Technical Memorandum – Final

2015 Water Model Update

To: City of Hallandale Beach
Department of Public Works
Utilities and Engineering

From: Hazen and Sawyer

Date: February 24, 2016

1.0 Background

The City of Hallandale Beach, herein referred to as the City, owns, operates, and maintains a potable water treatment system and distribution network. In 2007, the City requested that Hazen and Sawyer update the existing water hydraulic model. At the time, projected new development within the City was expected to increase the potable water demands from City customers. The 2007 Water Model Update provided water system updates based on the development projections. However, the recent economic downturn in South Florida resulted in a population and growth plateau. The analysis summarized in this Technical Memorandum (TM) was authorized by the City to update the 2007 water hydraulic model with current and future forecasted water demand rates. The goals of this water model update and analysis are as follows:

- Project water demands through 2035;
- Evaluate the adequacy of the existing distribution system to meet projected demands while maintaining desirable system pressures;
- Determine if the existing distribution system can satisfy the appropriate fire flow criteria through 2035; and
- Identify potential system improvements to correct present and future system deficiencies.

2.0 Existing Water Treatment and Distribution System

Water treatment facilities include a lime softening water treatment plant permitted at 10 million gallons per day (mgd) of capacity and a nanofiltration water treatment facility permitted at 6 mgd of capacity. The distribution network includes four million gallons (MG) of storage capacity at the water treatment facilities with a high service pumping station that provides a firm capacity of 18.5 mgd. The distribution network also includes the North Beach elevated storage tank (0.35 MG) at an elevation of 130 feet and almost 400,000 linear feet of distribution system piping. **Figure 1** presents the existing water treatment and distribution system, including the location of the water treatment facilities and storage tanks.

3.0 Baseline Water System Model

The City's existing water distribution network model was updated and calibrated for use in this analysis. The model was developed using the Water CAD version V8i hydraulic modeling software by Bentley Systems based on data provided by City sources. The model was updated under this project to include additional information to further refine the results of the analysis. Major assumptions made during the updating process are described below.

3.1 Source Data

The model was developed based on input of field operation data, the City's water atlas maps, capital improvement project records, and record drawing information provided by the City. Associated data parameters configured in the model include:

- Distribution system piping length and diameter
- Junction/node elevations
- Fire hydrant elevations
- Fire hydrant lateral lengths and diameters
- Water treatment plant discharge pressures and elevations
- Remote storage tank dimensions and operating levels

3.2 Model Updates

The existing water distribution model from 2007 was updated under this project to include the following information:

- New pipes installed in the service area after the 2007 model update
- Fire hydrants and corresponding laterals, including elevations, lateral lengths, and lateral diameters

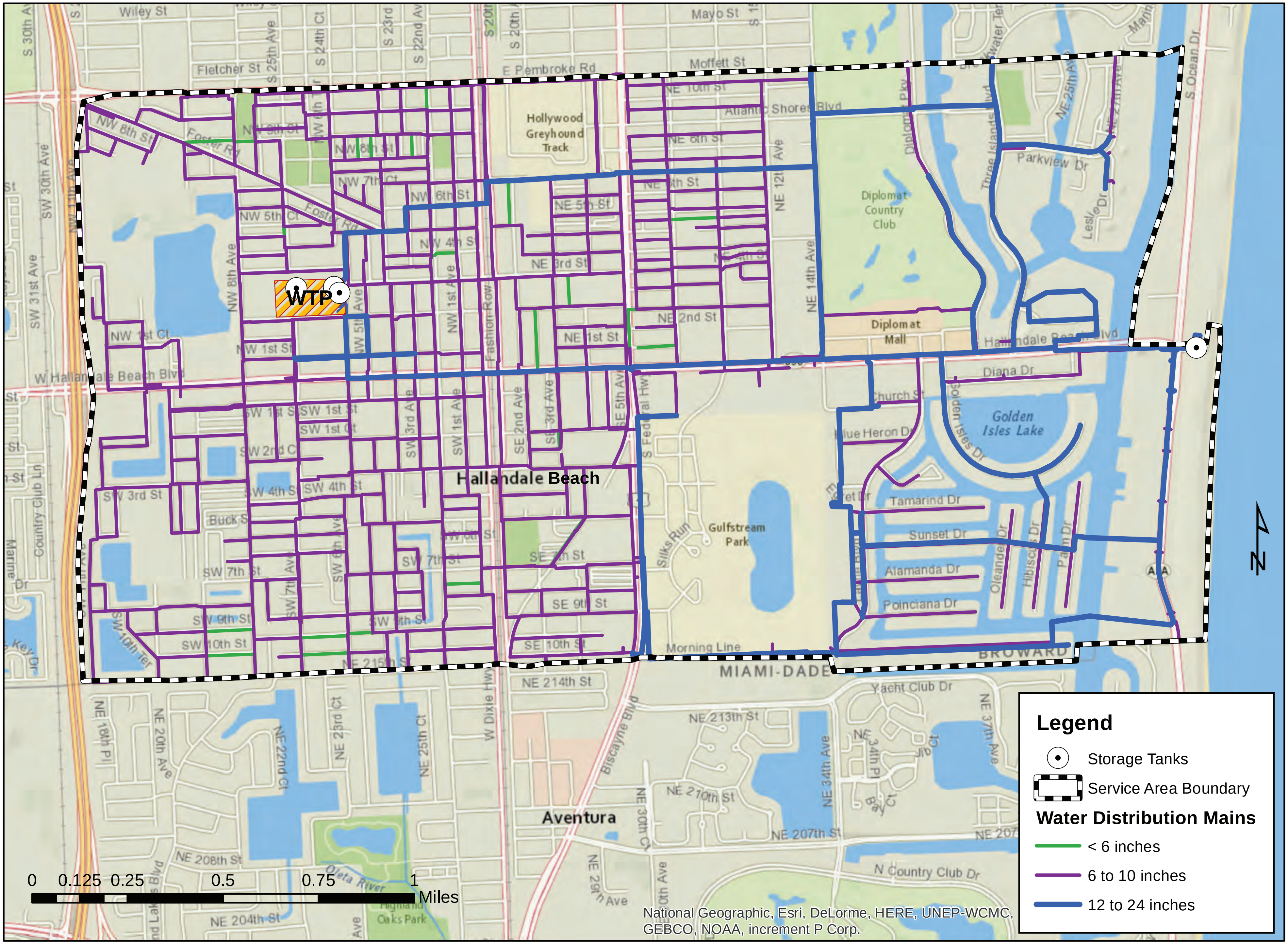

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Figure 1 - Potable Water Distribution Network

- Model junction/node elevations were updated based on elevation data obtained from the *Broward County 10 Ft Digital Elevation Model V1*, provided by the South Florida Water Management District.
- Updated water treatment plant high service pump station discharge pressure data obtained from the City's Supervisory Control and Data Acquisition (SCADA) system. Data were collected from the period September 2013 through August 2014.

High service pumping stations were incorporated into the model by simulating a reservoir with a set water surface elevation consistent with a nominal distribution system pressure of 58 psig, in line with current City operational practices.

3.3 Model Assumptions

Assumptions applied to the development of the water distribution system model and subsequent model runs include the following:

- Piping and hydrant layers detailing the water system accurately reflect the current state of the water distribution network.
- Annual average day demands provide the basis for the system's Average Day Flow (ADF) demand, Maximum Day Flow (MDF) demand, and Peak Hour Flow (PHF) demand.
- Hydrant laterals are six inches in diameter.
- Hydrants are installed at approximately 18 inches above grade.
- Distribution network pipes are installed approximately three feet below grade.
- Distribution network pipes included in the model are limited to those with diameters of six inches or greater. Pipes with diameters of four inches are included if they represent critical loops within the network.
- The City's water treatment plant maintains a distribution pressure of 58 psi, measured at the boundary of the plant.
- Evaluations of potential system improvements identified as part of this project are based on the assumption that water treatment plant high service pump improvements recommended in *High Service Pump Efficiency Evaluation* (Hazen and Sawyer, 2014) will be fully implemented. It is assumed that the high service pumping system will provide sufficient capacity and a stable distribution pressure of 70 psi, measured at the boundary of the plant.

4.0 Model Calibration and Verification

The water model is designed to predict the network's present and future operational performance under specific demand scenarios. The key verification performance parameters are pressure and flow. Verification of the accuracy of the model at a carefully defined instant of time is required to support the confident use of the model for making predictive simulations.

Model verification was accomplished by comparing field recorded pressure data to distribution network pressures predicted by the model. The confidence level assigned to the hydraulic model was determined by comparing model predicted pressures to actual field observed pressures. If the model predicted pressures and the field observed pressures diverged at specific locations within the distribution network, refinements to the model were made by adjusting parameters such as pipe roughness coefficients until model pressures and field pressures converged within an acceptable range.

4.1 System Data Collection

With the assistance of City personnel, six digital pressure recorders were installed at preplanned locations to monitor diurnal variations in water pressure at key locations throughout the City's service area. Twelve locations were monitored in two groups of six, with each group monitored for a period of seven to ten days. Data were collected from nine of the twelve locations. **Figure 2** shows the locations where these pressure recorders were installed within the network. **Table 1** presents a summary of the locations and recording timeframes.

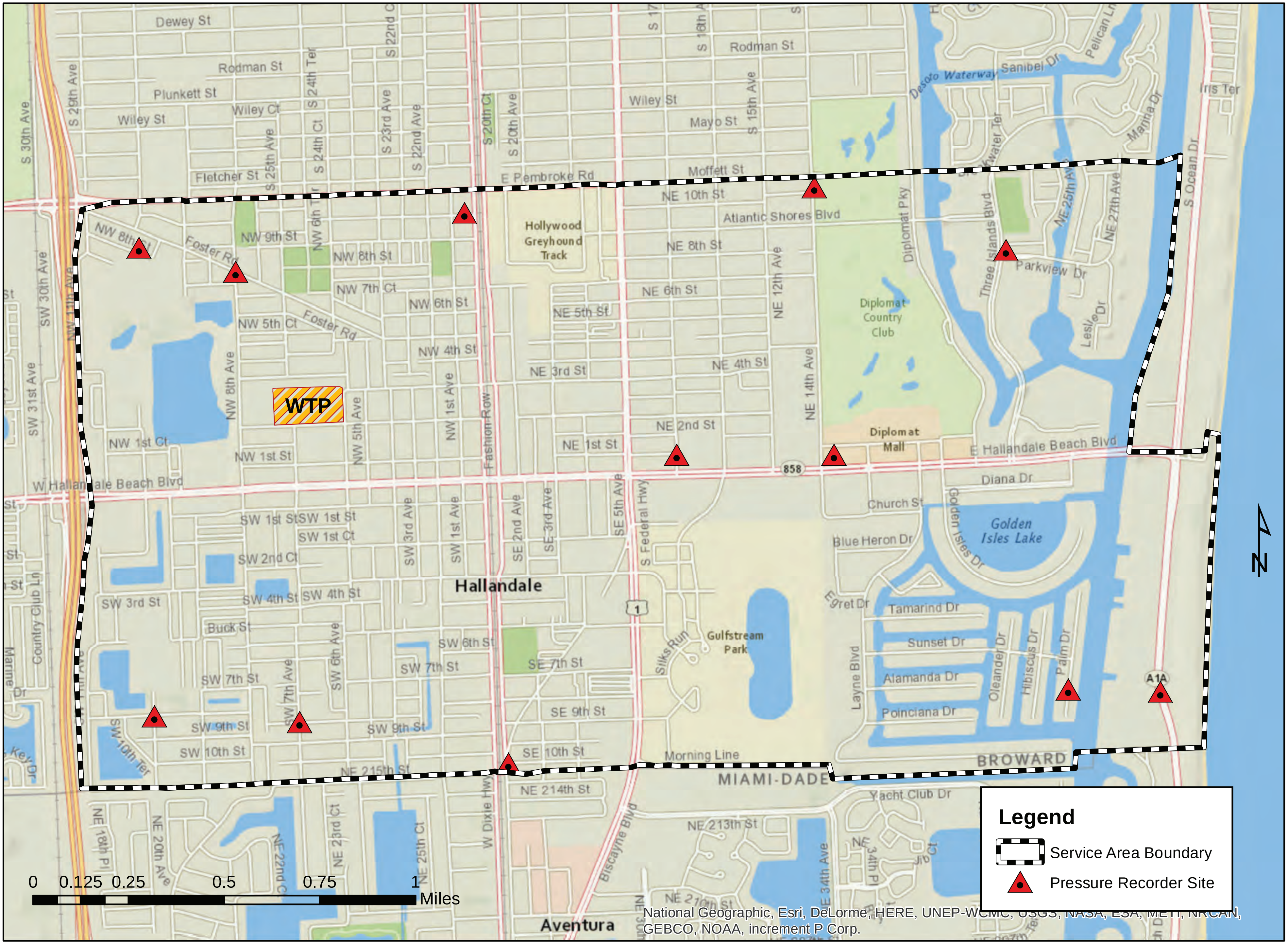

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Figure 2 - Pressure Recorder Sites

Table 1
Pressure Recorder Installation Locations

Hydrant Approximate Location for Pressure Recorder Installation	Pressure Recorder Location ID	Recording Timeframe		Comments
		8/26 to 9/3	9/3 to 9/11	
NW 8th St and NW 7th CT	1-1	x		Recorder Failed
SW 7th Ave and SW 8th St	1-2	x		
North Dixie Highway and NW 9th St	1-3	x		
Moffet St and NE 12th Ave	1-4	x		Recorder Failed
NE 14th Ave and Hallandale Bch Blvd	1-5	x		
Palm Drive Sunset Dr	1-6	x		
SW 8th St and SW 10th Ave	2-1		x	
Old Federal Highway and SE 10th St	2-2		x	
Foster Road and NW 8th Ave	2-3		x	
NE 8th Ave and NE 1st St	2-4		x	
Three Islands Blvd and Parkview Dr	2-5		x	Recorder Failed
A1A South	2-6		x	

Additional pressure data from the water treatment plant high service pump distribution pressure data were used for model calibration and verification. These data were collected from the plant SCADA system during the time period of 9/1/2013 through 8/31/2014. Water surface levels for the North Beach elevated storage tank were obtained from the City's telemetry server for the period 9/1/2013 through 5/30/2014.

Distribution flow data were obtained from the plant's SCADA system at fifteen minute time steps and from Monthly Operating Reports at daily time steps. Plant SCADA data were used to develop flow diurnals for those days selected for the model calibration process. MOR data were used to adjust the baseline demand (billed water demand) to match water supplied to the distribution network on those days selected for model calibration.

4.2 Model Calibration and Verification Results

The hydraulic model performance was verified by comparing the model predicted pressures to the field recorded pressures over a defined 24-hour period. September 2, 2013 and September 9, 2013 were the days selected as the basis for model calibration. **Table 2** summarizes the model calibration results.

Table 2
Model Calibration Results

Pressure Recorder Location ID	Hydrant Label in Model	Average Model Pressure [A]	Average Field Pressure [B]	Difference ([A]-[B])	% Difference with respect to [B]
1-2	H-195	56.3	55.4	0.9	1.7%
1-3	H-164	56.3	55.6	0.6	1.2%
1-5	H-447	56.4	56.1	0.4	0.6%
1-6	H-86	54.9	55.3	-0.3	-0.6%
2-1	H-280	57.8	57.0	0.9	1.6%
2-2	H-169	55.1	54.1	1.1	2.0%
2-3	H-191	56.5	56.6	-0.1	-0.2%
2-4	H-282	57.4	57.1	0.3	0.5%
2-6	H-8	56.0	56.0	0.0	0.0%

Differences between field gathered pressures and model simulated pressures were small, ranging from 0.0 to 2.0 percent for the nine sites where field data were successfully collected. The average difference between field and model pressures was less than 1.0 percent. These results indicate a close fit between distribution network actual performance and model simulated performance. Therefore, the model can be considered calibrated and useful for the hydraulic simulation of the system.

5.0 Current and Projected Flows

Potable water use is affected by service area population; the types, numbers, and sizes of commercial businesses and industries; rainfall and water table conditions; relative prices of water; and the distribution of water saving technologies. Current and projected water demands within the water distribution model are based on monthly potable water billing data for the period June 2013 through May 2014. A review of the billing data indicates June 2013 as the month with the greatest number of active accounts. Demand for this month was used as the basis for subsequent current and future demands in the model.

Potable water demands for future periods were based on projected population changes occurring within the City's service area. Projected population data is provided periodically by the Broward

County Planning and Redevelopment Division. One format in which this data is provided includes population by Traffic Analysis Zone (TAZ). TAZs are generally small defined geographical areas within the County which are typically used for traffic planning purposes. The County's population allocation model utilizes population forecast data provided by the Bureau of Economic and Business Research, University of Florida. The most recent population projections generated by Broward County were published in 2014. Projections were provided for every TAZ within the County with time steps at five year intervals beginning in 2015 and ending in 2040.

Sixteen TAZs fall within the City's service area. Projected population estimates for those TAZs were utilized to calculate population growth coefficients. The population growth coefficients were applied to current flow data for the base year 2014 to determine forecasted water demands. **Table 3** provides population projections within the City's service area through 2035. Current projections show population growth to be somewhat stagnant through the planning period of this project.

Table 3

Service Area Population Projections

Year	Number of Residents
2015	38,892
2020	39,712
2025	39,606
2030	40,267
2035	40,189

Table 4 presents current and projected water consumption rates through the year 2035. This data is based on billed water consumption as described previously.

Table 4

Current and Projected Water Consumption

(Based on Billed Water Consumption)

Year	Daily Water Demand (mgd)	Annual Water Demand (mgy)
2014	5.21	1,902
2015	5.39	1,967
2020	5.62	2,051
2025	5.59	2,040
2030	5.63	2,055
2035	5.60	2,044

mgd = million gallons per day

mgy = million gallons per year

Water production at the City's water treatment plant will be greater than billed consumption for both current and future periods due to unaccounted for water, system flushing, plant water utilization, and distribution system losses. A coefficient of 10 percent was used for estimating expected water plant production. This is consistent with the City's historical records as well as industry standards. **Table 5** presents projected water treatment plant production through the year 2035. These rates are provided on both an Average Day Flow (ADF) flow basis and a Maximum Day Flow (MDF) basis. ADF demand is defined as the average distribution flow from the water treatment plant over the modeling period of record. MDF demand is defined as the highest daily flow within that same period. Distribution system records from June 2013 through May 2014 were used as the modeling period of record for this project.

Table 5

Projected Water Treatment Plant Production

Year	Plant Finished Water Annual Average Day Flow (mgd)	Plant Finished Water Maximum Day Flow (mgd)
2015	5.93	7.47
2020	6.18	7.79
2025	6.15	7.75
2030	6.19	7.80
2035	6.16	7.76

mgd = million gallons per day

In addition to ADF demand and MDF demand, Peak Hour Flow (PHF) demand is also used as a driver for some modeling scenarios. PHF demand is defined as the highest hourly flow recorded during the maximum day of the modeling period of record. In some cases, historical operating records and typical industry values are also used to determine PHF factors. For the modeling scenarios described herein, a peaking factor of 1.26 was used for determining MDF and a peaking factor of 2.50 was used for determining PHF.

6.0 Network Evaluation

Projected flows through the year 2035 were incorporated into the updated and calibrated model and used to perform evaluations of the City's water distribution network. System performance was evaluated for meeting minimum fire flows, system pressures, and storage capacity. It is noted that model simulations are intended to provide instantaneous records of existing and future conditions. All results are approximations based on reasonable assumptions, estimates, and available data.

6.1 Network Evaluation Criteria

Model criteria used to identify network deficiencies are provided in **Table 6**.

Table 6

Hydraulic Model Evaluation Criteria

Performance Criteria	Value
Maximum pipe velocity, fps	8
Maximum pipe head loss, feet per 1,000 feet	10
Minimum system pressure, psi	35
Minimum system pressure during fire flow events, psi	20
Minimum fire flow at 20 psi residual system pressure, gpm	500
Minimum fire flow for multi-story complex, gpm	3,500
Minimum fire flow for Commercial District, gpm	2,000
Minimum fire flow for multi-family residential, gpm	1,500
Minimum fire flow for single family residential, gpm	500

fps = feet per second
psi = pounds per square inch
gpm = gallons per minute

6.2 Network Evaluation Scenarios

Model scenarios were performed as Extended Period Simulations (EPS). An EPS applies a diurnal curve to the daily demand to reflect typical water consumption throughout a 24 hour period. The diurnal curve used was based on operational flow data provided by the City. All model scenarios used for system evaluation were configured under MDF conditions. By using EPS at MDF conditions, PHF demands can also be evaluated as the highest point of the daily diurnal curve.

The principal model scenarios evaluated include the following:

- General system performance to evaluate distribution system pressure, pipe velocity, and pipe head loss;
- System wide fire flow simulations to determine if minimum fire flow requirements are met while maintaining minimum residual system pressures; and
- Specific fire flow simulations at five selected addresses to determine if minimum fire flow requirements are met at these critical locations within the distribution system.

Each scenario was simulated to incorporate projected flow demands for the years 2015, 2020, 2025, 2030, and 2035. Additional scenarios were developed to assess potential distribution network improvements required to address identified deficiencies.

7.0 Modeling Results

The results of the model simulations for the previously described scenarios reveal the need for some system improvements to address fire flow requirements.

7.1 General System Performance

General system performance was evaluated at each time step to determine if modeled distribution system pressures, pipe velocities, and pipe head loss meet the minimum system criteria outlined in Table 6. The results of all scenarios modeled show no improvements are required to address general system performance issues within the water distribution network. **Figure 3** provides a color coded representation of minimum system pressures across the service area for the year 2030, the year of highest projected demand. The minimum pressure requirement of 35 psi across the system was met for all nodes. **Figure 4** provides a color coded representation of pipe velocities across the City's service area for the year 2030. No pipes exceed the recommended maximum velocity of 8 fps. **Figure 5** provides a color coded representation of the anticipated headloss gradient across the service area for the year 2030. It is noted that the 16-inch transmission line leaving the City's water treatment plant will experience headloss exceeding the minimum system criteria of 10 feet per 1,000 feet. However, since the headloss is only slightly exceeded at 14 feet per 1,000 feet during peak hour flow conditions, it is not recommended at this time to upgrade this short section of pipe for hydraulic reasons only. Should other factors dictate replacement of this pipe (such as age and/or consideration of future higher water treatment plant discharge pressures), the City may want to consider a larger diameter.

7.2 System Wide Hydrant Fire Flows

Individual fire flow runs were executed on the 830 hydrants added to the model as part of the updating process. The runs utilized the automated sequential fire flow analysis function that is part of the WaterCAD V8 software used to model the City's distribution system. With the sequential fire flow functionality, the City's hydrants are evaluated on an individual basis to determine the minimum flow available at the hydrant nozzle when the local system pressure equals 20 psi. 20 psi is considered the

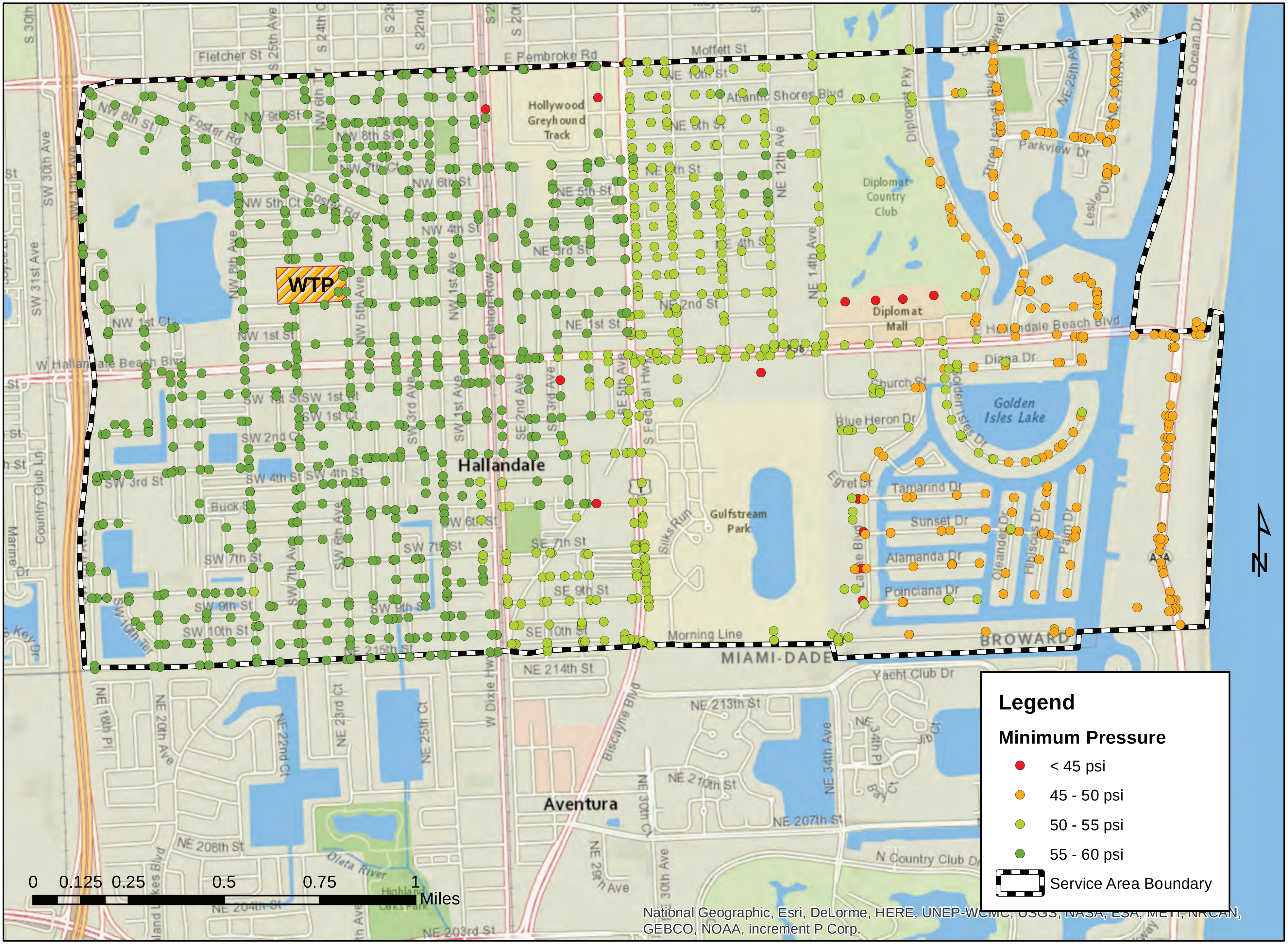

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Figure 3 - Network Minimum Pressures

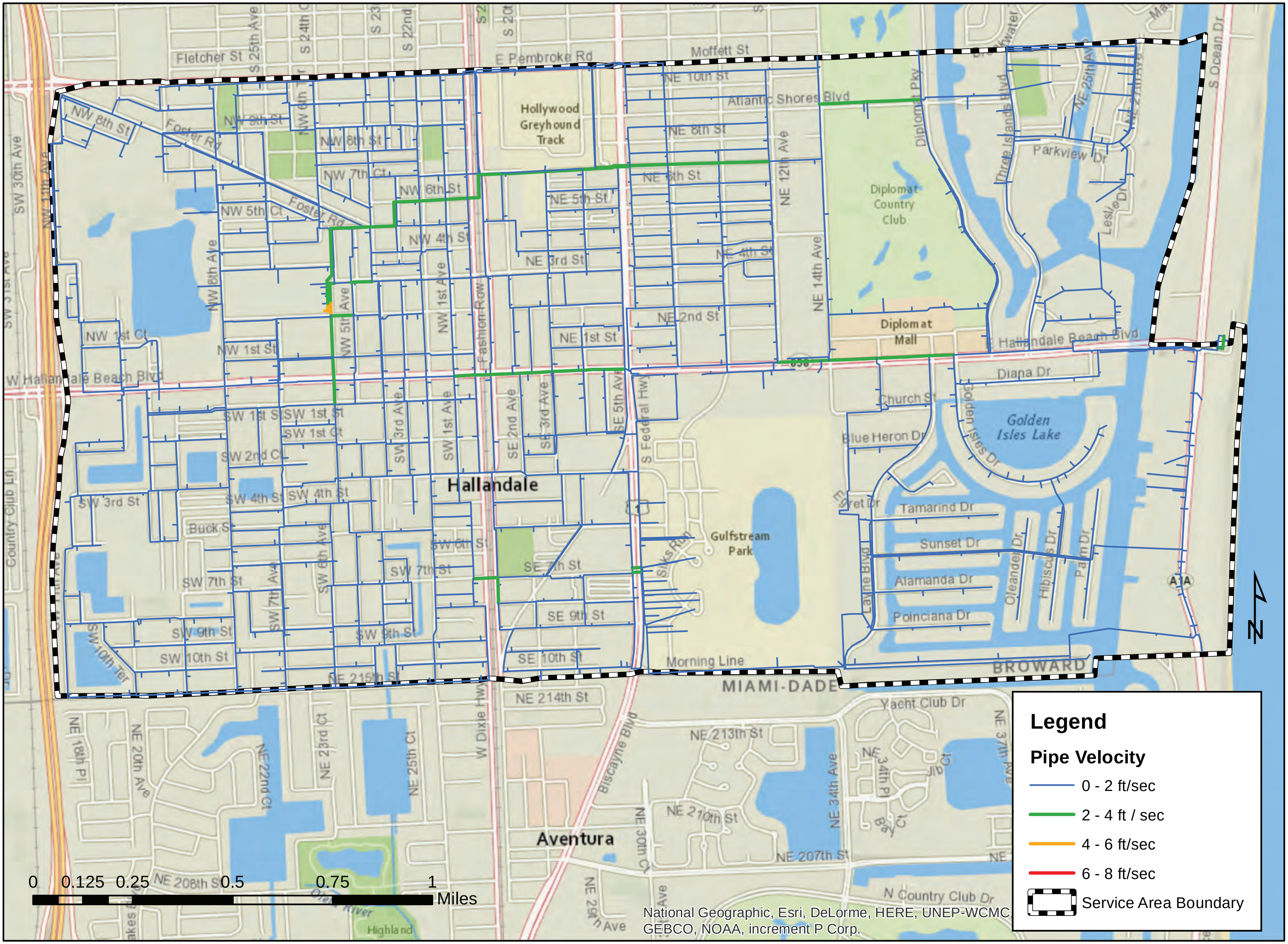

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Figure 4 - Network Pipe Velocities

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Figure 5 - Network Head Loss Gradients

minimum acceptable system pressure. Fire flow analyses are conducted as steady state runs rather than EPS runs. The model was run at each of the five time steps through 2035 at MDF.

The results of the individual fire flow runs at each of the time step demand levels indicate that sufficient flow is available to satisfy the 500 gpm minimum requirement at all hydrants with the exception of a cluster of nine hydrants in the southeast portion of the service area. The deficiencies were found in the area of Hibiscus Drive and Sunset Drive in the southeast section of the service area. Individual flows at these nine hydrants ranged from 351 gpm to 497 gpm. The system pressure for all fire flow runs from 2020 and beyond was set at 70 psi, consistent with the assumption that the City will have completed upgrades to the high service pumps at the water treatment plant by 2020. **Figure 6** presents the results of the sequential fire flow analysis referenced by color.

7.3 Fire Flow Analysis for Selected Sites

Five addresses were selected for individual fire flow analysis to determine if fire flow requirements are met while maintaining minimum system pressures. Selections were based on the type of development as well as geographical distribution. The Insurance Services Office (ISO) establishes standards for required water flow for fire suppression purposes for specific types of developments. For this evaluation, the goal with respect to site selection was to evaluate properties in the more spatially remote areas with significant ISO fire flow requirements. These areas are deemed to be the most vulnerable from a flow and pressure perspective. The selected sites and their associated ISO minimum fire flow requirements are provided in **Table 7**. **Figure 7** provides the locations of the five sites within the City's service area.

Table 7

Selected Sites and ISO Recommended Minimum Fire Flows

Site	ISO Recommended Minimum Fire Flow, gpm
Hallandale High School	3,500
Gulfstream Park	3,500
Multi-family residential complex at SW 11th Avenue and SW 8th Street	2,500
Seaside Retirement Resort at 2091 S. Ocean Drive	3,500
Multi-family residential complex at NE 10th Street and Parkview Drive	3,500

Using aerial photography within the GIS environment, hydrants were selected for evaluation at each site that would be within a reasonable proximity to address a fire event. The prescribed ISO fire flow requirements was divided equally between the selected hydrants and steady state runs were executed using MDF demand conditions. If a site's fire flow residual pressure was greater than the 20 psi minimum performance criteria, then the site's hydrants were deemed to deliver sufficient flow to address the assigned fire flow demand. Modeling results indicate that Hallandale High School and the

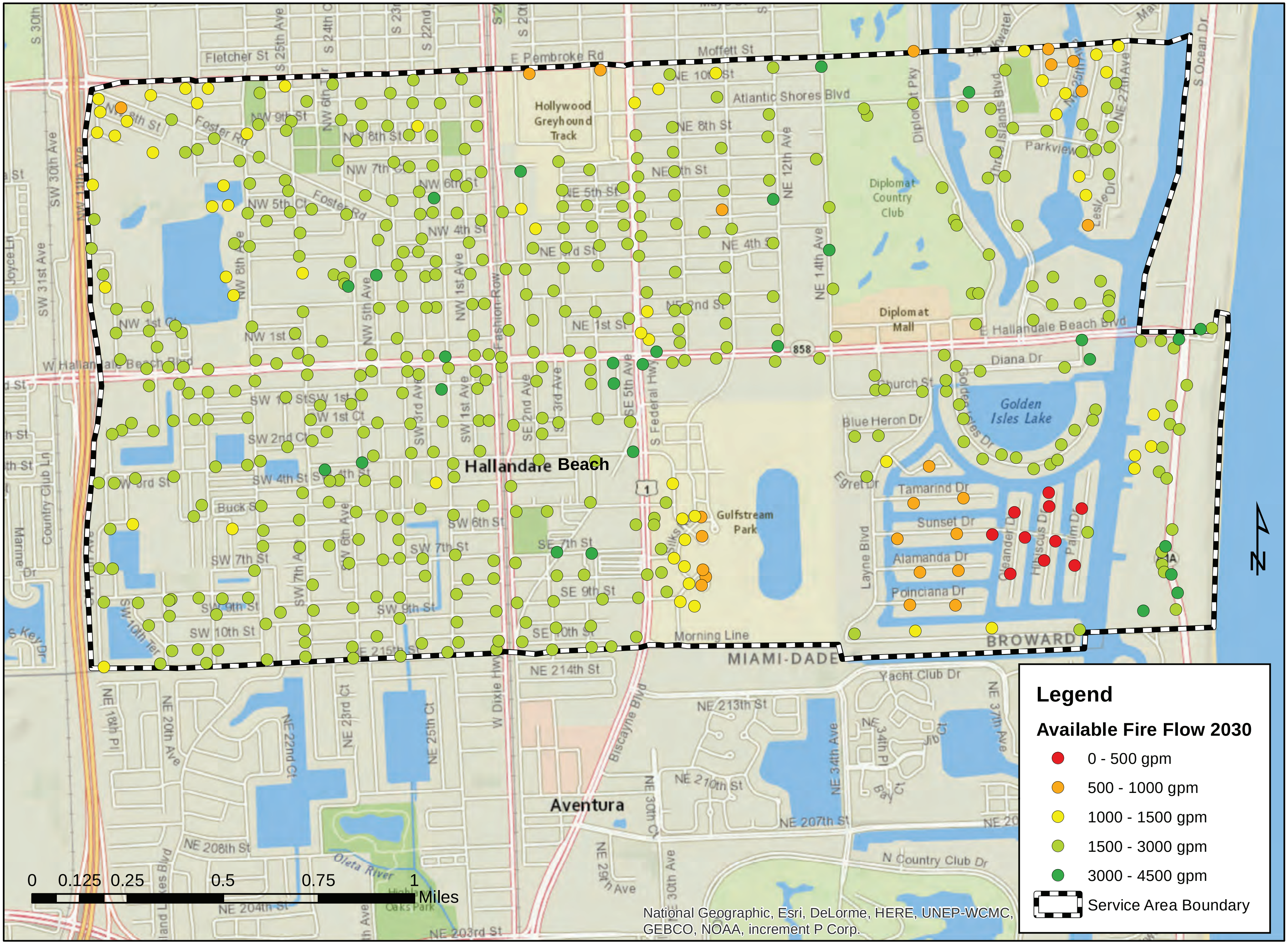

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Figure 6 - Sequential Fire Flow Availability

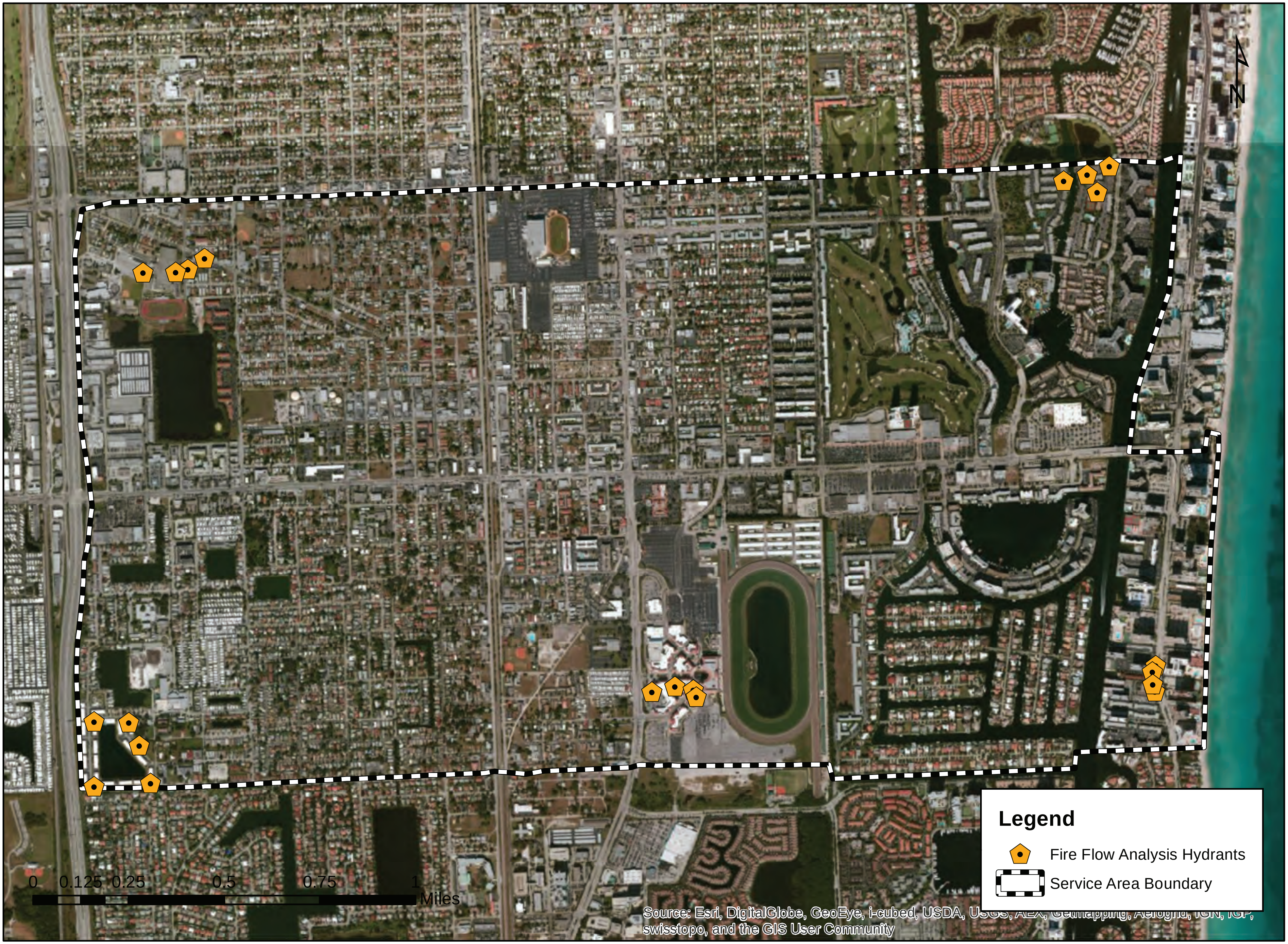

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Figure 7 - Individual Fire Flow Locations

multi-family residential complex at NE 10th Street and Parkview Drive may exhibit residual system pressures less than 20 psi during a fire flow event.

8.0 Recommendations

Recommendations for improvements to the existing water distribution system can be classified into two main categories. These include improvements required to meet fire flow demands and general renewal and replacement. While the scope of work for this project is limited to those improvements required to address hydraulic capacity issues and fire flow demands, it is important to consider the impacts of other factors when developing and budgeting for an overall Capital Improvements Program.

8.1 Fire Flow Improvements

System wide hydrant fire flow simulations revealed deficiencies in the area of Hibiscus Drive and Sunset Drive. These deficiencies can be resolved by interconnecting the 6-inch main on Hibiscus Drive with the 16-inch transmission line on Sunset Drive. **Figure 8** shows the location of the proposed improvement. The fire flow scenario was re-run assuming the installation of this interconnect. It was determined that all nine hydrants that previously exhibited deficiencies performed adequately, meeting minimum fire flow requirements of 500 gpm.

Improvements to address fire flow deficiencies at the selected hydrants serving Hallandale High School include the replacement of 3,330 linear feet of existing 4-inch water mains and 6-inch water mains with proposed 8-inch mains. **Figure 9** identifies the mains targeted for replacement. The 4-inch main running along NW 9th Street between NW 6th Avenue and NW 9th Avenue is constructed of cast iron and was installed in 1978. The 6 inch main running along Foster Road between 6th and 9th Avenues is asbestos cement pipe and was installed in 1969.

To address fire flow deficiencies for the site in the northwest corner of the City's service area (multi-family residential complex at NE 10th Street and Parkview Drive), 1,420 feet of 12 inch transmission main is proposed along Parkview Drive between Leslie Drive and NE 10th Street. The proposed main would be installed in parallel to existing 12-inch, 10-inch and 8-inch water mains. The location of this improvement is shown in **Figure 10**.

8.2 Renewal and Replacement

The City of Hallandale Beach has an established water distribution system which includes water mains and pumping equipment nearing the end of their useful service life. It is recommended that the City consider the development of a Renewal and Replacement program for distribution pumps and underground infrastructure. A formal program could assist the City in prioritizing replacement or rehabilitation of infrastructure based on such factors as age, condition, materials of construction, soil conditions, and previous failures. For purposes of developing a Capital Improvements Program, the City should consider annual renewal and replacement costs for its water system. Furthermore, the City should consider the potential effects of higher discharge pressures on the existing pipe network, particularly

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Figure 8 - Sequential Fire Flow Deficiencies

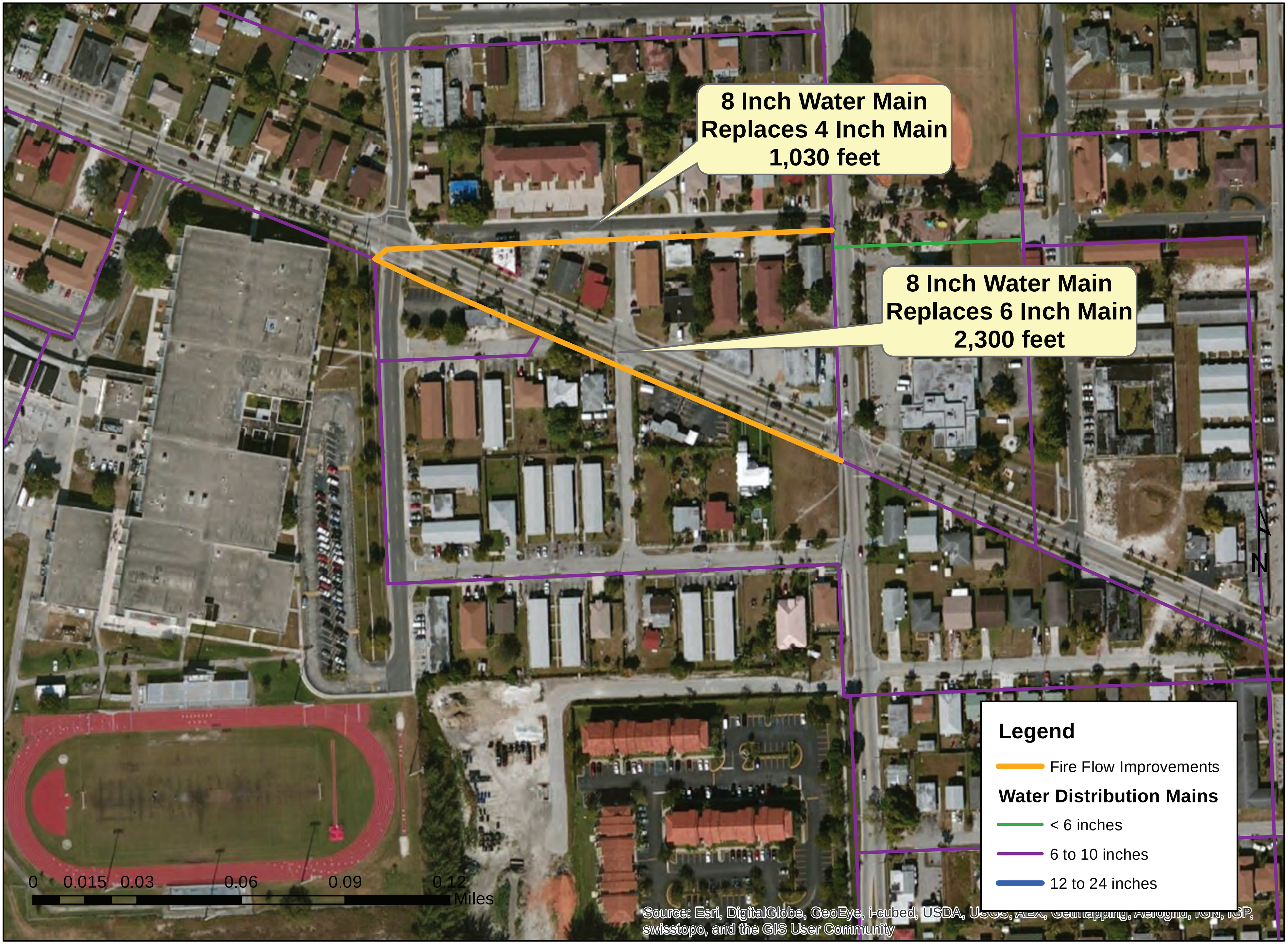

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Figure 9 - Fire Flow Improvements Hallandale Beach High School

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Figure 10 - Fire Flow Improvements NE 10th St and Parkview Drive

in the immediate vicinity of the water treatment plant. It is noted that the City has proactively initiated steps to address renewal and replacement within the confines of the Water Treatment Plant. Public Works staff are currently in the process of initiating an evaluation of water treatment plant facilities for a condition assessment and determination of overall renewal and replacement needs through the year 2035.

8.3 Future Development

It is noted that the City has recently received a number of applications for major developments within the last two years. It is recommended that the City review the additional water supply requirements necessary to accommodate this development. Potential revisions to the existing Water Use Permit may be required.

Depending on the extent of future development and variations to population projections, the City may consider the need for a Water Master Plan. A Water Master Plan identifies short and long range planning goals for the City and incorporates the results of detailed hydraulic analyses as well as re-newal and replacement requirements.

9.0 Conceptual Cost Estimates

Conceptual cost estimates for the improvements outlined in Section 8.1 are detailed in **Table 8**. Cost estimates do not include engineering, administrative, or construction management costs. Costs pre-sented are order of magnitude estimates based on published cost literature, past contractor bids, and past experience with similar sized systems. The accuracy of this type of estimate typically ranges from - 30 percent to + 50 percent.

Table 8

Conceptual Cost Estimates for Recommended Improvements

Location and Description	Length	Diameter	Conceptual Cost Estimate
Interconnect an existing 6-inch line with the existing 16-inch transmission line in the vicinity of Hibiscus Drive and Sunset Drive	--	--	<$50,000
Replace an existing 4-inch line on NW 9th Street between NW 9th Ave and NW 7th Terrace with new 8-inch line	1,030	8	$72,000
Replace an existing 6-inch line on Foster Road between NW 9th Avenue and NW 6th Avenue with new 8-inch line	2,300	8	$161,000
Install new water main parallel to existing water main on Parkview Drive between Leslie Drive and NE 10th Street	1,420	12-inch	$142,000