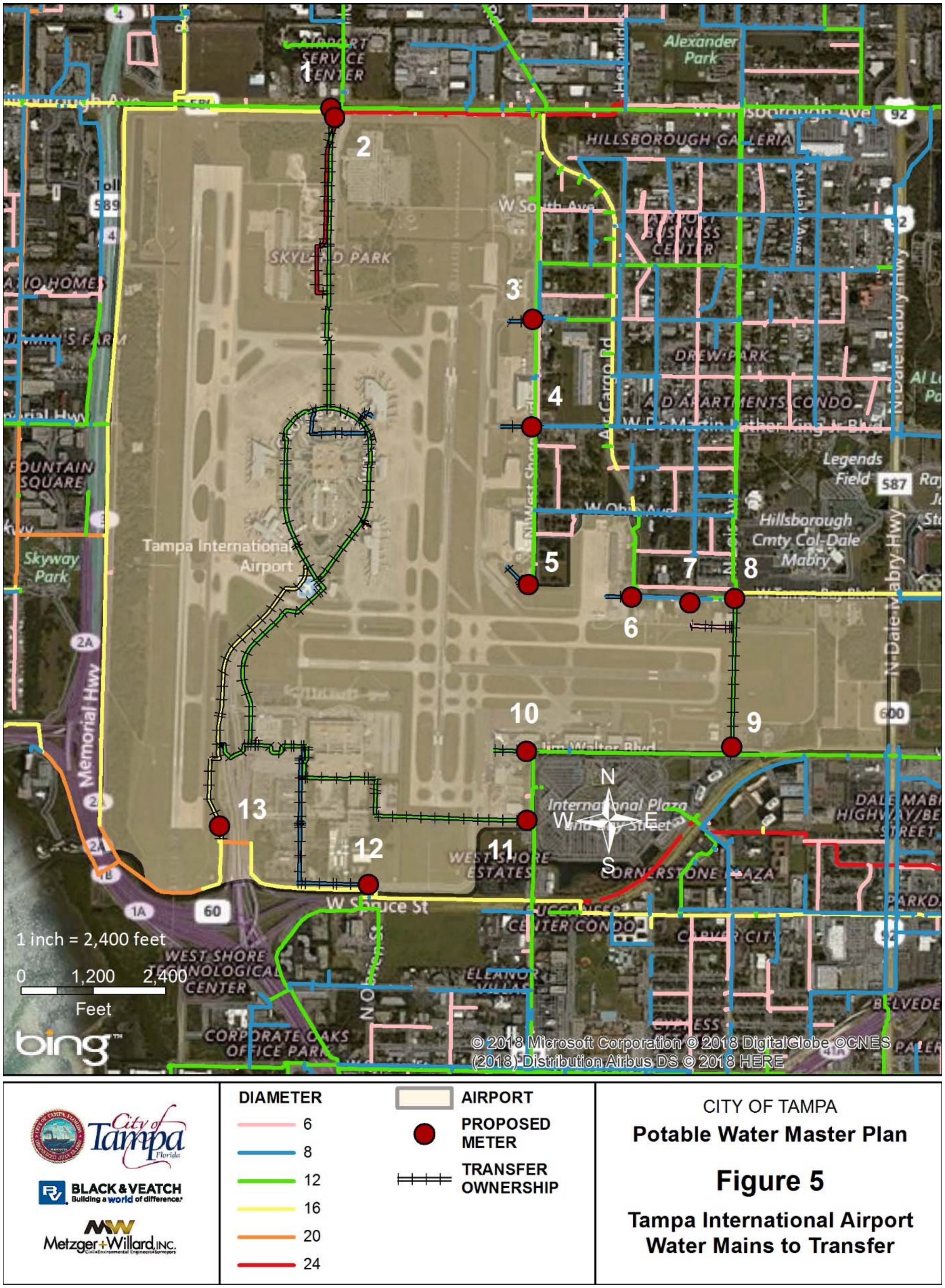

Figure 5: TIA Water Mains to Transfer

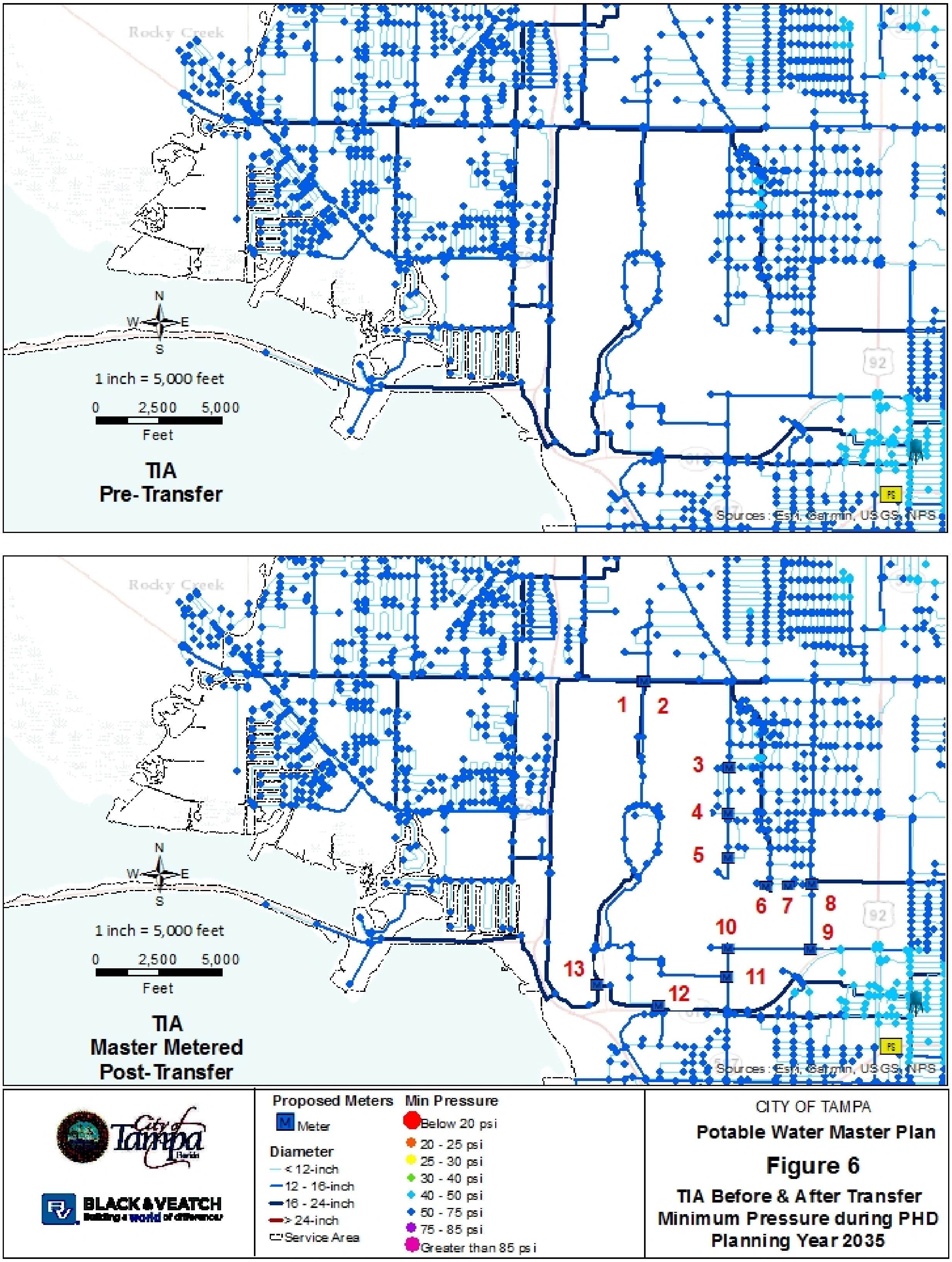

Figure 6: TIA Minimum Pressures with and without Master Meters

Figure 6 illustrates no significant impact from the master metering as described herein. The scenario does not include the improvements identified during the master plan project, including increasing the DLTWTF discharge pressure to 70 psi. These pressures are the result of a 65 psi discharge from the DLTWTF HSPS.

Table 3: TIA Proposed Master Meters

NO.	DIAMETER, IN	MATERIAL	AS-BUILT DATA	FACILITY ID	LOCATION
1.	12	CAS	3/17/69	1810462	W Hillsborough Ave and Air Cargo Rd
2.	24*	DIP	5/14/92	1810461	W Hillsborough Ave and Air Cargo Rd
3.	8	DIP	4/26/82	1810276	N Westshore Blvd and W Cayuga St
4.	8	CAS	6/17/71	2857904	N Westshore Blvd and W Martin Luther King Jr Ave
5.	8	DIP	2/26/80	1844530	N Westshore Blvd and W Tampa Bay Blvd
6.	8	DIP	1/12/00	1843648	Air Cargo Rd and W Tampa Bay Blvd
7.	6	CAS	U/K	1840656	W Tampa Bay Blvd and N Hubert Ave
8.	12	UCI	U/K	1839824	W Tampa Bay Blvd and N Lois Ave
9.	12	UCI	U/K	2005517	Jim Walter Blvd west of W Boy Scout Blvd/W Columbus Dr
10.	12	CAS	U/K	1841811	Jim Walter Blvd and entrance to Hertz RAC
11.	12	CAS	10/5/59	1839588	Airport Service Rd southeast of Runway 36R
12.	8	DIP	5/04	1840261	Airport Service Rd and N O'Brien S
13.	16*	DIP	5/04	1839370	E of Eisenhower Blvd at Fisheating Creek

* Due to the size of the main, two or more service branches would be required to provide a similar capacity of the existing main: For the 16-inch main, two 12-inch metering assemblies would be provided. For the 24-inch main, three 12-inch metering assemblies are required.

TAMPA INTERNATIONAL AIRPORT OPINION OF COST

For purposes of establishing an opinion of cost, which is summarized in **Table 4**, the following assumptions are included:

- Each meter assembly will require approximately 30 feet of main in the size of the main
- For meter assemblies requiring dual feeds approximately 60 feet of main is required
- For meter assemblies requiring three feeds approximately 90 feet of main is required
- The meter and backflow assembly are not included in the linear foot rates
- Meters will be installed in the public right-of-way, where possible and utility easements if required
- Separation of fire lines and potable water mains are not considered
- No new water customers; impact fees are not considered
- A detailed breakdown of the opinion of cost is provided in **Exhibit C**

Table 4: TIA Proposed Master Meters Costs

NO.	DIAMETER, IN	EXTENDED COST, $
1.	12	$48,780.00
2.	24*/12	146,340.00
3.	8	37,190.00
4.	8	37,190.00
5.	8	37,190.00
6.	8	37,190.00
7.	6	25,620.00
8.	12	48,780.00
9.	12	48,780.00
10.	12	48,780.00
11.	12	48,780.00
12.	8	38,720.00
13.	16*/12	97,560.00
TOTAL		**$700,900.00**

* For the 24-inch main, three 12-inch metering assemblies will be installed, each with a 10-inch RPZ backflow prevention device. For the 16-inch main, two 12-inch metering assemblies will be installed, each with a 10-inch RPZ backflow prevention device.

Summary and Conclusions

This evaluation included an analysis of eliminating or reducing the number of City-owned water distribution piping within the Port Tampa Bay and Tampa International Airport properties. Access to the system, as well as, lack of control of the use of the water main corridors were the major concerns with the long-term operation and maintenance of the system. The systems were modeled hydraulically with water mains suitable for transference of ownership were identified. Losses associated with the meter and backflow assemblies were included to simulate the after-transfer conditions. If ownership transference had negatively impacted the ability of the City to provide water capacity at operational pressures, transference of ownership would not be recommended.

In addition to maintaining system capacity, a major concern with the transference of ownership is system resiliency. System resiliency is achieved by looping the water distribution system into a grid. In the event of a line break or power outage, the number of system customers affected should be as few as possible. Resiliency concerns for both sites are addressed by identifying water mains that remain under City ownership.

Results of the modeling efforts indicate that, for Port Tampa Bay, no significant pressure losses were identified. However, the existing 20-inch water main from the intersection of Maritime Blvd and S 20th Street, while on Port Tampa Bay property, is critical in providing a redundant looped water source to the predominantly residential Davis Islands area. Davis Islands is also home to Tampa General Hospital, a critical facility within the City. The 20-inch main that crosses the channel from Davis Island and runs north/northeast to the port property entrance should remain under the ownership of the City. In addition, the 12-inch main from the port property entrance to the vicinity of 2520 Guy N. Verger Blvd should remain with the City to provide a looped system to the Howard F. Curren AWTP.

For Tampa International Airport, modeling results indicate no significant pressure losses were identified. However, the existing 16-inch water main along W. Spruce St and Memorial Highway, is critical in providing a redundant looped water source to the Northwest Tampa area and shall remain with the City.

Port Tampa Bay and Tampa International Airport would also realize benefits as a result of control responsibility of the existing water mains. On-site modifications can be easily achieved without the delays often associated with municipal projects. The City would be permitted an opportunity to review future modifications to the facilities through the City's standard utility service application process, which will be used to determine if pipeline sizing and meter sizing is adequate.

Implementation of the modifications will involve providing both PTB and TIA with incentives to adopt the existing mains. The opinion of cost for installing the meter assemblies is $195K for PTB and $701K for TIA.

The City will need to offer incentives to PTB and TIA for them to consider adopting the on-site water system portions identified within this analysis. One incentive that the City has used successfully in the past is to credit the cost of the meter assemblies to the monthly water bill. The mains identified for transfer have between 33 and 84 years of useful life remaining, as indicated in **Exhibits A** and **B.** The City may consider waiving costs associated with the transfer of these mains to PTB and TIA to provide additional incentive. Both facilities may be amenable to the transfer of ownership in order to reduce the need to provide access to facilities within their property.

EXHIBIT A. PORT TAMPA BAY WATER MAINS FOR TRANSFER

FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
HOOKER'S POINT					
1860311	CAS	12	10/4/1965	463.41	33
1860831	CAS	12	10/4/1965	29.628	33
1860832	CAS	12	10/4/1965	15.864	33
1860297	CAS	12	10/4/1965	509.31	33
1860837	CAS	12	10/4/1965	48.787	33
1860838	CAS	12	10/4/1965	42.035	33
1860219	CAS	12	10/4/1965	128.29	33
3027941	DIP	12	1/14/2014	269.53	84
3027941	DIP	12	10/4/1965	398.02	84
1860389	CAS	12	10/4/1965	84.802	82
1860308	CAS	8	11/4/1968	277.22	36
1860392	CAS	8	11/4/1968	234.66	36
1860395	CAS	8	11/4/1968	84.87	36
1860397	CAS	8	11/4/1968	19.167	36
1860396	DIP	8	6/10/1986	22.421	56
1860398	DIP	8	6/10/1986	14.994	56
1860227	DIP	8	6/10/1986	113.09	56
1860402	DIP	8	6/10/1986	33.729	56
1860306	CAS	12	?	631.7	33
1860407	CAS	12	?	116.42	33
1860505	CAS	12	?	48.345	33
1860415	CAS	12	?	136.4	33
1860479	CAS	12	1973	115.87	41
1860235	CAS	12	1973	292.49	41
1860849	CAS	12	1973	47.986	41
1860850	DIP	12	1973	26.473	43
1860851	DIP	12	1973	16.872	43
1860852	DIP	12	1973	17.445	43
1860853	DIP	12	1973	88.838	43
1999692	DIP	12	1973	190.88	43
1999691	DIP	12	1973	222.19	43
1860856	DIP	12	1973	34.684	43
1860221	DIP	8	9/24/1980	55.215	50
1860222	DIP	8	9/24/1980	156.74	50
1860900	DIP	8	9/24/1980	237.88	50
1860903	DIP	8	9/24/1980	228.09	50
1860904	DIP	8	9/24/1980	174.31	50
1860213	DIP	8	9/24/1980	230.37	50
1860212	DIP	8	9/24/1980	135.23	50
1860857	DIP	12	4/26/1985	31.011	55
1860214	DIP	12	4/26/1985	373.13	55
1860915	DIP	12	4/26/1985	16.125	55
1860918	DIP	12	4/26/1985	500.28	55
1860215	DIP	12	4/26/1985	493.23	55
1860217	DIP	12	7/18/1989	96.271	59
1860926	DIP	12	7/18/1989	397.21	59
1860216	DIP	12	7/18/1989	291.96	59
1860932	DIP	12	7/18/1989	118.75	59
1860933	DIP	12	7/18/1989	26.181	59
1860921	DIP	12	4/26/1985	42.186	55

FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
1860218	DIP	12	4/26/1985	13.239	55
2829282	DIP	12	7/12/2010	228.2	80
2829281	DIP	12	7/12/2010	395.12	80
2829276	DIP	12	7/12/2010	466.95	80
2829275	DIP	12	7/12/2010	100.95	80
2829274	DIP	12	7/12/2010	886.29	80
1853852	DIP	12	3/17/2000	25.174	70
1853853	DIP	12	3/17/2000	23.047	70
1853807	DIP	12	3/17/2000	8.154	70
1853805	DIP	12	3/17/2000	35.075	70
1869677	DIP	12	3/17/2000	25.117	70
1869676	DIP	12	3/17/2000	25.413	70
1852105	DIP	12	3/17/2000	230.32	70
1869675	DIP	12	3/17/2000	19.433	70
1852109	DIP	12	1/23/1997	621.52	67
1869672	DIP	12	1/23/1997	24.538	67
2806063	CAS	12	1/23/1997	423.27	65
2805255	PVC	12	5/4/2011	458.07	70
2805256	PVC	12	5/4/2011	449.43	70
2805257	PVC	12	5/4/2011	311.11	70
1854293	DIP	12	2/19/1979	553.56	49
1854289	DIP	12	3/5/1997	484.65	67
1854272	DIP	12	3/5/1997	475.11	67
1860846	DIP	12	3/5/1997	470.76	67
1860843	DIP	12	3/5/1997	438.47	67
2805715	DIP	12	2/19/1979	161.26	49
2805716	PVC	12	5/4/2011	378.34	70
2805693	PVC	12	5/4/2011	218.6	70
2805691	PVC	12	5/4/2011	12.637	70
1852117	DIP	12	?	9.797	84
1869690	DIP	12	11/12/2014	281.66	84
2806058	DIP	12	?	76.259	84
1869692	PVC	12	5/4/2011	188.94	70
2806050	DIP	12	?	90.212	84
2805850	CAS	12	9/28/1994	511.38	62
2805844	PVC	12	5/4/2011	95.963	70
1869699	DIP	12	9/28/1994	36.54	64
3029375	DIP	12	5/4/2011	329.41	81
2805842	DIP	12	9/28/1994	217.47	64
1869702	DIP	12	9/28/1994	35.812	64
1852118	DIP	12	9/28/1994	638.86	64
1812754	DIP	12	10/9/1995	163.12	65
1812735	DIP	12	6/20/1985	18.279	55
1846269	DIP	12	6/20/1985	14.171	55
1812736	DIP	12	6/20/1985	168.08	55
1846268	DIP	12	6/20/1985	19.108	55
1846270	DIP	12	6/20/1985	30.546	55
1846271	DIP	12	6/20/1985	19.629	55
1846272	DIP	12	6/20/1985	25.903	55
1812743	DIP	12	7/21/1996	389.85	66
1812767	DIP	12	10/9/1995	498.72	65
1812752	CAS	12	?	89.63	62

FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
3058230	CAS	12	?	108.42	62
2832710	PVC	12	11/1/2011	16.644	70
3058232	PVC	12	11/1/2011	36.881	70
PENDOLA POINT ROAD					
3010852	DIP	16	10/10/2001	2090.7	71
2819684	DIP	6	10/10/2001	6.404	71
1869630	DIP	16	10/10/2001	16.456	71
1855213	DIP	6	10/10/2001	1.143	71
1855212	DIP	6	10/10/2001	4.216	71
1869631	DIP	6	10/10/2001	4.946	71
1855217	DIP	16	10/10/2001	331.28	71
1855216	DIP	8	10/10/2001	3.498	71
1855215	DIP	8	10/10/2001	61.161	71
1869625	DIP	6	10/10/2001	6.888	71
1860606	DIP	6	10/10/2001	10.469	71
2826866	DIP	16	10/10/2001	321.88	71
2826865	DIP	6	11/28/2008	0.705	78
2826864	DIP	6	11/28/2008	42.481	78
2826863	DIP	6	11/28/2008	39.858	78
2826862	DIP	6	11/28/2008	5.564	78
2826861	DIP	6	11/28/2008	5.494	78
2826867	DIP	16	10/10/2001	474.82	71
3010856	DIP	16	10/10/2001	405.21	71
2829662	DIP	12	11/22/2001	1.79	71
3010860	DIP	12	11/22/2001	88.291	71
3063282	DIP	12	11/22/2001	5.817	71
2813924	DIP	12	11/22/2001	7.972	71
1869620	DIP	6	8/1/2011	2.709	81
1869621	DIP	6	10/10/2001	2.224	71
1855219	DIP	16	10/10/2001	24.558	71
1869619	DIP	12	10/10/2001	1.674	71
1855218	DIP	12	10/10/2001	1.218	71
1869618	DIP	12	2/8/1977	2.271	47
1869616	DIP	12	2/8/1977	130.44	47
1860613	DIP	6	2/8/1977	7.259	47
1869617	DIP	6	2/8/1977	7.18	47
1855221	DIP	12	2/8/1977	315.63	47
1860506	DIP	8	2/8/1977	4.595	47
1869612	DIP	8	2/8/1977	3.664	47
1869614	DIP	6	2/8/1977	3.716	47
1869615	DIP	6	2/8/1977	4.887	47
1869613	DIP	12	2/8/1977	21.574	47
1869611	DIP	12	2/8/1977	93.701	47
1860590	DIP	12	2/8/1977	348.5	47
1869609	DIP	6	2/8/1977	6.079	47
1869610	DIP	6	2/8/1977	3.264	47
1869608	DIP	12	2/8/1977	287.96	47
1860505	DIP	6	2/8/1977	12.185	47
1869606	DIP	6	2/8/1977	3.927	47
3010861	DIP	12	3/24/1986	1010.8	56
1869604	DIP	6	10/1/1984	5.103	54
1869605	DIP	6	10/1/1984	3.397	54

FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
1860189	DIP	12	3/24/1986	11.951	56
1864325	DIP	12	3/24/1986	3.551	56
1860264	DIP	12	3/24/1986	10.912	56
1864296	DIP	12	3/24/1986	3.551	56
1864312	DIP	12	3/24/1986	37.183	56
1864311	DIP	12	3/24/1986	347.94	56
1864294	DIP	12	3/24/1986	90.322	56
1860263	DIP	12	3/24/1986	2.098	56
1864292	DIP	12	3/24/1986	3.551	56
1864293	DIP	12	3/24/1986	428.71	56
3010863	DIP	12	5/17/1999	45.695	69
1864285	DIP	12	5/17/1999	3.21	69
3010862	DIP	12	5/17/1999	7.981	69
1864286	DIP	12	3/24/1986	65.717	56
1860192	DIP	12	3/24/1986	23.535	56
1864278	DIP	12	3/24/1986	6.25	56
1864277	DIP	12	3/24/1986	440.02	56
1864276	DIP	12	3/24/1986	20.08	56
1860193	DIP	12	3/24/1986	23.534	56
1864270	DIP	12	3/24/1986	6.25	56
1860237	DIP	12	3/24/1986	450.02	56
1860194	DIP	12	3/24/1986	23.535	56
1861678	DIP	12	3/24/1986	6.25	56
1860239	DIP	12	3/24/1986	257.84	56
1863403	DIP	12	3/24/1986	11	56
1860519	DIP	6	2/25/2005	5.694	75
1860518	DIP	6	2/25/2005	3.572	75
1860242	DIP	12	3/24/1986	487.43	56
1862971	DIP	12	3/24/1986	2.82	56
1863108	DIP	12	3/24/1986	3.298	56
1854346	DIP	12	3/24/1986	195.56	56
1860256	DIP	12	3/24/1986	3.447	56
1853919	DIP	12	3/24/1986	18.702	56
1860520	DIP	12	3/24/1986	4.046	56
1853918	DIP	12	3/24/1986	14.877	56
1853888	DIP	12	3/24/1986	220.89	56
1863397	DIP	12	3/24/1986	3.117	56
1863398	DIP	12	3/24/1986	3.908	56
1863174	DIP	12	3/24/1986	185.01	56
1770736	DIP	12	3/24/1986	262.96	56
1852178	DIP	12	3/24/1986	9.186	56
1852177	DIP	12	3/24/1986	11.13	56
1776982	DIP	12	3/24/1986	64.24	56
186024	DIP	12	3/24/1986	402.84	56
1776985	DIP	6	3/24/1986	1.955	56
1840446	DIP	6	3/24/1986	3.028	56
1770700	DIP	12	3/24/1986	1.957	56
1860240	DIP	8	3/24/1986	2.672	56
1770735	DIP	8	3/24/1986	4.118	56
1864317	DIP	12	4/27/2009	1.618	79
1864318	DIP	12	4/27/2009	69.567	79
1860265	DIP	12	4/27/2009	656.08	79

FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
2819354	DIP	12	4/27/2009	12.09	79
2819353	DIP	12	4/27/2009	11.532	79
3010881	DIP	12	4/27/2009	307.85	79
1860260	DIP	6	4/27/2009	6.91	79
1860259	DIP	6	4/27/2009	2.48	79
3010883	DIP	12	4/27/2009	300.65	79
1860262	DIP	6	4/27/2009	6.91	79
1860261	DIP	6	4/27/2009	2.48	79
3010877	DIP	12	4/27/2009	366.15	79
2819400	DIP	6	4/27/2009	6.921	79
3010871	?	6?	4/27/2009	7.361	79
2819391	DIP	12	4/27/2009	288.54	79
2819397	DIP	6	4/27/2009	10.026	79
2819396	DIP	6	4/27/2009	11.533	79
2819395	DIP	6	4/27/2009	18.874	79
2819394	DIP	6	4/27/2009	24.802	79
2819403	DIP	12	4/27/2009	11.451	79
2819402	DIP	6	4/27/2009	8.45	79
2819401	DIP	6	4/27/2009	9.23	79

EXHIBIT B. TAMPA INTERNATIONAL AIRPORT WATER MAINS FOR TRANSFER					
FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
1845128	DIP	12	1/19/1993	15.556	63
1810462	CAS	12	3/17/1969	826.11	37
1810246	CAS	12	3/17/1969	644.06	37
1810498	CAS	12	3/17/1969	731.28	37
1810540	CAS	12	3/17/1969	661.31	37
1813789	CAS	12	3/17/1969	130	37
1810245	DIP	24	1/19/1993	17.179	63
1810461	DIP	24	5/14/1992	2130.2	62
1811018	DIP	24	5/14/1992	17.869	62
2813351	DIP	24	5/14/1992	1079.5	62
2813352	DIP	24	5/14/1992	10.001	62
1813791	DIP	24	5/14/1992	20.001	62
1810538	DIP	12	5/14/1992	17.898	62
1810539	DIP	12	5/14/1992	10.249	62
1813792	DIP	24	5/14/1992	16.848	62
1813790	DIP	24	5/14/1992	29.422	62
1810537	DIP	24	5/14/1992	3.499	62
2818407	CAS	12	3/17/1969-3/10/1981	239.93	37
2818328	DIP	12	2/21/2011	9.983	81
2818329	DIP	12	2/21/2011	12.307	81
2818327	DIP	12	2/21/2011	529.87	81
2818330	DIP	12	2/21/2011	60.964	81
2818385	DIP	12	2/21/2011	4.876	81
2818405	CAS	12	3/17/1969-3/10/1981	727.69	37
1813856	CAS	12	3/17/1969	103	37
1810541	CAS	12	3/17/1969	303.18	37
1843668	CAS	12	6/17/1971	16.753	39
1813212	CAS	12	6/17/1971	185.54	39
1845136	CAS	12	6/17/1971	44.491	39
1845135	CAS	12	6/17/1971	121.36	39
1845140	DIP	12	5/3/2006	219.28	76
1845143	DIP	12	5/3/2006	23.04	76
1845144	DIP	12	5/3/2006	9.595	76
1883886	DIP	12	5/3/2006	333.73	76
3015230	DIP	12	5/3/2006	6.702	76
3015231	DIP	12	5/3/2006	73.755	76
3015229	DIP	12	10/8/2007	25.019	77
3015228	DIP	12	10/8/2007	14.379	77
2917331	DIP	12	10/8/2007	119.21	77
2858732	DIP	12	10/8/2007	198.42	77
3015164	DIP	12	10/8/2007	6.781	77
3015165	DIP	12	10/8/2007	59.631	77
2917335	DIP	12	10/8/2007	340.6	77
3015163	DIP	12	10/8/2007	6.895	77
2858649	DIP	12	10/8/2007	360	77
2858649	DIP	12	10/8/2007	4.244	77
2858601	DIP	12	10/8/2007	374.8	77
3015093	DIP	12	10/8/2007	24.709	77
2858558	DIP	12	10/8/2007	150.89	77
2858572	DIP	12	10/8/2007	136.02	77
2858573	DIP	12	10/8/2007	7.044	77

FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
2858575	CAS	12	6/17/1971	44.24	39
3015041	CAS	12	6/17/1971	367.65	39
1883894	CAS	12	6/17/1971	281.75	39
1883900	CAS	12	6/17/1971	17.13	39
1845131	CAS	12	6/17/1971	16.727	39
1845132	CAS	12	6/17/1971	194.41	39
2858725	DIP	12	6/17/1971	347.89	41
1774771	DIP	12	6/17/1971	61.685	41
1918523	DIP	12	6/17/1971	100.33	41
1841239	CAS	12	6/17/1971	17.004	39
1841240	CAS	12	6/17/1971	16.48	39
1918524	DIP	12	6/17/1971	99.468	41
1841243	DIP	12	6/17/1971	86.576	41
1841246	DIP	12	3/31/1995	121.43	65
2858722	DIP	12	3/31/1995	80.535	65
2858721	DIP	12	10/8/2007	188.01	77
3015348	DIP	12	10/8/2007	32.046	77
2858719	DIP	12	10/8/2007	49.852	77
2858718	DIP	12	3/31/1995	282.2	65
1844433	DIP	12	3/31/1995	18.581	65
1840347	DIP	12	3/31/1995	124.74	65
1844226	DIP	12	3/31/1995	20.314	65
1844434	DIP	12	3/31/1995	176.66	65
1844554	CAS	12	6/17/1974	312.7	42
1840351	DIP	12	12/19/1994	42.92	64
1840350	DIP	12	12/19/1994	6.044	64
1842070	CAS	12	6/17/1971	257.5	39
1842535	CAS	12	6/17/1971	326.79	39
1774772	DIP	12	6/17/1971	447.48	41
1883606	DIP	12	6/17/1971	186.32	41
1883604	DIP	12	6/17/1971	18.859	41
1883776	DIP	16	1/25/1987	20.182	57
1887600	DIP	16	1/25/1987	664.15	57
3032986	DIP	16	1/25/1987	1094.6	57
1881608	DIP	16	1/25/1987	881.21	57
3032988	DIP	16	1/25/1987	451.97	57
3032988	DIP	16	1/25/1987	518.53	57
1841620	DIP	16	5/4/2006	16.78	76
1841619	DIP	16	5/4/2006	182.73	76
1841622	DIP	16	5/4/2006	9.25	76
1841621	DIP	16	5/4/2006	26.651	76
1839375	HDPE	20	5/4/2006	119.1	66
1839376	DIP	16	5/4/2006	20.93	76
1839370	DIP	16	5/4/2006	1394.6	76
1841650	DIP	16	5/4/2006	10.994	76
1883599	CAS	12	6/17/1971	45.774	39
1883598	CAS	12	6/17/1971	150.62	39
1883899	CAS	12	?	57.437	39
1886506	CAS	12	?	43.08	39
1883603	CAS	12	?	171.12	39
1883602	CAS	12	?	314.14	39
1883601	CAS	12	?	891.95	39

FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
1883605	CAS	12	?	1312.6	39
1881582	CAS	12	?	502.01	39
1839354	DIP	12	5/4/2006	5.694	76
1837596	DIP	12	5/4/2006	99.681	76
3033370	DIP	12	5/26/1982	603.97	52
1837597	DIP	12	11/2/1955	57.894	25
1841623	DIP	12	11/2/1955	44.334	25
1839165	DIP	12	11/2/1955	76.368	25
1841624	DIP	12	11/2/1955	43.538	25
1839161	DIP	12	11/2/1955	196.02	25
1839161	DIP	12	10/30/1996	374.57	66
1841626	DIP	12	10/30/1996	33.064	66
1841626	DIP	12	11/2/1955	112.08	25
1841629	DIP	12	11/2/1955	41.672	25
1841630	DIP	12	11/2/1955	131.05	25
2861150	DIP	12	11/2/1955	41.728	25
1839182	DIP	8	1/27/1982	5.694	52
1839143	DIP	8	2/26/1971	177.14	41
1841632	DIP	8	2/26/1971	7.975	41
1839142	DIP	8	2/26/1971	40.001	41
1841633	DIP	8	2/26/1971	26.332	41
2919864	DIP	8	2/26/1971	33.335	41
2861138	DIP	8	2/26/1971	55.256	41
2861135	DIP	8	2/26/1971	243.56	41
2876029	CAS	8	2/26/1971	408.48	39
2876028	CAS	8	2/26/1971	340.01	39
1841638	DIP	8	2/26/1971	28.801	41
1841641	CAS	8	2/26/1971	45.211	39
1839149	CAS	8	2/26/1971	491	39
2876033	CAS	8	2/26/1971	240.04	39
2876032	CAS	8	2/26/1971	195.08	39
1839147	CAS	8	2/26/1971	11.547	39
1841646	CAS	8	2/26/1971	40.09	39
1839148	CAS	8	2/26/1971	64.131	39
1839157	CAS	8	2/26/1971	514.71	39
1839587	CAS	8	2/26/1971	289.87	39
1840263	CAS	8	2/26/1971	11.632	39
1840260	CAS	8	2/26/1971	202.43	39
1840261	CAS	8	2/27/1971	83.036	39
1841484	CAS	8	2/27/1971	9.107	39
1839586	CAS	8	5/4/2006	87.578	74
1839636	DIP	8	5/4/2006	9.214	76
2861149	DIP	12	11/2/1955	56.755	25
2861148	DIP	12	10/25/2005	39.094	75
2861147	DIP	12	10/25/2005	38.086	75
2861145	DIP	12	10/25/2005	10.318	75
2861139	DIP	12	10/25/2005	118.45	75
2861140	DIP	12	10/25/2005	329.27	75
2861133	DIP	8	10/25/2005	2.398	75
2861130	DIP	8	10/25/2005	57.058	75
2861131	DIP	8	10/25/2005	6.577	75
2861132	DIP	12	10/25/2005	8.697	75

FACILITY ID	MATERIAL	SIZE, IN	AS-BUILT DATE	LENGTH, FT	ANTICIPATED REMAINING LIFE EXPECTANCY
3015386	DIP	12	10/25/2005	4.536	75
2876085	DIP	12	10/25/2005	36.078	75
2876084	DIP	12	10/25/2005	231.93	75
2876083	DIP	12	10/25/2005	252.44	75
2876082	DIP	12	10/25/2005	535.03	75
2861155	DIP	12	10/25/2005	136.15	75
1840253	CAS	12	11/18/1959	614.5	27
1840250	CAS	12	11/18/1959	9.295	27
1841657	CAS	12	11/18/1959	1251.3	27
1841793	CAS	12	10/5/1959	24.247	27
1841794	CAS	12	10/5/1959	24.755	27
1839588	CAS	12	10/5/1959	429.34	27
1839197	CAS	12	10/5/1959	879.34	27
1841683	CAS	12	8/10/2001	10.425	69
1838930	CAS	12	8/10/2001	17.867	69
1838931	CAS	8	8/10/2001	20.336	69
1838929	CAS	8	8/10/2001	19.081	69
1838928	CAS	12	8/10/2001	15.751	69
1841682	CAS	12	8/10/2001	11.922	69
1839232	CAS	12	?	357.84	27
1841810	CAS	12	?	130.19	27
1841809	CAS	12	?	19.814	27
2005518	UCI	12	?	2034.2	27
1839820	CAS	6	6/19/1964	3.523	32
1840677	CAS	6	6/19/1964	61.216	32
1839825	CAS	6	?	28.943	32
1842162	CAS	6	?	309.09	32
1840676	CAS	6	?	9.295	32
1840680	CAS	6	?	331.56	32
1842163	CAS	6	?	14.034	32
1844269	DIP	6	?	6	34
1839824	UCI	12	?	482.29	27
1840648	CAS	6	?	152.16	27
1844282	CAS	6	?	24.2	27
1840678	CAS	6	?	9.298	27
1843647	DIP	8	1/12/2000	37.923	70
1843648	DIP	8	1/12/2000	159.46	70
3038293	DIP	8	1/12/2000	226.78	70
1843652	DIP	8	1/12/2000	17.045	70
1840274	DIP	8	1/12/2000	23.979	70
1844530	DIP	8	2/26/1980	157.41	50
1844531	DIP	8	2/26/1980	52.056	50
1839278	DIP	8	2/26/1980	287.08	50
1844535	DIP	8	2/26/1980	22.675	50
1844534	DIP	8	2/26/1980	15.288	50
1839277	DIP	8	2/26/1980	3.703	50
1840272	CAS	8	2/26/1980	75.588	48
1918841	CAS	8	6/17/1971	446.29	39
1810276	DIP	8	4/26/1982	414.27	52
1810279	DIP	8	4/26/1982	55.476	52

EXHIBIT C - OPINION OF COSTS DETAIL

PORT TAMPA BAY MASTER METER INSTALLATIONS OPINION OF COSTS

NO.	LOCATION	DIAMETER, IN	UNIT COSTS, $/LF	PIPE LENGTH, FT	PIPE COSTS, $	METERING ASSEMBLY COSTS, $	REDUCED PRESSURE ZONE BFP COSTS, $	EXTENDED COST, $
1.	2520 Guy N. Verger Blvd	12	286	30	$ 8,580.00	$ 11,850.00	$ 28,350.00	$ 48,780.00
2.	SW Corner of Barton Road	12	286	30	$ 8,580.00	$ 11,850.00	$ 28,350.00	$ 48,780.00
3.	Pendola Point Road and US Hwy 41	16/12	286	60	$ 17,160.00	$ 23,700.00	$ 56,700.00	$ 97,560.00
TOTALS					**$ 34,320.00**	**$ 47,400.00**	**$ 113,400.00**	**$ 195,120.00**

Notes:

Available sizes limit the size of the meter assembly at Pendola Point Roadway. The largest available RPZ is 10-inches.

At Pendola Point Road, two 12-inch metering assemblies and 10-inch RPZ backflow prevention devices are included.

For the 12-inch mains, there are two options: Provide one 10-inch RPZ with a higher pressure loss or provide two smaller units in parallel. For this analysis, one 10-inch RPZ is provided.

City provided meter costs of 4" - $4,950, 6" - $6,750, and 8" - $8,450. By linear interpolation, a 10" meter assembly is approximately $10,150 and a 12-inch meter assembly is approximately $11,850.

RPZ costs are as follows (Febco 2018 Price List):

10" $21,000 material + 35% installation or $28,350 total.
8" $16,000 material + 35% installation or $21,600 total.
6" $9,000 material + 35% installation or $12,150 total.
Assume lead free and non-rising stem valves.

TAMPA INTERNATIONAL AIRPORT METER INSTALLATIONS OPINION OF COSTS

NO.	LOCATION	DIAMETER, IN	UNIT COSTS, $/LF	PIPE LENGTH, FT	PIPE COSTS, $	METERING ASSEMBLY COSTS, $	REDUCED PRESSURE ZONE BFP COSTS, $	EXTENDED COST, $
1.	W Hillsborough Ave and Air Cargo Rd	12	286	30	$ 8,580.00	$ 11,850.00	$ 28,350.00	$ 48,780.00
2.	W Hillsborough Ave and Air Cargo Rd	24/12	286	90	$ 25,740.00	$ 35,550.00	$ 85,050.00	$ 146,340.00
3.	N Westshore Blvd and W Cayuga St	8	238	30	$ 7,140.00	$ 8,450.00	$ 21,600.00	$ 37,190.00
4.	N Westshore Blvd and W Martin Luther King Ave	8	238	30	$ 7,140.00	$ 8,450.00	$ 21,600.00	$ 37,190.00
5.	N Westshore Blvd and W Tampa Bay Blvd	8	238	30	$ 7,140.00	$ 8,450.00	$ 21,600.00	$ 37,190.00
6.	Air Cargo Rd and W Tampa Bay Blvd	8	238	30	$ 7,140.00	$ 8,450.00	$ 21,600.00	$ 37,190.00
7.	W Tampa Bay Blvd and N Hubert Ave	6	224	30	$ 6,720.00	$ 6,750.00	$ 12,150.00	$ 25,620.00
8.	W Tampa Bay Blvd and N Lois Ave	12	286	30	$ 8,580.00	$ 11,850.00	$ 28,350.00	$ 48,780.00
9.	Jim Walter Blvd west of W Boy Scout Blvd/W Columbus Dr	12	286	30	$ 8,580.00	$ 11,850.00	$ 28,350.00	$ 48,780.00
10.	Jim Walter Blvd and entrance to Hertz RAC	12	286	30	$ 8,580.00	$ 11,850.00	$ 28,350.00	$ 48,780.00
11.	Airport Service Rd southeast of Runway 36R	12	286	30	$ 8,580.00	$ 11,850.00	$ 28,350.00	$ 48,780.00
12.	Airport Service Rd and N O'Brien St	8	286	30	$ 8,580.00	$ 8,540.00	$ 21,600.00	$ 38,720.00
13.	E of Eisenhower Blvd at Fisheating Creek	16/12	286	60	$ 17,160.00	$ 23,700.00	$ 56,700.00	$ 97,560.00

TOTALS	**$ 129,660.00**	**$ 167,590.00**	**$ 403,650.00**	**$ 700,900.00**

Notes:

The largest available RPZ is 10-inches.

For the 12-inch mains, there are two options: Provide one 10-inch RPZ with a higher pressure loss or provide two smaller units in parallel. For this analysis, one 10-inch RPZ is provided.

City provided meter costs of 4" - $4,950, 6" - $6,750, and 8" - $8,450. By linear interpolation, a 10" meter assembly is approximately $10,150 and a 12-inch meter assembly is approximately $11,850.

RPZ costs are as follows (Febco 2018 Price List):

- 10" $21,000 material + 35% installation or $28,350 total.
- 8" $16,000 material + 35% installation or $21,600 total.
- 6" $9,000 material + 35% installation or $12,150 total.

Assume lead free and non-rising stem valves.

For Master Meter Location 2, the 24-inch main will be metered through three 12-inch meters with 10-inch RPZ backflow prevention devices for each. For Master Meter Location 13, the main will be metered through two 12-inch diameter mains, each with a 10-inch RPZ backflow prevention device.

Appendix F

ISO 55001 Assessment Report

FINAL

ISO 55001 Gap Assessment Technical Memorandum

Potable Water Master Plan

BLACK & VEATCH PROJECT NO. 190020

PREPARED FOR

City of Tampa Water Department

17 OCTOBER 2016

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Executive Summary

Black & Veatch has performed an asset management maturity assessment of the City of Tampa's Water Department (the Department) as part of the potable water distribution master plan project. The assessment is based on the requirements of the international asset management standard ISO (International Organization for Standardization) 55001:2014 Asset Management – Management System Requirements, and focuses on the City's water operations. To undertake this assessment, the Black & Veatch team reviewed documents and information provided by City staff, and facilitated six group interviews with City staff.

Overall, the Department achieved an average asset management maturity score of 1.6 which is in the "Aware" zone of the Institute of Asset Management's (IAM) maturity scale. This score is typical of a utility that has some elements of good practice asset management in place but has identified the need to improve its asset management approach. Each element is scored using a maturity scale of 0 to 4, where a score of 3 represents being in compliance with the ISO 55001 requirements and following good asset management practice. Ultimately, this is the level of maturity being targeted.

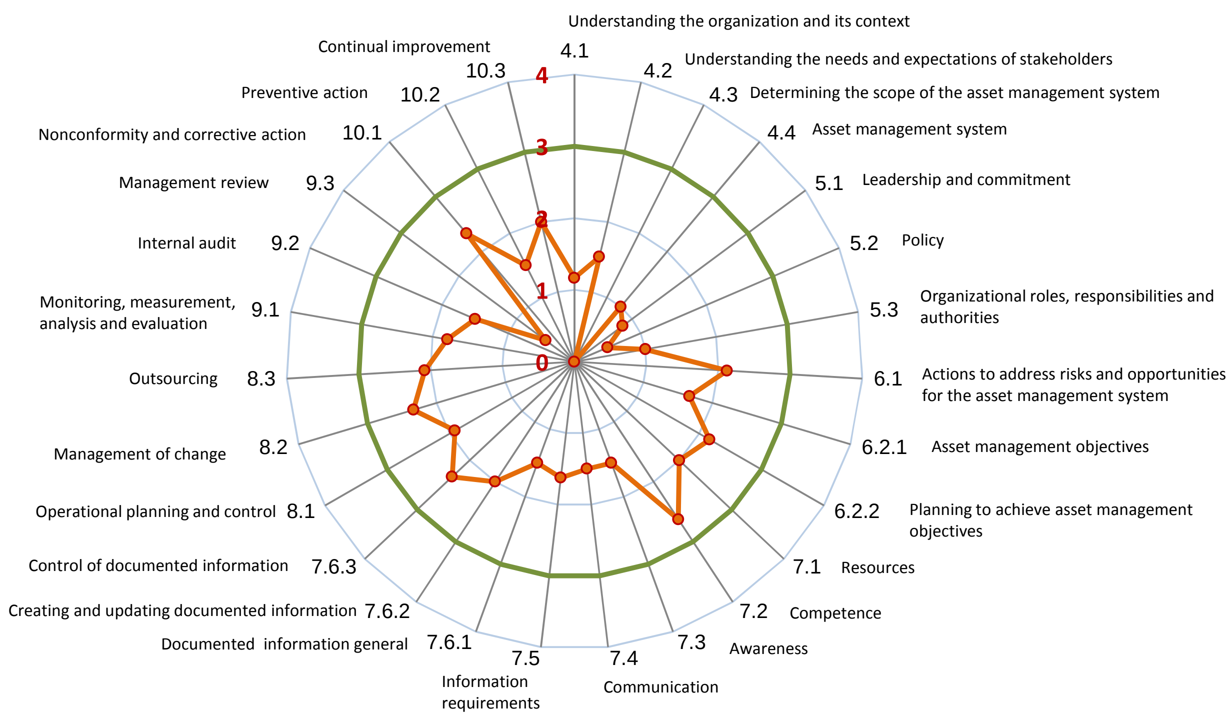


Figure E1 ISO 55001 Assessment Results

The Department leadership has recognized the need to implement a formal asset management program, and has commenced the process with the water master plan and this gap assessment. The 2012 Strategic Plan included some goals and objectives specific to asset management, some of which have been implemented such as the Geographic Information System (GIS) conversion to ArcGIS and the recent implementation of the InfoMaster software to support the risk assessment and rehabilitation planning and budgeting for the distribution system.

The Department has a number of good foundational elements on which to build: a planning process is in place with the CIP and master plan; key performance indicators are reported to the public; training is well managed with a skills matrix to determine training needs; the Water Treatment Facility (WTF) has well defined Standard Operating Procedures (SOPs) in place; and there are processes to respond to incidents. However, the Department lacks an overarching asset management framework, strategy and objectives, and asset management plans which results in lower scores in a number of areas.

Having sufficient staffing levels and resources are critical for successfully implementing and maintaining a successful asset management program. The gap assessment identified that it takes significant effort to obtain additional resources and there is no formal process to determine resource needs for the Department. Support groups from other City departments need to develop as well, and top management support is required for this, from the Public Works and Utility Services Administrator and Mayor.

Based on the assessment, the following recommendations were identified for the Department to close identified gaps and for other improvement opportunities:

- Update the Department's Strategic Plan;
- Develop an asset management framework in order to formalize and improve the approach to asset management, including an asset management policy and strategy;
- Form an Asset Management Steering Committee to provide oversight and direction for the asset management program;
- Implement a risk-based approach to planning and maintenance at the WTF;
- Review existing key performance indicators currently reported to determine how appropriate they are and consider alternative or additional metrics;
- Develop asset-specific asset management plans based on the information available;
- Develop a resourcing plan for the Department for implementing the asset management program;
- Develop a communications plan for the asset management program;
- Undertake a data needs assessment to determine what data is required for asset management (including planning, risk assessment, maintenance and operations);
- Review existing Department policies and update, retire or consolidate its policies as appropriate;
- Provide additional inspection resources to manage critical work activities;
- Put in place a more formal process for monitoring and reporting on CIP projects for the Department; and
- Develop an SOP for the Production Division that covers incident response, investigation and corrective action.

These recommendations will need to be further refined and prioritized as part of the Improvement Roadmap development which forms the next stage of this project. The Department will need to implement the recommendations in this report in order to develop and implement an asset management framework that is aligned with the ISO 55001 requirements.

1.0 Introduction

1.1 SCOPE

The City of Tampa's Water Department has engaged Black & Veatch Corporation to support an update to its master plan for the potable water distribution system. Phase 600 of the project involves Asset Management Program Development and Black & Veatch performing an asset management maturity assessment in support of developing an implementation plan for an Asset Management program that is consistent with the industry best practices. The assessment is based on the international standard ISO 55001:2014 Asset Management – Management System Requirements and focuses on the City's water operations.

The assessment included the following activities:

- Review of documentation and processes provided by staff
- Group interviews
- Identification of key gaps and improvement opportunities

1.2 INTRODUCTION TO THE ISO 5500X STANDARDS

The ISO 5500X standards are a set of standards created by the International Organization for Standards (ISO) specific to the implementation of a best practice asset management program which were initially built upon the British Standard PAS55. In 2004, the Institute of Asset Management (IAM) developed PAS 55:2004, the first publicly available specification for the optimized management of physical assets, which was adopted in the UK and published jointly with the British Standards Institution (BSI). PAS 55 has proven successful, with widespread adoption worldwide by utilities, transport, mining, process and manufacturing industries. Because of its success, PAS 55 became the default global standard. A 2008 update (PAS 55:2008) drew on input from 50 organizations from 15 industry sectors in 10 countries. However, it was recognized that PAS 55 still needed improvement in areas such as common language and terminology that could be understood globally and to extend its applicability to non-utility assets.

The growing need for a worldwide asset management standard was recognized and, in 2010, the ISO Project Committee 251 (PC251) was established by the ISO Technical Management Board to develop an international asset management standard. As had previously been the case with the introduction of ISO 9000 for quality systems, the relevant British Standard, PAS 55, was used as the basis for the new global standard. Following several key global meetings, working groups and sub-project team meetings involving more than 30 participating and 10 observing members in its development, the ISO 5500X standards were published in January 2014.

The ISO 5500X series consists of three standards:

- ISO 55000 Asset management—Overview, principles and terminology
- ISO 55001 Asset management—Management systems—Requirements
- ISO 55002 Asset management—Management systems—Guidelines for the application of ISO 55001

The objective of ISO 55001 is to guide and influence the design of an organization's asset management activities by embedding a number of key concepts and fundamental principles within a framework (referred to by ISO 55001 as a management system) for asset management.

ISO 55001 defines asset management as the "*coordinated activities of an organization to realize value from assets*". It also describes asset management as balancing the costs, opportunities and risks against the desired performance of the assets to achieve the organization's strategic objectives. According to ISO 55001 the fundamental principles of asset management are:

Value. Assets exist to provide value to the organization and to stakeholders.

Alignment. Asset management translates the organization's strategic objectives into asset management decisions, plans and activities.

Leadership. Leadership and commitment from all levels of management is essential for establishing and improving asset management within the organization.

Assurance. Asset management gives assurance that assets will fulfil their required purpose through effective governance.

The asset management system described by ISO 55001 consists of an organization's asset management policy, asset management strategy, asset management objectives, asset management plan(s) and the activities, processes and organizational structures necessary for their development, implementation and continual improvement. The asset management system includes organizational structure, roles and responsibilities, standards, information management systems, processes, and resources. Figure 1 below provides an outline of an asset management system.

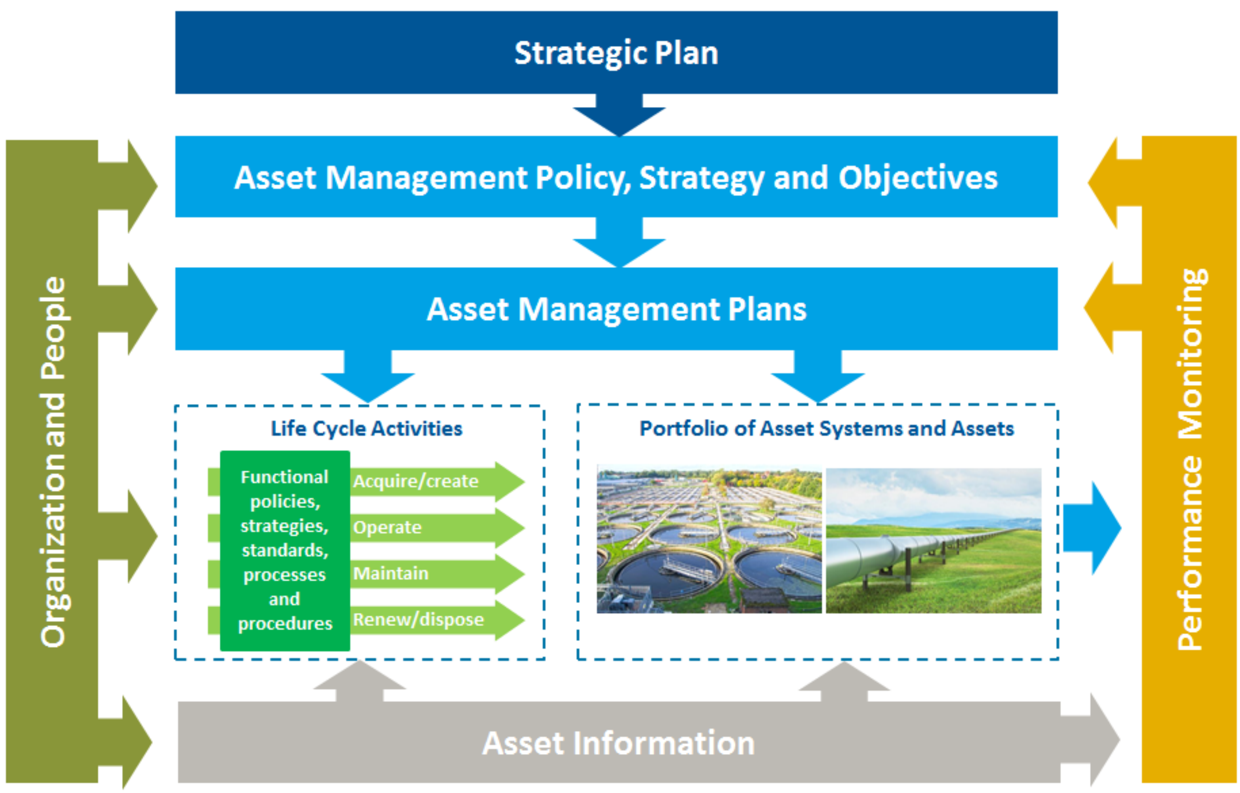


Figure 1 Components of an Asset Management System

ISO 55001 specifies 27 elements of good practice asset management (also referred to as Clauses) that a competent organization should have in place as part of an asset management system or framework. These elements can be categorized into seven fundamental areas of asset management, as shown in Figure 2.

4 Context of the Organization	•4.1 Understanding the organization and its context •4.2 Understanding the needs and expectations of stakeholders •4.3 Determining the scope of the asset management system •4.4 Asset management system
5 Leadership	•5.1 Leadership and commitment •5.2 Policy •5.3 Organizational roles, responsibilities and authorities
6 Planning	•6.1 Actions to address risks and opportunities •6.2.1 Asset management objectives •6.2.2 Planning to achieve asset management objectives
7 Support	•7.1 Resources •7.2 Competence •7.3 Awareness •7.4 Communication •7.5 Information requirements •7.6.1 Documented information general •7.6.2 Creating and updating documented information •7.6.3 Control of documented information
8 Operation	•8.1 Operational planning and control •8.2 Management of change •8.3 Outsourcing
9 Performance Evaluation	•9.1 Monitoring, measurement, analysis and evaluation •9.2 Internal audit •9.3 Management review
10 Improvement	•10.1 Nonconformity and corrective action •10.2 Preventive action •10.3 Continual improvement

Figure 2 Elements of ISO 55001

1.3 ASSESSMENT APPROACH

Black & Veatch is a Corporate Member of the IAM and is an IAM Endorsed Assessor approved to undertake ISO 55001 assessments. The IAM has an Endorsed Assessor scheme for the PAS 55 and ISO 55001 asset management standards. Black & Veatch was amongst the first organizations to be appointed by the IAM as Endorsed Assessors. By qualifying for this endorsement, Black & Veatch has demonstrated a commitment to the PAS 55 and ISO 55001 standards and a sufficient level of rigor and impartiality in our approach to this work. Black & Veatch is bound by the IAM Code of Conduct, and the particular requirements of the Endorsed Assessor scheme.

Under the Endorsed Assessor scheme Black & Veatch appoints individual assessors who have the required experience and knowledge of asset management and PAS 55 / ISO 55001, and who meet the requirements of the Global Forum for Maintenance & Asset Management Competency Specification for an ISO 55001 Asset Management System Auditor/Assessor. The individual approved assessor undertaking this assessment was Martin Jones, CEng.

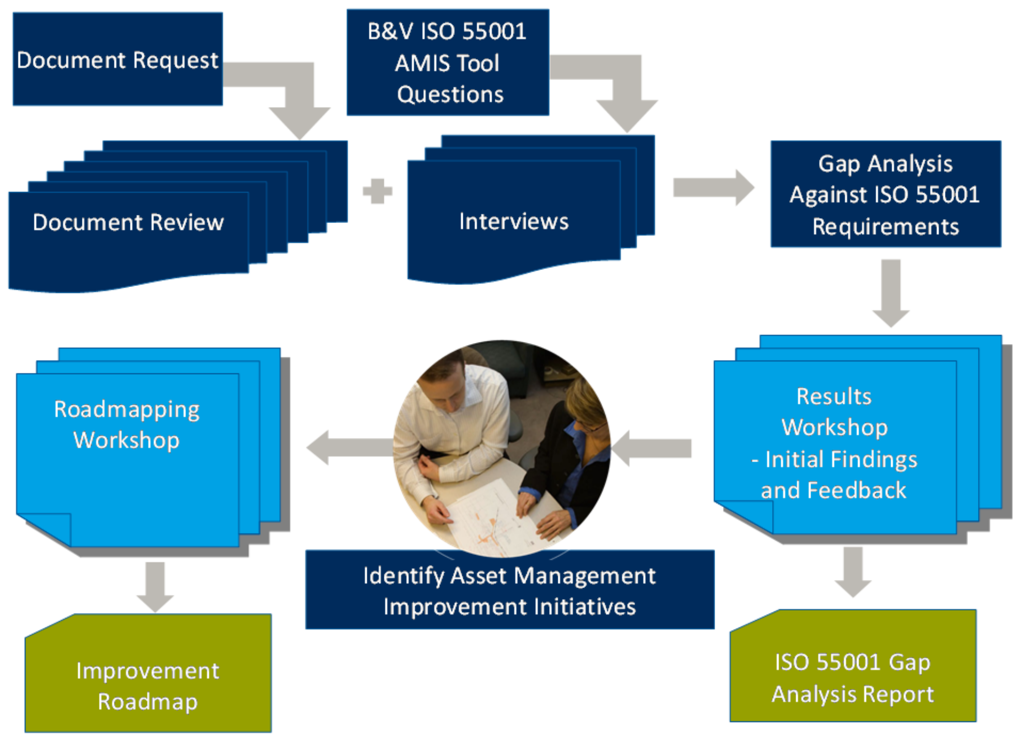


Figure 3 Overview of Assessment Approach

Black & Veatch's overall project approach is shown in Figure 3.To undertake this assessment, the Black & Veatch team reviewed documents and information provided by City staff, which included the 2012 strategic plan (status report 2015), organization chart, and samples of reports, communications, policies, and procedures. A list of the documents provided is included in Appendix A. A total of 7 group interviews were held with City of Tampa's Water Department staff as described below. Fleet Maintenance were also invited to the group interviews but were unable to attend. While it would have been helpful to document their observations it has not had any impact on the overall results of the assessment.

- Group 1 – Production Division Operations and Maintenance
- Group 2 – Management Team with focus on Strategy and Framework
- Group 3 – Design and Construction Management
- Group 4 – Planning
- Group 5 – Information Management
- Group 6 – Distribution System Operations and Maintenance
- Group 7 – Finance and Accounting

The interview questions were drawn from a set of 63 standard questions from Black & Veatch's Asset Management Insight System (AMIS) assessment tool. Each group was asked approximately 10-20 of the questions, with the questions chosen based on the group's responsibilities. Group interviews were schedule for 90 minutes to three hours. Each of the 27 elements of ISO 55001 was assessed based on the evidence provided by the document review and the interviews, with each element scored on a scale of 0 to 4. The scoring system is shown in Figure 4 below, with a score of 3 being in compliance with the ISO 55001 requirements (following "good practice"). A score of 4 indicates that the organization's asset management maturity is "beyond ISO 55001" requirements, where asset management practices are optimized and/or the organization is employing leading practice. To achieve full compliance with ISO 55001, an organization must score a 3 in each of the 27 elements.

Interviewees were asked to discuss what they considered to be appropriate maturity score for the department for each of the elements, and these scores were captured in the AMIS tool. In addition, the Black & Veatch assessment team gave a score for each element based on the document review. The scores were challenged and cross-referenced to other interviews amongst the assessment team to ensure consistency and remove any element of systematic bias, either too optimistic or pessimistic. The relative scores in each category reflect the magnitude of the gap to compliance and provide the basis for recommending improvements to the City of Tampa's Water Department asset management system and approach.

Innocent	Aware	Developing	Competent	Optimizing	Excellent
Maturity level 0	**Maturity level 1**	**Maturity Level 2**	**Maturity Level 3**	**Beyond ISO 55001**	
The organization has not recognized the need for this requirement and/or there is no evidence of commitment to put it in place.	The organization has identified the need for this requirement, and there is evidence of intent to progress it.	The organization has identified the means of systematically and consistently achieving the requirements, and can demonstrate that these are being progresses with credible and resourced plans in place.	The organization can demonstrate that it systematically and consistently achieves relevant requirements set out in ISO 55001.	The organization can demonstrate that it is systematically and consistently optimizing its asset management practice, in line with the organization's objectives and operating context.	The organization can demonstrate that it employs the leading practices and achieves maximum value from the management of its assets, in line with the organization's objectives and operating context.

Figure 4 ISO 55001 Asset Management Maturity Scale

2.0 ISO 55001 Assessment Findings

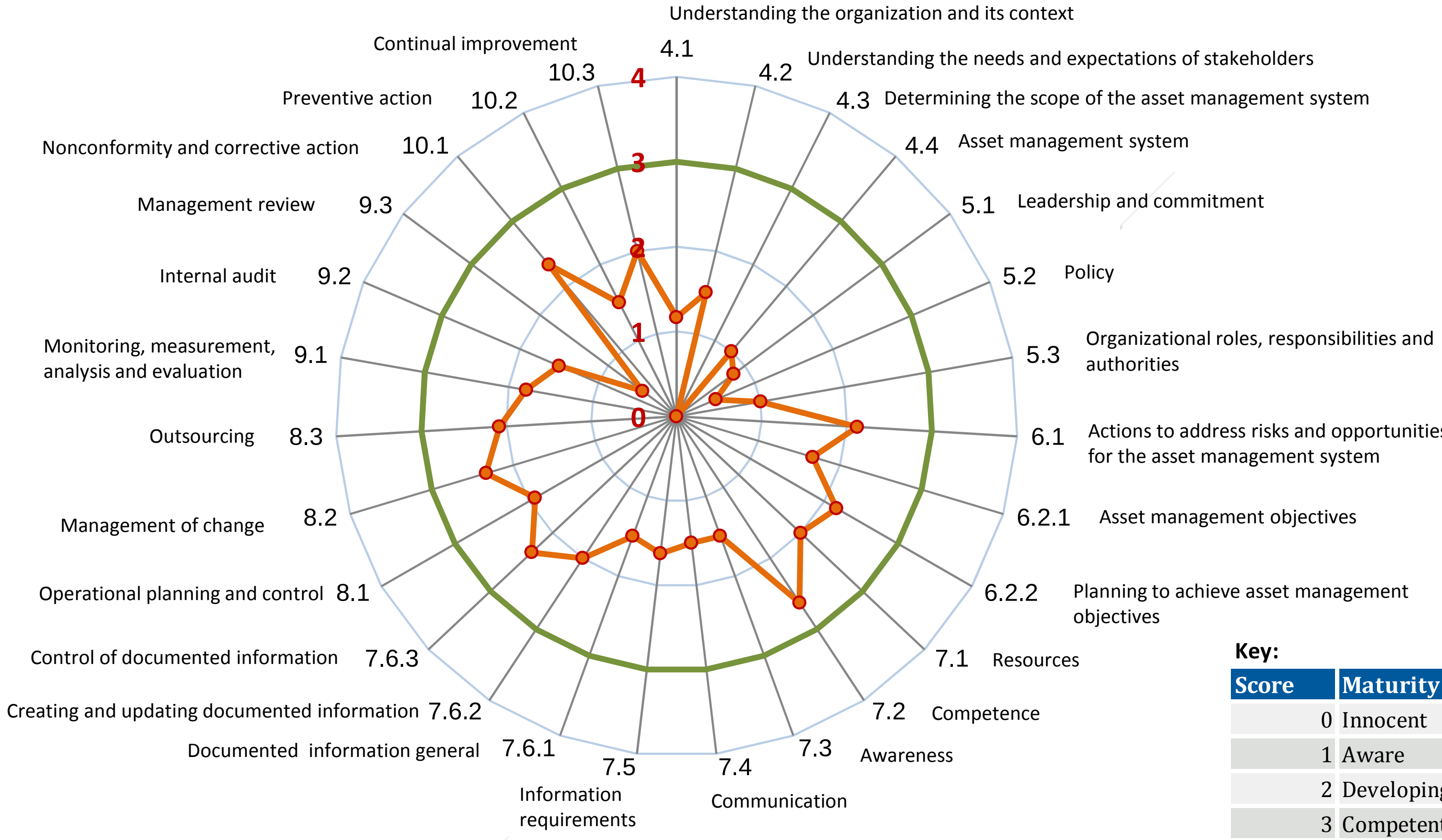
2.1 SUMMARY OF RESULTS

Overall, the City of Tampa's Water Department achieved an average asset management maturity score of 1.6 which is in the "Aware" zone of the maturity scale. The results are shown in Table 1 below and Figure 5 on the following page.

Table 1 City of Tampa Water Department ISO 55001 Assessment Scores

SECTION NUMBER AND NAME	MATURITY SCORE
4.1 Understanding the organization and its context	1.2
4.2 Understanding the needs and expectations of stakeholders	1.5
4.3 Determining the scope of the asset management system	0.0
4.4 Asset management system	1.0
5.1 Leadership and commitment	0.8
5.2 Policy	0.5
5.3 Organizational roles, responsibilities and authorities	1.0
6.1 Actions to address risks and opportunities	2.1
6.2.1 Asset management objectives	1.7
6.2.2 Planning to achieve asset management objectives	2.2
7.1 Resources	2.0
7.2 Competence	2.6
7.3 Awareness	1.5
7.4 Communication	1.5
7.5 Information requirements	1.6
7.6.1 Documented information general	1.5
7.6.2 Creating and updating documented information	2.0
7.6.3 Control of documented information	2.3
8.1 Operational planning and control	1.9
8.2 Management of change	2.3
8.3 Outsourcing	2.1
9.1 Monitoring, measurement, analysis and evaluation	1.8
9.2 Internal audit	1.5
9.3 Management review	0.5
10.1 Nonconformity and corrective action	2.3
10.2 Preventive action	1.5
10.3 Continual improvement	2.0
Average score	**1.6**

Average Maturity Score = 1.6 (Aware)



Key:

Score	Maturity Level
0	Innocent
1	Aware
2	Developing
3	Competent
4	Optimizing / Excellent

Figure 5 ISO 55001 Maturity Assessment Results

The following sections provide a summary of the findings, key gaps, and improvement opportunities identified by Black & Veatch based on the interviews with City staff and the documents reviewed. The sections are organized into the 7 fundamental areas and 27 elements/clauses of good practice asset management specified in ISO 55001. **Appendix B** provides the ISO 55001 requirements by clause.

2.2 CONTEXT OF THE ORGANIZATION

4.1 Understanding the organization and its context

Evidence and observations

A Water Department Strategic Plan was developed in 2012 with the principal driver to align with the Mayor's strategic plan. Staff stated that it does not necessarily reflect all the Department's pressing needs, and needs to be updated.

The Department is involved with other utilities on the Florida Water Environment Association Utility Council to address issues that affect it (e.g. cross connections). However, the Department tends to react to issues rather than be proactive and be the first participant in the conversation.

The Water Quality Section is engaged with regulators to stay on top of any changes to water quality requirements, and the Master Plan which includes future water demand projections is updated every 5 years.

The Department works with other City departments and relies on a number of departments for support services such as IT, contract administration and human resources. There are budget constraints with the City; the Department needs to be able to demonstrate to the City Administration the importance of asset management for the water system, so it can justify a higher level of funding based on a bottom-up risk-based business case that identifies needs and priorities, and come to a compromise with the Administration on an appropriate budget.

Staffing is reported to be the main internal issue. It takes significant effort to get additional resources and there is no formal process to determine resource needs for the Department. Responsibility for hiring of staff is external to the Department; there is no flexibility for staff hiring and response to needs is typically slow. Historically recruitment has been limited based on budget cuts and tends to be driven by reactive needs.

Gaps and improvement opportunities

Maturity Score:	**1.2**
Key Gaps:	• Department internal and external issues not defined in an asset management strategy. • Strategic objectives are out of date. • Asset management objectives not aligned with strategic objectives.

Improvement opportunities:

- The Department should update its Strategic Plan to identify the specific issues and challenges facing it now and in the future, to define its strategic objectives. An asset management strategy can be developed in parallel that identifies the specific external and internal issues that affect the Department, along with asset management objectives that are aligned with the strategic objectives.

- This gap assessment report will form part of the asset management strategy as it identifies specific internal issues relevant to asset management.

4.2 Understanding the needs and expectations of stakeholders

Evidence and observations

Stakeholders include regulators, customers, developers, other city departments, and internal staff. Requirements from regulators are well defined, but the Department is more reactive than pro-active in dealing with them.

The Mayor initiated the Economic Competiveness Committee (ECC) which led to a number of recommendations which supported developers. The Department was engaged with this initiative, and is engaging actively with developers.

The City has implemented a Key Account Program which has individuals within the water, wastewater and solid waste departments assigned to a key customer as an account manager. The main focus is to head off any issues and allow customers to be able to contact the same representative rather than the first available person in the call center if there is an issue. They will be more proactive in checking bills to ensure accuracy, but there is no specific outreach program or initiative to determine specific needs of the key accounts.

Criteria for asset management decision making based on stakeholder requirements has been incorporated in the InfoMaster risk criteria for assessing risk of the distribution network with the use of critical customers and areas. One example of where residential customer needs have been taken into consideration was the decision to install backflow meters for customers with separate irrigation meters. Customers have also indirectly influenced service levels for response times and call center metrics; these have been determined internally based on industry metrics and understanding of customer needs.

Requirements for regulatory reporting are well defined; the Department reports to regulators, credit rating agencies, and external auditors. Annual water quality reports are submitted, and some key metrics are reported on the dashboard which is on the City's website. However, there are times when the City requests specific reports but the Department either does not have the information or does not have easy access to it.

The City uses an Oracle financial system to record all revenue and expenditures and to provide financial reports. These include annual and quarterly reports for financial reporting externally, and monthly internal reports for City departments on budget status (expenditures against budget and actual revenue compared to projected revenue). There is no cost accounting for asset management as the financial system does not have the capacity to track work-related activities, so it is difficult to report actual costs for work on assets.

Gaps and improvement opportunities

Maturity Score:	1.5
Key Gaps:	• Requirements and expectations have not been fully determined for all key stakeholders. • Customers have not been consulted on levels of service. • Accuracy and appropriateness of financial reporting. There is no cost accounting.

Improvement opportunities:

- The Department should commission surveys or focus groups to determine customer needs, and is currently looking to appoint a consultant to undertake a survey. This could include asking customers what they would like to see on the City's dashboard.
- Consideration should be given to establishing a citizen's advisory council to be the focal point for customer consultation on the Department's plans and levels of service. This model is used successfully by other water utilities.
- Stakeholder needs and expectations should be documented in the asset management strategy.
- Cost accounting should be introduced to capture costs of work done on assets, so the Department can report how much it costs to replace one type of asset or repair another one. The Utility Management System planned for 2018 will have some capability to do this, although the Department noted that it will initially only touch only assets that are tied to customer account service such as meters and service lines, but will not include assets that are tied to the Production Division or the larger distribution system. The Department will need to leverage the existing tools that it has such as MaintScape and InfoMaster along with Oracle Financials as well for accurate cost accounting of all assets of the Department. Future phases of Utility Management System on Enterprise Workforce Asset Management should be implemented.

4.3 Determining the scope of the asset management system

Evidence and observations

The Department does not have a formal asset management framework in place and has not yet defined the scope.

Gaps and improvement opportunities

Maturity Score:	0
Key Gaps:	• Scope for asset management framework is not defined.

Improvement opportunities:

- The Department should define the scope of the asset management framework as part of the asset management strategy. The scope should identify what assets are included and the interfaces with other City departments. The scope should be aligned with the asset management policy and strategy.

4.4 Asset management system

Evidence and observations

The Department has some components of an asset management framework in place, including key metrics, the Master Plan and CIP, distribution system risk assessment, Standard Operating Procedures (SOPs), and information systems (GIS and the Water Treatment Facility computerized maintenance management system).

The 2012 Strategic Plan included some goals and objectives specific to asset management, some of which have been implemented (e.g. the GIS conversion to ArcGIS).

Gaps and improvement opportunities

Maturity Score:	1.0
Key Gaps:	• No formal asset management framework in place. • No asset management strategy.

Improvement opportunities:

- The Department should develop an asset management framework in order to formalize and improve its approach to asset management. The framework should contain the elements recommended in this report.
- An asset management framework document should be created that includes or provides reference to the key components of the framework. This could include:
  - Asset management policy
  - Asset management strategy and objectives
  - Description of the organization, roles and responsibility of the Department and supporting City departments
  - Reference to Department policies and procedures for lifecycle activities (planning, design, construction, operation and maintenance, disposal/replacement)
  - Reference to Master Plans and asset management plans
  - Description of the information systems
  - Performance metrics for monitoring and reporting
  - Communications plan
  - Process for management of change
  - Process for internal audit and management review
- The Department should develop an asset management strategy for implementing the asset management program and enhancing the Department's asset management capability. The asset management strategy should include:
  - Internal and external context
  - Stakeholder requirements
  - The Department's proposed approach to asset management
  - Asset management objectives
  - The resulting implementation plan from this report

2.3 LEADERSHIP

5.1 Leadership and commitment

Evidence and observations

The Department leadership has recognized the need to implement a formal asset management program, and has commenced the process with this ISO 55001 gap assessment. At the City level there is some effort to coordinate asset management, but a formal program has not yet been established. The City's Public Works and Utility Services Administrator and Mayor will provide support for the Department's asset management program, including approvals and provision of resources, and the Department will need to justify the program to them. The Department Director is the main decision maker for the Department's asset management program.

Currently some asset replacement and rehabilitation is reactive when the need is identified, but the commitment to replace infrastructure proactively is there.

Staff stated in the interviews that currently there are limited internal resources to support asset management work. Support groups, their models and processes need to develop as well, and top management support is required for this.

Gaps and improvement opportunities

Maturity Score:	0.8
Key Gaps:	• Asset management strategy, policy and objectives have not yet been established. • An asset management framework has not yet been developed and integrated with the Department's existing business processes. • Resource requirements for implementing the asset management program and maintaining the asset management framework have not yet been determined or provided. • There is no defined formal approach to risk by the City.

Improvement opportunities:

- The Department leadership should continue to provide support in developing the asset management framework and implementing the asset management program. The Department should consider forming an Asset Management Steering Committee to provide oversight and direction for the asset management program. An Asset Management Coordinator should be assigned to manage the implementation of the program.
- Having adequate resources to implement the asset management program is a key requirement for its success and sustainability. The Department leadership should assess the resource requirements for implementing the program and maintaining the asset management framework, and work with the City to ensure that sufficient resources are provided.
- If the City is not going to develop an approach to risk management with which the Department can align its asset risk, the Department could develop its own risk policy that aligns with the City's performance goals.

5.2 Policy

Evidence and observations

The Department does have a Mission and Vision statement in its Strategic Plan, but neither the City nor the Department has a specific policy on asset management.

Gaps and improvement opportunities

Maturity Score:	**0.5**
Key Gaps:	• Asset management policy has not been developed or communicated.

Improvement opportunities:

- As one of the first steps in developing the asset management program, the Department should develop an asset management policy. This is typically a one-page document that sets out the Department's vision and principles for asset management. It should also include a commitment to providing resources for asset management and to continual improvement.

5.3 Organizational roles, responsibilities and authorities

Evidence and observations

The Department has well defined roles and responsibilities for its day-to-day work. This includes organization charts and the City's standard job descriptions. However, roles and responsibilities for specific and emerging asset management activities are ad-hoc.

Gaps and improvement opportunities

Maturity Score:	**1.0**
Key Gaps:	• Roles and responsibilities for specific asset management activities have not been defined.

Improvement opportunities:

- Roles and responsibilities need to be determined and documented for asset management activities, including:
  - Development of the asset management policy, strategy and objectives
  - Implementation of the asset management program and maintenance of the asset management framework
  - Development and implementation of asset management plans, including risk assessments
  - Management review of the asset management framework and internal review or audit

  These roles and responsibilities should be documented in the asset management framework document, and job descriptions should be updated if appropriate.
- The Department should assign an "Asset Management Coordinator" with responsibility for developing and implementing the asset management program.

2.4 PLANNING

6.1 Actions to address risks and opportunities

Evidence and observations

Risk assessments have been in place for several years for linear assets. Rehabilitation and replacement plans have been prioritized based on risk as a function of likelihood of failure and consequence of failure. Factors such as key accounts, critical customers, water demand, main breaks, and reactive maintenance costs are considered as part of the risk assessments. The Planning Section has recently implemented InfoMaster to support the risk assessment and rehabilitation planning and budgeting for the distribution system.

A condition assessment project is currently underway at the WTF which will include a criticality assessment and assignment of a criticality score for each asset. The Production Division is able to monitor effectiveness of improvements through testing and data tracking in MaintScape.

An emergency response plan (ERP), continuity of operations (COOP) plan, process safety management (PSM) plan, and dam release plan are all in place and updated on a regular basis. The emergency preparedness plan is well documented with specific guidelines to follow. In the event of an emergency, there is an emergency operations center and three satellite response centers are activated. Staff participates in a severe weather exercise on an annual basis.

Gaps and improvement opportunities

Maturity Score:	2.1
Key Gaps:	• Plant and pump station capital improvements projects are not based on risk. • Emergency planning drills are not conducted on a consistent basis. • Formalized system restoration procedures manual has not been developed.

Improvement opportunities:

- Update the main break documentation manual and follow standardized document control procedures.
- Implement a risk-based approach for capital improvement project identification at the plant and pump stations. Continue improvements for cost estimating to predict cost forecasts for the rehabilitation and replacement plan.
- Monitor the effectiveness of pipeline improvements related to leaks or main breaks. Implementation of future phases of the proposed Utility Management System will be able to support tracking and reporting efforts. Consider coordinating leak detection with meter installations and testing new technologies during repair projects.
- Conduct emergency planning drills on an annual basis.
- Develop a formalized system restoration procedures manual for the distribution system.

6.2.1 Asset management objectives

Evidence and observations

A Strategic Plan was developed in 2012 and has been updated on an annual basis. Focus areas within the strategic plan include technology, rates and fees, water quality and supply, customer service, safety, asset management, reclaimed water, employee investment, communication, and environmental stewardship. The Department has identified the need to update the strategic goals and objectives and is referencing Water Research Foundation's (WRF) 10 attributes for Effectively Managed Water Utilities.

The Department holds annual meeting sessions, typically 5-6 sessions, to review the progress against the defined strategic objectives (except for this year due to leadership training).

The City has also developed a Comprehensive Plan which outlines service levels related to raw water quantity, fire flow reserves, and treatment pumping. The City maintains a dashboard on its external website reporting several metrics including water service outage, average call wait time and percentage of meters read accurately.

Gaps and improvement opportunities

Maturity Score:	**1.7**
Key Gaps:	• Goals and objectives included in the strategic plan are outdated. • Key performance indicators need to be updated to align with goals and objectives. • Existing key performance indicators and some level of service metrics are missing some industry standard metrics.

Improvement opportunities:

- As part of updating the Strategic Plan, develop clear strategic goals and objectives based on the WRF's 10 attributes for Effectively Managed Water Utilities: Product Quality, Infrastructure Stability, Operational Optimization, Employee and Leadership Development, Financial Viability, Customer Satisfaction, Operational Resiliency, Water Resource Adequacy, Stakeholder Understanding and Support, and Community Sustainability.
- Communicate the new asset management objectives and goals with staff as part of the annual review meetings.
- Review existing key performance indicators currently reported to determine how appropriate they are and consider alternative or additional metrics. Examples can be found in the AWWA *Benchmarking Performance Indicators for Water and Wastewater Utilities: Survey Data and Analyses Report* and the WRF/WERF report *Key Asset Data for Water and Wastewater Facilities*.

6.2.2 Planning to achieve asset management objectives

Evidence and observations

The Department has a well-defined capital improvement project workflow process in place for both linear and vertical assets. Staff use Oracle's Hyperion Financial Management tool to manage the projects and budgeting process. The budget is prepared annually and projects require justification in the project start-up sheet; projects are prioritized in an excel spreadsheet. The Mayor reviews CIP requests before they are approved by City Council.

Water distribution pipe rehabilitation and replacement projects are identified using a risk-based approach and the Water Department recently implemented the InfoMaster tool to support the risk analysis. The plant is moving towards a risk-based rehabilitation and repair plan as part of the on-going condition assessment project. There are no specific asset management plans in place for water distribution or plant assets. However, there are components of a plan documented as part of the on-going master plans.

Gaps and improvement opportunities

Maturity Score:	2.2
Key Gaps:	• Asset-specific asset management plans have not been developed.

Improvement opportunities:

- Develop asset-specific asset management plans. Some areas staff identified for inclusion in the asset management plans include valve exercising, large meter maintenance, and condition assessments at the WTF.
- It is noted that the Department has started to draft an asset management plan. WERF SIMPLE, ISO 55001 and ISO 55002 provide some guidance for developing asset management plans, but more detailed guidance is provided in the International Infrastructure Management Manual (IIMM) published by the Institute of Public Works Engineering Australasia. A structure for an asset management plan could include:
  - Introduction – scope and purpose of the plan, key elements.
  - Levels of service – asset-specific objectives and KPIs; targets and performance against them; regulatory and legislative requirements; condition.
  - Future demand – supply and demand issues that will affect the management and utilization of assets.
  - Lifecycle management plan – includes: risk assessment, maintenance plan, renewal/ replacement plan, creation/acquisition/upgrade plan, disposal plan.
  - Financial plan – budget forecasts (capital and O&M), funding strategy, asset valuations.
  - Plan monitoring and improvement – performance measures, improvement plan, monitoring and review procedures.
- Document the process for developing asset management plans.

2.5 SUPPORT

7.1 Resources

Evidence and observations

There are no formal resource plans in place for the Department. At the WTF maintenance plans are equipment specific with work orders assigned to specific staff. The management is monitoring work order efficiencies and analyzing workloads. It was reported that some preventive maintenance on instrumentation is not being completed on schedule due to them being down three technicians.

The Distribution Division operations group has around 100 staff split into separate groups; a group dedicated to preventive maintenance, a reactive operations group that is customer driven and a support group that performs a number of functions. Resource levels are based on historical level of activities and number of assets. This can limit the amount of preventive maintenance that can be done; for example staff indicated that staffing levels means that only the minimum amount of maintenance is performed on assets such as hydrants.

Planned preventive maintenance work is also affected by the constant reprioritization of work to react to the service requests and complaints that come in each day. Levels of service have increased over the last 8 years without an increase in the staffing levels and safety requirements have also increased time for doing work.

Cross-training of staff provides some flexibility and allows staff to be moved between the different groups as required. Preventive maintenance efforts are supplemented with contractors; the trend has been over time to refine core-business activities and utilize contractors for non-core activities.

A Planning Section staffing analysis has been carried out.

Gaps and improvement opportunities

Maturity Score:	**2.0**
Key Gaps:	• There are no forward-looking resource plans for the Department. • Resource needs for new asset management activities have not been assessed.

Improvement opportunities:

- Develop a resourcing plan for the Department which should include an assessment of staff needs to be able to do more proactive maintenance work, implement the asset management program and undertake the additional activities resulting from the program.
- Create a position of planner/scheduler at the treatment plant.

7.2 Competence

Evidence and observations

The City has job descriptions for different roles, and operations and laboratory staffs are required to have specific licenses and certifications. The Department uses a skills matrix to determine training needs and requirements for promotions. The training process involves regular feedback sessions and performance evaluations, and each employee has their own profile in the skills matrix to track skills and training. Training history is maintained and retests are required for some skills.

The on-the-job training provided is good, but with the increasing use of technology more external training is required, particularly to maintain certifications. However, it is difficult to get approval for external training and the City currently does not approve non-local training. In addition budgets for training have been cut.

For contractors, the contract scope requires contractor to provide competent staff. City staff inspect the quality of the contractors work, but because the lowest bidder is given the work this sometimes has an impact on quality.

Gaps and improvement opportunities

Maturity Score:	2.6
Key Gaps:	• External training not provided by City and insufficient budget. • Competencies and skills for new asset management activities have not been developed.

The Asset Management Program should include initiatives focusing on both technical and people skills and maintaining or developing competencies in specific areas. These could include:

- New technologies, including use of GIS and the planned Utility Management System that will be used as a maintenance management system by Distribution
- Maintaining existing competencies defined in the skills matrix
- External training to maintain certifications and keep up-to-date on technologies
- Competencies for specific asset management activities including risk assessment and developing asset management plans
- Future competency requirements should be considered in the Department resourcing plan.

7.3 Awareness

Evidence and observations

Operations and maintenance staff are aware of their work activities from their training and the Standard Operating Procedures in place. This includes core safety training including "right to know" and "lock-out tag-out". There is a safety committee that meets every month and an Arc Flash study was recently completed. However, safety procedures are not OSHA compliant as this is not a requirement for the City.

Regular team meetings are held to ensure staff are aware of and kept up-to-date on any issues that might affect them.

Gaps and improvement opportunities

Maturity Score:	**1.5**
Key Gaps:	• Asset Management Program has not been developed yet so staff is unaware of the implications and how they will contribute. • The asset management policy has not been developed yet so staff are unaware. • Contractors are not always sufficiently aware of the potential impacts of their work due to lack of City inspection resources.

Improvement opportunities:

- As part of the asset management program communications plan ensure that staff are made aware of the asset management program and the asset management policy when it is issued.
- Provide specialized safety training for the department and improve coordination with the City training coordinators.
- The Contract Administration Department (CAD) requires additional staff to control and monitor contractors. The communication between CAD, Planning and Operations needs to improve.

7.4 Communication

Evidence and observations

Internal communication within the Department is good. There are weekly group meetings, a monthly management team meeting, and an internal newsletter that is published quarterly. Staff has technology that allows for communication, such as cells phones, smart phones and computers, so email is often used for communication. The treatment plant has a weekly email that is sent out to staff (the "FYI") which provides information on production and plant condition. City-wide information is passed through the monthly and weekly meetings.

External communication includes use of press releases, tweets, the "Alert Tampa", the City's website (including the dashboard), bill inserts and door hangers. There is a centralized call center for all three of the City's utilities.

The need for a plan of outreach to customers has been identified as a need but this has not yet been progressed. There is currently no internal communication plan for the asset management program.

Gaps and improvement opportunities

Maturity Score:	**1.5**
Key Gaps:	• Need for customer outreach has been identified but not implemented. • A communications plan for the asset management program has not yet been developed or implemented.

Improvement opportunities:

- The Department should develop a communications plan to formalize its internal and external communications and support the asset management program. The communications plan forms a key component for managing change and implementing the program, and should include:
  - Plan for customer outreach and survey to identify customer needs

- Internal Department communications for the asset management program and with other City departments and the Administration
- Clear definition about what is communicated, when and how often, with whom and how (this should include media and methods).

7.5 Information requirements

Evidence and observations

The City converted to the ESRI ArcGIS platform for linear water distribution assets and has improved the availability and documentation of detailed attribute data. The ESRI local government information model is being used for standardization on attribute data. The City is exploring options on how to add plant assets into the ESRI ArcGIS platform.

Currently meter test sheets, hydrant tests, and main breaks are documented on paper form only. Main break data is then entered into a spreadsheet for use in the ESRI ArcGIS. The City is piloting the ESRI ArcGIS Collector Application for hydrants to collect data in the field. The water treatment plant uses MaintScape for asset and work order tracking. Fleet is using the application, FASTER, to track maintenance activities and recording of maintenance activities and repairs is well documented. The Call Center is currently using CISCO but is in the process of replacing the system starting August 2016. TOKAY is used to track backflow devices. MSS is used for meter asset data. Accela has the ability to track cost of installation and connection fees, but it is not currently being used effectively.

In most cases data attribution is a manual effort based on interpretation of written documentation and has caused issues with the quality of data. Labor, materials, and equipment are not tracked for work orders. The proposed Utility Management System includes mobile management capabilities for field use and is scheduled to be implemented in the first quarter of 2018. As part of this upgrade, mobile devices will be provided to staff for field use. The Planning division is working on documenting developer installed mains versus city installed mains.

Gaps and improvement opportunities

Maturity Score:	1.6
Key Gaps:	• Divisions are not consistently collecting or sharing information to support decision making and operations and maintenance activities. • Work order costs (labor, materials, equipment) are not documented for work performed. • Distribution does not have a CMMS.

Improvement opportunities:

- Undertake a data needs assessment to determine what data is required for asset management (including planning, risk assessment, maintenance and operations), what the gaps are and what data quality improvement or additional data is needed. Reference can be made to the WRF/WERF report *Key Asset Data for Drinking Water and Wastewater Utilities* for examples of data categories and attributes.
- Develop a formal standard and approach to collect, input, and extract data across divisions, including a training plan.

- Implement a computerized maintenance management system (CMMS) to support standardized data collection, including moving from paper to electronic and mobile data collection, and track operations and maintenance activities and costs for Distribution.

7.6.1 Documented information general

Evidence and observations

Each division has a shared drive with security privileges for access in place for data storage. Individuals outside of a division can be granted access to a shared drive as needed. SIRE, an enterprise content management system, is used to store record drawings and hydrant information. Production staff use MaintScape to store O&M manuals and pump drawings. Hard copy documents are stored in the library at the water plant. The Intranet is also used to store and organize documents.

The Department has a number of policies in place (administrative, customer service, and infrastructure-related) which clearly define the specific policy, have a document number and are authorized by the Water Department Director. However, the Department's own analysis identified that 40 out of the 43 policies are over 10 years old (30 date from 1999).

The Laboratory has good documentation and records in place, and the Production Division has good documented SOPs. The Distribution and Customer Services Division has an SOP manual but it does not cover all activities. It includes consumer services – some deficiencies were identified in a recent audit which have since been rectified. Staff stated that it is a time and resource challenge to develop SOPs and keep them up to date. The Engineering Division's procedures are not formalized.

Gaps and improvement opportunities

Maturity Score:	**1.5**
Key Gaps:	• Department policies are significantly out of date. • Key asset management framework documents such as an asset management policy and strategy, and asset management plans are not in place. • Some gaps in formalized SOPs for the Distribution and Customer Services Division • Engineering Division SOPs are not formalized.

Improvement opportunities:

- The Department should review its existing policies and update, retire or consolidate its policies as appropriate. Consideration should be given to consolidating technical manuals (i.e. TWD Technical Manual, TWD Reclaimed Technical Manual, TWD Cross Connection Control Technical Manual, etc.).
- The review should be extended past policies and technical manuals, and should also include ordinances, resolutions and SOPs with a goal of eliminating conflicting statements between the various document types. Policies should be centralized and organized to match the appropriate level in the organization chart (i.e. some policies are department wide, some policies only apply to a division or section), and should identify who has signature authority to establish policies for which work groups.

- Key documents for the asset management framework should be developed as part of the asset management program. This includes the asset management policy, strategy and objectives which could form part of the asset management framework document described under Element 4.4.

7.6.2 Creating and updating documented information

Evidence and observations

SOPs have been developed and follow a standardized format for Production, which includes a document title and number, revision number, effective date, review date and expiration date. Distribution has policies and procedures that are dated and have formal approval. The design and planning sections do not have controlled standard operating procedures. The Call Center is updating procedures and standardizing the format. The design section has checklists and workflows to document procedures.

Official documented procedures to create or update SOPs are not yet in place for any division. SOPs can be established by any leadership team.

Gaps and improvement opportunities

Maturity Score:	2.0
Key Gaps:	• Controlled SOPs are not in place for the Engineering Division. • No formal procedure to create or update SOPs.

Improvement opportunities:

- Develop a document control procedure that specifies the SOP and Policy creation and update process, as well as the format of the documents. Consideration should be given to using the Production SOP format as a standard format for the Department.
- Develop new SOPs and Policies using the new formats, and update existing SOPs and Policies when required.

7.6.3 Control of documented information

Evidence and observations

The Department uses shared drives with limited access to store and protect data. The shared drives are backed up nightly. There are authentication controls in place for access to systems. Access control is in place for buildings. Treatment plant records drawings have been scanned and combined into a single pdf with indexed pages. Data received from consultants is scanned and stored with project files using HPTrim, which is also used for Department documents.

Hard copy data is accessible by plant staff which leaves data unprotected. Older documentation/record drawings still need to be scanned and archived. Staff would like to implement automated processes for data documentation to phase out paper copies. The Department is considering options for a 3-D viewer, such as BIM, to link plant drawings and make information more accessible to staff electronically.

Gaps and improvement opportunities

Maturity Score:	2.3
Key Gaps:	• Not all documentation and record drawings have been scanned and archived which limits accessibility to staff.

Improvement opportunities:

- Scan and archive older documentation and as-builts at the WTF.
- Develop a document control procedure as part of the asset management framework document that specifies the storage and retention requirements.
- As new processes and procedures are developed for the asset management framework, asset management information systems and other activities, ensure that documentation is controlled (as should be specified in the document control procedure) and made accessible to staff.

2.6 OPERATION

8.1 Operational planning and control

Evidence and observations

Standard Operating Procedures (SOPs) are in place at the WTF and have been recently updated. The updated SOPs are awaiting management approval before distributing. SOPs for the lab facility are well documented. A protocol for developing new SOPs and the review frequency schedule of existing SOPs needs to be established. An on-the-job training program has been established with sign-off processes in-place to ensure understanding. Currently only about 50 to 60-percent of preventative maintenance procedures are in place for plant assets. Establishing the remaining preventative maintenance procedures needs to continue. A detailed process is in place to document retiring/disposing of assets in both the plant's MaintScape CMMS and with financing/accounting. The renumbering process for retired assets needs to be reviewed for consistency between the CMMS and accounting.

A water distribution procedures manual is in place including meter installation, meter maintenance, construction and maintenance, and utility services procedures. Each of the available procedures is well documented with specific steps outlined. The procedures manual is only in hard copy form and needs to be produced electronically to allow updating. Distribution maintains a good list of assets for maintenance. Preventative maintenance processes are maintained and updated as new assets are in service. Procedure manuals for preventative maintenance activities are only in place for some activities. Scheduling and tracking of preventative maintenance work is done manually. A system to collect and update attribute data or track work activities is not in place. There is not a consistent method to document and track retirement of assets.

Identified capital improvement projects are approved based on available funding. The in-house design team would then develop the design for pipelines and prepare a package for the construction services management group. The WATAPP database is used to track projects. Beginning with an authorization form, the project is entered in the WATAPP database and each milestone is updated. After completion of a pipeline project, the assets are documented in the GIS. A developer agreement is in place to transfer new assets to the City. The agreement establishes the warranty and cost and is signed by the developer before release. Plant projects include substantial or final completion certificates requirements in the construction agreement.

The Design and Construction group have a flow chart and checklist in place to help manage projects including a utility review process. However, the current system is not set-up well to share information between groups and needs to be updated. An area of concern is once a project has been passed to the Construction Management Division of the Contract Administration Department, the Water Department is not kept in the loop on progress. A field inspection manual was developed in 1983 and needs to be updated and processes improved to support communication across groups. Multiple technical specifications have been produced; however, the last official update was in 2002. In most cases, consultants will update specifications as needed for use on a project. The specifications need to be updated and combined into a single standard and produced in electronic format.

The Revenue and Finance Department has a process in place for fixed asset accounting and uses a quarterly questionnaire to determine whether there are any asset additions or disposals to be updated in the Oracle financial system. There is a fixed asset disposal form which is used to dispose of assets.

Gaps and improvement opportunities

Maturity Score:	**1.9**
Key Gaps:	• Preventative maintenance processes not developed for a large portion of plant assets. • Inconsistent method of renumbering retired assets throughout the divisions. • Procedure manuals not developed for all preventative maintenance activities for water distribution. Available procedure manuals are only in hard copy form. • Outdated field inspections manual and technical specifications.

Improvement opportunities:

- Develop a standard protocol for the development of SOPs as part of the asset management framework document that specifies the review frequency for SOPs.
- Develop a document control procedure as part of the asset management framework document that specifies requirements for document numbering, version control, and review and approval.
- As part of development of asset-specific asset management plans, document the standardized numbering scheme for retired assets.
- Develop procedures for preventative maintenance activities for water distribution assets that are missing. Reproduce existing procedures in electronic form to support updating and distribution. Review procedures for continuity with other departments and divisions.
- Implement a CMMS to support operations and maintenance activities and track work history and costs.
- Update the field inspection manual including identifying steps to improve communication across all groups.
- Develop a single technical specifications standard that can be referenced by all divisions.

8.2 Management of change

Evidence and observations

Change is managed differently in each Division, but the Department does plan for changes and tries to develop an understanding of the change before it happens. There is no formal change management policy; rather changes are agreed at different stages.

Regulatory changes are infrequent for the Division, but when they do happen they are reviewed. New products and technologies are reviewed prior to their introduction; the Department usually delays changes to allow time for testing. Other examples of change management by the Department include the update of the specification in response to supply chain constraints regarding a specific insertion valve, the VFD replacement project due to obsolescence of the existing VFDs, and similarly the SCADA project to replace PLC 5.

It was stated that generally the City is good at communicating when there is going to be change, for example with recent changes to the IT infrastructure.

The Department has been using the same meter types for the last 20 years and there is standardized training on the current technology. But the Department does not have time to review different options and assess the impact of changing to different meter types.

Gaps and improvement opportunities

Maturity Score:	2.3
Key Gaps:	• There is no formal process for change management in place.

Improvement opportunities:

- The Department should develop a formal process for management of change as part of the asset management framework. This should cover changes to:
  - Organizational structure, roles or responsibilities.
  - The asset management policy, strategy or objectives.
  - Processes or procedures for asset management activities.
  - New assets, asset systems or technology (including obsolescence).
  - New legal, regulatory and environmental requirements.
  - Supply chain constraints, including approved contractors and suppliers.
  - Demands for products and services, contractors or suppliers.
- The change management aspects of the asset management program should be taken into account when developing and implementing the communications plan, and associated training. Consideration should be given to managing cultural changes as well as impacts of any organizational changes associated with implementing the program.

8.3 Outsourcing

Evidence and observations

The Department has outsourced its utilities locating service (one call system) whereas the Wastewater Department does its locates internally. The Department has not formally assessed the risk associated with this; the decision was based on resources. Meter installation services are also outsourced along with some other distribution system maintenance tasks.

Outsourced activities are managed with the general terms of City contracts. A contract is in place for the locate contractor, but it is not very specific as legislation defines work requirements.

Contracts are also in place with consultants for design and inspection services. The scope of work is defined and managed by a Department project manager; however there are no liquidated damages included in the consultant contracts. The Department has an issue with quality control of surveyors as the documentation received from surveyors is not always clear and there are limitations on quality control by Department staff.

As-built information from CIP project contractors is reviewed and confirmed by inspectors. The locate contractor shares information on utilities and information is provided to consultants and contractors as requested. The UMAP/GIS license is shared, and there is a dedicated email for external requests for information (watermapsandasbuilts@tampagov.net); there is a plan to provide web access to SCADA data. Interviewees commented that a lot of time is spent identifying and providing information.

There is an issue with as-built information received from developers as it is not always finalized properly, such as when initial design drawings are provided as as-builts. There is a process to manage this but it is not always enforced. There is a process in place that works well for subdivision work.

The Contract Administration Department (CAD) is responsible for contractor inspections, but they don't have sufficient resources to manage all contractors effectively. The Department does not have any control over the inspections and CAD is not accountable to the Department. However, in some cases the Distribution Division has dedicated its own resources to monitor critical activities carried out by contractors. The Department considers that CAD (as well as some other City Departments) does not see the Department as a customer.

Gaps and improvement opportunities

Maturity Score:	**2.1**
Key Gaps:	• There is no formal assessment of risks of outsourced activities. • Monitoring and controlling the performance of outsourced activities could be improved. • There are insufficient resources for inspection activities.

Improvement opportunities:

- The Department should put in place a process to formally assess risks of outsourced activities and to ensure adequate controls are in place to mitigate the risks (it was noted by Department staff that Tampa Bay Water has some good case studies related to this concept, including what happens when you outsource the management of a project).

- The Department should work with CAD to agree on the Department's requirements for reporting of contractor performance and determining what can be done to monitor and record contactor performance to ensure a poor performing contractor is suitably managed.
- The Department's interactions with CAD should be re-assessed. A "service-level" agreement should be considered, where the Department is a client and the CAD is a service provider, so that CAD becomes more accountable for performance and financial efficiency.
- Additional inspection resources need to be provided to manage critical work activities. The Department should look at other options if CAD cannot provide resources, such as using engineering consultants to provide inspectors.

2.7 PERFORMANCE EVALUATION

9.1 Monitoring, measurement, analysis and evaluation

Evidence and observations

The City reports Water Department key performance indicators in the Dashboard on the City's website. These indicators include service outages, call center average wait time, percentage of fire hydrants inspected, and pH of finished water.

There are regulatory requirements for water quality reporting and the Department has to produce an annual water quality report that is sent to customers. The laboratory uses LIMS for water quality monitoring & reporting. The WTF also produces daily production reports.

The SCADA historian is used to trend process data and MaintScape provides reports on maintenance activity, including costs for parts and labor. The WTF is undergoing a formalized condition assessment as part of the DLTWTF master plan..

The Customer Service Center (CSC) reports monthly on metrics such as number of calls received and average call wait time. Customer complaints are received by the CSC, but some go direct to the Mayor and some come through field services which are not effectively recorded.

The Distribution Division does not have a CMMS for workload monitoring and reporting, and instead uses spreadsheets. An example of the Workload Tracking/ Planning/ Scheduling spreadsheet was provided.

CAD uses an excel spreadsheet to track projects. It is updated on a monthly basis; however it does not provide full details on project performance (against budget and schedule) and no reports are provided to the Department. There are weekly project management meetings to review progress.

The City Revenue and Finance Department monitors and reports on a number of financial metrics. It tracks debt service coverage and the fixed asset inventory for equipment and vehicles is updated quarterly, and forecasts CIP expenditure incorporating inflation. The City's CFO presents a review of budget compared expenditures to the City Council approximately half way through each fiscal year, and an annual report is published on the City's website. Monthly variance reports are provided for the Mayor and all Department heads and administrators; quarterly reports are published on the intranet. An internal bi-monthly report is given to the Water Director showing actual expenses and revenue against budget. The Finance Department is planning to provide access to Oracle and training for project managers.

Gaps and improvement opportunities

Maturity Score:	1.8
Key Gaps:	• Customer complaint data is not effectively captured. • There is no defined plan on what metrics to monitor, evaluate and report. • Condition assessments of vertical assets have only just commenced. • No formal process for reporting CIP project progress. • Distribution does not have a CMMS.

Improvement opportunities:

- Clearly define what metrics are to be monitored and reported. This should include a review of what is reported on the City Dashboard to ensure that the most appropriate metrics reflecting levels of service are used. Consideration should be given to the performance metrics used in the AWWA benchmarking.
- Implement condition assessment for the WTF part of the DLTWTF master plan and collect run time information for equipment.
- CAD should put in place a more formal process for monitoring and reporting on CIP projects to the Department. This should include regular reporting on progress to the Department and identification of project issues (such as behind schedule, over budget, specific risks).
- There is a need for a post-evaluation process and feedback form for consultants and contractors. This information could then be used to inform the pre-qualification and selection for contractors and consultants.

9.2 Internal audit

Evidence and observations

The City has an internal audit function. There is a formal group audit process which assesses what is done compared to what the policy says. These audits are more financially focused and do not focus on how assets are managed. The Accounting Department does an inventory audit check with some physical inspection to check what is in place. Financial audits are performed annually. Internal audit has a schedule but is flexible; the normal cycle is five years for internal audit.

Gaps and improvement opportunities

Maturity Score:	1.5
Key Gaps:	• There is no asset management framework and no formal audit process in place.

Improvement opportunities:

- As the asset management framework is implemented, the Department should implement a review process or self-audit process using internal Department staff. The process should define the scope and methodology of the audit.

- Selected staff should receive training in the audit process, and staff from different divisions should be used to support the audits. A Department-specific audit schedule should be developed.

9.3 Management review

Evidence and observations

Executive meetings are scheduled monthly and there are internal Department biweekly and weekly management meetings. However, there is no formal management review process in place.

Gaps and improvement opportunities

Maturity Score:	**0.5**
Key Gaps:	• There is no formal management review process in place for the asset management framework.

Improvement opportunities:

- The Department should consider establishing an Asset Management Steering Committee of representatives from across all Department groups and functions to manage the implementation of the asset management program.
- A management review process should be established that consists of formal meetings with the Department management that considers:
  - Asset performance and performance against established KPIs.
  - Identified risks and changes in risk profiles.
  - Results of internal audits.
  - Corrective actions identified from incident investigations and root cause analysis.
  - Opportunities for continual improvement.
  - The status of actions from previous management reviews and the effectiveness of the actions.

2.8 IMPROVEMENT

10.1 Nonconformity and corrective action

Evidence and observations

Processes are in place for Production and Distribution staff to respond to incidents and staff is available on standby at weekends and out of hours. Staff responds to the incident, investigate and assess to determine if it needs immediate attention, needs to be monitored or can be programed for later work.

Production staff hold review meetings and document what happened - a “Post Mortem”. A wide range of staff are involved in the review, but if they can’t figure out what happened a consultant will be used to do a more detailed investigation. Reports and presentations are prepared on what happened and with recommendations for corrective actions – an example was provided for a septic sludge event. Changes to SOPs or maintenance can be implemented quickly, but if it requires capital investment it is a longer process.

Distribution staff assess each incident that occurs. If it is a main break they look at available information such as year pipe was installed, if other failures have occurred in the same area or with the same type of pipe. Engineering is involved to investigate further if a trend is noticed. However this is not done for all incidents due to the volume of work and lack of resources. A plan for corrective action would be determined from the investigation. An SOP for responding to incidents has been developed by the Production Division and is awaiting approval.

If someone breaks a water main (e.g. a contractor) they investigate, take pictures and complete a System Damage Report that is submitted to the City's Risk Management and Central Services Division.

Gaps and improvement opportunities

Maturity Score:	**2.3**
Key Gaps:	• There is no formal incident investigation SOP for Production or Distribution.

Improvement Opportunities:

- Develop an SOP for Production that covers incident response, investigation (including root cause analysis if appropriate) and corrective action.
- As required, further develop the Distribution SOP for incident response to include investigation and corrective action.

10.2 Preventive action

Evidence and observations

Production maintenance tasks are mainly time based with some condition based, and there is a high preventive maintenance to corrective maintenance ratio.

Distribution has a large meter preventive maintenance program with annual testing determining the need to replace meter. Hydrants and backflows are inspected annually. There is a valve operating truck that is used for valve exercising, but here is a lack of resources to exercise the required valves annually.

Gaps and improvement opportunities

Maturity Score:	**1.5**
Key Gaps:	• Distribution has no CMMS to effectively manage work orders. • Production lacks data on run times to inform maintenance and is not fully utilizing the CMMS.

Improvement opportunities:

- Improve utilization of Production CMMS to capture equipment run times and use that information to inform maintenance planning. Also improve BCI information capture of I&C calibration data.
- Develop a valve exercising program that takes into account valve criticality (e.g. transmission mains, location to critical customers). The program should include capturing data on valves and their GIS coordinates.

- Implement a CMMS to support Distribution on tracking and documenting operation and maintenance activities.

10.3 Continual improvement

Evidence and observations

The Department has identified the need for continual improvement with respect to asset management. The Strategic Plan contains a number of goals and objectives for improvement that the Department has been implementing. This includes the InfoMaster risk assessment, the DLTWTF master plan project that includes condition assessment and criticality at the treatment plant, updating SOPs at the plant, and this gap assessment project.

The Department is a member of the American Water Works Association (AWWA); there are budget constraints on conference attendance as well as time constraints, but the Department is presenting at AWWA Water Infrastructure Conference in November 2016. There is limited City-wide participation in local AWWA events.

Support is provided for continuing education, including CEU for operators and PE license renewal.

Gaps and improvement opportunities

Maturity Score:	**2.0**
Key Gaps:	• AM framework audit and management review processes not in place. • No formal incident investigation process. • Little participation in local AWWA and other industry events.

Improvement opportunities:

- Implementing elements of the framework and closing the gaps identified in this report will contribute to the continual improvement of the Department's asset management. A key area of focus should be on formalizing feedback from incidents, internal audits or reviews to ensure actions are taken that contribute to the continual improvement of asset performance and the asset management framework.
- Develop a plan for participation in industry events, including attending local and national conferences (the AWWA Utility Management Conference will be held in Tampa in February 2017 which provides an excellent opportunity for staff to attend).
- Consider opportunities to participate in industry benchmarking, including the AWWA performance indicators benchmarking.

3.0 Conclusions and Recommendations

3.1 CONCLUSIONS

The Department achieved an average asset management maturity score of 1.6 from the assessment, which is in the "Aware" zone of the maturity scale. This score is typical of a utility that has some elements of good practice asset management in place but has identified the need to improve its asset management approach.

The Department leadership has recognized the need to implement a formal asset management program, and has commenced the process with the Water Master Plan and this gap assessment. The 2012 Strategic Plan included some goals and objectives specific to asset management, some of which have been implemented (e.g. the GIS conversion to ArcGIS), and the Department has recently implemented the InfoMaster software to support the risk assessment and rehabilitation planning and budgeting for the distribution system.

The Department has a good planning process in place with the CIP and master plan, key performance indicators are reported to the public, training is well managed with a skills matrix to determine training needs, the WTF has well defined SOPs in place, and there are processes to respond to incidents. However, the Department lacks an overarching asset management framework, strategy and objectives, and asset management plans which results in lower scores in a number of areas.

Having sufficient staffing levels and resources are critical for successfully implementing and maintaining a successful asset management program. The gap assessment identified that it takes significant effort to obtain additional resources and there is no formal process to determine resource needs for the Department. Support groups from other City departments need to develop as well, and top management support is required for this, from the Public Works Administrator and Mayor. There are no formal resource plans in place for the Department, so a resource plan will need to be developed for the asset management program.

The assessment has identified a number of gaps against ISO 55001 requirements and good practice asset management, as well as a number of improvement opportunities. A gap analysis assessment can appear to be critical in its nature; however, this assessment is the first step in the process of formalizing the gap closure activities, and developing a clearly defined improvement plan. A number of the identified gaps can be closed relatively simply (e.g. development of the asset management policy), while others will require more sustained development.

3.2 RECOMMENDATIONS

The Department should implement the following recommendations in order to develop and implement an asset management framework that is aligned with the ISO 55001 requirements. These recommendations will need to be further refined and developed into the Improvement Roadmap.

Context of the Organization

1. Update the Strategic Plan to identify the specific issues and challenges facing the Department now and in the future. Develop clear strategic goals and objectives based on the WRF's 10 attributes for Effectively Managed Water Utilities.

2. Develop an asset management framework in order to formalize and improve the approach to asset management. The framework should contain the elements recommended in this report, and an asset management framework document should be created that includes or provides reference to the key components of the framework. The framework document should define the scope of the asset management framework.

3. Develop an asset management strategy for implementing the asset management program and enhancing the Department's asset management capability. It should document stakeholder needs and expectations and should build on this gap assessment.

4. Cost accounting should be introduced to capture costs of work done on assets, so the Department can report how much it costs to replace one type of asset or repair another one.

Leadership

5. Form an Asset Management Steering Committee to provide oversight and direction for the asset management program. The Department should also assign an "Asset Management Coordinator" with responsibility for developing and implementing the asset management program.

6. Develop an asset management policy that sets out the Department's vision and principles for asset management.

7. Determine roles and responsibilities for asset management activities and documented in the asset management framework document. Job descriptions should be updated if appropriate.

Planning

8. As part of the WTF master plan project implement a risk-based approach for prioritizing capital improvement projects identified for the plant and pump stations.

9. Improve emergency response by conducting emergency planning drills on an annual basis and develop a formalized system restoration procedures manual.

10. Review existing key performance indicators currently reported to determine how appropriate they are and consider alternative or additional metrics.

11. Develop asset-specific asset management plans based on the information that is available and most beneficial. Document the process for developing asset management plans.

Support

12. Develop a resourcing plan for the Department which should include an assessment of staff needs to be able to do more proactive maintenance work, implement the asset management program and undertake the additional activities resulting from the program. The resourcing plan should also consider staff needs in supporting departments, including additional inspectors. Consider future staff competency requirements as part of the resourcing plan, and

develop initiatives focused on both technical and people skills and maintaining or developing competencies in specific areas.

13. Develop a communications plan to formalize the Department's internal and external communications and support the asset management program. This should include a plan for customer outreach and survey to identify customer needs. The communications plan should ensure that staff is made aware of the asset management program and the asset management policy when it is issued. The change management aspects of the asset management program should be taken into account when developing and implementing the communications plan.
14. Undertake a data needs assessment to determine what data is required for asset management (including planning, risk assessment, maintenance and operations), what the gaps are and what data quality improvement or additional data is needed.
15. Develop a formal standard and approach to collect, input, and extract data across divisions, including a training plan.
16. Implement a computerized maintenance management system (CMMS) to support standardized data collection, including moving from paper to electronic mobile data collection, and track operations and maintenance activities and costs for Distribution.
17. Review existing Department policies and update, retire or consolidate its policies as appropriate. This could include consolidation into separate technical manuals.
18. Develop a document control procedure that specifies the SOP and Policy creation and update process, the format of the documents, and document storage and retention requirements. Consideration should be given to using the Production SOP format as a standard format for the Department. Develop new SOPs and Policies using the new formats, and update existing SOPs and Policies when required.

Operation

19. Develop procedures for preventative maintenance activities for water distribution assets that are missing. Reproduce existing Distribution procedures in electronic form to support updating and distribution. Review procedures for continuity with other departments and divisions.
20. Update the field inspection manual including identifying steps to improve communication across all groups.
21. Develop a single technical specifications standard that can be referenced by all divisions, including standard specifications for the plant and pump stations.
22. Develop a formal process for management of change as part of the asset management framework. This should cover changes to: organizational structure, roles or responsibilities; the asset management policy, strategy or objectives; processes or procedures for asset management activities; new assets, asset systems or technology (including obsolescence); and new legal, regulatory and environmental requirements.
23. The Department should put in place a process to formally assess risks of outsourced activities and to ensure adequate controls are in place to mitigate the risks.

24. The Department's interactions with CAD should be re-assessed. A "service-level" agreement should be considered, where the Department is a client and the CAD is a service provider, so that CAD becomes more accountable for performance and financial efficiency. The Department should work with CAD to agree on the Department's requirements for reporting of contractor performance and determining what can be done to monitor and record contactor performance to ensure a poor performing contractor is suitably managed.

25. Additional inspection resources need to be provided to manage critical work activities. The Department should look at other options if CAD cannot provide resources, such as using Department inspectors or contracting engineering consultants to provide inspectors.

Performance evaluation

26. Clearly define what metrics are to be monitored and reported. This should include a review of what is reported on the City Dashboard to ensure that the most appropriate metrics reflecting levels of service are used. Consideration should be given to the performance metrics used in the AWWA *Benchmarking Performance Indicators for Water and Wastewater Utilities: Survey Data and Analyses Report* and the WRF/WERF report *Key Asset Data for Water and Wastewater Facilities*. Consideration should also be given to the metrics identified for each of the ten attributes of effectively managed water sector utilities as listed in Effective Utility Management, A Primer for Water and Wastewater Utilities, 2008.

27. CAD should put in place a more formal process for monitoring and reporting on CIP projects for the Department. This should include regular reporting on progress to the Department and identification of project issues (such as behind schedule, over budget, specific risks).

28. As the asset management framework is implemented, the Department should implement a review process or self-audit process using internal Department staff.

29. A management review process should be established that consists of formal meetings with the Department management to review the performance of the assets and the asset management framework and identify opportunities for continual improvement.

Improvement

30. Develop an SOP for Production that covers incident response, investigation and corrective action. As required, further develop the Distribution SOP for incident response to include investigation, root cause analysis and corrective action.

31. Improve utilization of Production CMMS to capture equipment run times and use that information to inform maintenance planning. Also improve BCI information capture of I&C calibration data.

32. Develop a valve exercising program that takes into account valve criticality (e.g. transmission mains, location to critical customers). The program should include capturing data on valves and their GIS coordinates, including valves at the plant.

33. Develop a plan for participation in industry events, including attending local and national conferences. Consider opportunities to participate in industry benchmarking, including the AWWA performance indicators benchmarking.

Appendix A – Interview Attendees

GROUP INTERVIEW	ATTENDEES
Group 1 – Production Division Operations and Maintenance	Brian Pickard Chris Wetz Carlos Estrada Dawn Lei Chuck Weber (part)
Group 2 – Management Team with focus on Strategy and Framework	Chuck Weber Elias Franco Seung Park Brian Pickard
Group 3 – Design and Construction Management	Seung Park Brian Pickard Rory Jones Roy McKenzie, Daniel Peterson
Group 4 – Planning	Seung Park Brian Pickard Brett Warner
Group 5 – Information Management	Seung Park Brian Pickard Brett Warner Elias Franco Karl Craig Christina Morales Marion Sell Rob Edwards
Group 6 – Distribution System Operations and Maintenance	Elias Franco Patrick Leonard Ron Calderoni Brian Pickard
Group 7 – Finance and Accounting	Kelli Reed Pamela McCarter Sabrina McAdoo Daniel Rosenberg Peggy Curtin Michael Perry Brian Pickard
Group 8 – Fleet Management	Travis Riley (with Water Department)

Appendix B—Documentation Received for Review

CITY OF TAMPA DOCUMENTATION RECEIVED FOR REVIEW		
	DOCUMENT	DESCRIPTION
1	06-03-2016 TABLE OF ORGANIZATION	Org Chart
2	2015_WUP_Annual Report	FY2015 Annual Report to SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
3	041116 staffing analysis memo	PLANNING SECTION STAFFING LEVEL ANALYSIS
4	20160624_Dashboard	Planning section metric tracking dashboard
5	About Us - Contract Administration _ City of Tampa Intranet	Contract admin home page
6	AGENDA FORMAT	Planning Section Staff Meeting Agenda
7	City ENews - 2016 Hurricane Season	Internal communication - hurricane safety
8	City ENews - Archives Awareness Week	Internal communication
9	City Wide Information Technology Management_ Policy	IT Policy
10	ECM_Summary_0	Enterprise Content Management Project
11	Enterprise Change Management Overview _ City of Tampa Intranet	IT change management home page
12	finalJan-Mar2016_1	Tampa water dept. newsletter
13	Individual Performance Plan	Template
14	Initial Assignments for Utility Permit Techs	informal SOP
15	Internal Audit _ City of Tampa Intranet	Internal audit home page
16	May 2016 Key Metrics Score Card	Key metrics score card - customer service
17	ORG CHART - Utilities Permit Tech Vacancy rev5	Planning dept. vacancy
18	Projects List	Planning Section Master Non-Recurring Projects List
19	Sample Releases	Examples of news releases
20	Strategic Plan 2015	Tampa water dept. strategic plan 2012 status report 2015
21	T&I About Us	Technology and Innovation - home page
22	TWD-COOP-2015-V20150831_ALL	Continuity of Operations plan
23	UMS Fact Sheet 20150514	Utility Management system fact sheet
24	URL for Job Descriptions	Link to City website with job descriptions
25	Water Dept. Training Manual SIRE	Training manual for SIRE (doc management system?)
26	Water Quality Report 2015	Water quality report - annual regulatory requirement
27	Workplan_FY2016_SYP09112015	Action plan for specific improvements
28	City of Tampa - AMP - Horizontal Assets	AM Plan template

CITY OF TAMPA DOCUMENTATION RECEIVED FOR REVIEW		
	DOCUMENT	DESCRIPTION
29	Figure 1 - Typical Asset Management Plan Sections	Example of AM plan sections
30	Figure 1 - COTWD Org Chart	City of Tampa org chart for AM plan
31	Figure 2 - COTWD Core Processes and Practices	AM 10 step process
32	Figure 2 - Main-Break Data Capture Form	Example of main break report form
33	City of Tampa Asset Management	Superseded part complete AM Plan
34	Asset Management Plan Tables	Inventory information for the distribution system
35	Capital Improvement Plan folder	Various CIP files + InfoMaster files
36	2009 Master Plan folder	Master plan files, including risk based asset prioritization
37	Manual - Access Database for Main and Service Breaks	Planning procedure
38	Manual - ArcGIS Geocoding Main and Service Breaks	Planning procedure
39	Manual - Maintenance of Metered Flushing Stations	Planning procedure
40	Manual - Monthly_Non-Revenue_Water_Reports	Planning procedure
41	Manual - Processing Main and Service Breaks	Planning procedure
42	Manual - Project Tracking for Hydraulic Modeling	Planning procedure
43	Water Department Policies	Policies
43	A15. Utility Notification.pdf	
44	A16. Backflow Prevention Assembly Tech Certification.pdf	
45	A17. Backflow Prev Dev Tech Cert Program.pdf	
46	A19. Use of City Vehicles.pdf	
47	A20. Automatic Fuel Dispensing Card.pdf	
48	A21-Sale of Scrap Hydrants.pdf	
49	A21. Sale of Scrap Hydrants_9202010.pdf	
50	A23. Customer Notification for Service Interruptions.pdf	
51	A25. Collection for Damage to Department Property.pdf	
52	A27. Access Authorization MBWTP.pdf	
53	A28. Plant Tours.pdf	
54	A31. Professional Organization Membership.pdf	
55	A32. Existing Water Service Review.pdf	

CITY OF TAMPA DOCUMENTATION RECEIVED FOR REVIEW		
	DOCUMENT	DESCRIPTION
56	A33. David L Tippin Water Treatment Facility Access and Parking.pdf	
57	A34. Determination of Water Use Restriction Citation Recipient.pdf	
58	A4. Safety.pdf	
59	A5. Accident Review Process.pdf	
60	B1. Commitments.pdf	
61	B10. Priority Service.pdf	
62	B12. Customer Service Calls (Triage).pdf	
63	B13. Downtown and South Tampa CIAC.pdf	
64	B14. Northeast Area CIAC.pdf	
65	B15. Master-Metered Single Family Subdivision-08072013.pdf	
66	B2. Main Extension Aid in Construction.pdf	
67	B3. Temporary Service Portable Meters.pdf	
68	B4. No Service Pipe Present.pdf	
69	B6. EMERGENCY CALLS AND COMPLAINTS.pdf	
70	B6. Emergency Calls and Complaints_signed.pdf	
71	B7. BILLING COMPLAINTS.pdf	
72	B7. Billing Complaints_signed.pdf	
73	B8. Billing Adjustment Procedure.pdf	
74	B8. Billing Adjustment Procedure_signed.pdf	
75	B9. Turn Off at Multi-Family Dwellings.pdf	
76	C1. Water Main Conflicts.pdf	
77	C10. Fire Service Maintenance.pdf	
78	C11. Fire Hydrant Standardization.pdf	
79	C12. Fire Hydrant Data.pdf	
80	C13. Fire Flow Analyses.pdf	
81	C14. Scrap Metal Disposal Policy.pdf	
82	C15. Damage to Utilities.pdf	
83	C16. Wet Taps.pdf	
84	C17. Closed Valves.pdf	

CITY OF TAMPA DOCUMENTATION RECEIVED FOR REVIEW		
	DOCUMENT	DESCRIPTION
85	C18. Hillsborough County Department of Health Notification.pdf	
86	C19. Installation of New Water Facilities.pdf	
87	C2. Meter Relocations.pdf	
88	C20. Fire Systems - Backflow Protection.pdf	
89	C20.Fire Systems - Backflow Protection.pdf	
90	C21. Locating Utilities.pdf	
91	C3. Meter Disposal.pdf	
92	C4. Meter Testing.pdf	
93	C5. Meter Test Frequency.pdf	
94	C6. Paperwork Flow Large Meter Installation & Fire Mains.pdf	
95	C7. Abandoned Meter Removal.pdf	
96	C8. Abandoned Service Line Removal.pdf	
97	C9. Cross Connection Control.pdf	
98	RE TWD Policy Ages.msg	
99	Table of Contents.pdf	
100	Water Department Policy Update 2.xlsx	
101	Water Department Policy Update.xlsx	
102	Water-Department-Policies.pdf	
103	Water Treatment Facility - SOPs	Water treatment plant standard operating procedures (index and various example documents)
104	Copy of Document Control	Summary of documents including QC status, location, revision dates
105	EPA 300.0 SOP Rev 6.0	water quality laboratory standard operating procedure
106	Cost Summary and Detail report	Cost report from MaintScape
107	Developer Application Flow Chart	Developer Application Flow Chart
108	Developer Project Flow	Workflow for developer install projects
109	Procedure and work order	Work order form from MaintScape
110	Water Meter Flow Chart 1	Water meters project tracking form
111	Watermain and Fire Line Project Flow Chart 1	Watermain and fire line project tracking form
112	Workload 11-5-2015	Division Workload Tracking/Planning/Scheduling spreadsheet

CITY OF TAMPA DOCUMENTATION RECEIVED FOR REVIEW		
	DOCUMENT	**DESCRIPTION**
113	Cayenta Statement of Work for City of Tampa-Excerpt for BV	Utility Management System statement of work
114	DOC071816-07182016-002	Budget process overview with calendar
115	DOC071816-07182016-003	Budgeting 101 Operating Budgets presentation
116	DOC071816-07182016-004	Budgeting 102 CIP and Debt presentation
117	Emergency Protocols	Emergency response protocol quick reference guide MBWTP
118	Emergency Phone Numbers	List of emergency phone numbers
119	Monthly Meter Reading Performance Report	Meter readings summary report
120	RFP Utility Management System Excerpt for BV	Request for Proposals for Utility Management System
122	Capital assets and depreciation policies and procedures	City's capitalization and depreciation policy
123	FY16 Water Dept. Monthly BI Reports- July 2016	Example of a financial report for the Department

Appendix C—ISO 55001 Requirements by Clause

4.1 Understanding the organization and its context

ISO 55001 Requirement

The organization identifies internal and external issues relevant to its purpose; and considers these in designing its asset management system.

The organization confirms that its asset management objectives are fully aligned to, and consistent with, its organizational objectives.

4.2 Understanding the needs and expectations of stakeholders

ISO 55001 Requirement

The organization identifies stakeholders that are relevant to the asset management system, and captures their requirements and expectations.

Relevant stakeholder requirements are determined for recording of financial and non-financial information relevant for asset management, and for their reporting internally and externally.

The organization determines criteria for asset management decision making which includes where appropriate consultation with relevant stakeholders.

4.3 Determining the scope of the asset management system

ISO 55001 Requirement

The scope of the asset management system is clearly documented in terms of its boundaries, applicability, interfaces with other management systems and the asset portfolio covered.

The scope of AMS is aligned with the SAMP, the asset management policy, and takes account of relevant internal and external issues and needs and expectations of stakeholders.

4.4 Asset management system

ISO 55001 Requirement

The organization shall establish an asset management system, documenting as appropriate, the various components required for people, process, information, technology and with appropriate linkages to other organizational functions and management systems.

The organization shall develop a Strategic Asset Management Plan (SAMP) which documents the role of the asset management system in achieving the asset management objectives.

5.1 Leadership and commitment

ISO 55001 Requirement

Top management shall demonstrate leadership and commitment to the asset management system, and shall ensure that the asset management policy, the SAMP and asset management objectives are all in place and are consistent with the organizational objectives.

The asset management system is fully integrated with the organization's business processes.

The approach used for managing asset management related risk is aligned with the organization's risk management approach.

Top management ensures that resources are made available for the asset management system and promotes continual improvement.

5.2 Policy

ISO 55001 Requirement

The organization shall establish and document an asset management policy, which is authorized by top management and communicated within the organization and is available to relevant stakeholders.

5.3 Organizational roles, responsibilities and authorities

ISO 55001 Requirement

Top management shall ensure that the responsibilities and authorities for relevant roles are assigned and communicated within the organization.

6.1 Actions to address risks and opportunities

ISO 55001 Requirement

The organization demonstrates that risks and opportunities that could affect the ability of the asset management system to achieve its intended outcomes are adequately considered and processes put in place to assure that the desired outcomes are achieved and undesired effects are mitigated.

6.2.1 Asset management objectives

ISO 55001 Requirement

The organization should establish and document asset management objectives, at relevant functions and levels, to align with and enable the achievement of the organizational objectives and asset management policy.

6.2.2 Planning to achieve asset management objectives

ISO 55001 Requirement

The organization shall establish and documented its planning processes, methods and decision criteria for developing the asset management plan(s) to achieve its asset management objectives.

The organization has plan(s) in place, to achieve the AM Objectives, which are aligned with the AM policy and the SAMP. The plans document what is to be done, by when, who is to be responsible and the resources required to successfully implement them.

7.1 Resources

ISO 55001 Requirement

The organization can demonstrate that it has evaluated and provided adequate resources to establish, maintain and improve the asset management system.

The organization has a fully developed and embedded approach to identifying resource requirements for achieving the asset management objectives, and that plans can be demonstrated as aligned to resources.

Resource management includes management of tools, facilities and equipment that are required for the control of asset management activities.

7.2 Competence

ISO 55001 Requirement

The organization shall determine the necessary competence of persons doing work under its control that affects performance of assets, asset management or asset management system.

The organization shall ensure that staff are competent on the basis of appropriate education, training or experience. This includes identifying training requirements and planning and delivering training.

Current and future competency needs and requirements should be reviewed, and staff competency records maintained.

7.3 Awareness

ISO 55001 Requirement

The organization's staff should be aware of how their work activities can have an impact on the effectiveness of the asset management system and achievement of asset management objectives. Staff should be aware of the asset management policy.

7.4 Communication

ISO 55001 Requirement

The organization should determine the need for communication internally and externally relevant to assets, asset management and the asset management system. This includes what is communicated, when, with whom and how.

7.5 Information requirements

ISO 55001 Requirement

All information identified as required for asset management purposes is defined, along with the sources, quality assurance requirements and processes to manage the information. The information is traceable and consistent, including between financial and non-financial information.

7.6 Documented information general

ISO 55001 Requirement

The organization's asset management system shall include:

documented information as required by ISO 55001

documented information for applicable legal and regulatory requirements

other documented information necessary for the effectiveness of the asset management system.

When creating and updating documented information the organization should ensure that information is appropriately identified, formatted, reviewed and approved, and appropriate media is used.

Documented information is available and suitable for use, where and when it is needed, and it is adequately protected.

8.1 Operational planning and control

ISO 55001 Requirement

The organization shall plan, implement and control the processes needed to meet requirements and implement the asset management plans.

The organization shall demonstrate it is controlling the processes for implementing its asset management plans.

8.2 Management of change

ISO 55001 Requirement

Changes impacting the asset management system should be identified and assessed before a change is implemented. This can include: organizational structure, new processes, new assets or technology, new standards, new suppliers or contractors.

8.3 Outsourcing

ISO 55001 Requirement

The organization has an established risk management process that ensures outsourced processes and activities are controlled consistent with achieving asset management objectives, and integrated with the organization's asset management system.

9.1 Monitoring, measurement, analysis and evaluation

ISO 55001 Requirement

The organization shall determine:

What needs to be monitored and measured

The methods for monitoring, measurement, analysis and evaluation

When the monitoring and measuring should be performed

When the results of the monitoring and measurement shall be analyzed and evaluated

The organization shall evaluate and report on:

The asset performance

Asset management performance, including financial and non-financial performance

The effectiveness of the asset management system

9.2 Internal audit

ISO 55001 Requirement

The organization shall conduct internal audits at planned intervals to provide information to assist in the determination on whether the asset management system:

Conforms to the organization's requirements and requirements of ISO 55001

Is effectively implemented and maintained

The organization shall plan, establish, implement and maintain an audit program.

9.3 Management review

ISO 55001 Requirement

Top management shall review the organization's asset management system, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness.

10.1 Nonconformity and corrective action

ISO 55001 Requirement

The organization should have processes and resources available which enable it to react appropriately to the range of non-conformities or incidents which could occur with its assets or within its AM system.

The organization should have in place processes for investigating nonconformities or incidents to determine their cause and whether similar nonconformities exist or could potentially occur.

Potential actions are evaluated to determine whether they are appropriate for the effects of, or risks encountered as a result of, the nonconformity or incident.

Nonconformities, investigations and actions are documented and records retained compliant with relevant processes.

10.2 Preventive action

ISO 55001 Requirement

The organization shall establish processes to proactively identify potential failures in asset performance and evaluate the need for preventative action.

10.3 Continual improvement

ISO 55001 Requirement

The organization shall continually improve the suitability, adequacy and effectiveness of its asset management and the asset management system.

Appendix G

Asset Management Implementation Plan Technical Memorandum

FINAL

Asset Management Implementation Plan Technical Memorandum

Potable Water Master Plan

BLACK & VEATCH PROJECT NO. 190020

PREPARED FOR

City of Tampa Water Department

20 DECEMBER 2016

Asset Management Implementation Plan

The Asset Management Implementation Plan consists of an action plan and schedule for implementing improvements to the City of Tampa Water Department's (the Department) approach to asset management, and closing the gaps identified in the ISO 55001 gap assessment (refer to the ISO 55001 Gap Assessment Technical Memorandum).

The initial Asset Management Implementation Plan was developed with Department staff in a "Roadmapping" workshop on 7 September 2016 and has been further reviewed and updated since then. The asset management initiatives consist of:

1. Update Water Department Strategic Plan
2. Form AM Steering Committee
3. Develop AM Framework (including Policy, Strategy and Objectives)
4. Develop Water Department Resourcing Plan
5. Develop Water Department Communications Plan
6. Develop Key Performance Indicators
7. Data Needs Assessment
8. Implement Data Management Processes
9. Update Water Department Policies and SOPs
10. Develop SOP for Incident Response, Investigation and Corrective Action
11. Update technical specifications
12. Implement Facilities Risk Management
13. Emergency Response Improvements
14. Develop Asset Management Plans
15. Implement Utility Management System
16. Contract Management Improvements
17. Production CMMS Improvements
18. Implement Cost Accounting

The action plan lists out each of the initiatives, with specific actions and recommendations, the timeframe for completion, and the priority of the action. A high-level consideration of resources needed to implement the initiative is included, and a Department lead has been assigned to each action.

The action plan and schedule are included in the following sections of this technical memorandum.

Nr	Initiative	Recommendation	Lead	Resources / Notes	Timeframe	Priority
1	Update Water Department Strategic Plan	1. Update the Strategic Plan to identify the specific issues and challenges facing the Department now and in the future. Develop clear strategic goals and objectives based on the ten attributes of effectively managed water sector utilities as stated in "Effective Utility Management, A Primer for Water and Wastewater Utilities, 2008".	Chuck Weber	Internal: Seung Park, Elias Franco and John Ranon	Completed in 2 months	High
2	Form AM Steering Committee	5. Form an Asset Management Steering Committee to provide oversight and direction for the asset management program. The Department should also assign an "Asset Management Coordinator" with responsibility for developing and implementing the asset management program.	Chuck Weber	Internal	After Strategic Plan	High
3	Develop AM Framework (including Policy, Strategy and Objectives)	2. Develop an asset management **framework** that contains the elements recommended in the gap assessment report. An asset management framework document should be created that includes (or provides reference to) the key components of the framework and defines the scope.		Resource requirements will be determined by the Strategic Plan	6 months; After Strategic Plan	Medium
		6. Develop an asset management **policy** that sets out the Department's vision and principles for asset management.			1 month	High
		3. Develop an asset management **strategy** for implementing the asset management program and enhancing the Department's asset management capability. It should document stakeholder needs and expectations and should build on this gap assessment.		Strategy set by Strategic Plan. Develop as part of AM Framework	2 months	High
		7. **Determine roles and responsibilities** for asset management activities and documented in the asset management framework document. Job descriptions should be updated accordingly.		Develop as part of framework document.		Medium
		22. Develop a formal process for **management of change** as part of the asset management framework. This should cover changes to: organizational structure, roles or responsibilities; the asset management policy, strategy or objectives; processes or procedures for asset management activities; new assets, asset systems or technology (including obsolescence); and new legal, regulatory and environmental responsibilities.		Internal.		Low
		28. As the asset management framework is implemented, the Department should **implement a review process** or self-audit process using internal Department staff.				Low
		29. A **management review process** should be established that consists of formal meetings with the Department management to review the performance of the assets and the asset management framework and identify opportunities for continual improvement.		As part of steering committee		Medium
4	Develop Water Department Resourcing Plan	12. **Develop a resourcing plan** for the Department which should include an assessment of staff needs to be able to do more proactive maintenance work, implement the asset management program and undertake the additional activities resulting from the program. The resourcing plan should also consider staff needs in supporting departments, including additional inspectors. Consider future staff competency requirements as part of the resourcing plan, and develop initiatives focused on both technical and people skills and maintaining or developing competencies in specific areas.			Ongoing - but initial plan 2 months. After Committee and Roles and Responsibilities.	High
		23. The Department should put in place a process to formally **assess risks of outsourced activities** and to ensure adequate controls are in place to mitigate the risks (it was noted by Department staff that Tampa Bay Water has some good case studies related to this concept, including what happens when you outsource the management of a project).				Medium
		25. **Additional inspection resources** need to be provided to manage critical work activities. The Department should look at other options if CAD cannot provide resources, such as using Department inspectors or contracting engineering consultants to provide inspectors.		Aligned with recommendation 12 and 23		High
		33. Develop a **plan for participation in industry events**, including attending local and national conferences. Consider opportunities to participate in industry benchmarking, including the AWWA performance indicators benchmarking.		Aligned with recommendation 12, 23 and 25.		High

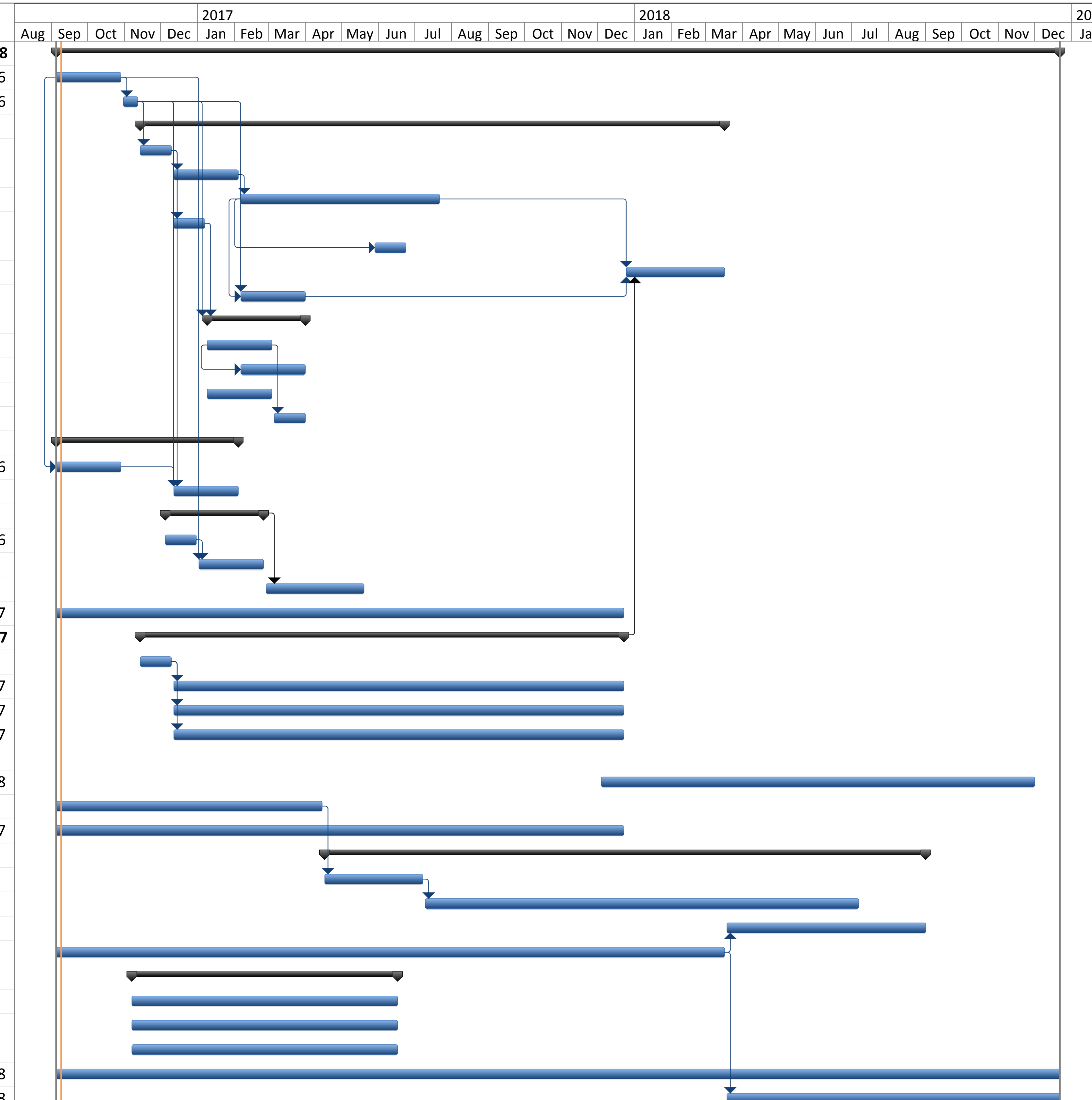
City of Tampa Florida

BLACK & VEATCH Building a world of difference.

Nr	Initiative	Recommendation	Lead	Resources / Notes	Timeframe	Priority
5	Develop Water Department Communications Plan	13. Develop a communications plan to formalize the Department's internal and external communications and support the asset management program. This should include a plan for customer outreach and survey to identify customer needs. The communications plan should ensure that staff is made aware of the asset management program and the asset management policy when it is issued. The change management aspects of the asset management program should be taken into account when developing and implementing the communications plan.			Survey in next 2 months to provide input into Strategic Plan	High
6	Develop Key Performance Indicators	10. **Review existing key performance indicators** currently reported to determine how appropriate they are and consider alternative or additional metrics.			Start. By Dec. 2016	High
		26. **Clearly define what metrics are to be monitored and reported**. This should include a review of what is reported on the City Dashboard to ensure that the most appropriate metrics reflecting levels of service are used. Consideration should be given to the performance metrics used in the AWWA *Benchmarking Performance Indicators for Water and Wastewater Utilities: Survey Data and Analyses Report* and the WRF/WERF report *Key Asset Data for Water and Wastewater Facilities*. Consideration should also be given to the metrics identified for each of the ten attributes of effectively managed water sector utilities as listed in *Effective Utility Management, A Primer for Water and Wastewater Utilities, 2008*.			After Strategic Plan. Dec 2016	High
7	Data Needs Assessment	14. Undertake a data needs assessment to determine what data is required for asset management (including planning, risk assessment, maintenance and operations), what the gaps are and what data quality improvement or additional data is needed. Focus should be centered on a) Data collection systems that are mobile and electronic in nature and b) "Normalize" or standardizing data input formats and c) And otherwise use best practices for database development / management.			Start early 2017 - 3 months	Medium
8	Implement Data Management Processes	15. Develop a formal standard and approach to collect, input, and extract data across divisions, including a training plan.			In process of implementing	Medium
9	Update Water Department Policies and SOPs	17. **Review existing Department policies** and update, retire or consolidate its policies as appropriate. This could include consolidation into separate technical manuals. Consideration should be given to consolidating technical manuals (i.e. TWD Technical Manual, TWD Reclaimed Technical Manual, TWD Cross Connection Control Technical Manual, etc.). The review should be extended past policies and technical manuals, and should also include ordinances, resolutions and SOPs with a goal of eliminating conflicting statements between the various document types. Policies should be centralized and organized to match the appropriate level in the organization chart (i.e. some policies are department wide, some policies only apply to a division or section). Identify who has signature authority to establish policies for which work groups.		Prefer consistent formatting, numbering, etc. before updating all SOPs and creating new ones.	Complete by 12/1/2017	Medium
		18. **Develop a document control procedure** that specifies the SOP and Policy creation and update process, the format of the documents, and document storage and retention requirements. Consideration should be given to using the Production SOP format as a standard format for the Department. Develop new SOPs and Policies using the new formats, and update existing SOPs and Policies when required.			Start 12/1/2016	High
		19. **Develop procedures for preventative maintenance activities** for water distribution assets that are missing. Reproduce existing Distribution procedures in electronic form to support updating and distribution. Review procedures for continuity with other departments and divisions.			Complete by 12/1/2017	Medium
10	Develop SOP for Incident Response, Investigation and Corrective Action	30. Develop an SOP for Production that covers incident response, investigation and corrective action. As required, further develop the Distribution SOP for incident response to include investigation, root cause analysis and corrective action.		Note: this is not an emergency response plan, but rather an investigation after an asset failure.	Complete by 12/1/2017	Medium
11	Update technical specifications	21. Develop a single technical specifications standard that can be referenced by all divisions, including standard specifications for treatment plants and pump stations.		including front end / Div 1 specs.	Start 12/1/2017	Medium
12	Implement Facilities Risk Management	8. As part of the WTF master plan project implement a risk-based approach for prioritizing capital improvement projects identified for the plant and pump stations.		part of the WTF Master Plan	Complete by 4/17/2016	Medium

Nr	Initiative	Recommendation	Lead	Resources / Notes	Timeframe	Priority
13	Emergency Response Improvements	9. Improve emergency response by conducting emergency planning drills on an annual basis and develop a formalized system restoration procedures manual. Drills could include gas release drills for the Production Division or main isolations for the Distribution Division.	City Emergency Management Dept.	Emergency Response Center actively working on system restoration plans	Complete by 12/1/2017	Medium
14	Develop Asset Management Plans	11. **Develop asset-specific asset management plans** based on the information that is available and most beneficial. Document the process for developing asset management plans.			Commence after WTF master plan report	Medium
		32. **Develop a valve exercising program** that takes into account valve criticality (e.g. transmission mains, location to critical customers). The program should include capturing data on valves and their GIS coordinates, including valves at the plant.		Start end of next year with UMS implementation	Starting Q1 2018	High
15	Implement Utility Management System	16. Implement a computerized maintenance management system (CMMS) to support standardized data collection, including moving from paper to electronic and mobile data collection, and track operations and maintenance activities and costs for Distribution.	IT Department		Has already started. Planned for Q1 2018	Medium
16	Contract Management Improvements	20. **Update the field inspection manual** including identifying steps to improve communication across all groups.			Start in Nov 16, End in June 17	High
		24. The Department's interactions with CAD should be re-assessed. A **"service-level" agreement** should be considered, where the Department is a client and the CAD is a service provider, so that CAD becomes more accountable for performance and financial efficiency. The Department should work with CAD to agree on the Department's **requirements for reporting of contractor performance** and determining what can be done to monitor and record contactor performance to ensure a poor performing contractor is suitably managed.				High
		27. CAD should put in place a more **formal process for monitoring and reporting on CIP projects** for the Department. This should include regular reporting on progress to the Department and identification of project issues (such as behind schedule, over budget, specific risks).				High
17	Production CMMS Improvements	31. Improve utilization of Production CMMS to capture equipment run times and use that information to inform maintenance planning. Also improve BCI information capture of I&C calibration data.		Part of SCADA Master Plan.	End 2018	Medium
18	Implement Cost Accounting	4. Cost accounting should be introduced to capture costs of work done on assets, so the Department can report how much it costs to replace one type of asset or repair another one.		Phase II of UMS. Strategic plan to identify what should be included in cost accounting	End 2018	Medium

ID		Task Mode	Task Name	Duration	Start	Finish
1			**Tampa Water Department Asset Management Program**	**600 days**	**Mon 9/5/16**	**Fri 12/21/18**
2			**1. Update Water Department Strategic Plan**	40 days	Mon 9/5/16	Fri 10/28/16
3			**2. Form AM Steering Committee**	10 days	Mon 10/31/1	Fri 11/11/16
4			**3. Develop AM Framework (including Policy, Strategy and Objec**	**350 days**	**Mon 11/14/1**	**Fri 3/16/18**
5			Develop AM Policy	20 days	Mon 11/14/1	Fri 12/9/16
6			Develop AM Strategy	40 days	Mon 12/12/1	Fri 2/3/17
7			Develop AM Framework Document	120 days	Mon 2/6/17	Fri 7/21/17
8			Determine Roles and Responsibilities	20 days	Mon 12/12/1	Fri 1/6/17
9			Develop Management of Change Process	20 days	Mon 5/29/17	Fri 6/23/17
10			Implement Internal Review Process	60 days	Mon 12/25/1	Fri 3/16/18
11			Implement Management Review Process	40 days	Mon 2/6/17	Fri 3/31/17
12			**4. Develop Water Department Resourcing Plan**	**60 days**	**Mon 1/9/17**	**Fri 3/31/17**
13			Assess Needs and Develop Resource Plan	40 days	Mon 1/9/17	Fri 3/3/17
14			Asses Risks of Outsourced Activities	40 days	Mon 2/6/17	Fri 3/31/17
15			Provide additional inspection resources	40 days	Mon 1/9/17	Fri 3/3/17
16			Develop Plan for Participation in Industry Events	20 days	Mon 3/6/17	Fri 3/31/17
17			**5. Develop Water Department Communications Plan**	**110 days**	**Mon 9/5/16**	**Fri 2/3/17**
18			Customer outreach and Survey	40 days	Mon 9/5/16	Fri 10/28/16
19			Develop Communications Plan	40 days	Mon 12/12/1	Fri 2/3/17
20			**6. Develop Key Performance Indicators**	**60 days**	**Mon 12/5/16**	**Fri 2/24/17**
21			Review Existing KPIs	20 days	Mon 12/5/16	Fri 12/30/16
22			Define Metrics to be Monitored and Reported	40 days	Mon 1/2/17	Fri 2/24/17
23			**7. Data Needs Assessment**	60 days	Mon 2/27/17	Fri 5/19/17
24			**8. Implement Data Management Processes**	340 days	Mon 9/5/16	Fri 12/22/17
25			**9. Update Water Department Policies and SOPs**	**290 days**	**Mon 11/14/1**	**Fri 12/22/17**
26			Develop Document Control Procedure	20 days	Mon 11/14/1	Fri 12/9/16
27			Review and Update Existing Policies	270 days	Mon 12/12/1	Fri 12/22/17
28			Develop and Update Water Distribution SOPs	270 days	Mon 12/12/1	Fri 12/22/17
29			**10. Develop SOP for Incident Response, Investigation and Corrective Action**	270 days	Mon 12/12/16	Fri 12/22/17
30			**11. Update Technical Specifications**	260 days	Mon 12/4/17	Fri 11/30/18
31			**12. Implement Facilities Risk Management**	160 days	Mon 9/5/16	Fri 4/14/17
32			**13. Emergency Response Improvements**	340 days	Mon 9/5/16	Fri 12/22/17
33			**14. Develop Asset Management Plans**	**360 days**	**Mon 4/17/17**	**Fri 8/31/18**
34			Document Process for Developing AM Plans	60 days	Mon 4/17/17	Fri 7/7/17
35			Develop Asset-Specific Asset Management Plans	260 days	Mon 7/10/17	Fri 7/6/18
36			Valve Exercising Program	120 days	Mon 3/19/18	Fri 8/31/18
37			**15. Implement Utility Management System**	400 days	Mon 9/5/16	Fri 3/16/18
38			**16. Contract Management Improvements**	**160 days**	**Mon 11/7/16**	**Fri 6/16/17**
39			Update Field Inspection Manual	160 days	Mon 11/7/16	Fri 6/16/17
40			Improve Contractor Performance Management	160 days	Mon 11/7/16	Fri 6/16/17
41			Improve Program Reporting	160 days	Mon 11/7/16	Fri 6/16/17
42			**17. Production CMMS Improvements**	600 days	Mon 9/5/16	Fri 12/21/18
43			**18. Implement Cost Accounting**	200 days	Mon 3/19/18	Fri 12/21/18



Project: msproj11
Date: Fri 9/9/16

Task | Summary | External Milestone | Inactive Summary | Manual Summary Rollup | Finish-only
Split | Project Summary | Inactive Task | Manual Task | Manual Summary | Deadline
Milestone | External Tasks | Inactive Milestone | Duration-only | Start-only | Progress

Appendix H

Risked Based Prioritization Technical Memorandum

FINAL

RISK BASED PIPELINE PRIORITIZATION

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

26 MAY 2017

Revision 1

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APPENDIX

1. Introduction

This technical memorandum summarizes the process used to assign a risk score and classification to each water main within the City of Tampa's (City) potable water service area. The resulting risk scores and classifications are then used to prioritize the City's risk based potable water main rehabilitation and replacement efforts.

2. Risk Based Prioritization Approach

The City is leveraging Innovyze's InfoMaster software to improve its risk-based prioritization methods. The risk-based prioritization model that incorporates the City's available GIS information and selected risk factors. **Appendix A** summarizes the risk-based prioritization results and **Appendix B** describes the methods used to review and analyze the City's GIS data. The risk factors consider likelihood of failure (LOF) and consequence of failure (COF) criteria as listed in **Table 1**. A workshop series was used to obtain concurrence on the relative importance and scoring scheme for each criterion considering customer service levels, economics, public health and public safety.

A scoring range of 1 to 5, where 5 is most likely to fail or has the greatest consequence, was used for the LOF and COF factors to align with InfoMaster's standard 5x5 risk matrix. A weighting factor was applied to each scoring criteria to determine the overall risk score of each individual pipe. The City is currently updating its potable water distribution hydraulic model and plans to incorporate the results into the risk-based prioritization scheme. A preliminary scoring scheme has been generated to accommodate the City's CIP budget schedule. The final scoring scheme will be implemented when results are available from the potable water system hydraulic model calibration effort.

Table 1: Likelihood of Failure and Consequence of Failure Criteria

CATEGORY	SELECTED CRITERIA	
Likelihood of Failure (LOF)	Breaks on Individual Pipe Segments	
	Remaining Life	
	Aggressive Soil Area	
Consequence of Failure (COF)	**Social / Health / Safety**	**Economics**
	Critical Customer Impact	Right-of-Way Ownership and Crossings
	Population Density	Water Demand
	Repeatable Breaks on Individual Pipe Segments	Diameter
	Contaminated Soil	Interconnect Location
	Additional Fire Hydrants	2015 Planned Paving Projects
	* Modeled Velocity/High Head Loss	
	* Available Fire Flow	
	* Service Main Replacements	
* Future criteria based on availability of model data		

3. Likelihood of Failure Criteria and Scoring Strategy

In coordination with City staff, likelihood of failure (LOF) factors and associated scoring and weighting were selected for use in the initial prioritization and planned future prioritization. The LOF factors are described in detail below and summarized in **Table 2** and **Appendix A**.

Table 2: Likelihood of Failure Summary

CRITERIA	ABBREVIATION	INFOMASTER ID	PRELIMINARY SCORING WEIGHT	FINAL SCORING WEIGHT
Breaks on Individual Pipe Segments	BR	WAT_LOF26 - BreakCnt_Updated_Normalized	45%	45%
Remaining Life	RL	WAT_LOF23 - RemainingLife_EstServiceLife	45%	45%
Aggressive Soil Area	AS	WAT_LOF22 - Aggressive Soil & Metallic Pipe	10%	10%

3.1 BREAKS ON INDIVIDUAL PIPE SEGMENTS (BR)

Water mains with historic failures are generally more likely to experience future failures. Therefore water main failure history is important to consider while projecting the likelihood that a water main will break in the future. The main break data maintained by the City is tracked by street address and consists of 6,025 water main break events. B&V developed a procedure to spatially associate a pipe with each documented main break and grouped the results based on high, medium, and low confidence. The detailed procedure is summarized in **Appendix B – Section 1**. The water main break count used in the risk analysis is based on water main breaks within the high and medium confidence level groups. 'Manmade' water main breaks, water main breaks with pipe size < 2", water main breaks associated with proposed pipes, and water main breaks that occurred prior to the pipe installation year are not counted towards the water main break count. A total of 4,435 water main breaks met this criteria and were used in the prioritization effort. Some pipe segments had numerous (up to 25) recorded breaks between fiscal years 2000 – 2015. The number of breaks was normalized by length of pipe in feet to assess the overall vulnerability of the pipe. The normalization provides a number of water main breaks per pipe length. An assigned scoring weight of 45% for initial prioritization and 45% for planned future prioritization will be applied in the risk calculations. The following scoring criteria were used:

1: 0 breaks
2: <= 0.0022 breaks/ft
3: 0.0022 - 0.0036 breaks/ft
4: 0.0036 - 0.0072 breaks/ft
5: 0.0072 - 1.8760 breaks/ft

3.2 REMAINING LIFE (RL)

Average estimated life expectancies by material were used to calculate the remaining life for each water main. A survival curve analysis was performed using the Kaplan-Meier methodology and incorporated the total observed population of water mains for each pipe material, the age of each water main as of year 2015, and the main break occurrences between years 2000 and 2015. The Weibull function was used to represent the survival probability for each pipe material. The average estimated life expectancies were determined based on the 50th percentile of the Weibull estimated survival probability. The average estimated life expectancies for pipe materials with insufficient data to support the survival curve analysis were based on the AWWA Buried No Longer 2012 report or assumed, applicable. The survival curve analysis is described in detail in the Data Quality Review and Survival Curve Technical Memorandum prepared by Black & Veatch (submitted April 2017). **Table 3** provides the average estimated life expectancies by material.

Table 3: Average Life Expectancy by Pipe Material

MATERIAL	AVERAGE LIFE EXPECTANCY (YEARS)
Asbestos Cement (1)	46
Cast Iron (1)	86
Copper (1)	40
Concrete Segments (Bolted) (2)	105
Clay Tile (3)	100
Ductile Iron (1)	88
Fiberglass Reinforced (1)	77
Galvanized Pipe (1)	101
High Density Polyethylene (1)	78
Polyethylene (1)	77
Polyvinyl Chloride (1)	77
Steel (2)	70
Transite (1)	46
Unlined Cast Iron (1)	80

(1) Average life expectancies are estimated at the 50th percentile of the Weibull survival probability curve. Fiberglass Reinforced and Polyethylene were assumed similar to PVC. Transite was assumed similar to Asbestos.
(2) AWWA Buried No Longer 2012 Report
(3) Assumed life expectancy
See Data Quality Review and Survival Curve Technical Memorandum prepared by Black & Veatch (submitted April 2017) for details.

The formula to calculate the remaining life is shown below.

Remaining Life Estimate

$$Remaining\ Life = (Install\ Year\ + Average\ Life\ Expectancy) - Year\ 2015$$

An assigned scoring weight of 45% for initial prioritization and 45% for planned future prioritization will be applied in the risk calculations. The following scoring criteria were used:

1: >15 years remaining life
2: 11 - 15 years remaining life
3: 6-10 remaining life
4: 2 - 5 years remaining life
5: <=1 year remaining life

3.3 AGGRESSIVE SOIL AREA (AS)

Aggressive soils adversely impact metallic pipe integrity increasing the likelihood of failure. Pipe materials considered susceptible to aggressive soils include cast iron (CAS), unlined cast iron (UCI), steel pipe (SP), galvanized pipe (GP), and ductile iron pipe (DIP). The Aggressive Soil Area criterion was defined in InfoMaster as a multi-parameter criterion that considers the aggressive soil areas and pipe material. A buffer of 50 ft around the areas identified as having aggressive soils was used to select all pipes that may touch or are close to the edge of the defined area. Scoring is limited to two options based on whether a pipe is within a defined aggressive soil area (given a score of 5) or not within a defined aggressive soil area (given a score of 1). Non-metallic pipes were given a score of 1. An assigned scoring weight of 10% for initial prioritization and 10% for planned future prioritization will be applied in the risk calculations.

4. Consequence of Failure Criteria and Scoring Strategy

In coordination with City staff, consequence of failure (COF) factors and associated scoring and weighting were selected for use in the initial prioritization and planned future prioritization. The COF factors are described in detail below and summarized in **Table 4** and **Appendix A**.

Table 4: Consequence of Failure Summary

CATEGORY	CRITERIA	ABBREVIATION	INFOMASTER ID	PRELIMINARY SCORING WEIGHT	FINAL SCORING WEIGHT
Social/ Health/ Safety	Critical Customer Impact	CC	WAT_COF23 - Critical Customers_Basedon Pipe	15%	10%
	Population Density	PD	WAT_COF14 - Population Density	10%	10%
	Repeatable Breaks on Individual Pipe Segments	RBR	WAT_COF24 - Repeatable Breaks_BreakPipe	5%	5%
	Contaminated Soil	CS	WAT_COF39-Contaminated Soils_All	10%	5%
	Additional Fire Hydrants	FH	WAT_COF41 - Additional FHAs	5%	5%
	*Modeled Velocity/High Head Loss	MV	Not Used	0%	10%
	*Available Fire Flow	FF	Not Used	0%	10%
	*Service Line Replacements	SL	Not Used	0%	5%
Economics	Right-of-Way Ownership and Crossings	RCX	WAT_COF45 - ROW_WaterCrossing	10%	5%
	Water Demand	WD	WAT_COF47 - Water Demand_Diam	15%	10%
	Diameter	DIA	WAT_COF5 - Diameter	15%	10%
	Interconnect Location	IC	WAT_COF15 - InterConnectLocs_Intersect	10%	10%
	2015 Planned Paving Projects	PP	WAT_COF40 - Paving Plan	5%	5%

* Future criteria

4.1 SOCIAL/ HEALTH/SAFETY CRITERIA

4.1.1 Critical Customer Impact (CC)

Water mains serving critical customers (hospitals, jails, sensitive areas, etc.) are assigned a higher consequence risk factor due to possible environmental impacts or loss of service to nearby critical customers. Scoring is limited to two options based on whether a pipe serves a critical customer (given a score of 5) or does not serve a critical customer (given a score of 1). An assigned scoring weight of 15% for initial prioritization and 10% for planned future prioritization will be applied in the risk calculations. The following is a brief overview of the critical customers that were associated to pipes in the GIS network. **Appendix B - Section 3** provides additional detail on the methodologies that were used to associate pipes to critical customers.

- Critical customers included the following:
    - Top 20 users based on FY2015 water demand
    - Airports
    - Hospitals
    - Jails
    - Macdill Airforce Base
    - Port of Tampa
    - Schools and the University of South Florida campus
- EOC-ERC Facilities (2015 Critical Facilities) included the following:
    - Main Crossings
    - Adult Day Care Center, Adult Family Care Home, Ambulatory Surgical Center, Assisted Living Facility, Com Center, Crisis Stabilization Unit/ Short Term Residential Treatment Facility, Dam / Operation Shelter, Data Center, Elevated Water Tank, EOC, Fire Station, Hospital, Nursing Home, Police Department, Residential Treatment Facility, Shelter, W Pump Station, W Storage Tank, Water Treatment Plant & Storage, WW Treatment Plant
- Sensitive Areas
    - Davis Islands, Downtown, Harbor Island, Hyde Park, SOHO, Westshore, Ybor
- Tourist Attractions
    - Art Museums, Cruise Terminals, Performing Arts Center, Sports Arenas, Busch Gardens Tampa Bay, The Florida Aquarium, Adventure Island, Glazer Children's Museum, Lowry Park Zoo

4.1.2 Population Density (PD)

Pipes serving denser population areas were considered more critical due to the number of customers potentially impacted by a water main failure. An assigned scoring weight of 10% for initial prioritization and 10% for planned future prioritization will be applied in the risk calculations. The following scoring criteria were used:

1: <= 3 pop/ac
2: 3 - 7 pop/ac
3: 7 - 10 pop/ac
4: 10 - 15 pop/ac
5: > 15 pop/ac

4.1.3 Repeatable Breaks on Individual Pipe Segments (RBR)

Water main breaks were considered as a consequence of failure due to a) Impacts to the public during water main break repairs and b) The public's desire to reduce water main repair frequency. The same data that is described in Section 3.1 was used for this criteria. An assigned scoring weight of 5% for initial prioritization and 5% for planned future prioritization will be applied in the risk calculations. The following scoring criteria were used (same as LOF):

1: 0 breaks
2: <= 0.0022 breaks/ft
3: 0.0022 - 0.0036 breaks/ft
4: 0.0036 - 0.0072 breaks/ft
5: 0.0072 - 1.8760 breaks/ft

4.1.4 Contaminated Soil (CS)

A pipe failure within a known contaminated soil area could cause health and safety impacts to the surrounding system and increase repair costs. Scoring is limited to two options and is based on whether a pipe is within a defined contaminated soil area (given a score of 5) or not within a defined contaminated area (given a score of 1). The contaminated soil areas were based on jet fuel lines identified by the City and information maintained by the Florida Department of Environmental Protection (FDEP) (available for download at http://geodata.dep.state.fl.us/). The FDEP contaminated areas included all sites listed in each of the datasets listed below.

- Brownfield sites
- Clean-up sites
- State cleanup areas
- Hazardous waste areas
- Fuel facilities
- Solid waste facilities

The FDEP contaminated soils data sets were combined into two data sets; one for point features and the other for polygon features. The jet fuel line and FDEP datasets were analyzed separately and then combined as a multi-parameter criterion to calculate the COF score for each water main. Pipes were selected based on a buffer of 300 ft around the identified contaminated soil areas. A 300 ft buffer was also used around jet fuel lines identified by the City. An assigned scoring weight of 10% for initial prioritization and 5% for planned future prioritization will be applied in the risk calculations.

4.1.5 Additional Fire Hydrants (FH)

The City installs fire hydrants per its spacing standards as part of all water main installation projects provided sufficient fire flow capacity is being installed. Increasing the number of fire hydrants within the water system provides additional public safety benefits to the City. Detailed information on how the number of potential new fire hydrants for each water main segment was determined is included in **Appendix B – Section 2**. The scoring and weighting for this criterion will be used to adjust the overall risk score by assigning a higher score to pipes that will add more hydrants. An assigned scoring weight of 5% for initial prioritization and 5% for planned future prioritization will be applied in the risk calculations. The following scoring criteria were used:

1: 0 additional hydrants (100% of pipe length is within Fire Hydrant Area)
2: 1 additional hydrant (length of pipe outside Fire Hydrant Area >0 and <= 450ft)
3: 2 additional hydrants (length of pipe outside Fire Hydrant Area >450 and <= 900ft)
4: 3 additional hydrants (length of pipe outside Fire Hydrant Area >900 and <= 1,350)
5: >=4 additional hydrants (length of pipe outside Fire Hydrant Area > 1,350)

4.1.6 Modeled Velocity/High Headloss (MV)

Modeled velocity and / or high headloss is not included in the initial prioritization; however, will be considered in the planned future prioritization. An assigned scoring weight of 10% for planned future prioritization will be applied in the risk calculations.

4.1.7 Additional Fire Flow (FF)

Additional fire flow is not included in the initial prioritization; however, will be considered in the planned future prioritization. An assigned scoring weight of 10% for planned future prioritization will be applied in the risk calculations.

4.1.8 Service Line Replacement (SL)

As part of water main projects, the City considers replacement of service lines when possible. The scoring and weighting will be used to adjust the overall risk score by assigning a higher risk score to pipes that will replace more service lines. Service line replacements are not included in the initial prioritization; however, will be considered in the planned future prioritization update. An assigned scoring weight of 5% for planned future prioritization will be applied in the risk calculations.

4.2 ECONOMIC CRITERIA

4.2.1 Right-of-Way Ownership/Crossings (RCX)

The repair costs for water main breaks within the right-of-way (ROW) ownership of major roads, railroads and/or water bodies can be significant. Each of the three ROW criteria were developed separately and then combined as a multi-parameter criterion to calculate the COF score for each water main. The following buffers were used to identify pipes within costly ROWs: 50 ft buffer from the center line of local/collector road and arterial road; 100 ft buffer from the centerline of a railroad or federal/state highway. Water body crossings were scored based on whether the pipe crossed the water body or not. An assigned scoring weight of 10% for initial prioritization and 5% for planned future prioritization will be applied in the risk calculations. The following scoring criteria were used:

1: Not within a Railroad or Road (local/collector/arterial/highway) ROW; Does not cross water body
2: Within Local/Collector Road ROW
3: Within Arterial Road ROW
4: Not Used
5: Within Railroad ROW or Fed/State Highway ROW; Crosses water body

4.2.2 Water Demand (WD)

Using the InfoMaster valve criticality tool, the valve isolation areas (or termed “pounding areas” in InfoMaster) were identified and subsequently the water demand associated with each valve isolation area. This criterion is used to determine the magnitude of service disruption due to a water main failure within the valve isolation area. The FY2015 average annual water meter data was used to determine the water demand within the valve isolation area. The total average annual water demand was applied to all water main segments in the isolation area. If a meter was not assigned to a valve isolation area, flow was not allocated to the water main segments. In these cases, a score of “1” was assigned to water main segments with a diameter of 14-inch or less and a score of “3” was assigned to water main segments with a diameter of 16” and greater. An assigned scoring weight of 15% for initial prioritization and 10% for planned future prioritization will be applied in the risk calculations. The following scoring criteria were used:

1: <5,000 gpd, <14” water main segments where flow was not assigned to an isolation area
2: 5,000 - 20,000 gpd
3: 20,000 - 50,000 gpd, >=14” water main segments where flow was not assigned to an isolation area
4: 50,000 - 100,000 gpd
5: > 100,000 gpd

4.2.3 Diameter (DIA)

Typically if a larger main fails the impact to the surrounding area in the form of decreased system pressure, ability to operate water facilities, etc. is greater and the replacement costs can be higher. Therefore the water main diameter was included as a criterion to weight larger water mains higher. An assigned scoring weight of 15% for initial prioritization and 10% for planned future prioritization will be applied in the risk calculations. The following scoring criteria were used:

1: <= 6 inch
2: 8 inch
3: 10 inch - 12 inch
4: 14 inch - 24 inch
5: >= 30 inch

4.2.4 Interconnect Location (IC)

Pipes serving wholesale customers were considered to be a higher economic risk to the City due to customer inconveniences, contract requirements, and loss of revenue. Scoring is limited to two options and is based on whether a pipe serves a wholesale customer (given a score of 5) or does not serve a wholesale customer (given a score of 1). An assigned scoring weight of 10% for initial prioritization and 10% for planned future prioritization will be applied in the risk calculations. The wholesale customers at the following connection addresses were included as follows:

- Hillsborough County
  - 9135 Florida Mining Blvd
  - 5103 E Kirby St
  - 2606 S 82nd Ave
  - 70th & Kingston Dr

  - 2424 S 70th Ave
  - 4200 S 78th St
  - 5398 Old US Hwy 41A
  - US 301 / HC Interconnect
  - Pebble Creek
- Tampa Bay Water
  - Morris Bridge WTP
  - North Boulevard
  - US 301 / Causeway Blvd

4.2.5 2015 Planned Paving Projects (PP)

The City considers inclusion of water main replacement projects as part of road paving projects due to economic reasons. If a pipe is within a planned road paving project area it will be assigned a higher risk score based on the City's road paving schedule. An assigned scoring weight of 5% for initial prioritization and 5% for planned future prioritization will be applied in the risk calculations. Scoring is based on the year of the planned road paving project as follows:

1: >= 5 Years (2021 planning year or greater); not within a planned road paving project
2: Within 4 years (2020 planning year)
3: Within 3 years (2019 planning year)
4: Within 2 years (2018 planning year)
5: Within 1 year (2015, 2016, 2017 planning year)

5. Risk Analysis

5.1 RISK SCORE

An overall risk score is calculated for each water main segment. The overall risk score is calculated by multiplying the total LOF score and the total COF score.

To determine the total LOF score, each individual LOF factor is multiplied by the assigned weighting and then summed. To determine the COF score, each individual COF factor is multiplied by the assigned weighting and summed. The criteria weightings for each LOF and COF criteria are shown in **Table 5**. The formula used to calculate the overall risk score for each water main segment is as follows:

$$\begin{aligned} \mathit{Overall\ Risk\ Score} &= [(L_{BR} \times W_{BR}) + (L_{RL} \times W_{RL}) + (L_{AS} \times W_{AS})] \times [((C_{CC} \times W_{CC}) + (C_{PD} \times W_{PD}) \\ &+ (C_{RBR} \times W_{RBR}) + (C_{CS} \times W_{CS}) + (C_{FH} \times W_{FH}) + (C_{RCX} \times W_{RCX}) + (C_{WD} \times W_{WD}) \\ &+ (C_{DIA} \times W_{DIA}) + (C_{IC} \times W_{IC}) + (C_{PP} \times W_{PP}) \end{aligned}$$

Table 5: Criteria Weightings

CRITERIA		PRELIMINARY SCORING WEIGHT (W)
Likelihood of Failure (L)		
Breaks on Individual Pipe Segments	BR	45%
Remaining Life	RL	45%
Aggressive Soil Area	AS	10%
Consequence of Failure (C)		
Critical Customer Impact	CC	15%
Population Density	PD	10%
Repeatable Breaks on Individual Pipe Segments	RBR	5%
Contaminated Soil	CS	10%
Additional Fire Hydrants	FH	5%
Right-of-Way Ownership and Crossings	RCX	10%
Water Demand	WD	15%
Diameter	DIA	15%
Interconnect Location	IC	10%
2015 Planned Paving Projects	PP	5%

5.2 RISK CLASSIFICATION

To determine the risk classification for each water main segment (referred to as Risk “By Grading” in the InfoMaster results), the Bi-Directional Distribution risk assessment method using a 5x5 risk matrix is utilized. The 5x5 risk matrix classifies the overall risk scores into low, medium low (M. low), medium, medium high (M. high), and high levels. The overall risk score range for each risk classification is user defined (or risk “by grading”). The risk classifications range from negligible to extreme as shown in **Figure 1**. The risk classification (risk (by grading)) for each water main segment is based on where the LOF and COF scores intersect within the matrix.

	LOF - Low	LOF - M. Low	LOF - Medium	LOF - M. High	LOF - High
COF - High	Medium	Medium	High	Extreme	Extreme
COF - M. High	Medium	Medium	High	High	Extreme
COF - Medium	Low	Medium	Medium	High	High
COF - M. Low	Negligible	Low	Medium	Medium	High
COF - Low	Negligible	Negligible	Low	Medium	High

Figure 1: Overall Risk Score Classification Matrix

As part of the bi-directional risk method set-up within InfoMaster, the lower and upper boundaries of the COF and LOF scores can be determined either “By Percentage” or “By Value”. The “By Value” method uses the calculated COF and LOF total scores and classifies each water main segment within user defined ranges as shown in **Figure 2**. The City selected the “By Value” method. This allows the City to a) Utilize the overall risk score distribution as an annual performance metric and b) Consistently identify the higher risk water main segments year to year.

Two examples are provided below to demonstrate how pipes were classified into the risk levels.

- Pipe ID 1853815 has a COF score of 3.15 (M. High) and a LOF score of 5.0 (High); therefore the risk level/risk (by grading) is Extreme.
- Pipe ID 1846702 has a COF score of 3.4 (M. High) and a LOF score of 1.0 (Low); therefore the risk level/risk (by grading) is Medium.

The alternative InfoMaster method of the bi-directional risk method, “By Percentage”, divides the overall score for COF and LOF for each pipe by the highest overall COF and LOF score and then uses the lower to upper boundary percentage ranges to classify the pipes into the defined risk levels. The “By Percentage” method provides a continuous update on the highest priority pipes based on the percentage of the overall COF and LOF score ranges.

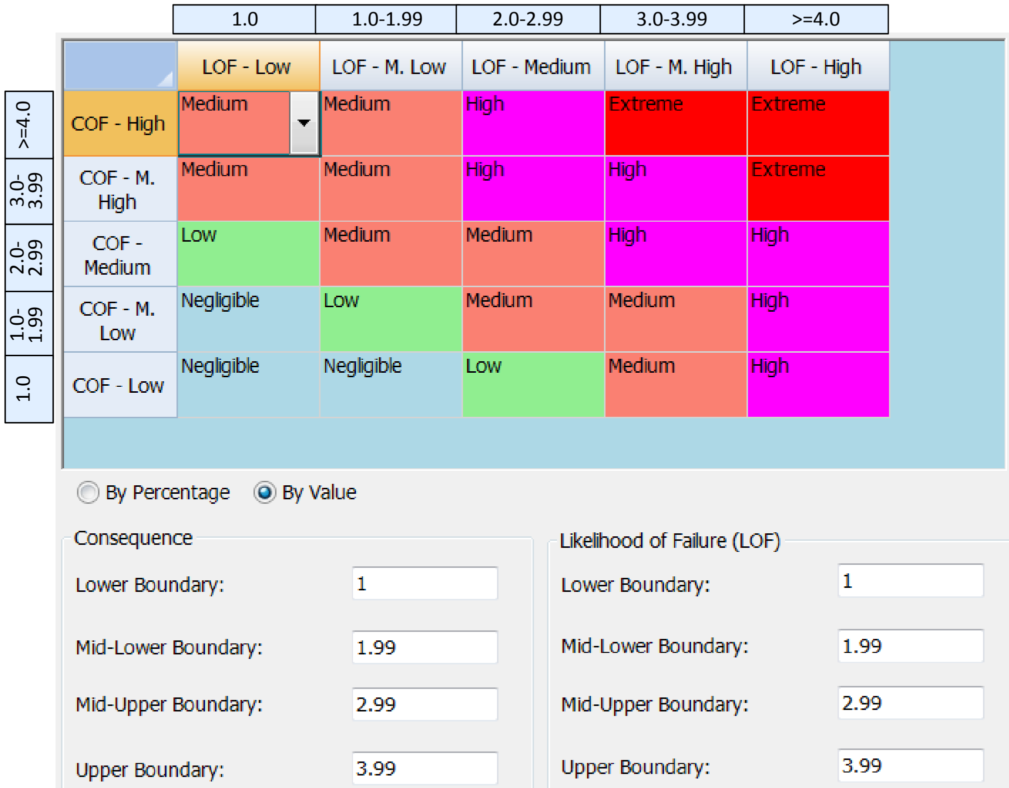


Figure 2: Bi-Directional Risk Method – By Value

6. Results Summary

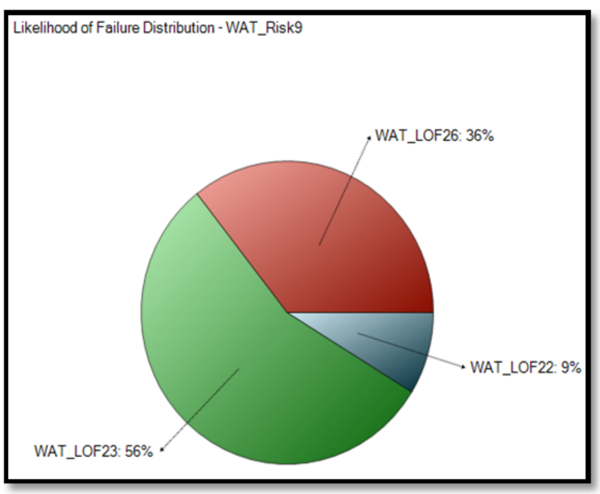
6.1 OVERALL RISK SCORING RESULTS

The results of the COF and LOF contribution using the "By Value" method are shown in **Figure 3**. Water main segments not active or owned by the City of Tampa were not included in the results. **Figure 4** and **Figure 5** show the percent contribution of each of the LOF and COF factors. The percent contribution is determined by summing the scores calculated for an individual LOF/COF factor of all water main segments and dividing by the overall total sum for all LOF/COF factors. A 22x34 figure showing the risk levels by water main (Figure C-1) is also included in **Appendix C**. InfoMaster includes a custom report tool that summarizes the overall risk analysis as an HTML link. This report can be accessed in the InfoMaster files provided. The HTML report includes a risk summary details and consequence of failure and likelihood of failure summary details.

COF and LOF Contribution

	LOF - Low	LOF - M. Low	LOF - Medium	LOF - M. High	LOF - High
COF - High	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles
COF - M. High	293 Pipes, 16.9 miles	118 Pipes, 6.3 miles	64 Pipes, 3.1 miles	9 Pipes, 0.4 miles	1 Pipes, 0.0 miles
COF - Medium	10391 Pipes, 308.0 miles	1707 Pipes, 70.4 miles	3080 Pipes, 83.0 miles	388 Pipes, 19.2 miles	95 Pipes, 5.1 miles
COF - M. Low	54200 Pipes, 1187.4 miles	4939 Pipes, 169.8 miles	10463 Pipes, 230.3 miles	502 Pipes, 30.8 miles	268 Pipes, 14.3 miles
COF - Low	79 Pipes, 1.0 miles	15 Pipes, 0.1 miles	3 Pipes, 0.1 miles	0 Pipes, 0.0 miles	0 Pipes, 0.0 miles

Figure 3: Bi-Directional Risk Method – By Value Risk Matrix Results



INFOMASTER ID	CRITERIA
WAT_LOF22	Aggressive Soil Area
WAT_LOF23	Remaining Life
WAT_LOF26	Breaks on Individual Pipe Segments

Figure 4: LOF Contribution to Risk Scoring

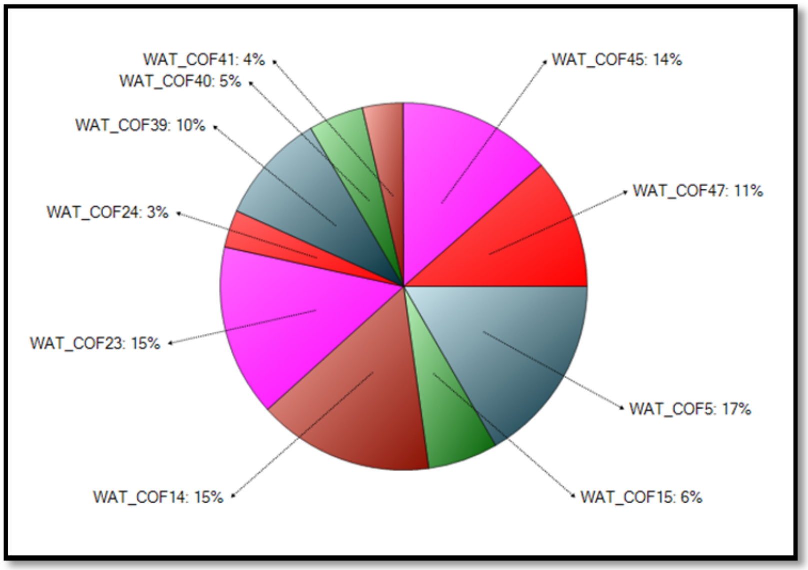


Figure 5: COF Contribution to Risk Scoring

INFOMASTER ID	CRITERIA
WAT_COF5	Diameter
WAT_COF14	Population Density
WAT_COF15	Interconnect Location
WAT_COF23	Critical Customer Impact
WAT_COF24	Repeatable Breaks on Individual Pipe Segments
WAT_COF39	Contaminated Soil
WAT_COF40	2015 Planned Paving Projects
WAT_COF41	Additional Fire Hydrants
WAT_COF45	Right-of-Way Ownership and Crossings
WAT_COF47	Water Demand

6.2 LINEAR ASSET R&R GAP ANALYSIS RESULTS

To support TWD in future decision making towards water distribution rehabilitation and replacement (R&R) system planning, a gap analysis was performed based on current funding versus total and annual replacement cost needs. Valve, fire line service, hydrant, and distribution main replacement needs were included in the analysis. The following **Table 6** and **Figure 6 – Figure 8** provide a summary of the gap analysis results. Assumptions used to support the gap analysis are provided in **Appendix D**.

Table 6: Total and Annual Replacement Costs

CATEGORY TYPE	TOTAL COUNT/ LENGTH (MI)	TOTAL REPLACEMENT COST	REPLACEMENT / REHABILITATION SCHEDULE	ANNUAL COST
Valve	49,704	$904,772,541	20-year (Replace)	$45,239,000
Fire Line Services	2,571	$40,880,323	86-year (Replace)	$475,000
Hydrant	14,094	$581,096	20-year (Rehab)	$29,000
Distribution Mains	2,146 mi	$3,448,968,221	Varies (Replace)	--

Assumptions:
1 Base/Fee/Rate charges assumed to increase at a rate matching inflation. All dollar values shown in 2018 dollars.
2 Developer funded pipeline R&R rate is reduced by 50% to account for pipes being taken out of service prior to the pipe being in service for its entire projected lifespan.
3 Domestic & irrigation service replacements are included in the pipeline R&R $/ft estimates

Figure 6: Annual Replacement Cost (Years 2018 – 2103) versus City and Developer Current Funding Rate

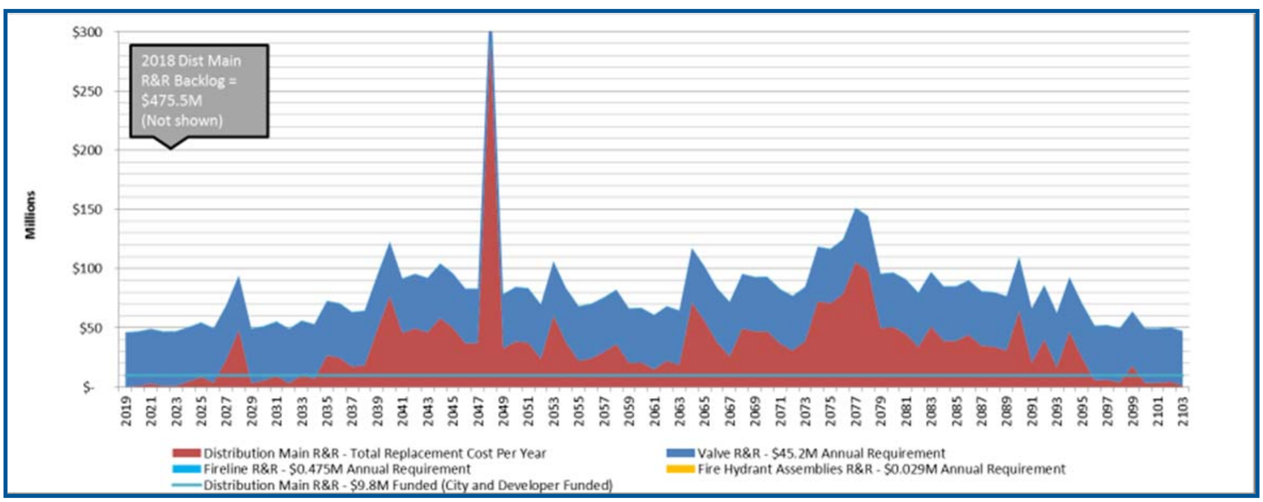


Figure 7: Annual Replacement Cost (Years 2018 – 2037) versus City and Developer Current Funding Rate

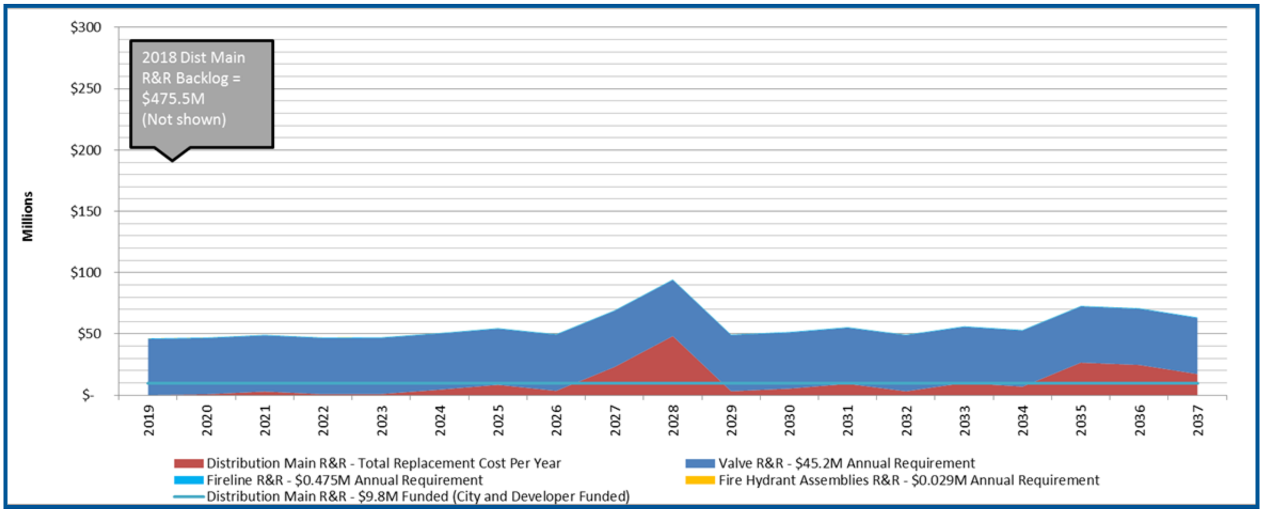
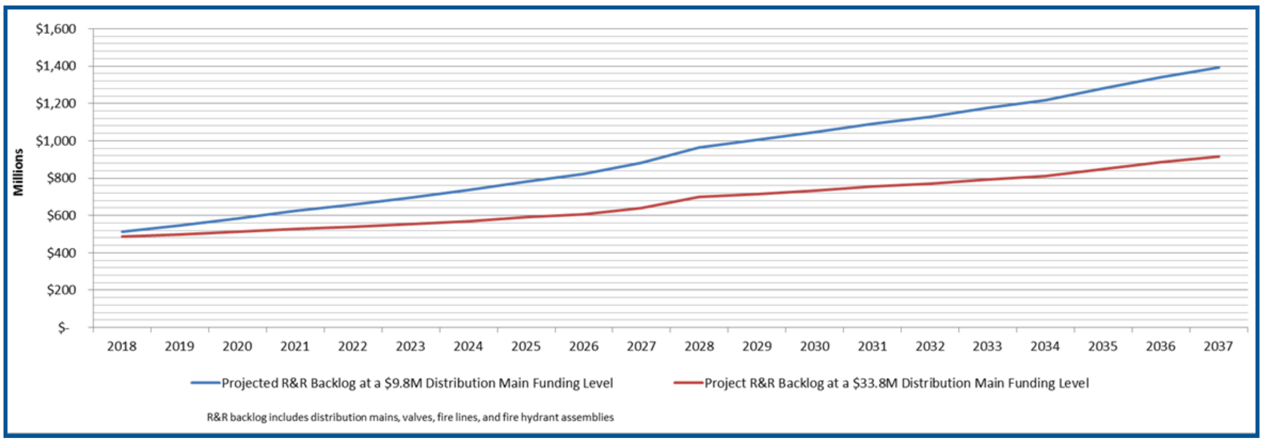


Figure 8: Projected R&R Backlog at Various Distribution Main Funding Levels



Note: Funding levels are based on distribution main replacement costs needed up to year 2037

6.3 VALVE REPLACEMENT DECISION TOOL

Black & Veatch developed a spreadsheet tool to support TWD in standardizing the decision making process for valve replacement. Two options are considered for evaluation:

- Option A represents immediate valve replacement, with later pipe and valve replacement. The immediate valve replacement cost (present value) and cost of pipe and valve replacement at end of the life (present value) are summed together for a total present value cost and comparison to Option B.

- Option B represents immediate pipe and valve replacement. The cost for immediate pipe and valve replacement (present value) is calculated for comparison to Option A. This option would be economical when the remaining life of the pipe is limited.

All costs and calculations are presented as present value. Appendix E provides further details on the set-up and calculations used in the spreadsheet template. The spreadsheet tool was provided to TWD separately in Microsoft Excel format.

Appendix A— Likelihood and Consequence of Failure Criteria Summary

	INITIAL PRIORITIZATION MATRIX										PLANNED FUTURE PRIORITY MATRIX
	Criteria	Criteria Comment	Data Source	Scoring Criteria					Scoring Weight	
				1	2	3	4	5		
Likelihood of Failure	Breaks on Individual Pipe Segments	Number of reported breaks on individual pipe segment between FY2000 - FY2015. Break count based on high and medium confidence level breaks (see confidence level definitions, excludes 'manmade' break types, breaks with pipe size < 2", proposed pipes). Includes 4,435 High/Medium confidence breaks out of 6,025 total breaks. Number of breaks normalized by pipe length in feet.	Main break shapefiles FY2000-FY2015; wMains - Water_Infrastructure.gdb	0 breaks	<= 0.0022 breaks/ft	0.0022 - 0.0036 breaks/ft	0.0036 - 0.0072 breaks/ft	0.0072 - 1.8760 breaks/ft	45%	45%
	Remaining Life	Average estimated life expectancies by pipe material were used to calculate the remaining life for each water main.	Survival Curve Analysis	>15 years remaining life	11 - 15 years remaining life	6-10 years remaining life	2 - 5 years remaining life	<=1 year remaining life	45%	45%
	Aggressive Soil Area	Pipes (only consider metallic pipes - UCI, CAS, SP, GP, DIP) within Port Tampa Bay, Davis Islands, Harbor Islands, "Fingers" in South Tampa. Used a 50ft buffer to get all pipes that may touch or are close to polygon edge of defined area.		Pipe not within aggressive soil; Non-metallic pipe	--	--	--	Metallic pipe within aggressive Soil	10%	10%
	Total LoF Score								**100%**	**100%**

		INITIAL PRIORITIZATION MATRIX										PLANNED FUTURE PRIORITY MATRIX
		Criteria	Criteria Comment	Data Source	Scoring Criteria					Scoring Weight	
					1	2	3	4	5		
Consequence of Failure	Social/Health/Safety	Critical Customer Impact	Top 20 users, airports, hospitals, jails, Macdill Airforce Base, Port of Tampa, Schools/USF, EOC-ERC facilities, Sensitive Areas (Davis Islands, Harbor Island, Downtown, Hyde Park, SOHO, Westshore, Ybor), Sports Arenas, Art Museums, Cruise Terminals, Performing Arts Center, Tourist Attractions (Busch Gardens Tampa Bay, The Florida Aquarium, Adventure Island, Glazer Children's Museum, Lowry Park Zoo)	Water_Meters.shp, Tax_Parcels_20150924.shp, CriticalFacilities2015.shp, ESRI Data	Pipe does not serve critical customer	--	--	--	Pipe serves critical customer	15%	10%
		Population Density	Higher score assigned to mains serving denser populations	2010taz_5yr_pop_data_to_map.shp - based on 2015 population and acres	<= 3 pop/ac	3 - 7 pop/ac	7 - 10 pop/ac	10 - 15 pop/ac	> 15 pop/ac	10%	10%
		Repeatable Breaks on Individual Pipe Segments	Number of reported breaks on individual pipe segment between FY2000 - FY2015. Break count based on high and medium confidence level breaks (see confidence level definitions, excludes 'manmade' break types, breaks with pipe size < 2", proposed pipes). Includes 4,435 High/Medium confidence breaks out of 6,025 total breaks. Number of breaks normalized by pipe length in feet.	Main break shapefiles FY2000-FY2015	0 breaks	<= 0.0022 breaks/ft	0.0022 - 0.0036 breaks/ft	0.0036 - 0.0072 breaks/ft	0.0072 - 1.8760 breaks/ft	5%	5%
		Contaminated Soil	The contaminated soil areas were based on jet fuel lines identified by the City and information maintained by the Florida Department of Environmental Protection (FDEP) including brownfield sites, clean-up sites, state cleanup areas, hazardous waste areas, fuel facilities, solid waste facilities. Pipes were selected based on a buffer of 300 ft around the identified contaminated soil areas.	FDEP Sources (WASTE_FACS_PT_ST.shp, STATE_CLEANUP_SP.shp, HAZWASTE_SP.shp, CLEANUP_SITES_SP.shp, FUEL_FACILITIES.shp, BROWNFIELD_SITES.shp, BROWNFIELD_AREAS.shp); JetFuel_Ammonia_Lines.shp	Pipe not within contaminated area	--	--	--	Pipe within contaminated area	10%	5%
		Additional Fire Hydrants	Based on current hydrants along pipe and determining additional hydrants needed using 450ft along pipe.	wLateralLines, wHydrants - Water_Infrastructure.gdb	0 additional hydrants	1 additional hydrant	2 additional hydrants	3 additional hydrants	>=4 additional hydrants	5%	5%
		Modeled Velocity/High Head Loss	Based on model data		TBD	TBD	TBD	TBD	TBD	0%	10%
		Available Fire Flow	Based on model data		TBD	TBD	TBD	TBD	TBD	0%	10%
		Service Line Replacements	Considered as an added value to the City where the more service mains that can be replaced with a pipe project the higher the score.	wLateralLines - Water_Infrastructure.gdb	TBD	TBD	TBD	TBD	TBD	0%	5%

		INITIAL PRIORITIZATION MATRIX										PLANNED FUTURE PRIORITY MATRIX
		Criteria	**Criteria Comment**	**Data Source**	**Scoring Criteria**					**Scoring Weight**	
					1	**2**	**3**	**4**	**5**		
Consequence of Failure	**Economical**	Right-of-Way Ownership/Crossings	Assign highest score based on 3 parameters: Within Railroad ROW, Within Road ROW, and Water Body Crossing. 50ft buffer used for local/collector road and arterial road. 100ft buffer used for railroad and Fed/State Highway	Railroads_20150925, Road_Centerlines_20150924, Water_Facilities_TWD.shp	Not within a railroad or road ROW or Does not cross water body	Within Local/Collector Road ROW	Within Arterial Road ROW	--	Within Railroad ROW or Within Fed/State Highway ROW or Crosses water body	10%	5%
		Water Demand	Calculated total annual average demand per valve isolation area (area between the valves is a pounding area) – total water demand applied to all segments in valve isolation area	Water_Meters.shp	<5,000 gpd; <14" water main segments where flow was not assigned to isolation area	5,000 - 20,000 gpd	20,000 - 50,000 gpd; >=14" water main segments where flow was not assigned to isolation area	50,000 - 100,000 gpd	> 100,000 gpd	15%	10%
		Diameter	Larger mains assumed to have higher consequence and replacement cost	wMains - Water_Infrastructure.gdb	<= 6"	8"	10" - 12"	16" - 24"	>= 30"	15%	10%
		Interconnect Location	Pipes serving a wholesale customer (Hillsborough County and Tampa Bay Water)	COT_Interconnect.shp	Does not serve wholesale customer	--	--	--	Serves wholesale customer	10%	10%
		2015 Planned Paving Projects	Water main projects will be considered with planned paving projects. Scoring criteria is used to increase overall score if pipes are within a planned paving project area (50 ft buffer used).	PavingPlan.shp (2015 planned projects)	>= 5 years (2021 planning year or greater)	Within 4 years (2020 planning year)	Within 3 years (2019 planning year)	Within 2 years (2018 planning year)	Within 1 year (2015, 2016, 2017 planning year)	5%	5%
		Total CoF Score								**100%**	**100%**

Appendix B— GIS Methods Summary

1 Main Break and GIS Data Preparation

The following sections discuss the methods that were used to prepare the water main break and potable water mains for the risk based prioritization analysis.

1.1 MAIN BREAK DATA

Water main break data was provided by the City in GIS shapefile format for fiscal years 2000 through 2015. The main break shapefiles containing a total of 6,025 records were merged into a single "master" main break point feature class.

1.1.1 Main Break Fields

The following fields were extracted from each main break shapefile and appended to the "master" main break feature class.

- "KIND_OF_PIPE" – Water main material recorded at break location
- "REPORTDATE" – Date on which main break incident occurred
- "PIPE_SIZE" - Water main diameter recorded at break location
- "ADDRESS" – Full street address at break location
- "TYPE_OF_BREAK" – location / direction of break on pipe (e.g. "circ", "join", "mnmd")

1.1.2 Main Break Data Review

The master main break feature class was reviewed for attribute consistency. For example, diameters such as "2/25" and "360" were changed to "2.25" and "36" respectively. In addition, material values in the master main break feature class were modified to be consistent with material domain values in the water mains feature class. This included the following changes:

- Changed "DI" to "DIP"
- Changed "CI", "CAS", "CIQ", "CIR" to "CAS"
- Changed "GLAV", "GALV" to "GP"
- Changed "PVD" for three records to "PVC"
- Changed "ENAM" (enameled cast iron) to "CAS"

In addition, to maximize potential matching water main candidates, main breaks with a recorded diameter of 1.x (e.g. 1.25, 1.5) or 2.x (e.g. 2.25) were changed to 1" or 2" respectively. This was done to water mains with 1.x or 2.x diameters as well to ensure potential matches with main breaks. Lastly, the City indicated to exclude main break records identified as manmade ("mnmd" or "nmmd") in the "TYPE_OF_BREAK" field; 104 records were removed from the master main break features class.

1.2 GIS DATA PREPARATION

1.2.1 Water Mains with Missing Installation Date

The City provided B&V with a spreadsheet ("Water_Main_Install_Date (SENT 20151223).xls") containing updated installation dates for 65,534 water main records. This spreadsheet was used to assign an installation date to 48,286 (55%) potable water main records that were previously missing an installation date. 18,700 remaining water mains (~21%) still had missing installation dates. Materials and/or diameters were also updated based on this spreadsheet.

1.2.1.1 Remaining Water Mains with Missing Installation Year

An installation decade was estimated for water mains with a missing installation year using the AWWA Material by Decade (Error! Reference source not found.) included in the American Water Works Association's 2012 Report "Buried No Longer", or based on the surrounding pipes. The decade year was estimated using the first year the material type was installed based on the GIS data and within the commercially available or predominately in use timeframe. **Table 1** provides a summary of the assumed installation year for each pipe material.

Figure 9:Summary of AWWA Material by Decade Data

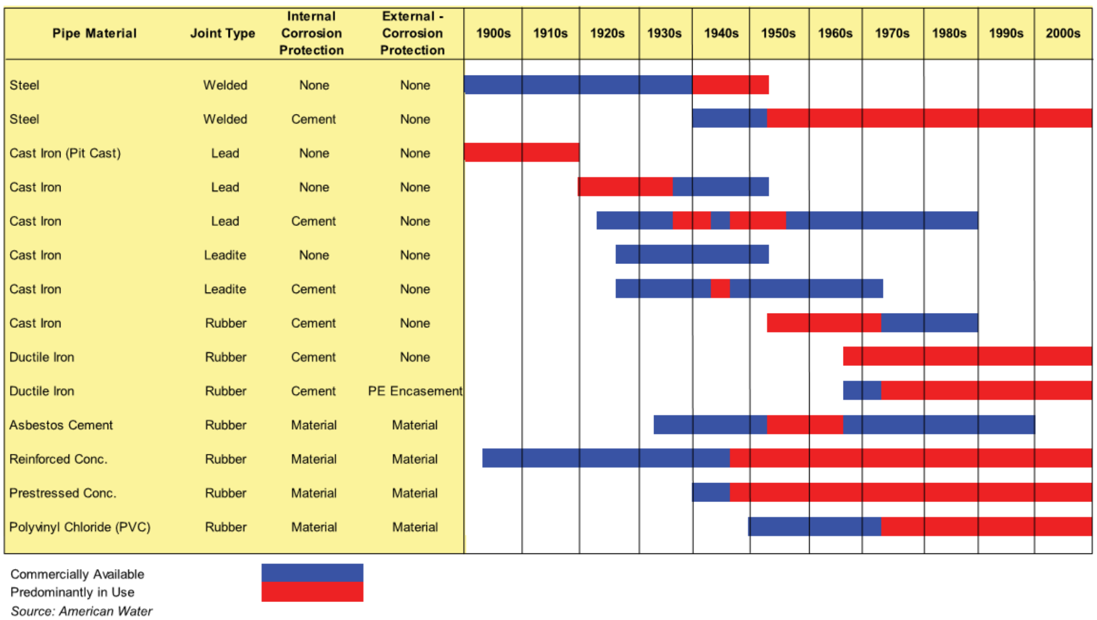


Table 7: Assumed Installation Year by Pipe material

PIPE MATERIAL	ASSUMED INSTALLATION YEAR	PIPE MATERIAL	ASSUMED INSTALLATION YEAR
Asbestos Cement	1930	High Density Polyethylene	1950
Cast Iron	1900, 1960	Polyvinyl Chloride	1970, 1990
Copper	1900	Steel	1950
Concrete Segments (Bolted)	1970	Transite	1930
Ductile Iron	1960	Unlined Cast Iron	1920
Galvanized Pipe	1900		

1.2.2 Water Mains with Missing Pipe Material

Mains that were missing the pipe material (18 records) were populated based on adjacent pipes with similar installation dates. These assumptions will be reviewed and confirmed by the City.

1.2.3 Water Mains with Missing Diameters

The City provided B&V an updated geodatabase for mains that were missing diameters. There were 345 pipe records missing diameters. As part of this update, the City also identified several pipe records that should be deleted and/or not included in the InfoMaster pressurized mains feature class. A total of 51 records were updated with diameters. The remaining 294 records were either identified as plant piping, service lines, USF private lines, capped mains, or flagged for deletion. Records flagged to be deleted were removed from the InfoMaster pressurized mains feature class. The life cycle status was revsied to be inactive for the records flagged as "Capped Mains" and owner field was revised to be "Private" for the remaining records. These mains should not be considered for the replacement/rehabilitation planning.

1.2.4 Potable Mains

The City of Tampa water mains feature class includes Potable, Raw, Reclaimed and ASR water main types. For the purposes of the water distribution risk assessment, potable mains were extracted from the water mains feature class for use in InfoMaster. The City indicated to not include any proposed pipes as indicated in the "FileNO" field. The following SQL query was used in GIS to screen out proposed mains and non-potable water mains.

SQL Syntax: WATERTYPE = 'Potable' AND FILENO not like '*Proposed*'

As previously mentioned, to maximize potential matching to main breaks, water mains with a diameter of 1.x (e.g. 1.25, 1.5) or 2.x (e.g. 2.25) were changed to 1" or 2" respectively.

It should be noted that there were five abandoned potable water mains. These mains were left in the potable water mains layer for main break trending purposes, but will not be used as part of the recommend replacement / rehabilitation planning.

1.3 ASSOCIATION OF MAIN BREAKS TO WATER MAINS

The City's main break records are addressed based and do not have a pipe association. In order to identify a pipe for each main break, the main break addresses were geocoded. In many instances, a geocoded main break might actually be located closer to a water main with a different diameter and/or material than to the actual main where the break occurred. Therefore, to ensure that main breaks were spatially associated to the correct water main, a "One to Many" spatial join was used to spatially assign multiple water main candidates to the nearest main break within 100ft. Upon the completion of the One to Many spatial join, a series of SQL queries in Access were used to assign a match confidence level to each water main to indicate how successful the match was to the nearest main break. The following criteria were used to assign a match confidence level to each water main that was within 100ft of a main break.

High Confidence Match

High Confidence matches included pipes that were installed prior to the main break incident and shared the same diameter and material as the nearest main break.

High Confidence Match Criteria:

- Water Main Diameter = Recorded Main Break Diameter
- Water Main Material = Recorded Main Break Material
- Water Main Installation Date < Recorded Main Break Date

High-Low Confidence Match

High-Low Confidence matches included pipes that were installed prior to the main break incident and shared the same diameter as the nearest main break. The material match requirement was relaxed to allow Cast Iron, Unlined Cast Iron or Ductile Iron mains to be matched to main breaks that were recorded with one of these material types. The High-Low Confidence Match level considers the chance that the wrong material may have been recorded during the main break investigation or repair.

High-Low Confidence Match Criteria:

- Water Main Diameter = Recorded Main Break Diameter
- Water Main Material and Recorded Main Break Material are CAS, UCI or DIP
- Water Main Installation Date < Recorded Main Break Date

Medium Confidence Match

The Medium Confidence level was designed to allow a match if two out of the three High Confidence match criteria were achieved. The medium confidence match allowed flexibility in water main material to recorded main break material match and main breaks with 'Null' break dates. However, the Medium Confidence match criteria did not relax the requirement for diameter nor main breaks with a break date that occurred prior to a pipe installation date.

Medium Confidence Match Criteria

- Main Break Not Previously Defined as High Confidence
- Water Main Diameter = Recorded Main Break Diameter
- Water Main Material = Recorded Main Break Material
- Recorded Main Break Date is Null

Or

- Main Break Not Previously Defined as High Confidence
- Water Main Diameter = Recorded Main Break Diameter
- Recorded Main Break Material is missing (Null)
- Water Main Installation Date < Recorded Main Break Date

Or

- Main Break Not Previously Defined as High Confidence
- Water Main Diameter = Recorded Main Break Diameter
- Water Main Material <> Recorded Main Break Material
- Water Main Installation Date < Recorded Main Break Date

<u>Medium-Low Confidence Match1 and 2</u>

The Medium –Low confidence Match 1 and 2 levels were designed to further relax the Medium confidence level requirements to allow for additional match candidates between water mains and the nearest main break.

Medium-Low Confidence Match 1

The Medium-Low Confidence Match 1 level used the same criteria as the Medium Confidence level but assumed a match between a water main and nearest main break if the water main diameter and recorded main break diameter were within 2 inches. For example, a 6” cast iron pipe installed in 1950 near a recorded 8” ductile iron main break that occurred in 2005 would be considered a Medium-Low match. It should be noted that if an 8” ductile iron water main was near the recorded 8” ductal iron main break, then that main would have already been considered as a High Confidence match and the 6” cast iron pipe would have been ignored.

Medium-Low Confidence Match 1 Criteria:

- Same criteria as Medium Confidence match
- Main Break Not Previously Defined as High or Medium Confidence
- Assumes a match on diameter if Water Main Diameter is > or < 2” of Recorded Main Break Diameter

Medium-Low Confidence Match 2

The Medium-Low Confidence Match 2 level relaxes the material requirement for Cast Iron, Unlined Cast Iron and Ductile Iron mains. This confidence level allows a main break with a recorded material of Cast Iron, Unlined Cast Iron or Ductile Iron to match with a Cast Iron, Unlined Cast Iron or Ductile Iron water main. The Medium-Low Confidence Match 2 level considers the chance that the wrong material may have been recorded during the main break investigation or repair.

Medium-Low Confidence Match 2 Criteria:

- Not Previously Defined as High or Medium Confidence
- Water Main Diameter = Recorded Main Break Diameter
- Water Main Material and Recorded Main Break Material are CAS, DIP or UCI
- Recorded Main Break Date is Null

<u>**Low Confidence Match**</u>

Low Confidence matches included main breaks that were not considered as High, High-Low, Medium, Medium-Low 1 or Medium-Low 2 matches.

Main Break Analysis in MS Access

SQL queries were used in MS access to identify main breaks and matching water mains that met the High, Medium or Low Confidence Criteria. Since a main break could potentially have two or more high or medium water main matches, the longest water main for each main break that met the confidence criteria was used to represent the water main where the main break occurred. **Table 8** shows an example of where a high confidence main break was assigned to four water mains within 100ft of the geocoded main break. As shown in **Table 8**, Main Break FID "20" was within 100ft of four water mains that shared the same material and diameter as the main break. In addition, all four water mains had installation dates that occurred prior to the main break incident. Therefore, all four of these water mains were considered as High Confidence candidates. However, the main break was assigned to water main "1830691" since it was the longest of the four candidates.

Table 8: Example of High Confidence Main Break Match

BREAK ID	BREAK DATE	BREAK ADDRESS	BREAK SIZE	BREAK MATERIAL	WMAIN ID	WMAIN INSTALLDATE	WMAIN MATERIAL	WMAIN DIA	LENGTH
20	27-Oct-14	9207 N 10th St	12	CAS	1835709	21-Dec-46	CAS	12	78
20	27-Oct-14	9207 N 10th St	12	CAS	1831346	20-Dec-67	CAS	6	6
20	**27-Oct-14**	**9207 N 10th St**	**12**	**CAS**	**1830691**	**21-Dec-46**	**CAS**	**12**	**216**
20	27-Oct-14	9207 N 10th St	12	CAS	1830937	20-Dec-67	CAS	6	23

Table 9 shows an example of five water mains within 100ft of main break "1682". Three of these water mains met the Medium Confidence criteria; however, the main break was assigned to water main "1842371" since it was the longest of the three candidates.

Table 9: Example of Medium Confidence Main Break Match

BREAK ID	BREAK DATE	BREAK ADDRESS	BREAK SIZE	BREAK MATERIAL	WMAIN ID	WMAIN INSTALL DATE	WMAIN MATERIAL	WMAIN DIA	LENGTH
1682	22-Feb-10	4102 N Armenia Ave	12	CAS	1842088		CAS	12	31
1682	**22-Feb-10**	**4102 N Armenia Ave**	**12**	**CAS**	**1842371**		**CAS**	**12**	**324**
1682	22-Feb-10	4102 N Armenia Ave	12	CAS	1850760		CAS	2	579
1682	22-Feb-10	4102 N Armenia Ave	12	CAS	1855660		CAS	2	49
1682	22-Feb-10	4102 N Armenia Ave	12	CAS	3024674		CAS	12	35

Summary of Main Break and Water Main matches by Confidence Level

Table 10 provides a summary of main breaks by confidence level. 2,627 water mains were assigned one or more High and / or Medium confidence main break.

Table 10: Summary of Main Breaks by Confidence Level

MAIN BREAK CONFIDENCE LEVEL	OVERALL CONFIDENCE LEVEL	NUMBER OF MAIN BREAKS
High	High	2,844
High-Low		774
Medium	Medium	590
Medium Low 1		207
Medium Low 2		21
Low	Low	1,589
Total		6,025

2 Fire Hydrant Service Area Development

2.1 HYDRANT SERVICE AREAS

ArcGIS “Network Analyst” was used to identify “Hydrant Service Areas” in the distribution system where Water Mains were within 450ft of a Hydrant Tee along the water system network. Network tracing in Network Analyst requires line features to be split at intersections such as pipe tees and crossings. Since many of the Water Mains in the City’s network are not split at “Hydrant Lateral” locations, “Hydrant Tees” were generated at the point where a Water Main and Hydrant Lateral connect in order to split the pipe at the Hydrant Tee location. The unique pipe ID was preserved so that split pipes would retain their original ID. The following summarizes the GIS analysis that was performed to develop “Hydrant Tees” by leveraging the Hydrants, Fittings (Tees), Laterals and Water Main feature classes.

2.2 NETWORK ANALYST

Network Analyst is a tool in ArcGIS Desktop that is used to analyze distances, travel time and other distance and time related analysis typically performed on network data sets (e.g. Road networks, water networks, etc.). Network Analyst can be used to generate “Service Areas”. A network Service Area is a region that encompasses all streets (or pipes) that can be accessed within a given distance or travel time from one or more facilities. Using the Hydrant Tees as network “Facilities”, Water Mains that fall outside a giving distance from a Hydrant along the network can be identified.

The following parameters were used in the Network Analyst tool to develop Service Area polygons:

- Length was set to in feet
- Defaults Breaks were set to 450ft from facility (Hydrant Tee).
- Service Area polygons output set to “Detailed”
- Service Area polygons trimmed to 10ft perpendicular from pipe (for visualization purposes).

Once the settings were entered, the “Solve” icon was executed. The Network Analyzer then created “Hydrant Service Area” polygons which followed the water mains 450ft from each Hydrant Tee point. **Figure 10** shows an example of “Hydrant Service Areas” that were generated using the Network Analyst tool. The green areas represent Hydrant Service Areas. The length of pipe inside a Hydrant Service Area was within 450ft of a hydrant.

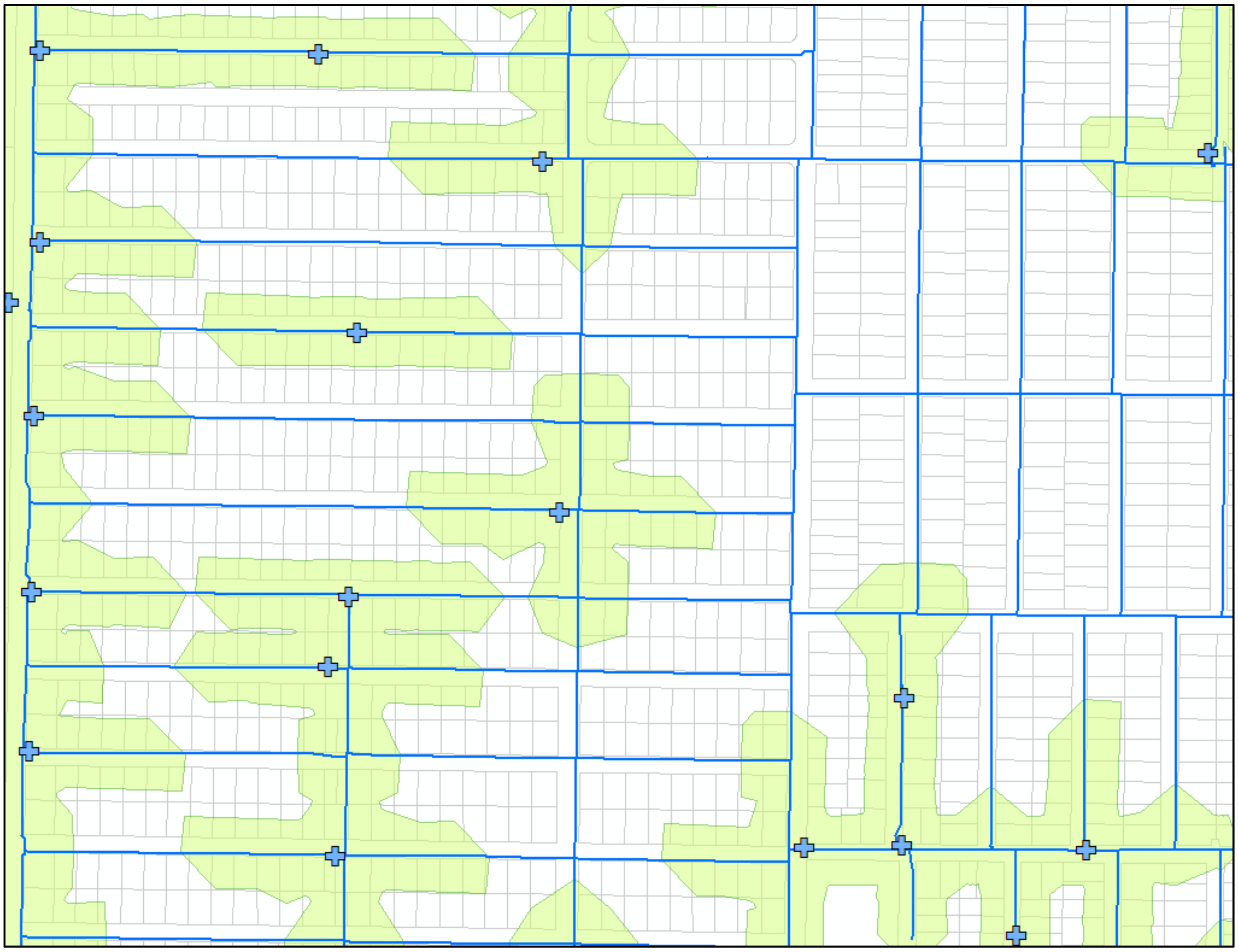


Figure 10: Hydrant Service Areas

The “Identity” tool in ArcGIS was used to split pipes by Hydrant Service Area in order to calculate the length of pipe inside and outside a Hydrant Service Area. The resulting GIS layer was then imported into Excel to summarize the unique water main ID (OID) by length inside and outside a Hydrant Service Area. The following criteria were used in determining Consequence of Failure (CoF) scores for pipe segments that had all or a portion of their length outside a Hydrant Service Area:

- If pipe not outside of Hydrant Service Area, Score = 1, (no additional FHA)
- If length of pipe outside Hydrant Service Area <=450ft, Score = “2”, (1 additional FHA)
- If length of pipe outside Hydrant Service Area between 451 to 900ft, Score = “3” (2 additional FHA)
- If length of pipe outside Hydrant Service Area between 901 to 1,350, Score = “4” (3 additional FHA)
- If length of pipe outside Hydrant Service Area > 1,350, Score = “5”, (>=4 additional FHA)

2.3 DEVELOPMENT OF HYDRANT TEES

Laterals lines in the "wLaterals" feature class that intersected hydrant points were spatially selected in order to identify Hydrant Laterals. Note that most of the Hydrant Laterals in the City's distribution network are split by a hydrant valve. Therefore, in order to select all hydrant laterals up to the water main tee, lateral lines that intersected hydrants were used to select additional laterals until all hydrant laterals up to the water main tee were selected. In some instances, three or more laterals were selected in order to select all segments in a lateral up to the water main tee. Hydrant Laterals were then merged so that a single pipe segment existed between a hydrant and the connecting water main. **Figure 11** shows an example of a lateral split into two segments by a hydrant valve in the existing "wLaterals" feature class. The lateral line that intersected with the hydrant point was used to select the additional lateral(s) up to the water main. The selected hydrant laterals between the water main and hydrant were then merged into one lateral line segment.

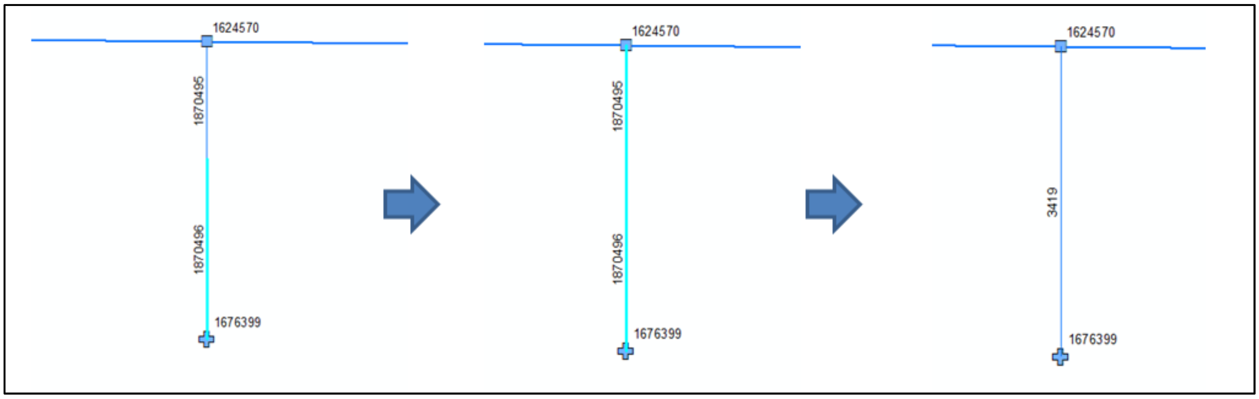


Figure 11: Selection of "Hydrant Laterals".

"Fittings" (Tees, Crosses, etc.) that intersected Hydrant Laterals and Water Mains were then selected to represent "Hydrant Tees". 13,407 Hydrant Tees were identified. An example of two Hydrant Tees are shown in **Figure 12**.

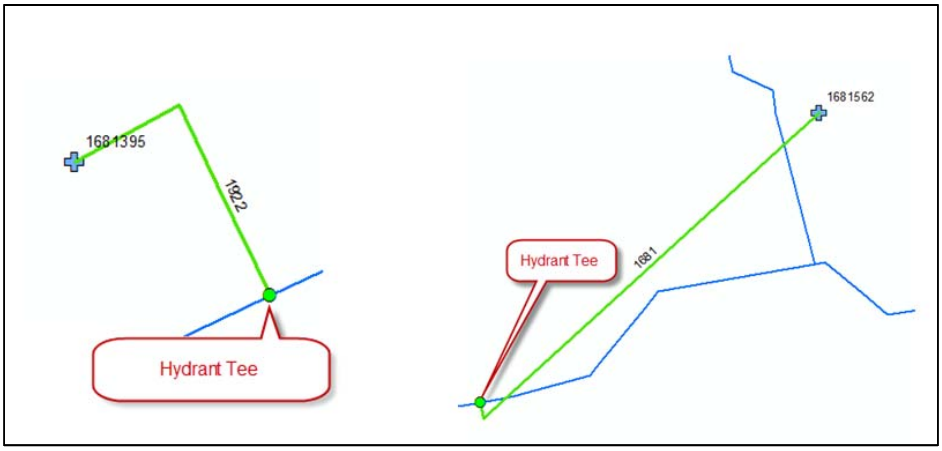


Figure 12: "Hydrant Tees"

It should be noted that there were areas in the distribution system where hydrant locations appeared to be irregular placed in the City's GIS. However, the location of the Hydrant Tee's appeared to be correct. The process used to select Hydrant Tees was not affected by the Hydrants that appeared to be in the wrong location. These irregularly placed hydrants are shown in **Figure 13** and **Figure 14**.

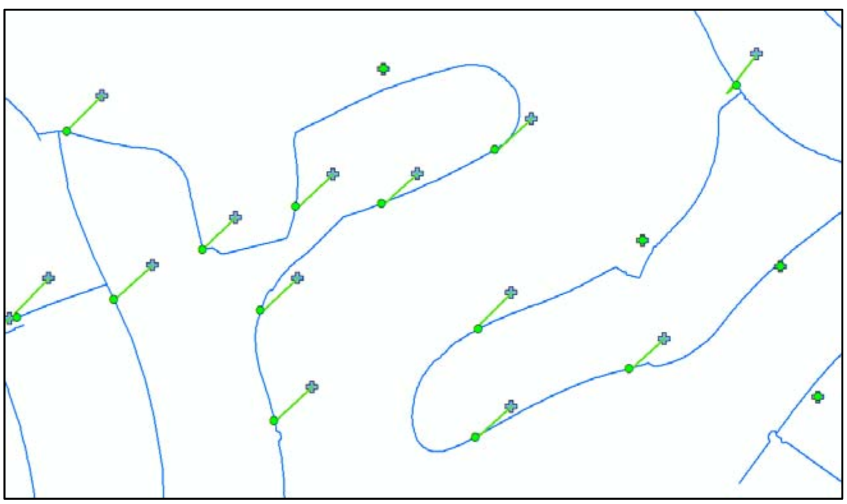


Figure 13: Irregular Placement of Hydrants

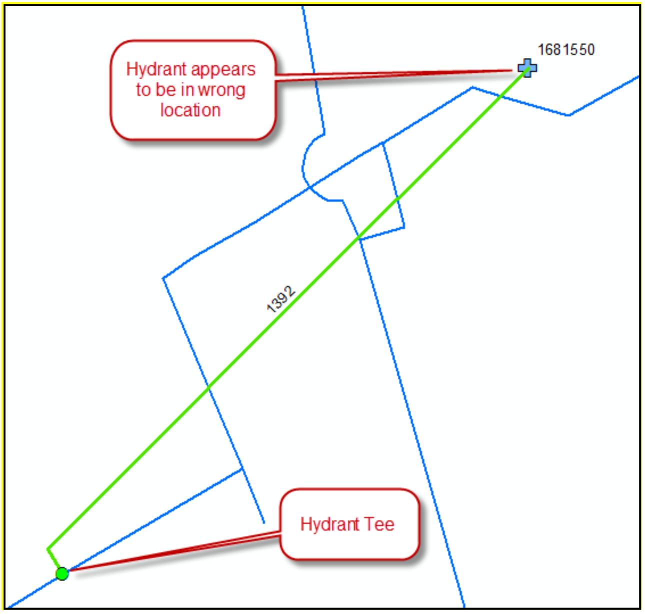


Figure 14: Irregular Placement of Hydrants

A total of 651 hydrants in the City's GIS were not connected to a hydrant lateral. Of those hydrants, 632 were within 100ft of a water main and were added to the "Hydrant Tee" feature class and snapped to the closest water main. The remaining 19 Hydrants that were greater than 100ft from the nearest water main were manually reviewed and deemed to be too far to determine which water main served the hydrant. **Figure 15** provides an example of hydrants in the GIS (circled in red) that were greater than 100ft from the nearest water main and not used in the analysis.

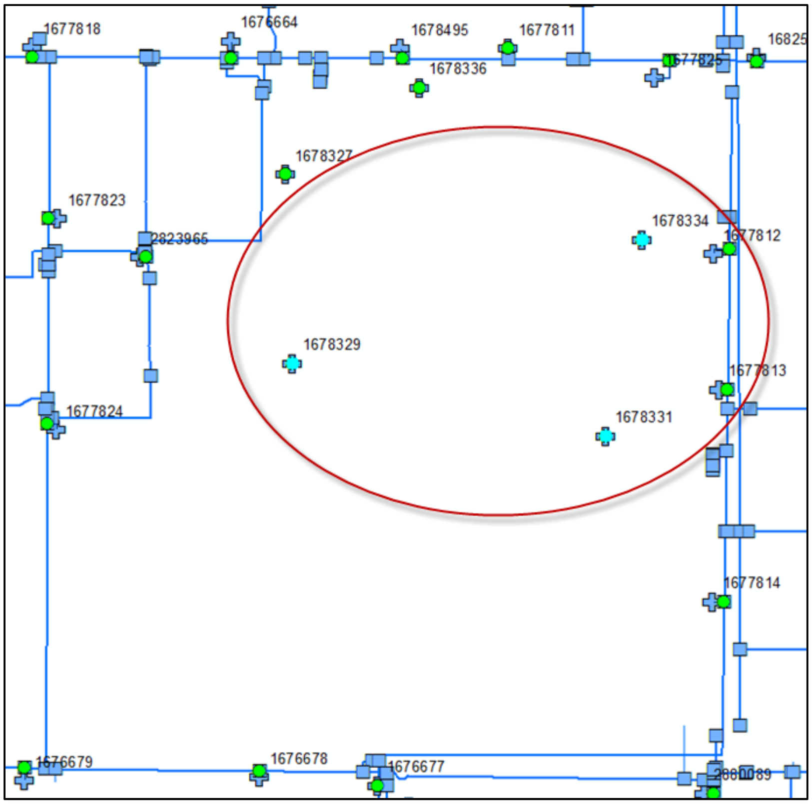


Figure 15: Hydrants > 100ft from nearest Water Main

ArcGIS tools were used to snap the 632 hydrant tee feature class to the closest water main within 100ft. The hydrant tee feature class was then used to split the water main segments so that the Network Analyst would properly trace the network and generate "Service Areas" to represent the 450ft extent of the Hydrant Service Area to determine if additional hydrants are needed.

A unique Water Main ID (OID) previously generated by B&V was preserved during the split so that split pipes would retain the same unique ID and the results of the analysis could be related back to the InfoMaster model.

3 Critical Customers

Critical Customers were assigned to the nearest distribution main based on a series of manual, semi-automatic, and automatic procedures. Fields were added to the InfoMaster wPressurizedMains layer for each critical customer type (e.g. School, Hospital, Top 20, Airport, Lowry Zoo, ERC_EOC, etc.). These fields were populated for a pipe if it served one or more of these critical customers based on the methods described below.

3.1 SCHOOLS

The location of 159 public and private elementary schools, junior high schools, academies and high schools were provided in a point GIS feature class. Parcels polygons for these schools were selected using the point feature class. Distribution mains that were within 25ft of a "school" parcel were identified as a critical customer and populated with a "1" in the "School" field. Pipes for 17 school locations not within a parcel were manually reviewed up to adjacent tees and / or crosses to complete a loop and assigned a "1" in the "School" field.

3.2 HOSPITALS

All eight hospital locations were manually reviewed. Pipes within 25ft of a hospital parcel up to adjacent tees and / or crosses to complete a loop were assigned a "1" in the "Hospital" field.

3.3 ERO-ERC

The location of 210 ERC-ERO critical facilities were screened out from a point GIS feature class provided by the City. Parcel polygons were selected using the point feature class. The eight hospitals were excluded from the list of ERC-ERO facilities since they were assigned to pipes separately. Distribution mains within 25ft of an ERC-ERO parcel were identified as a critical customer and populated with a "1" in the "ERC_ERO" field. 18 facilities were not within a parcel and were manually assigned to the nearest pipe or pipes up to adjacent tees and / or crosses to complete a loop.

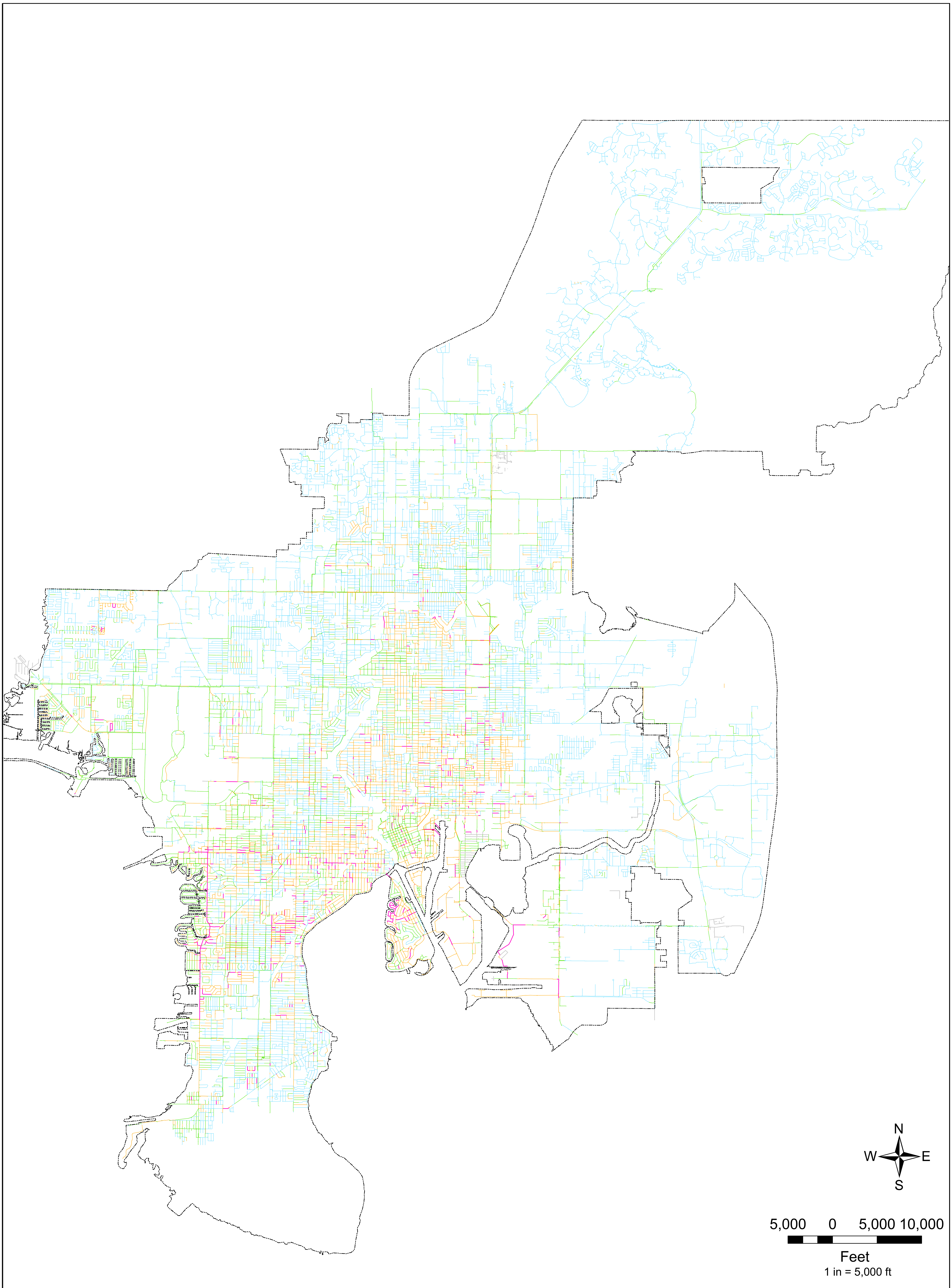
3.4 CRITICAL USER PARCELS

Specific locations throughout the city were defined as critical areas. These areas included the Airports, MacDill AFB, Straz Center, Sports Arenas, Port Authority, Photographic Arts Museum, Lowry Zoo, Jails, Island of Adventure, Glazer Children's Museum, Florida Aquarium, Fairgrounds, and Busch Gardens. Pipes within 25ft of these critical parcels were manually identified up to adjacent tees and / or crosses to complete a loop and populated with a "1" in the specific critical user field (e.g. "MacDill_AFB", "Lowry_Zoo", etc.) in the wPressurizedMains InfoMaster layer.

3.5 TOP 20 USERS

Top 20 users were derived from 2015 consumption (Oct 2014 to Sept 2015). Pipes that served these users were manually identified up to adjacent tees and / or crosses to complete a loop and populated with a "1" in the "Top_20_User_Name" field.

Appendix C— Risk Summary Figure



City of Tampa Florida

BLACK & VEATCH
Building a world of difference.

Risk Classification Level

- Negligible
- Low
- Medium
- High
- Extreme
- Not Included in Evaluation

CITY OF TAMPA
Potable Water Master Plan
Appendix C
Figure C-1
Risk Analysis

Printed: 3/20/17

Appendix D— R&R Gap Analysis Assumptions

The following sections summarize the assumptions used as part of the R&R gap analysis development.

1. Valve R&R

- Total Replacement Cost $904,772,541
- 20 yr replacement schedule
- Yields $45,239,000/year

2. Fire Line R&R

- Total Replacement Cost $40,880,323
- Estimated 86 yr life expectancy
  - o Based on weighted average of life expectancy of each pipe type
- Yields $475,353/year

3. Hydrant R&R

- Total Replacement Cost $581,096
- 20 yr rehabilitation schedule
- Yields $29,067/year

4. Distribution Mains R&R

- Replacement year calculated based on average life expectancy minus install year
- Replacement cost based on year 2018 dollars
- Base/Fee/Rate charges assumed to increase at a rate matching inflation
- All active pipes and owned by City of Tampa (as used in the 2016 InfoMaster model) are considered in total replacement cost
  - o Pipes identified in a CIP were not excluded from total replacement cost
- Year 2018 Unit Cost
  - o Table 1.4 Water Pipeline R&R Unit Cost Estimates Assumed in the FY17 Budget Proposal (March 29, 2016 Memorandum)
  - o Unit cost for 6-inch was used for diameters 6-inch and less
  - o Domestic & irrigation service replacements are included in the pipeline R&R $/ft estimates

Diameter	Unit Cost	Diameter	Unit Cost	Diameter	Unit Cost
0.75	$ 224	8	$ 238	24	$ 794
1.5	$ 224	10	$ 286	30	$ 969
1	$ 224	12	$ 286	36	$ 1,169
2	$ 224	14	$ 465	42	$ 1,436
3	$ 224	16	$ 465	48	$ 1,970
4	$ 224	18	$ 554	54	$ 1,970
6	$ 224	20	$ 554	60	$ 1,970

- Distribution Main Average Life Expectancy

MATERIAL	AVERAGE LIFE EXPECTANCY (YEARS)
Asbestos Cement (1)	46
Cast Iron (1)	86
Copper (1)	40
Concrete Segments (Bolted) (2)	105
Clay Tile (3)	100
Ductile Iron (1)	88
Fiberglass Reinforced (1)	77
Galvanized Pipe (1)	101
High Density Polyethylene (1)	78
Polyethylene (1)	77
Polyvinyl Chloride (1)	77
Steel (2)	70
Transite (1)	46
Unlined Cast Iron (1)	80

(1) Average life expectancies are estimated at the 50th percentile of the Weibull survival probability curve. Fiberglass Reinforced and Polyethylene were assumed similar to PVC. Transite was assumed similar to Asbestos.
(2) AWWA Buried No Longer 2012 Report
(3) Assumed life expectancy
See Data Quality Review and Survival Curve Technical Memorandum prepared by Black & Veatch (submitted Dec 2016) for details.

- Cost $3,448,968,221
  - 20 year Replacement Total (for years 2018-2037) $675,848,622
    - Yields $33,800,000/year
    - Year 2018 includes costs for pipe replacements needed in 2018 and all earlier years (i.e pipes with a replacement year from 1940 – 2017)

5. Funding

- Average $9,500,000, includes city funded and developer funded
- Base/Fee/Rate charges assumed to increase at a rate matching inflation.
- Developer funded pipeline R&R rate is reduced by 50% to account for pipes being taken out of service prior to the pipe being in service for its entire projected lifespan

Appendix E — Valve Replacement Spreadsheet Template Overview

The following describes the Valve Replacement Spreadsheet Template set-up. Details for each tab, including the data and formulas used in the spreadsheet, are listed below.

NOTE: Tabs have been color-coded in the spreadsheet as shown below. The workbook has been "protected" and all calculated fields have been locked for editing. A password to unprotect the spreadsheet has not been set. TWD can add a password at any time.

1. Approach – Approach Tab

This tab provides a brief overview of the two options reviewed to determine the economic point for pipe replacement.

- Option A represents immediate valve replacement, with later pipe and valve replacement. The immediate valve replacement cost (present value) and cost of pipe and valve replacement at end of the life (present value) are summed together for a total present value cost and comparison to Option B.
  - PV_1 = PV(VR) + PV (P&VR)$_1$
    - PV = Present Value, VR = Valve Replacement, P&VR = Pipe and Valve Replacement
- Option B represents immediate pipe and valve replacement. The cost for immediate pipe and valve replacement (present value) is calculated for comparison to Option A. This option would be economical when the remaining life of the pipe is limited.
  - PV_2 = PV (P&VR)$_2$
    - PV = Present Value, P&VR = Pipe and Valve Replacement
- Economic Point for Pipe Replacement
  - If $PV_1 > PV_2$ Then Replace Pipe Now (i.e. pick the least cost option)

2. Input-Output – Input-Output Tab

A form template was developed to enter parameters needed to support the above calculations. The following data inputs are used:

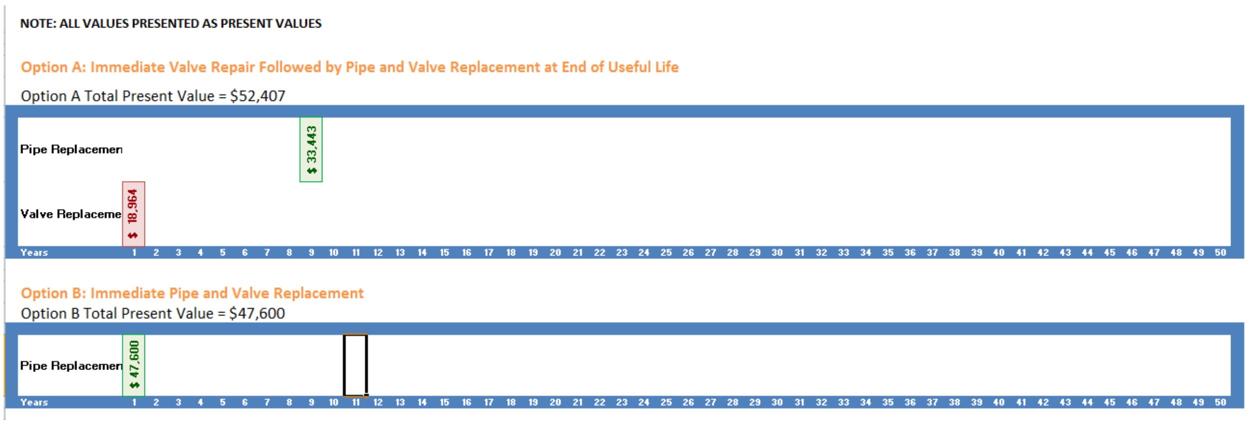
- Pipe Information
  - Valve & Pipeline Diameter (inches) – user entry required
  - Pipe Material – user entry required (pick list)
  - Pipeline Installation Year – user entry required
  - Pipe Estimated Life Expectancy – calculated value
    - Referenced from the Useful Life Table
- Evaluation Information
  - Replacement Year for Consideration – user entry required
  - Pipe Age – calculated value

    - $Pipe\ Age = Replacement\ Year\ for\ Consideration - Pipeline\ Installation\ Year$

  - Remaining Life of Pipe (Years) – calculated value
    - $Remaining\ Life = Pipe\ Estimated\ Life\ Expectancy - Pipe\ Age$
  - Length of Repair for Valve Replacement Only (feet) – user entry required
  - Length of Repair for Valve + Pipeline Replacement (feet) – user entry required
  - Discount or Depreciation Rate of Pipeline – user entry required
- Replacement Option
  - Option A: Valve Replacement with later pipe and valve replacement
    - Immediate Valve Replacement Cost (Present Value) – calculated value
      - Replacement cost based on Valve & Pipeline Diameter
        - Reference to Replacement Cost Tab
    - Cost of Pipe and Valve Replacement at End of Life (Present Value) – calculated value
      - Present value cost calculation based on Remaining Life of Pipe (Years), Valve & Pipeline Diameter (inches), Replacement Cost, and Discount Rate
    - Total Present Value – calculated value
      - Sum of Immediate Valve Replacement Cost (Present Value) and Cost of Pipe and Valve Replacement at End of Life (Present Value)
  - Option B: Immediate pipe and valve replacement
    - Cost of Immediate Pipe and Valve Replacement (Present Value) – calculated value
      - Pipe Unit Cost (includes valve) X Length of Repair
    - Total Present Value – calculated value
      - Equal to Cost of Immediate Pipe and Valve Replacement (Present Value)
  - Lowest Cost Option
    - Determined based on Total Present Value calculated for Option A and Option B – select the lowest cost
      - If Option A > Option B, then select Option B (Valve&Pipe Replacement)
      - If Option A < Option B, then select Option A (Valve Replacement)

3. Cash Flow – Cash Flow Tab

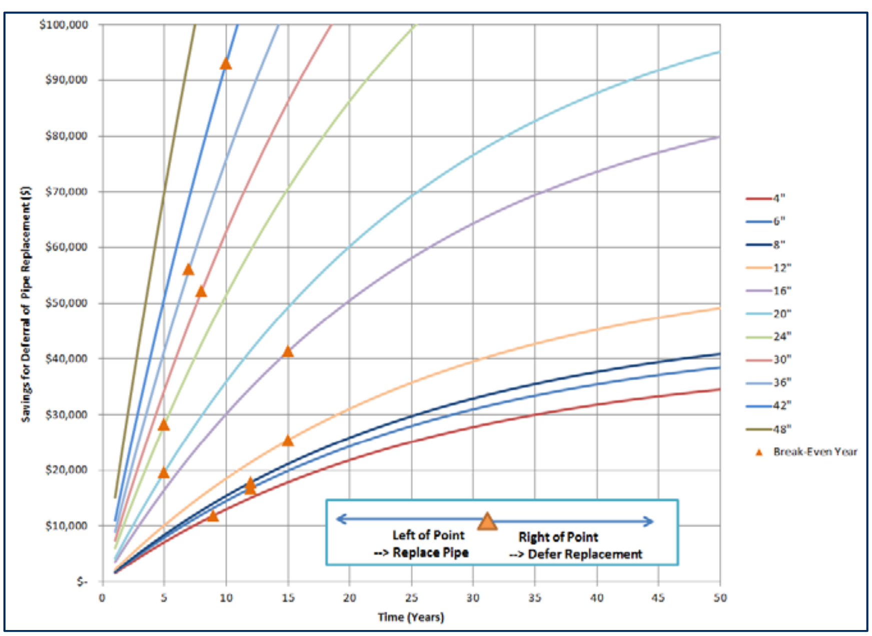
Provides a graphical representation of Option A: Immediate Valve Repair Followed by Pipe and Valve Replacement at End of Useful Life and Option B: Immediate Pipe and Valve Replacement as calculated. Note that all values presented are present value.



4. Decision Chart – Decision Chart Tab

A chart was developed to graphically represent the savings for deferral of pipe replacement. The values on the chart will update based on the input parameters. The break-even point for each diameter is shown on the graph.

As a general guide, (1) if the remaining life (in years) is left of the break-even point, replace the pipe, or (2) if the remaining life (in years) is right of the break-even point, defer pipe replacement.



5. Replacement Costs – Replacement Costs Tab

TWD provided unit cost data for use in calculating the replacement costs for valves and pipes. The valve unit cost is based on the unit cost for a gate valve and includes material, labor, and overhead costs from TWD's annual contract. The pipe unit cost includes the valve replacements along the path of the pipe as well as mobilization, restoration, and other material, labor, and overhead costs.

6. Useful Life Table – Useful Life Table Tab

The average life expectancy by material is used to calculate the remaining life. A survival curve analysis was performed using the Kaplan-Meier methodology and incorporated the total observed population of water mains for each pipe material, the age of each water main as of year 2015, and the main break occurrences between years 2000 and 2015. The Weibull function was used to represent the survival probability for each pipe material. The average estimated life expectancies were determined based on the 50th percentile of the Weibull estimated survival probability.

The survival curve analysis was performed by Black & Veatch and details of the analysis are documented in the Water Main Data Quality Review and Survival Curve Development Technical Memorandum submitted on April 11, 2017.

7. Calcs – Calcs Tab

This tab provides the calculations for the Present Value Pipe Replacement Cost and the Present Value Savings for Deferring Pipe Replacement by diameter (4-inch to 48-inch). The calculation results are referenced in the "Input-Output" tab. Note that all values presented are present value.

Appendix I

Water Main Data Quality Review and Survival Curve Development Technical Memorandum

FINAL

WATER MAIN DATA QUALITY REVIEW AND SURVIVAL CURVE DEVELOPMENT

Potable Water Master Plan

B&V PROJECT NO. 190020

PREPARED FOR

City of Tampa

11 APRIL 2017

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LIST OF FIGURES

1. Introduction

This technical memorandum summarizes the data quality review of the City of Tampa Water Department's (TWD) potable water mains and the survival curve development. The survival curve analysis is dependent on three main sources of data: pipe material, installation date, and main break history. In order to ensure the results from the survival curve analysis were as accurate as possible, a data quality review was performed on the material and installation dates. The purpose of the data quality review was to identify pipes where the material and installation date do not align to improve the results of the survival curve analysis. The 2012 AWWA Buried No Longer publication (2012 AWWA Report), which documents "historic production and use of water pipe by material", was used as a guide to identify pipes where the material and installation data did not align with the general timeframe for use. Pipes identified outside the general timeframe for use and associated main breaks were excluded from the survival curve analysis.

2. Data Quality Review

Under Phase 700, Risk Based Pipeline Prioritization, of the 2015 Potable Water System Master Plan, Black & Veatch developed a risk-based prioritization model using Innovyze's InfoMaster tool. As part of this effort, the TWD's water mains ("wMains") feature class was imported into InfoMaster's "Pressurized Main" feature class. Black & Veatch coordinated with TWD to populate data gaps in the water main geodatabase to support development of the risk-based prioritization. TWD provided available material, diameter, and/or as built dates to populate missing data. Remaining gaps in installation dates were populated based on the 2012 AWWA Report. The updated "Pressurized Main" feature class is the source data used for the data quality review. All pipe records, including inactive pipes and non-City owned pipes, were reviewed as these pipes are considered part of the master source of data.

Black & Veatch compared the TWD assigned material type and installation dates for all pipe records in the "Pressurized Main" feature class against the material predominantly used timeframe based on the 2012 AWWA Report.

Figure 1 illustrates the data provided in the 2012 AWWA Report regarding commercially available and predominantly used materials by time frame. High-Density Polyethylene (HDPE) was not included in the 2012 AWWA Report and was assumed to have a similar timeframe as PVC. Copper was not provided in the 2012 AWWA Report either and was assumed based on common typical installation years. **Figure 2** graphically shows the TWD assigned range of installation dates.

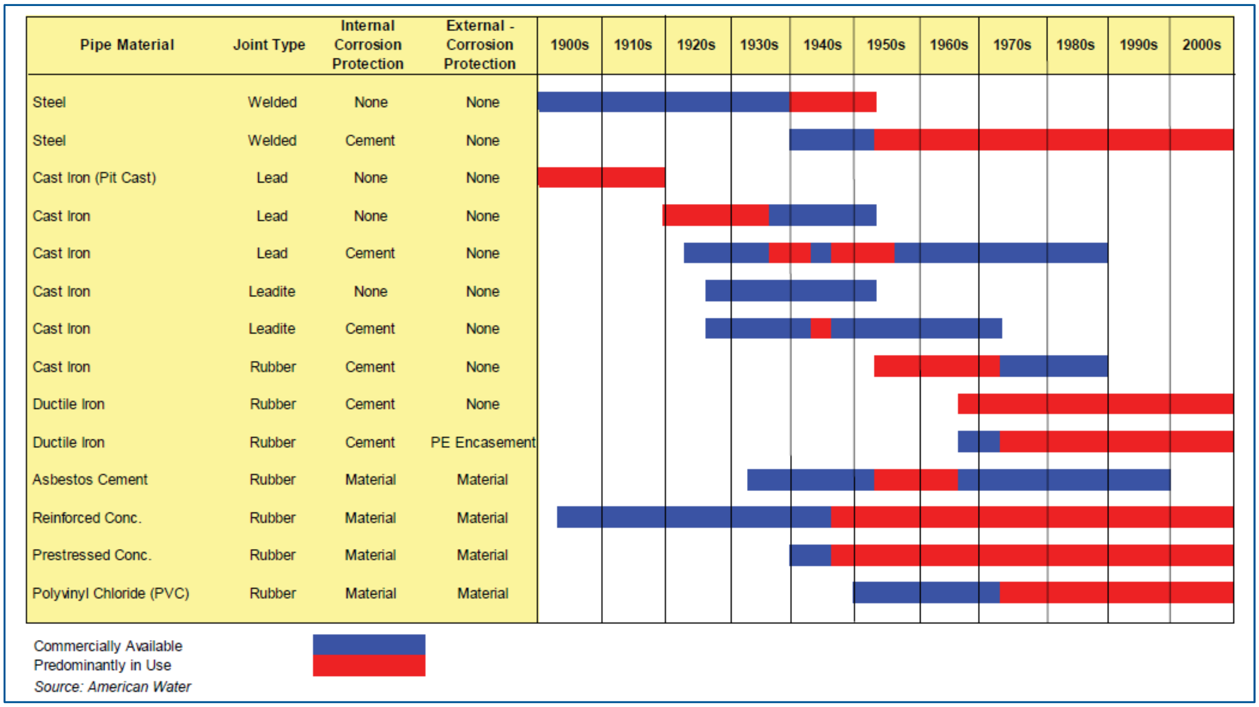


Figure 1: Historic Production and Use of Water Pipe by Material (2012 AWWA Report)

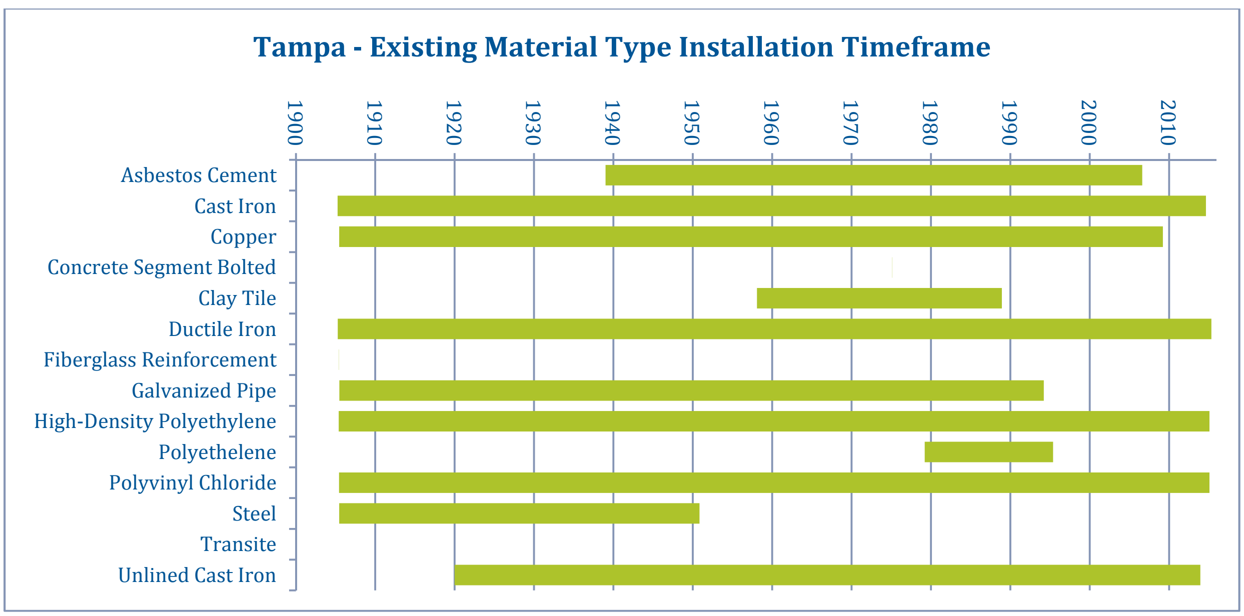


Figure 2: Initial Timeframe of Tampa Water Pipe Installation Dates

The range of TWD assigned installation dates for each pipe material is presented in **Table 1**. Pipes that had an assumed installation year assigned based on previous work performed by Black & Veatch are not included in the summary table. **Table 1** also shows the selected timeframes used for each material type based on the 2012 AWWA Report used to perform the data quality review. Installation dates for material types in the TWD data that fell outside the selected timeframe were flagged for further review.

Table 1: Tampa Water Department and 2012 AWWA Report Installation Dates

MATERIAL	TAMPA WATER DEPARTMENT		2012 AWWA REPORT	
	Existing Minimum Install Date (1)	Existing Maximum Install Date (1)	Selected Minimum Install Date	Selected Maximum Install Date
Asbestos Cement	1/2/1939*	8/16/2006*	1/1/1953	12/31/1979
Cast Iron	4/4/1905	8/30/2014*	1/1/1900	12/31/1989
Copper	6/12/1905*	3/26/2009*	1/1/1960 (2)	12/31/1996 (2)
Concrete Segments (Bolted)	2/17/1975	2/17/1975	-	-
Clay Tile	2/1/1958	12/12/1988	-	-
Ductile Iron	4/7/1905*	5/4/2015	1/1/1965	12/31/2015
Fiberglass Reinforced	5/21/1905	5/21/1905	-	-
Galvanized Pipe	6/23/1905*	3/23/1994	1/1/1920	12/31/1994
High Density Polyethylene	5/27/1905*	2/6/2015	1/1/1990	12/31/2015
Polyethylene	3/26/1979	5/23/1995	1/1/1950	12/31/1995
Polyvinyl Chloride	6/7/1905*	2/6/2015	1/1/1972	12/31/2015
Steel	6/19/1905	11/6/1950	-	-
Transite	Not populated	Not populated	-	-
Unlined Cast Iron	1/1/1920	12/16/2013*	1/1/1900	12/31/1955

(1) Pipes that had an assumed installation year assigned based on previous work performed by Black & Veatch are not included.
(2) The 2012 AWWA Report does not include install dates for Copper. Minimum and Maximum install dates are based on an assumed range of installation years.
* denotes installation dates outside those identified by the 2012 AWWA Report or assumed dates.

A total of 2,127 pipe segments were identified where the TWD assigned installation date occurred before or after the selected timeframe. Of these pipe segments, 6 are not owned by the City of Tampa and 1 pipe is indicated as inactive. All pipe segments with an assumed installation date (18,667 pipes) have also been flagged for further review by TWD for revision of the installation date and confirm the pipe material. Of these pipe segments, 283 are not owned by the City of Tampa and 115 are indicated as inactive. It is also suggested that due to the minimal number of remaining active segments, the pipe segments with a material type of clay tile (2 pipe segments), concrete segments (bolted) (2 pipe segments), fiberglass reinforced (1 pipe segment), polyethylene (5 pipe segments), steel (3 pipe segments), and transite (3 pipe segments) also be reviewed to confirm the material and installation date. **Tables 2 through 4** summarize the total number of pipe segments by material type that are identified for further review by TWD. This accounts for approximately 23% and 21% of the total pipe segments and total length, respectfully, that should be reviewed further by TWD. A GIS feature class with the pipe segments identified for further review has been provided to TWD. **Attachment A** includes figures for each pipe material to present the geographic distribution of the pipes identified for further review.

Table 2: Pipe Segments with TWD Assigned Installation Date Discrepancy

MATERIAL	PIPES IDENTIFIED FOR REVIEW		TOTAL PIPE COUNT	TOTAL LENGTH (MI)	PERCENTAGE OF PIPES TO BE REVIEWED	
	PIPE COUNT	LENGTH (MI)			% TOTAL COUNT	% TOTAL LENGTH
Asbestos Cement	27	0.2	295	11.2	9%	2%
Cast Iron (1) (2)	1,210	20.2	33,034	930.0	4%	2%
Copper	22	0.3	116	1.2	19%	23%
Ductile Iron Pipe	669	13.9	39,562	904.8	2%	2%
Fiberglass Reinforced	1	0.2	1	0.2	100%	100%
Galvanized Pipe	6	0.1	108	1.6	6%	5%
High Density Polyethylene	35	0.8	1,868	33.8	2%	2%
Polyvinyl Chloride (1)	31	0.7	6,157	155.0	1%	0.5%
Unlined Cast Iron (1)	126	2.1	6,056	124.6	2%	2%
Total	**2,127**	**38.5**	**87,197**	**2162.5**	**2%**	**2%**

(1) Includes pipes not owned by the City of Tampa (6 pipe segments total, 1 CAS, 4 PVC, 1 UCI)
(2) Includes 1 inactive pipe

Table 3: Pipe Segments with Assumed Installation Date

MATERIAL	PIPES IDENTIFIED FOR REVIEW		TOTAL PIPE COUNT	TOTAL LENGTH (MI)	PERCENTAGE OF PIPES TO BE REVIEWED	
	PIPE COUNT (1)	LENGTH (MI)			% TOTAL COUNT	% TOTAL LENGTH
Asbestos Cement	22	1.1	295	11.2	7%	10%
Cast Iron (1) (2)	6,523	165.7	33,034	930.0	20%	18%
Concrete Segments (Bolted)	1	0.001	2	0.001	50%	72%
Copper	20	0.1	116	1.2	17%	8%
Ductile Iron Pipe (1) (2)	6,186	126.2	39,562	904.8	16%	14%
Galvanized Pipe (1)	61	1.3	108	1.6	56%	77%
High Density Polyethylene (2)	441	7.5	1,868	33.8	24%	22%
Polyvinyl Chloride (1) (2)	259	8.4	6,157	155.0	4%	5%
Steel	1	0.1	3	0.2	33%	45%
Transite	3	0.1	3	0.1	100%	100%
Unlined Cast Iron (1) (2)	5,150	103.3	6,056	124.6	85%	83%
Total	**18,667**	**413.9**	**87,204**	**2162.6**	**21%**	**19%**

(1) Includes pipes not owned by the City of Tampa (283 pipe segments total, 8 CAS, 21 DIP, 2 GP, 28 PVC, 224 UCI)
(2) Includes inactive pipes (115 pipe segments total, 7 CAS, 79 DIP, 5 HDPE, 2 PVC, 22 UCI)

Table 4: Minimal Remaining Active Pipe Segments

MATERIAL	PIPES IDENTIFIED FOR REVIEW	
	TOTAL COUNT (1)	LENGTH (MI)
Clay Tile	2	0.0003
Concrete Segments (Bolted)	2	0.001
Fiberglass Reinforced	1	0.25
Polyethylene	5	0.13
Steel	3	0.17
Transite	3	0.13
Total	**16**	**0.55**

3. Data Improvement Recommendations

It is recommended that TWD perform a detailed review to confirm and/or update the material type and/or installation date for the 23% of pipe segments that either (1) did not align with the 2012 AWWA Report timeframes, (2) missing an installation date and an assumption was made, or (3) have a material type of clay tile, concrete segments (bolted), polyethylene, steel, and transite. Main breaks associated with any pipe identified for further review should also be reviewed for confirmation of the correct pipe and/or update of the identified break pipe material on the break record.

As part of continually improving the GIS data source used for reporting, modeling, and asset management, additional data quality reviews can be performed by TWD as described below to confirm and/or update the master data:

1. Pipes with duplicate facility IDs
   a. Renumber pipes with duplicate facility IDs to ensure each facility ID is unique.
2. Pipe assigned to Main Breaks
   a. Each main break record within FY2000-FY2015 was assigned to a pipe as part of the main break analysis effort performed by Black & Veatch (Phase 700, Risk-Based Prioritization task) using multiple confidence level criteria. The assigned pipe should be confirmed for all main breaks.
3. Water mains that may be included in the wLateral feature class
   a. Water mains that are included in the wLateral feature class should be removed and added to the wMains feature class.
4. Service lines that may be included in the wMains feature class
   a. Service lines that are included in the wMains feature class should be removed and added to the wLaterals feature class.
5. Splits in pipes where a node (valve, hydrant, or fitting) is not located
   a. Determine if a valve, hydrant, or fitting is missing at two adjoining pipes or if the pipe segments should be merged as a single pipe.
6. Pipes not split at a node (valve, hydrant, or fitting)
   a. Determine if a pipe should be split at an existing node or if the pipe is a duplicate and should be removed.

7. Multiple pipes in the same location
    a. Review if overlapping pipe(s) should be inactive
    b. Review for pipe duplication (individual pipe segments between nodes may have been added and the original pipe segment may have not been deleted)

4. Survival Curve Analysis

Survival curves were developed for each pipe material to estimate the remaining life expectancy for the TWD water mains. The survival curve represents the percentage of pipes that survived at each time period. The survival curve analysis follows the Kaplan-Meier methodology and incorporates the total observed population of water mains for each pipe material, the age of each water main as of year 2015, and the main break occurrences between years 2000 and 2015 to develop a hazard curve and survival curve. The hazard curve represents the ratio of pipes that broke within the total observed pipe population at a specific age. The observation period was based on the pipe age, where each pipe was evaluated based on age during the available main break history. The hazard curve and survival curve were developed for the "first break" occurrence and "all main break occurrences" within the observed ages for each pipe. Pipe materials that did not have sufficient data to support the survival curve analysis were not included.

A template spreadsheet was developed for continued use by TWD to perform the survival curve analysis. **Attachment B** provides details on the set-up of the template spreadsheet and includes the instructions on how to update and re-run the survival curve analysis. The instructions on how to update and re-run the survival curve analysis is also included in the spreadsheet template on the "Instructions" tab. The following three figures represent the available results in the spreadsheet.

(1) Survival Curves and Weibull Survival Probability Curve – The survival curves are plotted based on the "first break" and "all main breaks" for both the "as-is" and "modified" pipe population. This graph includes the survival probability distribution curve based on the Weibull function and total observed pipe population (modified).

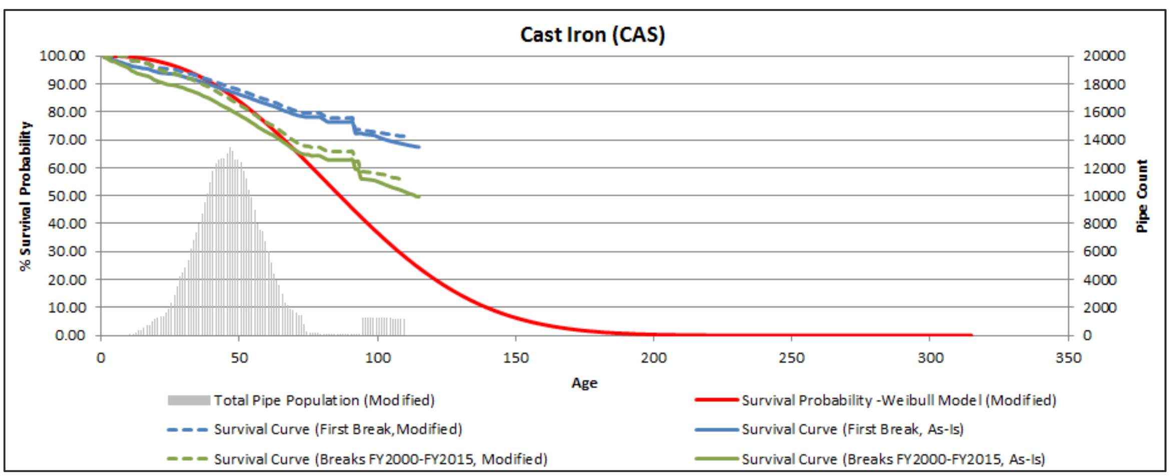


Figure 3: Survival Curves and Weibull Survival Probability Curve

(2) Hazard Curve – The hazard curves are plotted based on the "first break" and "all main breaks" for based on the "modified" pipe population. This graph includes the total observed pipe population (modified).

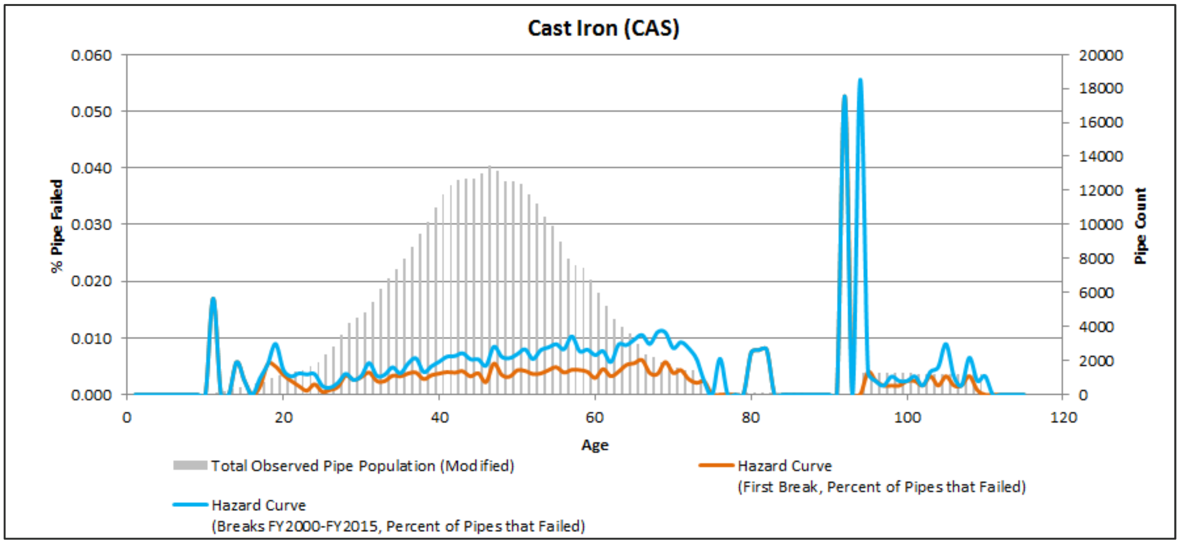


Figure 4: Hazard Curve

(3) Total Observed Pipe Population As-Is vs Modified– The "as-is" and "modified" pipe population is plotted.

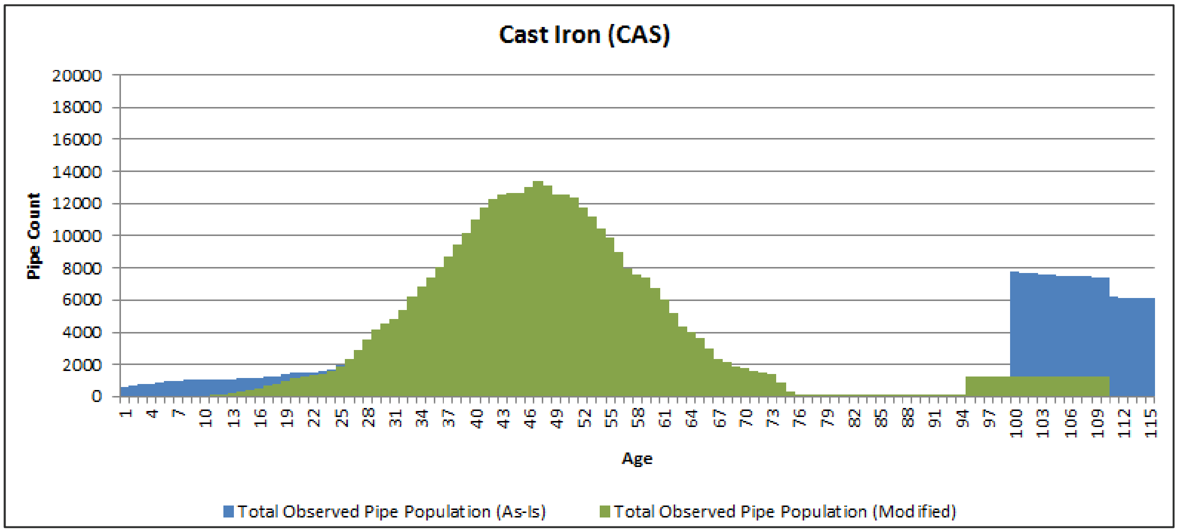


Figure 5: Total Observed Pipe Population As-Is vs Modified

4.1 DATA SOURCE

The "as-is" and "modified" total population of water mains were also reviewed as part of the analysis. The "as-is" water main population included all mains except those flagged as inactive or not owned by the City of Tampa. The "modified" water main population excluded pipes flagged for further review as discussed in **Section 2** in addition to those flagged as inactive or not owned by the City of Tampa. The survival curve analysis could not be performed on pipe materials that did not have any break history; these included steel, transite, concrete segments (bolted), fiberglass reinforced, polyethylene, and clay tile. Main breaks that occurred before year 2000 or had a Medium_Low2 confidence level (water main material and recorded main break material could be either cast iron, ductile iron, or unlined iron as documented in the Risk Based Pipeline Prioritization, Attachment A Technical Memorandum) were not included in the analysis. In addition, main breaks that occurred on any water main excluded from the analysis were also excluded.

4.2 METHODOLOGY

The Weibull function was used to represent the survival probability for each pipe material. The Weibull function is a straight-forward approach to develop a distribution curve in a spreadsheet format and is widely used. The Weibull function uses two parameters to develop the distribution curve: a shape parameter and scaling parameter, as shown in the formula below. The scale parameter corresponds to the "characteristic" life, at which 63% of the population would be expected to have failed. The two parameters were calibrated to develop an appropriate distribution curve based on the Kaplan-Meier "first break" and "all main breaks" survival curves.

Weibull Cumulative Distribution Equation (Reference Microsoft Excel Help Guide)

$F(x; \alpha, \beta) = 1 - e^{-(\frac{x}{\beta})^{\alpha}}$, where

x= Age of pipe

α = Shape parameter

β = Scale parameter; corresponds to the "characteristic" life, at which 63% of the population would be expected to have failed

Microsoft Excel includes the Weibull distribution function, WEIBULL.DIST, and was used in the spreadsheet template.

4.3 AVERAGE LIFE EXPECTANCY RESULTS

The average life expectancies are based on the 50th percentile of the Weibull estimated survival probability. The average life expectancies for pipe materials that did not have sufficient data to support the survival curve analysis are based on the 2012 AWWA Report or assumed, as applicable. **Table 5** provides the estimated life expectancy results for each pipe material. The estimated life expectancy will be used to determine the remaining life for each water main to support the risk-based prioritization for the TWD water mains.

The estimated remaining life will be calculated for each pipe record as shown in the formula below and added as an attribute within the InfoMaster Pressurized Mains feature class. "Remaining Life" is a factor included in the likelihood of failure criteria used in the risk-based prioritization methodology.

Remaining Life Estimate

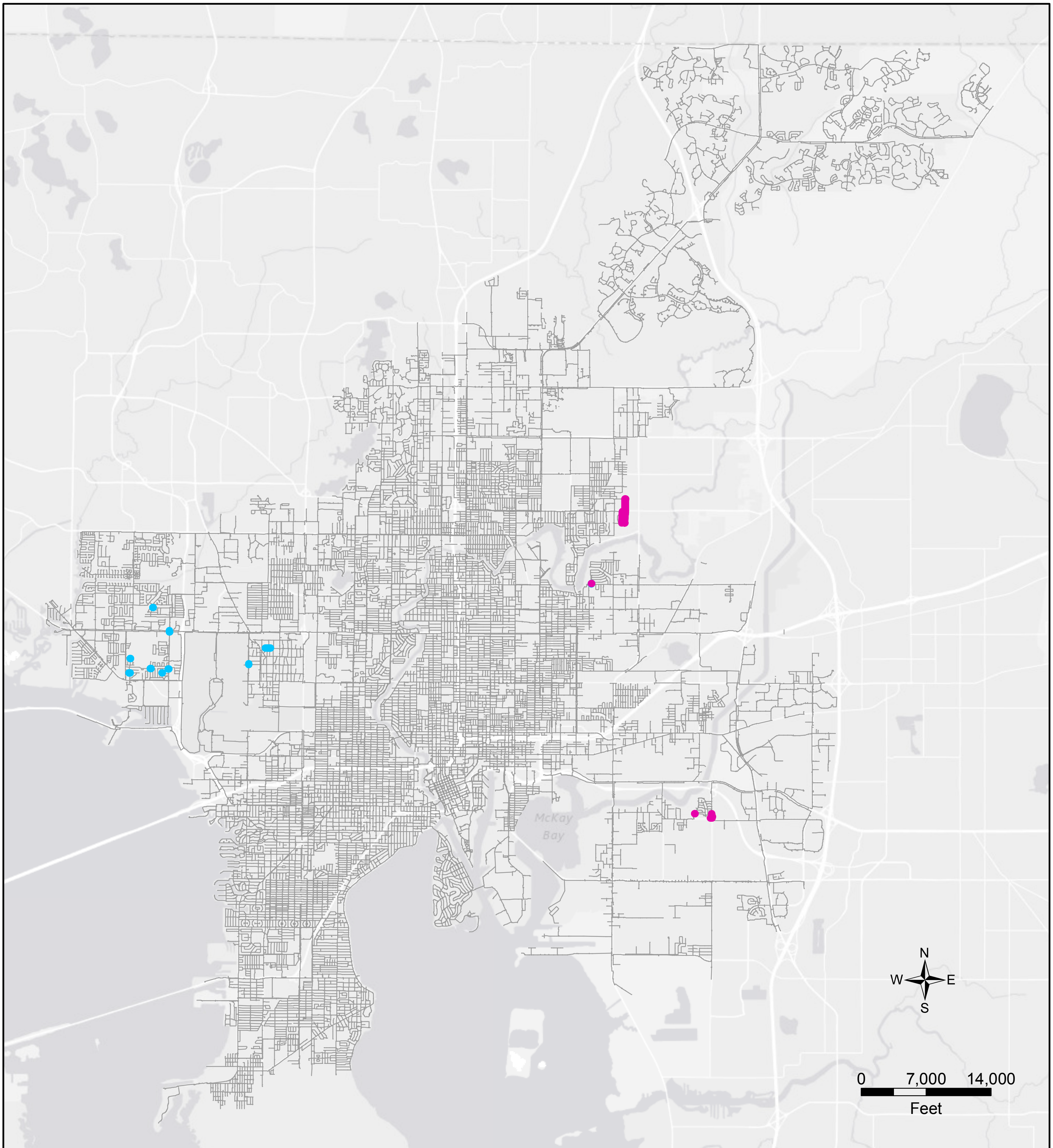
$$Remaining\ Life = (Install\ Year\ + Average\ Life\ Expectancy) - Year\ 2015$$

Table 5: Average Life Expectancy

MATERIAL	AVERAGE LIFE EXPECTANCY (YEARS)		
	WEIBULL SURVIVAL PROBABILITY (1)	AWWA – 2012 REPORT (2)	SELECTED
Asbestos Cement	46	90	46
Cast Iron	86	110	86
Copper	40	*Not Available*	40
Concrete Segments (Bolted)	*Not Available*	105 (2)	105
Clay Tile (4)	*Not Available*	*Not Available*	100
Ductile Iron	88	80	88
Fiberglass Reinforced	*Not Available*	55 (2)	77 (3)
Galvanized Pipe	101	*Not Available*	101
High Density Polyethylene	78	*Not Available*	78
Polyethylene	*Not Available*	55 (2)	77 (3)
Polyvinyl Chloride	77	55	77
Steel	*Not Available*	70	70
Transite	*Not Available*	90 (2)	46 (3)
Unlined Cast Iron	80	*Not Available*	80

(1) Average life expectancies are based on the "Modified" pipe population for each pipe material and are estimated at the 50th percentile of the Weibull survival probability curve.
(2) The 2012 AWWA Report average life expectancy is assumed to be 50th percentile. The AWWA report does not include life expectancy for all pipe materials. The following assumptions were made in order to estimate the remaining life for each pipe material.
Concrete Segments (Bolted) – Assumed similar to Conc & PCCP
Fiberglass Reinforced – Assumed similar to PVC
Polyethylene – Assumed similar to PVC
Transite – Assumed similar to Asbestos
(3) Pipe materials that did not have break history were not included in the survival curve analysis. The following assumptions were made in order to estimate the remaining life for each pipe material based on the Weibull survival probability curve estimates.
Fiberglass Reinforced – Assumed similar to PVC
Polyethylene – Assumed similar to PVC
Transite – Assumed similar to Asbestos
(4) Clay Tile was assumed to have an average life expectancy of 100 years.

Attachment A – Pipe Segments Identified for Further Review



Legend

- Assumed Installation Date
- Installation Date Discrepancy
- Pressurized Mains

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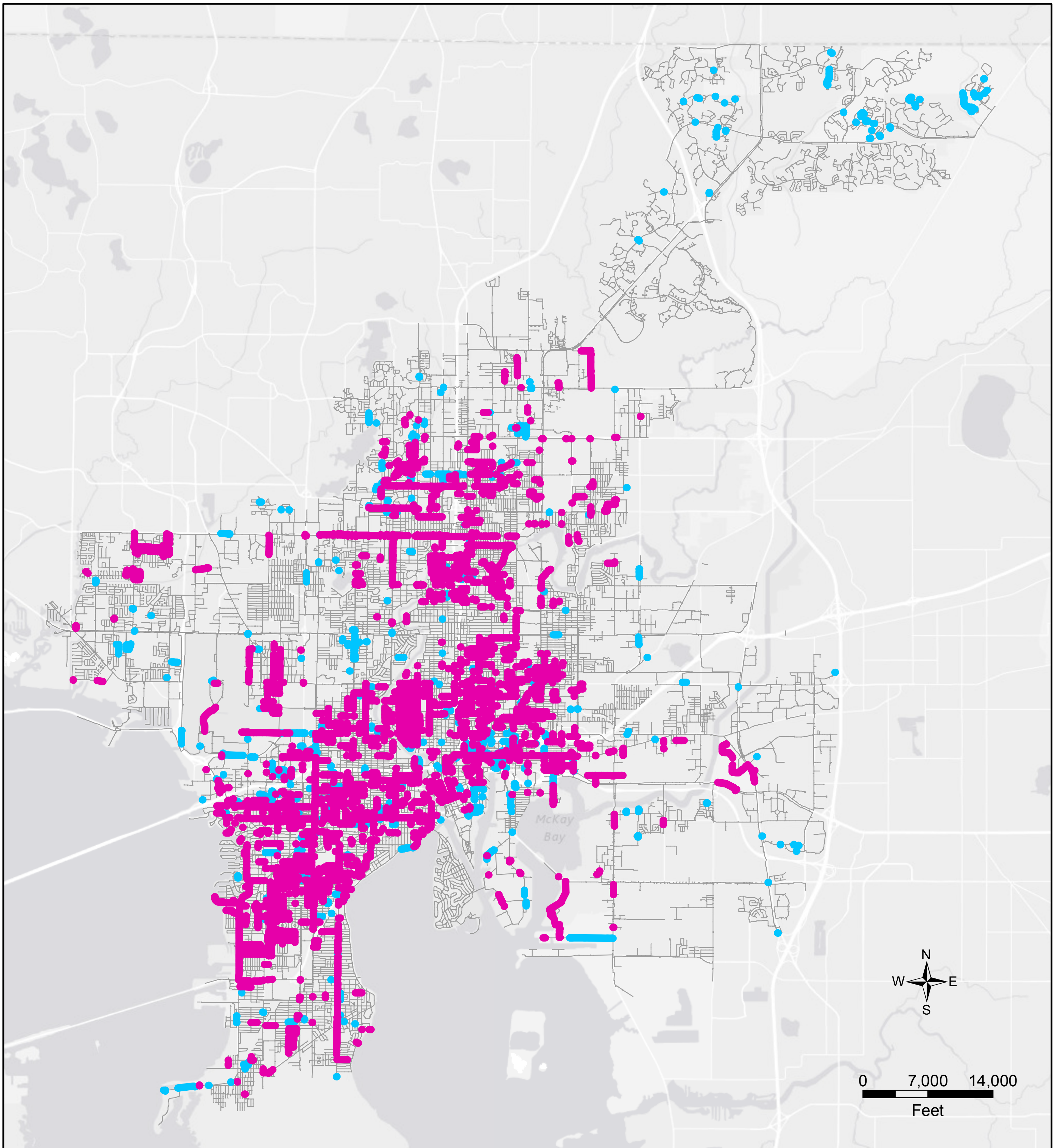
Potable Water Master Plan

Asbestos Cement Assumed Installation Date and Installation Date Discrepancy

Figure A-1



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Legend

- Assumed Installation Date
- Installation Date Discrepancy
- Pressurized Mains

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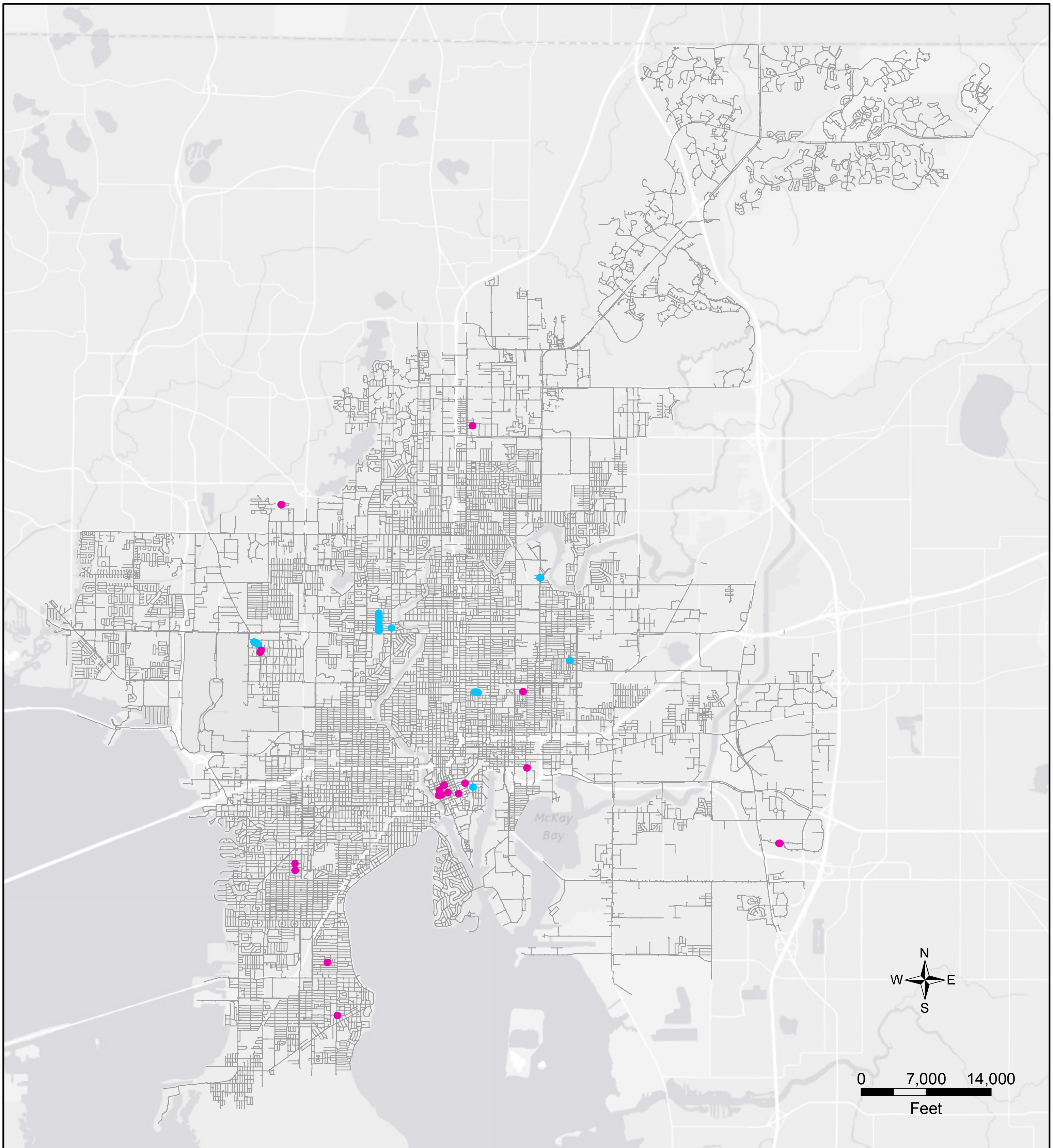
Cast Iron
Assumed Installation Date and Installation Date Discrepancy

Figure A-2



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Legend

Assumed Installation Date

Installation Date Discrepancy

Pressurized Mains

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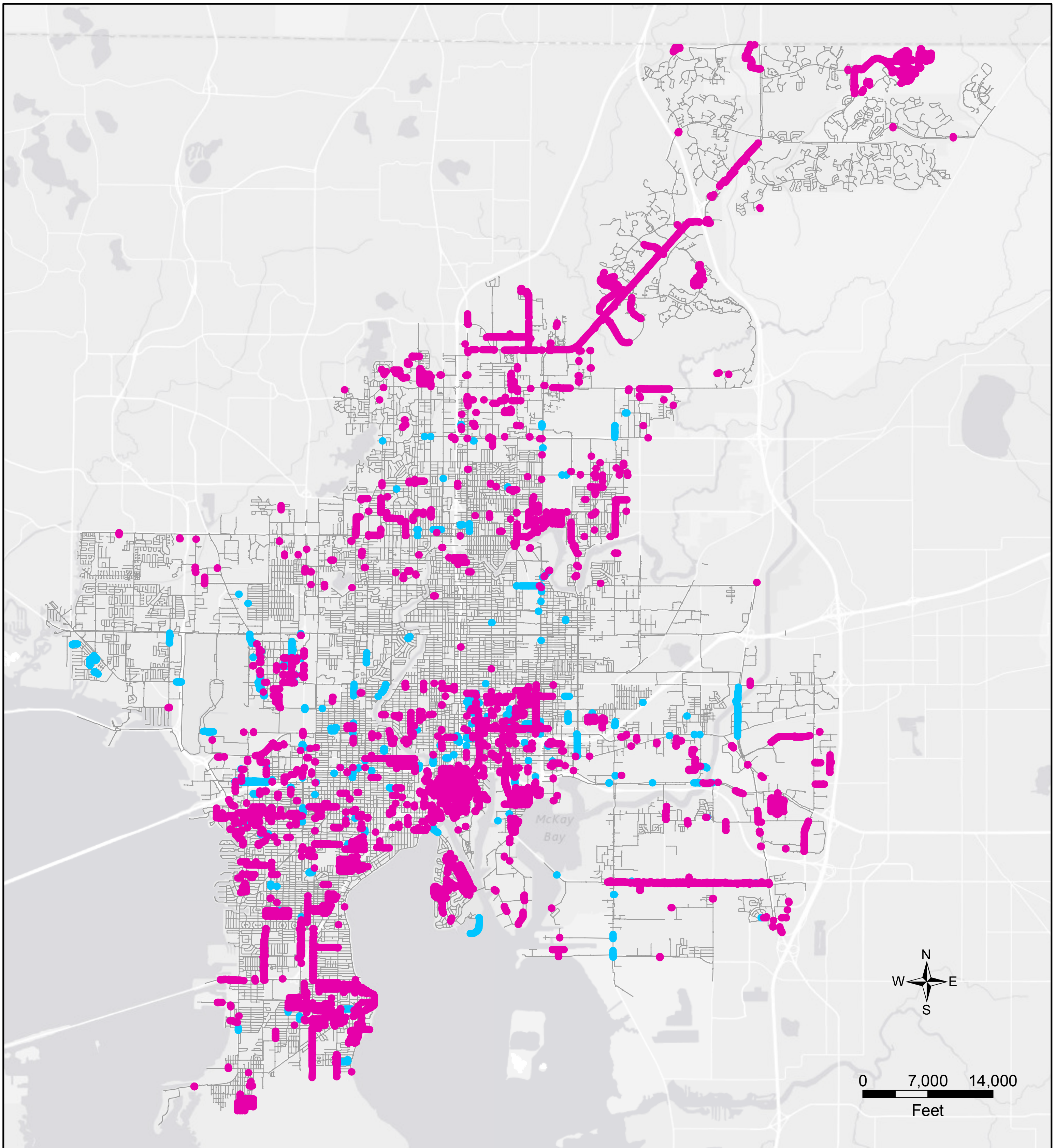
Copper
Assumed Installation Date and Installation Date Discrepancy

Figure A-3



Legend

- Assumed Installation Date
- Installation Date Discrepancy
- Pressurized Mains

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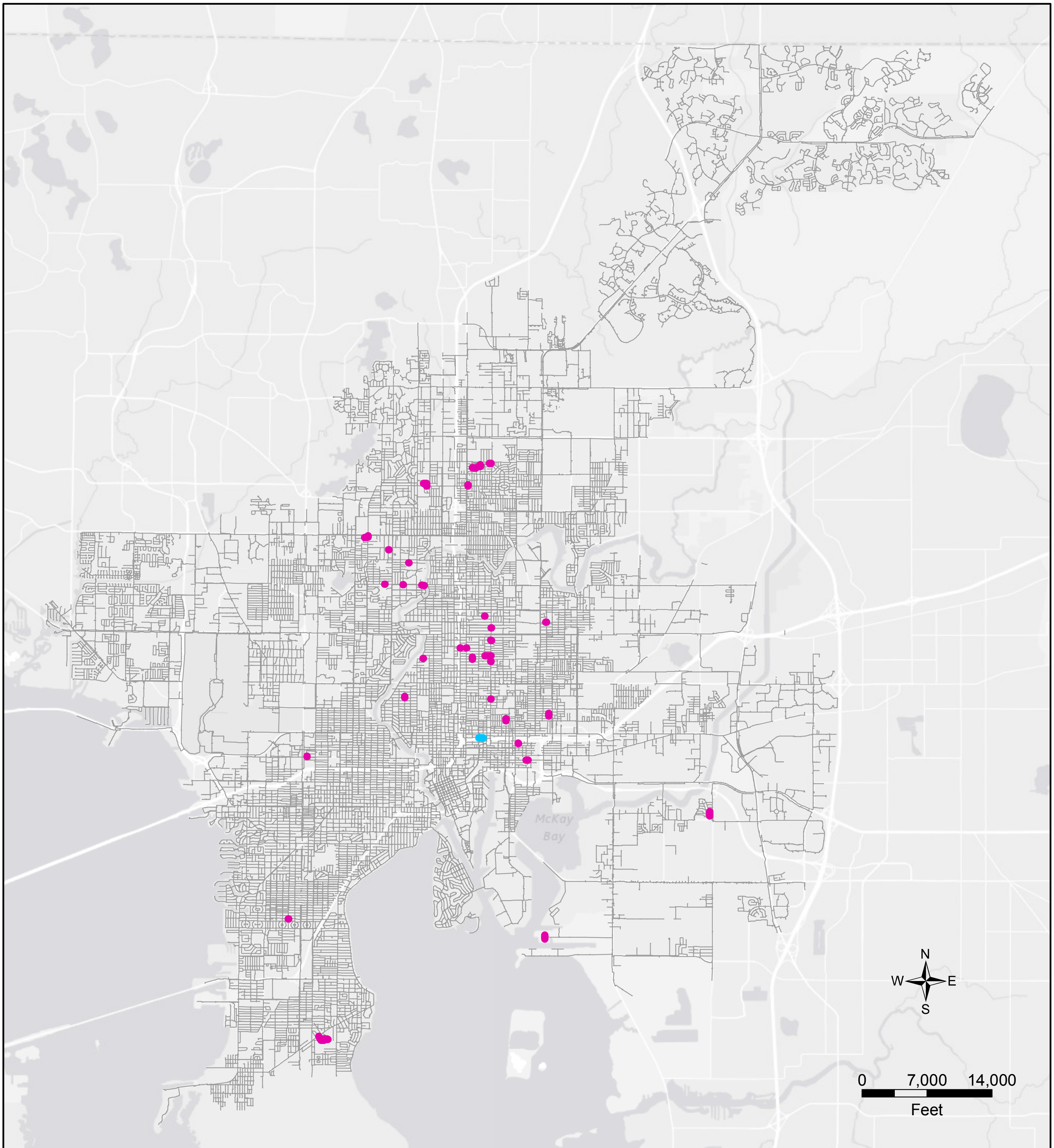
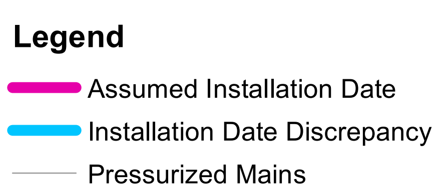
Potable Water Master Plan

Ductile Iron
Assumed Installation Date and Installation Date Discrepancy

Figure A-4





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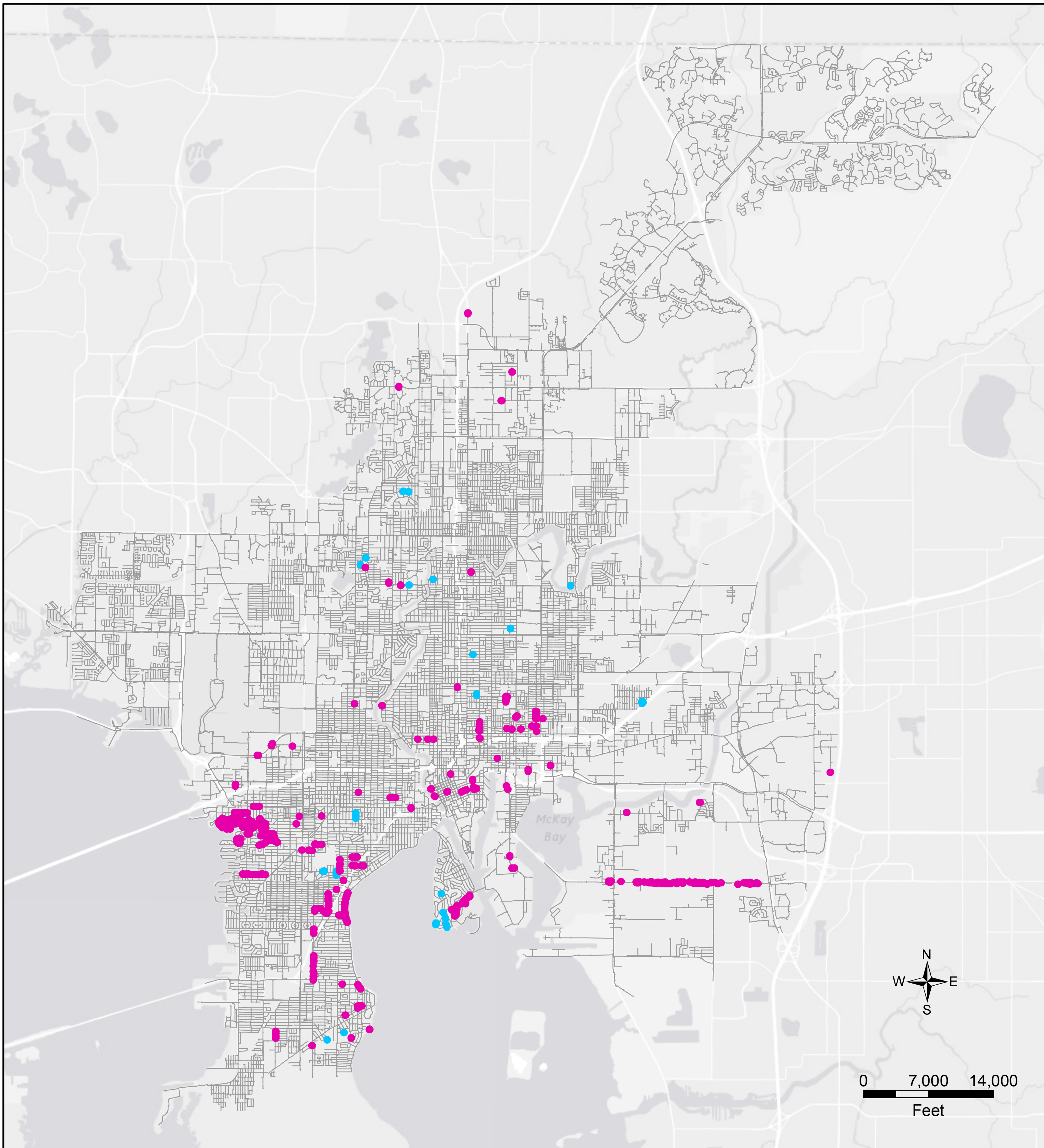
Galvanized Pipe Assumed Installation Date and Installation Date Discrepancy

Figure A-5



Legend

- Assumed Installation Date
- Installation Date Discrepancy
- Pressurized Mains

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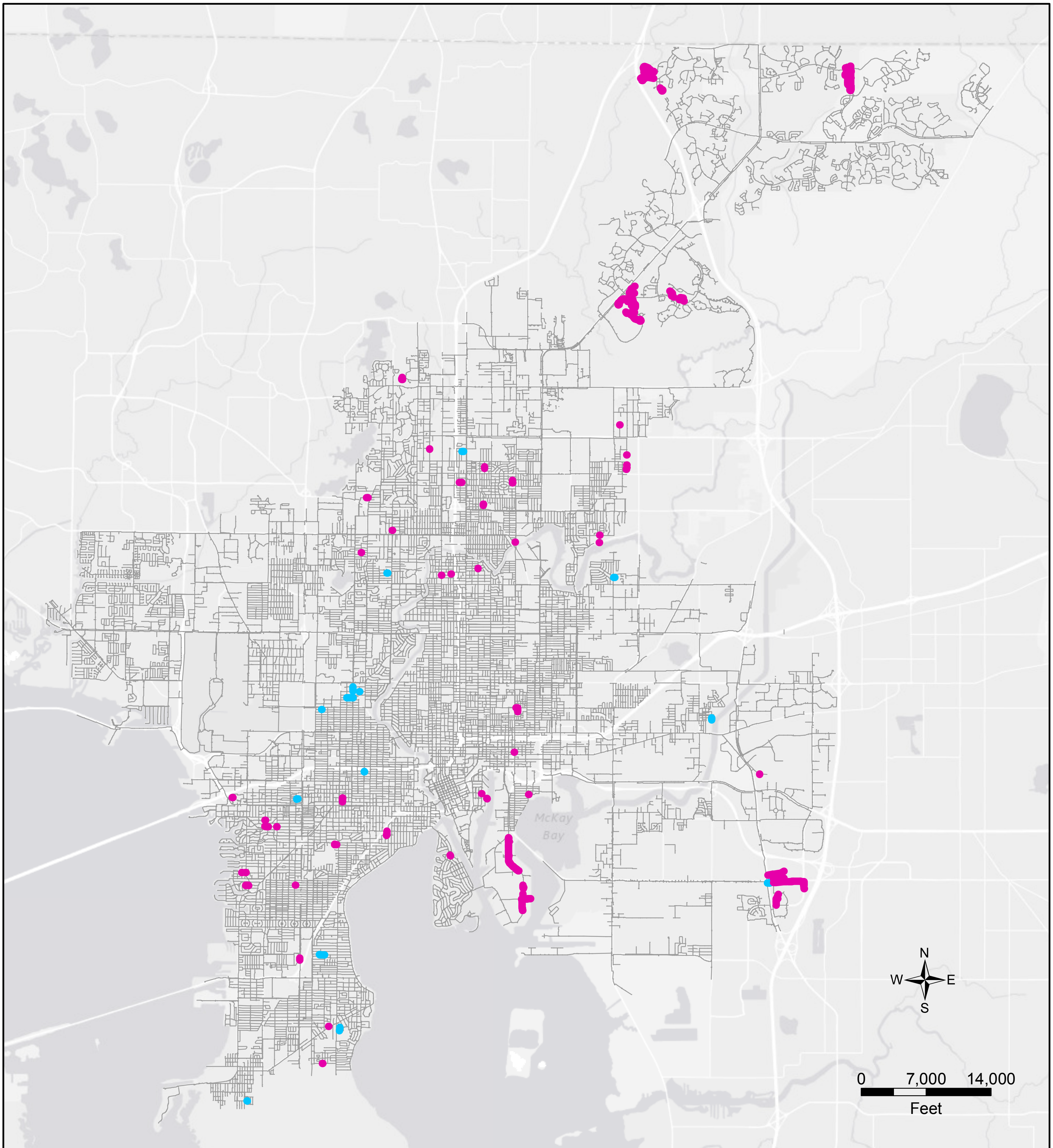
High Density Polyethylene Assumed Installation Date and Installation Date Discrepancy

Figure A-6



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Legend

- Assumed Installation Date
- Installation Date Discrepancy
- Pressurized Mains

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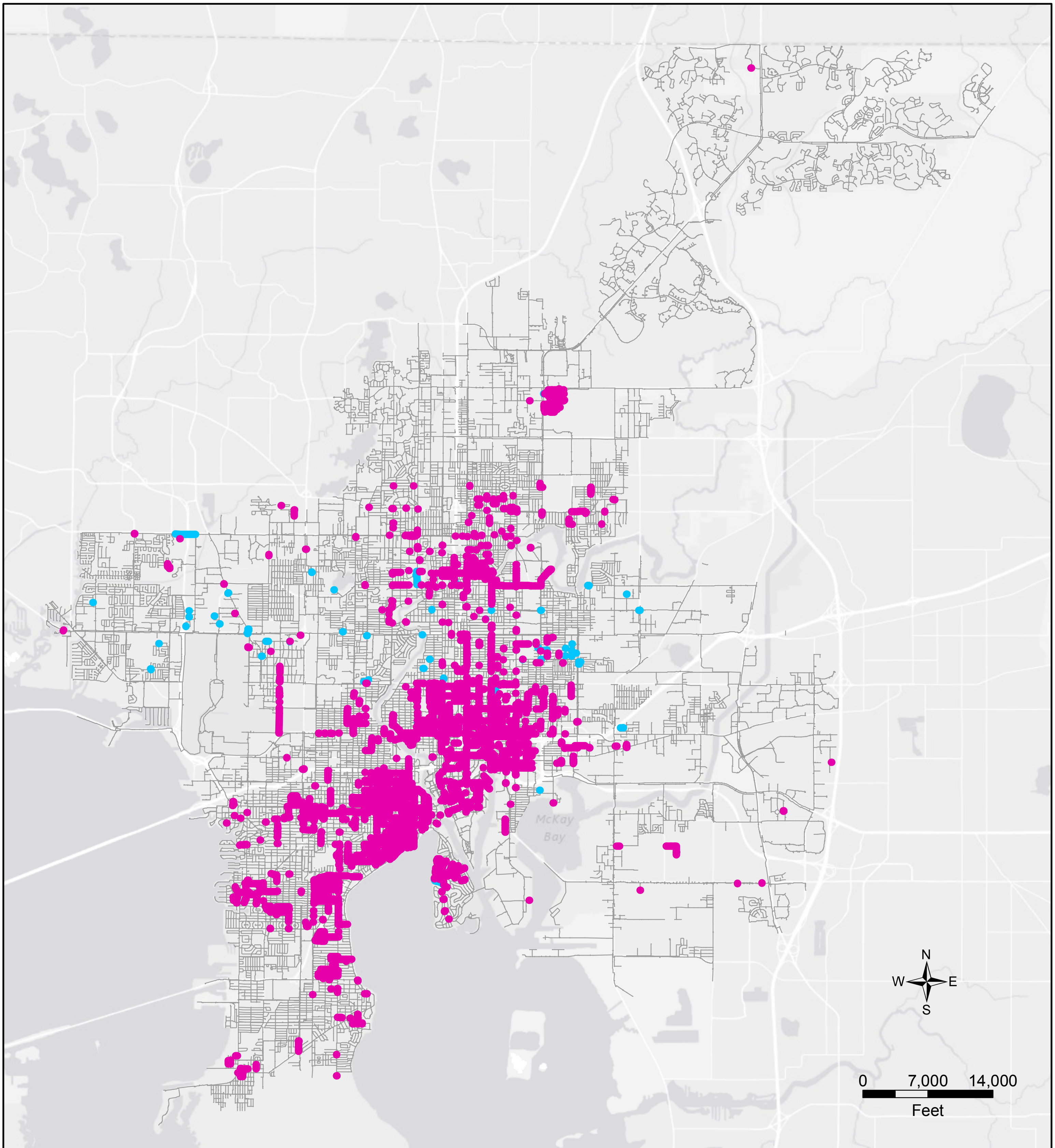
Potable Water Master Plan

Polyvinyl Chloride Assumed Installation Date and Installation Date Discrepancy

Figure A-7



Legend

- Assumed Installation Date
- Installation Date Discrepancy
- Pressurized Mains

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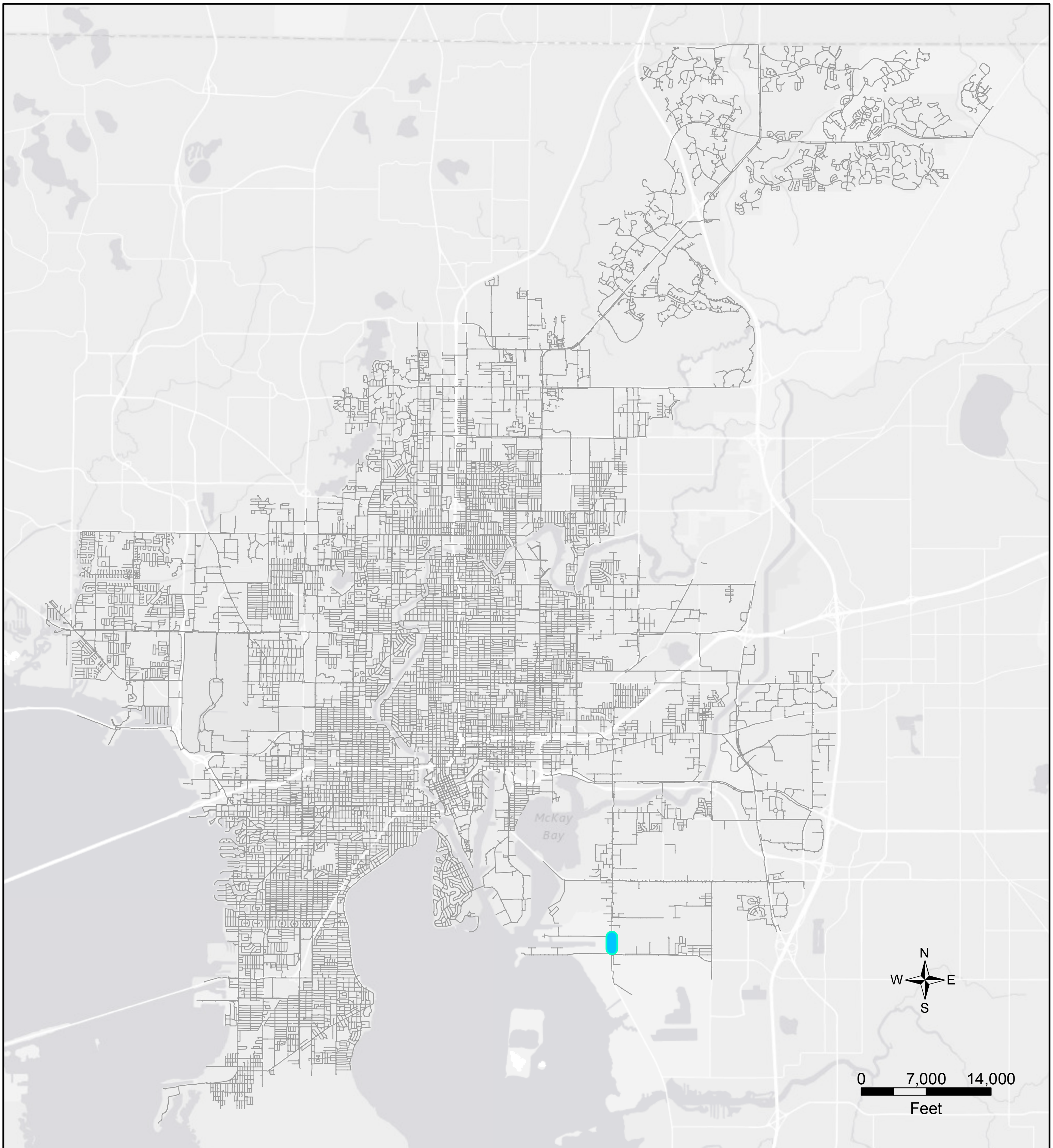
Potable Water Master Plan

Unlined Cast Iron Assumed Installation Date and Installation Date Discrepancy

Figure A-8



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Legend

- Installation Date Discrepancy
- Remaining Active Segment
- Pressurized Mains

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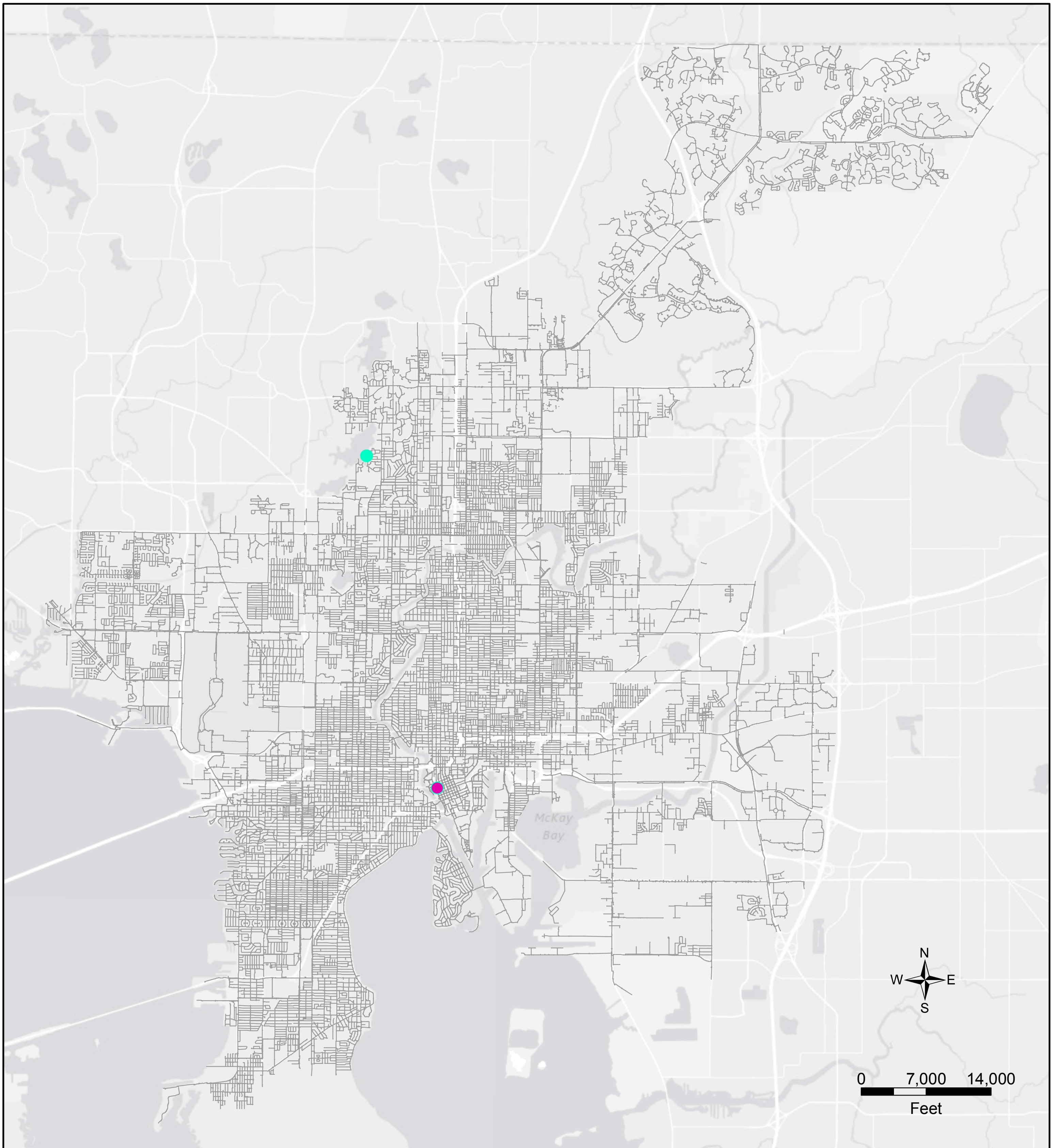
Potable Water Master Plan

Fiberglass Reinforced Installation Date Discrepancy and Remaining Active Segment

Figure A-9



Legend

Assumed Installation Date

Remaining Active Segments

Pressurized Mains

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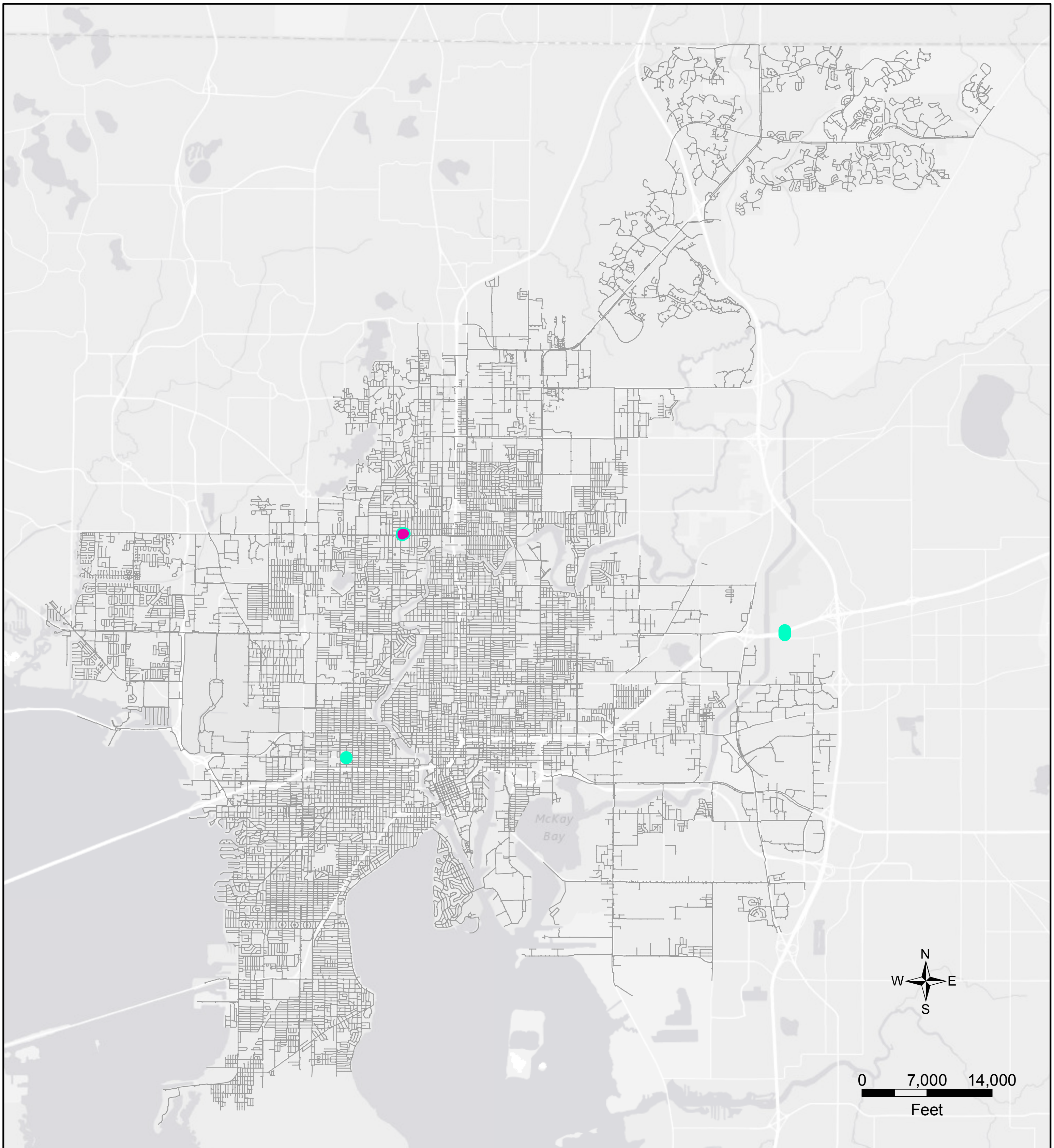
Potable Water Master Plan

Concrete Segments (Bolted) Assumed Installation Date and Remaining Active Segments

Figure A-10



Legend

- Assumed Installation Date
- Remaining Active Segments
- Pressurized Mains

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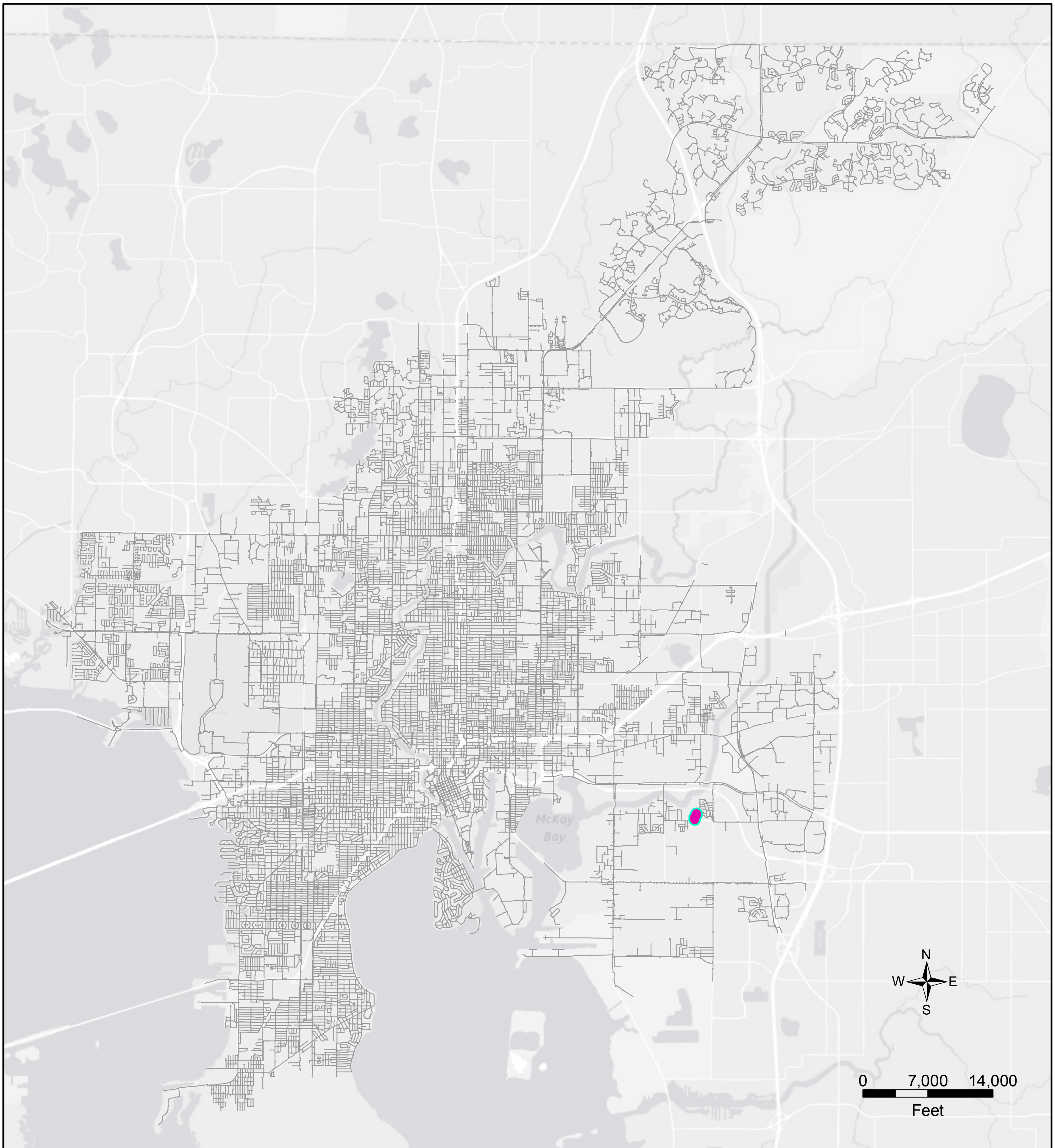
Steel
Assumed Installation Date and Remaining Active Segments

Figure A-11



Legend

- Assumed Installation Date
- Remaining Active Segments
- Pressurized Mains

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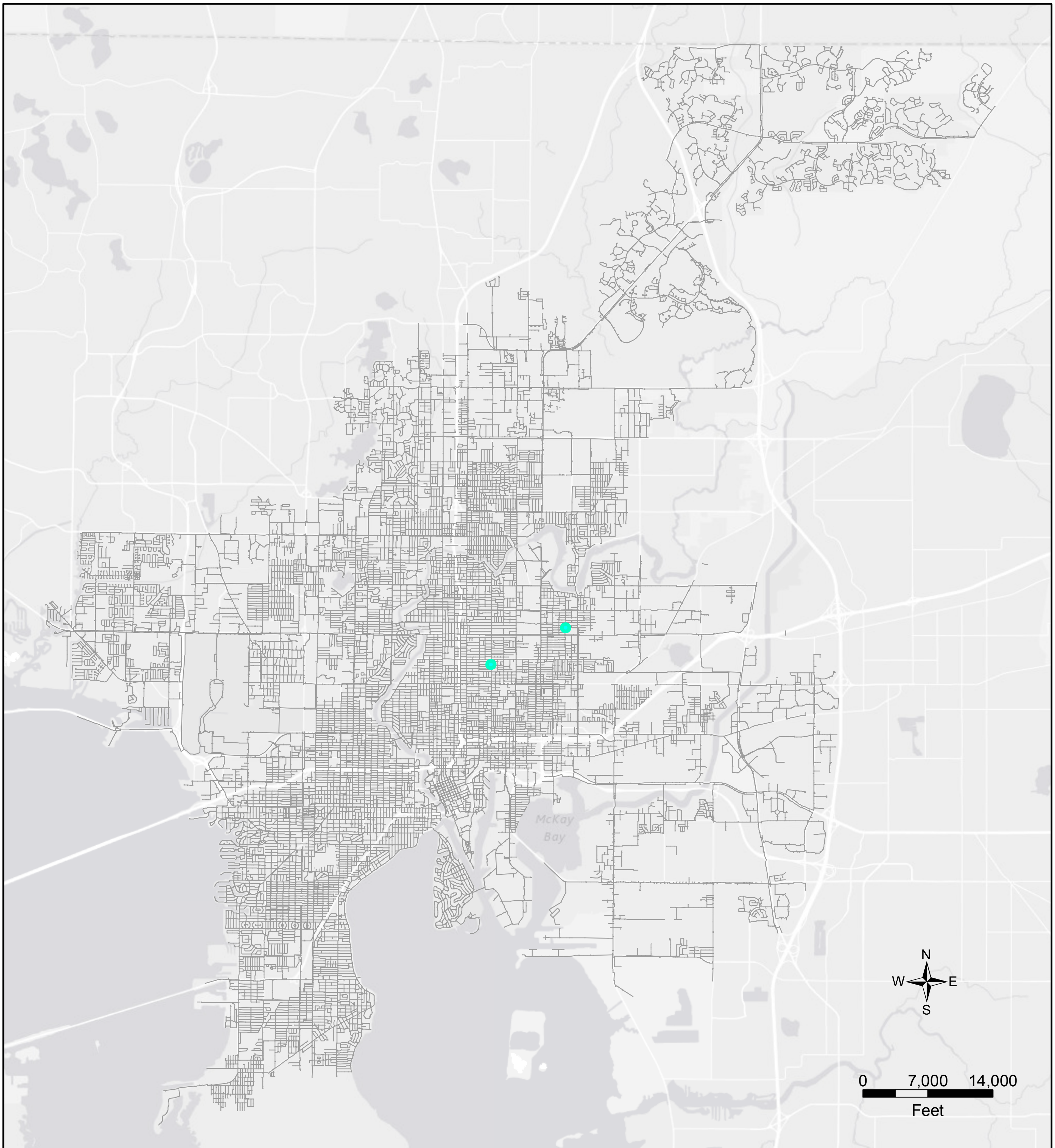
Transite
Assumed Installation Date and Remaining Active Segment

Figure A-12



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Legend

Remaining Active Segments

Pressurized Mains

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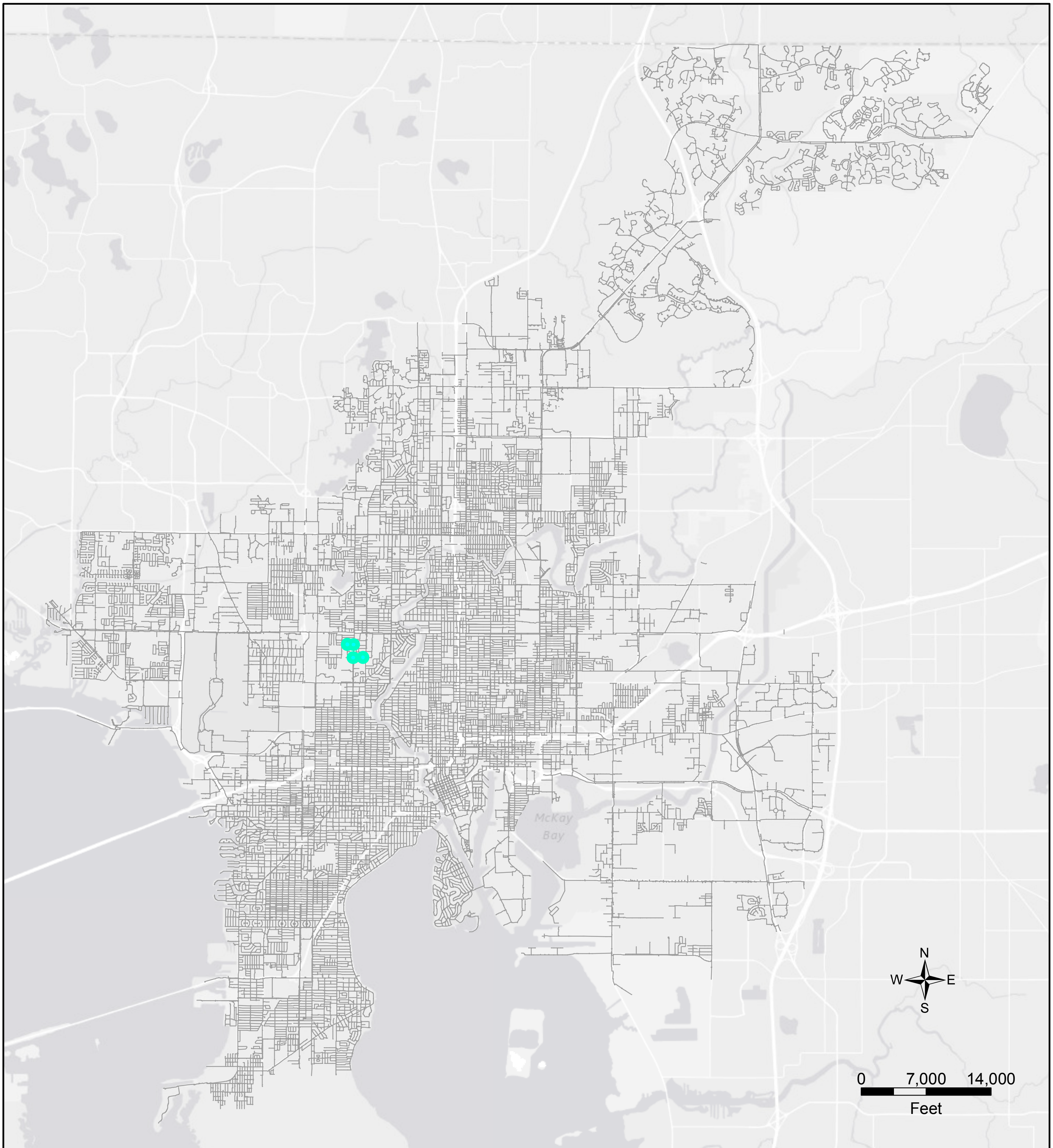
Potable Water Master Plan

Clay Tile
Remaining Active Segments

Figure A-13



Legend

Remaining Active Segments

Pressurized Mains

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Potable Water Master Plan

Polyethylene
Remaining Active Segments

Figure A-14

Attachment B – Survival Curve Template Spreadsheet Guideline

B1. Survival Curve Spreadsheet Template Overview

The following describes the Survival Curve Development Template Spreadsheet set-up. Details for each tab, including the data and formulas used in the spreadsheet, are listed below.

NOTE: Tabs have been color-coded in the spreadsheet as shown below. The workbook has been "protected" and all calculated fields have been locked for editing. A password to unprotect the spreadsheet has not been set. TWD can add a password at any time.

1.1 Instructions – Red Tab

This tab provides a brief overview of each tab within the spreadsheet and the instructions to update the survival curves. The instructions are provided in the following section.

1.2 Reference Info - Gray Tab

The following three (3) sources of information were referenced to support the survival curve analysis:

- Buried No Longer: Confronting America's Water Infrastructure Challenge. American Water Works Association, 2012
- Microsoft Excel Help Guideline - Weibull.DST function
- Remaining Asset Life: A State of the Art Review. Water Environment Research Foundation, 2009 – Herz

1.3 Data Exports - Blue Tabs

The pressurized mains and main break data are the two main sources of data used for the survival curve analysis. The pressurized mains and main break data were both exported from the InfoMaster model feature classes, Pressurized Mains and IMID_SVServiceRequest, respectively. This data can be updated from TWD's master source of data. As described in Section 2 – Data Quality Review, pipes that were flagged for further detailed review were not included in the survival curve analysis. As TWD confirms or updates the attribute data for these flagged pipes, the pipe records can be removed from the list.

The following tabs were included for each source data:

- PressurizedPipes_Data
- ServiceRequest_MainBreak_Data
- Pipes_ToNotInclude

1.4 Data for Analysis - Orange Tabs

The exported pressurized mains and main break data were re-formatted to include only the data fields required for the survival curve analysis. Additional calculation fields needed for the analysis were added for each data set. All calculation fields are highlighted in gray. The required data fields and calculations used for each data set are described below.

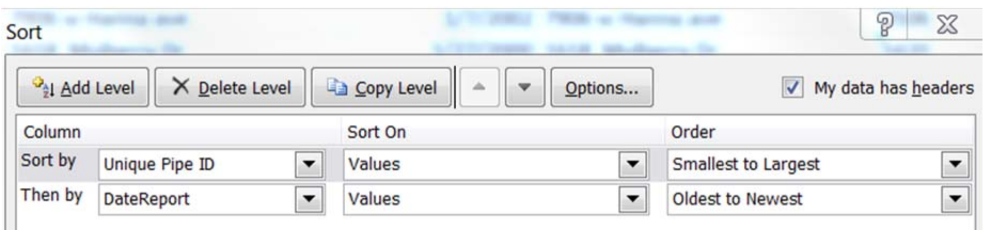
PressurizedPipes Tab

- Data Fields
  - OBJECTID – The object ID is the unique ID automatically assigned in the geodatabase. Due to the duplicate facility IDs, the Object ID was considered the unique ID and used for all lookup values. Once the duplicate facility IDs have been revised, TWD's assigned facility ID can be used.
  - FacilityID – TWD's assigned Facility ID
  - LegacyID - TWD's assigned Legacy ID
  - InstallDat – Install date for each pipe
  - Material – Material for each pipe
  - Diameter – Diameter for each pipe
  - LifecycleS – Lifecycle status indicates the status of each pipe as Active (ACT) or Inactive (INA). Inactive pipes are excluded from the analysis. This data was populated from the Active Flag field in TWD's wMains where True = Active and False = Inactive.
  - OwnedBy – Indicates ownership of each pipe as 1 – City of Tampa, -1 – Private, or 2 – Hillsborough County. Pipes not owned by City of Tampa are excluded from the analysis.
- Calculated Fields
  - MainBreak – Counts the number of main breaks for each pipe record
  - Year – Indicates pipe install year based on the install date
  - Age – Calculates the age of the pipe based on the evaluation year (currently set to year 2015)
  - Survived – Indicates if the pipe had a break occurrence, "1" indicates no breaks, "0" indicates a break has occurred
  - AgeatFirstBreak – If a main break occurred on the pipe, the age of the pipe at the time of the first break will be populated. This formula looks up the Age at Break field from the ServiceRequest_MBs tab. If a main break did not occur, the field is left blank.

- Begin Age – Calculates the beginning age of the pipe based on the observed timeframe of the available main break data. The observed timeframe is based on the earliest complete calendar year of the main break data. For this initial analysis, main break data from FY2000 – FY2015 was available. Year 2000 represents the earliest complete calendar year; therefore any breaks that occurred in late 1999 were excluded.
- End Age or Age at First Break - If a main break occurred on the pipe, the "Age at First Break" year will be populated; else the "Age" year will be populated.
- Pipes_ToNotInclude – If a pipe is included in the "Pipe_ToNotInclude" tab, a "1" will be populated, else a "0" will be populated.

ServiceRequest_MBs Tab

The main break data needs to be sorted to determine the proper break sequence to identify the first break. Follow the sorting order as shown below for the data set (columns A-K):



- Data Fields
  - OBJECTID – The object ID is the unique ID automatically assigned in the geodatabase.
  - ID – ID automatically assigned when the main break shapefiles were combined into a single shapefile
  - Type – Break type assigned for InfoMaster
  - Descriptio – Type of breaks assigned by TWD
  - StatusComm – Confidence level assigned by Black & Veatch as part of the main break analysis.
  - FacilityID – TWD's assigned Facility ID for associated pipe
  - RefStreet – Street address of main break
  - DateReport – Date of main break occurrence
  - Address - Street address of main break
  - SourceID – Same as ID field
  - Unique Pipe ID – Object ID of the associated pipe

- Calculated Fields
  - Age at Break – Year of Break minus Install Year
  - InstallDate – Lookup of the install date of the associated pipe
  - InstallYear – Indicates pipe install year based on the install date
  - BreakYear – Indicates year of the break occurrence
  - BreakSequence – Each break occurrence on a pipe was numbered in sequential order. The first row was assigned a "1". The remaining rows were calculated.
  - Material – Lookup of the material of the associated pipe
  - Pipes_ToNotInclude – If a pipe is included in the "Pipe_ToNotInclude" tab, a "1" will be populated, else a "0" will be populated.
  - PipeStatus – Lookup of the lifecycle status of the associated pipe
  - Pipe_Owner – Lookup of the owner of the associated pipe

1.5 Survival Curve Analysis and Weibull Function - Green Tabs

The survival curve analysis was prepared for both the "as-is" and "modified" pipe data set and each pipe material installed in the water distribution system. The "As-Is" survival curve analysis includes all active pipes within the water distribution system that are owned by the City of Tampa. The "Modified" survival curve analysis further excludes pipes that are flagged for further detailed review based on the data quality review. The following fields are used to develop the hazard curve, survival curve, and Weibull distribution curve. All fields are calculated.

- Age – Represents the age in years, starting with year 1
- Total Observed Pipe Population – Counts the number of pipes within the selected material type that has a "Begin Age" year less than or equal to the given age and an "End Age or Age at First Break" year greater than or equal to the given age. Pipes that are inactive or not owned by the City of Tampa are not included in the count.
- Observed Pipes that Broke (First Break) – Counts the first break on any pipe within the selected material type that occurred in the given age timeframe
- Hazard Curve (First Break, Percent of Pipes that Failed) – Calculates the ratio of "Observed Pipes that Broke (First Break)" to the "Total Observed Pipe Population"
- Survival Curve (First Break) – Calculates the survival probability percentage for each age timeframe based on the Hazard Curve (First Break, Percent of Pipes that Failed)
- Observed Pipes that Broke (All Main Breaks FY2000-2015) – Counts all breaks on any pipe within the selected material type that occurred in the given age timeframe
- Hazard Curve (Breaks FY2000-FY2015, Percent of Pipes that Failed) – Calculates the ratio of "Observed Pipes that Broke (All Main Breaks FY2000-2015)" to the "Total Observed Pipe Population"

- Survival Curve (Breaks FY2000-FY2015) – Calculates the survival probability percentage for each age timeframe based on the Hazard Curve (Breaks FY2000-FY2015, Percent of Pipes that Failed)
- Survival Probability – Weibull Function – Generates the survival probability using the Weibull function based on the shape parameter (Alpha) and scaling parameter (Beta). Both the shape parameter (Alpha) and scaling parameter (Beta) are entered manually in the spreadsheet and adjusted to generate a representative distribution curve for each material type and data set.
- Survival Probability – Weibull Function For Lookup – Rounds the survival probability percentage to zero decimals for use in the lookup value for the average life expectancy
- Average Life Expectancy – Lookup for the year where the survival probability based on the Weibull function is closest to the 50th percentile

1.5.1 Herz Methodology

The Herz calculation was included in the template spreadsheet for comparison purposes. The Herz calculation was developed specifically for the water industry and uses 3 parameters to develop the distribution curve, a shape parameter, scaling parameter, and time parameter, as shown in the formula below. The additional time parameter in the Herz calculation represents the lag time from asset installation to first failure or amount of time where no pipe renewal is assumed to occur. Based on the available main break data, most material types show a break in the first year of installation which may not be the best representation for each material. For comparison purposes, a 5 year time lag period was used for the Herz calculation. The results between the Weibull and Herz functions were indistinguishable.

If the Herz calculation will be used further by TWD, it is recommended that each material type be evaluated in detail to determine the most appropriate time value to use. In order to determine the appropriate time value to use for each pipe material and the shape and scaling parameter, numerous manual iterations will need to be performed within the spreadsheet. Due to the complexity of balancing three factors, this spreadsheet tool does not provide a cost to benefit ratio.

<u>Herz Cumulative Distribution Equation</u>

$F(t; a, b, c) = 1 - \frac{a+1}{a+e^{b(t-c)}}$ where

t = Age of pipe

a = Shape parameter

b = Scale parameter

c = Time parameter; this time parameter can either represent an amount of time where no pipe renewal is assumed to occur or the age from first installation to first break.

1.6 Survival Probability Graphs – Brown Tab

The Weibull survival probability curves for each material type and “modified” data set were plotted in a single graph for comparison.

1.7 AWWA Average Service Life and Duplicate Pipes - Purple Tabs

- AWWA Tab – The average service life (in years) from the 2012 AWWA Buried No Longer Report was summarized for each available material type
- Duplicate Pipes – A pivot table was prepared listing the Facility IDs and count of pipes with the same facility ID. A count greater than 1 indicates the number of pipes with the same assigned facility ID.

B2. Instructions to Update Survival Curves

The following instructions were included in the spreadsheet template on the "Instructions" tab.

Due to the complex formulas used in the spreadsheet, the workbook has been set to "Calculate Manually". To update the calculations in the workbook, push the "Calculate Now" button.

Calculate Now

Note: The workbook is protected and all calculation fields are locked. A password to unprotect the spreadsheet has not been set. TWD can add a password at any time.

1. Enter the year of evaluation or the last date of the data update.
    a. This year will update the age calculation for the pipes (Tab: PressurizedPipes, Column M)
    b. Currently set to year 2015
2. Enter the earliest complete calendar year of main break data.
    a. This year will update the begin age calculation for the main breaks (Tab: PressurizedPipes, Column P). Example: Main break data used for this initial calculation is based on FY2000 - FY2015. Although year 1999 breaks are included in the data set, Year 2000 represents the earliest complete calendar year to align with the observed start year.
    b. Currently set to year 2000
3. As needed, update the "PressurizedPipes_Data" tab with pipe data.
4. As needed, update the "ServiceRequest_MainBreak_Data" tab with main break data.
5. As needed, remove pipes from the Pipes_ToNotInclude tab when attribute data has been verified and updated in the raw pipe data (in the "PressurizedPipes_Data" tab).
6. Update the "PressurizedPipes" tab with the appropriate data as noted in the section above.
7. Update the "ServiceRequest_MBs" tab with the appropriate data as noted in the section above.
8. Hit the "Calculate Now" button above to update the calculations in the workbook. Note each of the green tabs will be updated.
9. For each of the pipe materials, review the Weibull and Herz parameters to adjust the survival probability curve based on the data.
    a. Weibull
        i. Alpha = Shape parameter
        ii. Beta = Scale parameter; corresponds to the "characteristic" life, at which 63% of the population would be expected to have failed
    b. Herz
        i. a = Shape parameter
        ii. b = Scale parameter
        iii. c = Time parameter; this time parameter can either represent an amount of time where no pipe renewal is assumed to occur or the age from first installation to first break.