FINAL PRELIMINARY ENGINEERING REPORT

Brunswick County

Southeast Area Improvements - St. James

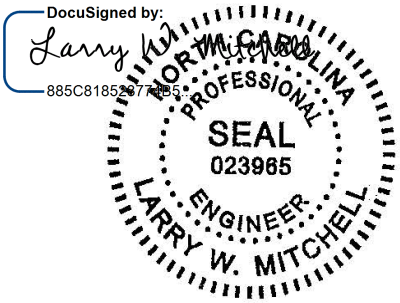
JULY 2023

BRUNSWICK COUNTY NORTH CAROLINA

CDM Smith

Brunswick County

Southeast Area Improvements - St. James



7/11/2023

Final Preliminary Engineering Report

July 2023

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Section 1
Introduction

1.1 Background

Brunswick County is in the southern coastal plains of eastern North Carolina. The land is essentially flat and consists mostly of agricultural lands, medium-density residential areas, commercial areas, tourist beaches, conservation areas, and military areas. The county extends east to the Cape Fear River, north to the county border, west to the North Carolina/South Carolina border, and south to the Atlantic Ocean.

In addition to residential customers, Brunswick County Utilities (County) serves wholesale and industrial users in a rapidly growing coastal area of North Carolina. This system also serves resort areas and, therefore, must supply demands during "off season" and "peak season." The County provides water service to 45,940 retail customers, eight wholesale customers, and numerous residents from two water treatment plants (WTPs).

Among the County's residential and commercial customers are several thousand customers in the Town of St. James (Town). The Town consists primarily of single-family residential development and limited commercial development. All land use types use irrigation systems, and irrigation demand is high. The Town is served by a water distribution network that was not designed to convey high volumes of water for irrigation during peak demand periods. As a result, areas of the Town experience low pressure during peak demand periods, especially in summer when demands throughout the County's system are higher.

In 2016, the County had a study produced to evaluate options for improving water pressure within the Town during peak demand periods. Although a couple of the recommendations have been implemented and pressures have improved, there are still concerns about low pressure within the local water system.

In 2022, the Town and the County secured funds to make improvements to the water system to address low pressure concerns. CDM Smith was selected to perform a preliminary engineering report (PER) to evaluate options to further improve service. This PER will revisit the previous (2016) recommendations that have not been implemented and explore other solutions to improve water pressure within the Town.

1.2 Project Purpose

The purpose of this project is to analyze the existing water system within and around the Town and to identify deficiencies with improvements to improve pressures during peak periods, and to address fire flow availability issues where present. The scope of work includes the following tasks:

1. Review of existing data.
2. Complete field pressure testing and fire flow tests.

3. Calibrate the hydraulic model.
4. Evaluate system performance and identify deficiencies.
5. Develop and evaluate alternatives to improve performance.
6. Develop Capital Improvement Plan recommendations.

1.3 Study Limitations

Findings and recommendations in this document are valid as of the production date and are based on the information referenced herein. Changes in the rates or patterns of growth within the study area, changes in water use patterns, implementation of more detailed investigations, or changes in regulations may affect the conclusions and recommendations presented in this report.

Section 2

Existing System Description

2.1 Water Description System

The County water system layout is depicted in **Figure 2-1**. The County operates two water plants:

- The Northwest Water Treatment Plant (NWTP) is in the northern part of the county, near Mount Misery Road and the Town of Northwest. The NWTP has a current capacity of 24 mgd and is currently being expanded to 48 MGD.
- The 211 WTP is located adjacent to the St. James on Highway 211. The 211 WTP has a permitted capacity of 6 mgd, although production is limited to 5 mgd based on available well supply.

Water flows from the NWTP south and west to supply the County's residents and businesses. The primary flow route is along Highway 17 and through a series of three major pump stations:

1. The Bell Swamp ground storage tank (GST) and booster pump station (BPS). The Bell Swamp facility has two banks of pumps that primarily move water south/west along Highway 17 (BPS #8S) or south along NC 87 (BPS #8E).
2. BPS #9 located near Bolivia along Highway 17.
3. BPS #6 located on the west side of Shallotte.

There are also several pump stations that boost water toward the oceanfront communities and wholesale customers.

Under off-peak demand conditions, the NWTP and 211 WTP can supply most of the system without the need for booster pumping. All booster stations have bypass lines that allow flow to pass the stations without pumping. Under peak demand conditions, the booster stations are operated as necessary to keep downstream tanks full.

The distribution system around the Town is shown in **Figure 2-2**. The water supplied to the Town comes from the 211 WTP and from the NWTP the overall County network. The pipelines supplying the Town are the 16-inch main on E.F. Middleton Boulevard, the 12-inch main on Highway 211 east of Midway Road SE, and the 12-inch and 24-inch mains near the 211 WTP. A connection exists between the Oak Island system and the Town across the intracoastal water way that can allow water to pass onto Oak Island or into St. James, as needed.

2.2 Demands

CDM Smith used billing data and a geographic information system (GIS) meter point feature class provided by the County to identify most water demand locations. Some larger users that did not have a meter point record were geocoded. The resulting point demands were then loaded as customer meters into the hydraulic model. All existing customer demands are assumed constant for future demand scenarios, except for wholesale customer demands.

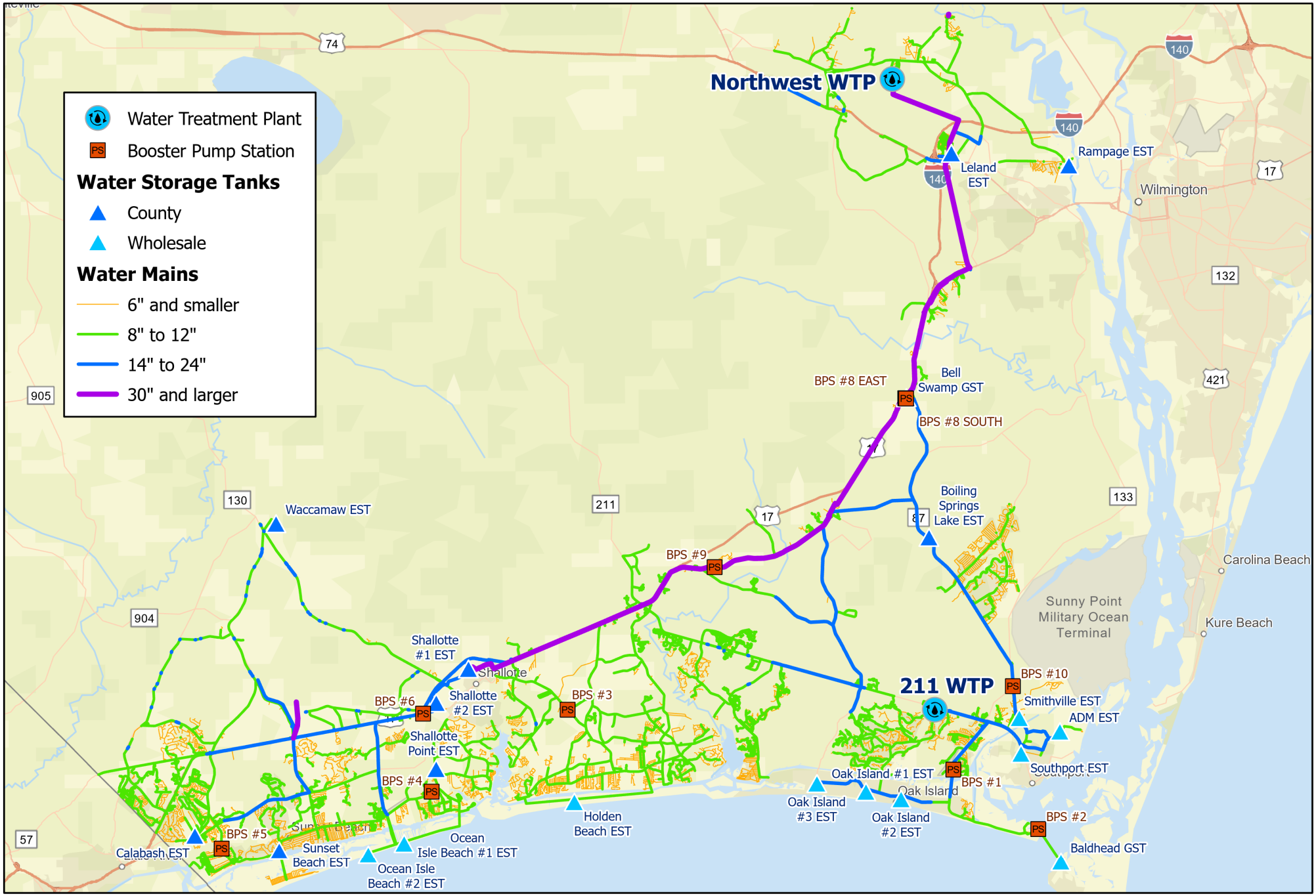

Figure 2-1: Brunswick County Existing Water System

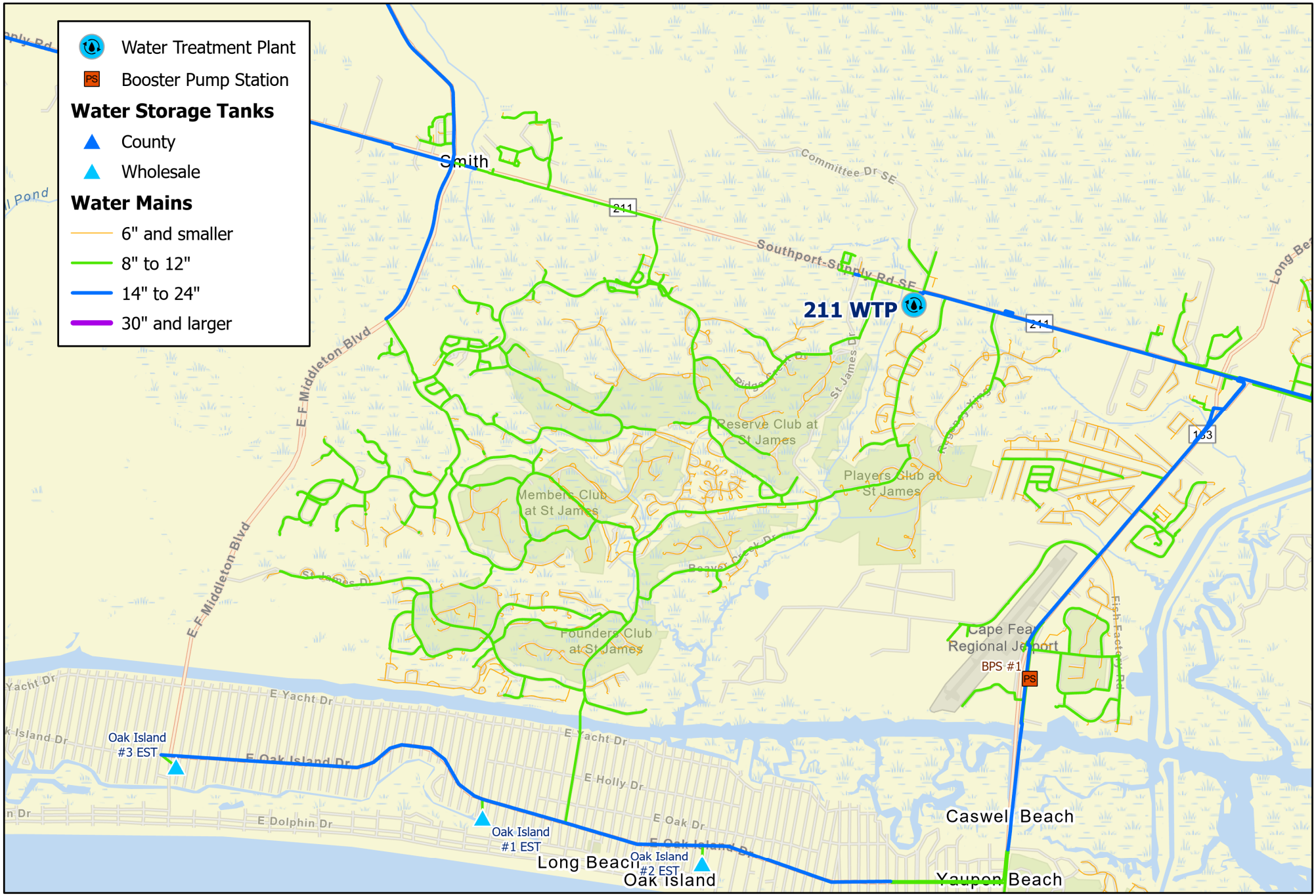

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Figure 2-2
Local Southeast Service Area

Customer meter demands were multiplied by a peaking factor (PF) to simulate maximum day demand (MDD). The MDD PF was estimated using the 2020 average daily demand (ADD) and the 2019 MDD, because of the COVID outbreak on 2020 peak demands. A summary of the existing demands for the Town area is shown in **Table 2-1.**

Table 2-1. Town of St. James Existing Water Demands

User Type	Water Demand – Million Gallons per Day (mgd)	
	2020 ADD	2020 MDD
Residential	0.48	0.77
Residential Irrigation	0.90	1.43
Commercial	0.01	0.02
Commercial Irrigation	0.02	0.04
Total	**1.41**	**2.26**

Each customer meter and demand node in the model includes a diurnal (usage) pattern based on the meter type. The diurnal pattern was applied for the existing and future model simulations in this study. The diurnal patterns used in the model for residential and commercial customers were derived from similar-sized coastal utilities. The irrigation pattern was derived based on a review of pressure data that indicated that peak irrigation demands typically occur between 3 AM and 7AM. This individual pattern peaks the demand at a factor of 6.0 for four hours per day. The patterns used in the model to simulate Town usage are shown in **Figure 2-3.** The composite pattern is based on the resulting average day demand pattern for all existing customer meters in the Town of St. James, and results in a peak factor of about 4.6.

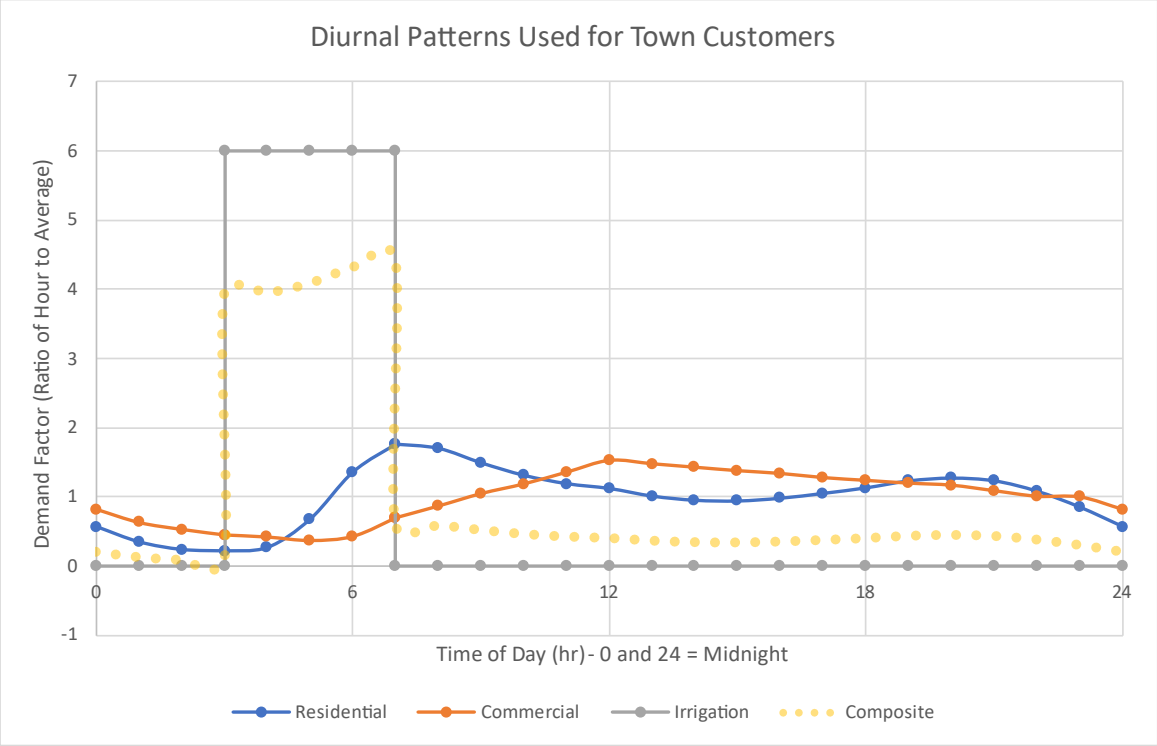

Figure 2-3. Diurnal Demand Patterns Applied to Town Customer Meters

2.3 Model Calibration and Verification

The accuracy of a computer model is highly dependent on its degree of calibration. To determine if a computer model is calibrated, actual field conditions based on hydrant flow tests are simulated using the model. System operating parameters (e.g., system pressures, pump flows, etc.) generated by the model are compared with the parameters measured in the field. However, exact calibration may not be possible for every test.

Hydrant flow tests were conducted by CDM Smith and County staff at strategic locations identified by CDM Smith. The hydrant test locations are shown in **Figure 2-4**. This figure also shows the locations of "fixed" pressure monitors used to collect additional pressure data. Key tank levels, pump flows, and water treatment plant discharge pressure data were recorded at the time of each flow test. The model was configured to match the system conditions for each test, and computer simulations were conducted to compare model results with the field test results. Simulated comparison points are considered calibrated if the results are within 5 psi of the static pressure (no hydrant flow) and 10 psi of the residual pressure (hydrant flowing). A summary of the results is provided in **Table 2-2**. The model results compared well (within 5 psi for static and 10 psi for residual pressure difference) with the field test results conducted on October 20, 2022. No adjustments were needed to calibrate the model. CDM Smith additionally reviewed pressures measured by pressure monitors in the field during the October testing period. This comparison resulted in the change to the diurnal curve used for irrigation meters, since most of the irrigation usage appeared to occur between 3AM and 7AM.

Table 2-2. Hydrant Test Results

Test No.	Flow (gpm)	Static Pressure (psi)			Residual (Flowing) Pressure (psi)			
		Field	Model	Difference	Field	Model	Difference	Relative Difference
1	700	54	**53.6**	-0.4	36	**33.8**	-2.2	1.8
2	1,100	72	**69.1**	-2.9	60	**61.6**	1.6	-4.5
3	785	65	**62.9**	-2.1	46	**45.9**	-0.1	-2.0
4	700	54	**53.7**	-0.3	36	**43.1**	7.1	-7.4
5	620	60	**57.4**	-2.6	28	**21.3**	-6.7	4.1

In addition to the static calibration based on fire flow tests, CDM Smith also made a comparison of predicted model operation versus field data collected at five points in the system. Prior to hydrant flow testing, CDM Smith placed a pressure monitor on or near each entrance main into or out of the St. James area. These locations were identified in Figure 2-4. Pressure was continuously monitored for these points from October 20, 2022, until October 25, 2022. The monitors indicated that irrigation was occurring nightly, usually from about 3 AM until 7 AM. The cumulative effect of many irrigation meters was sufficient to cause a large drop in pressure across the area, visible at all five locations.

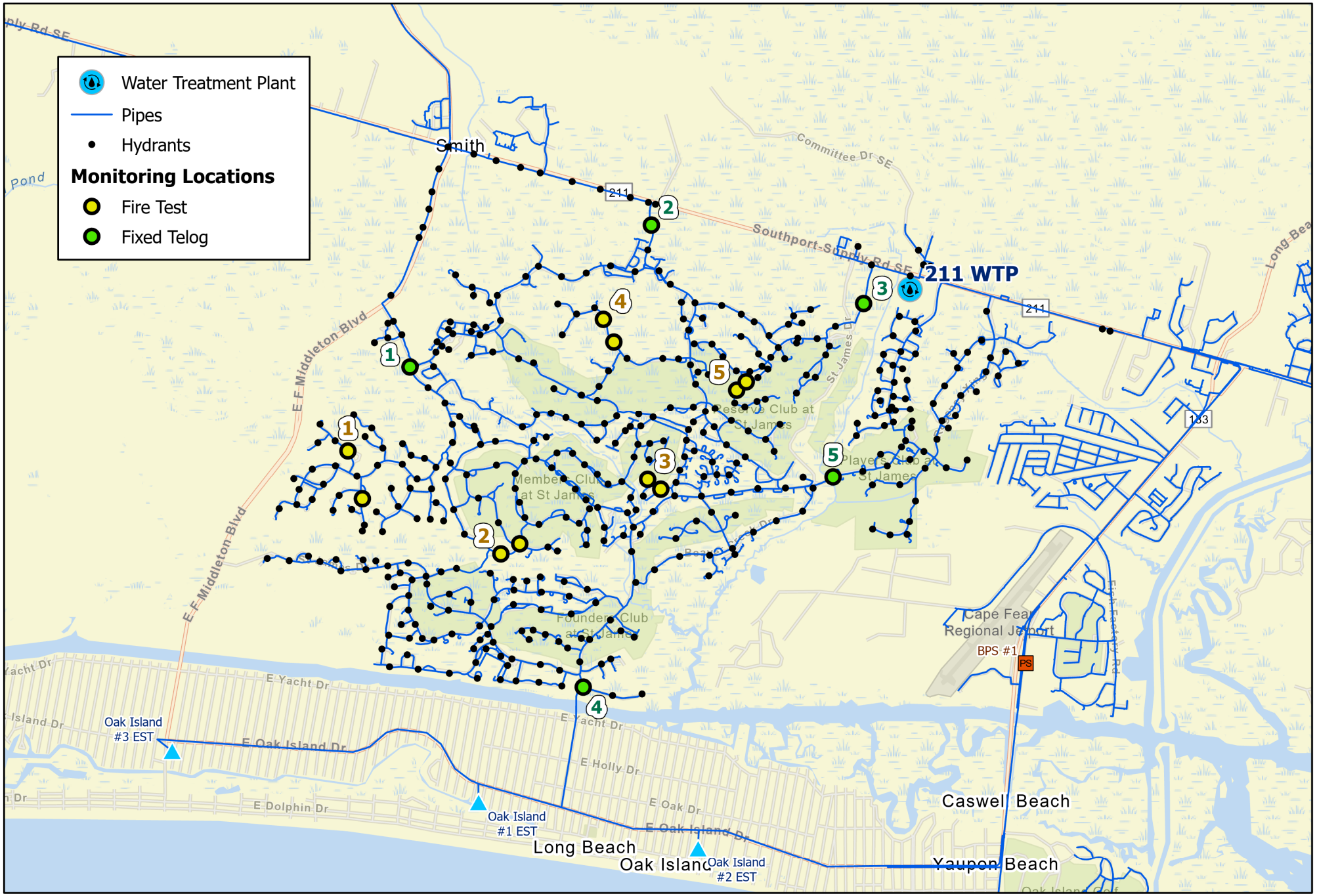

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Figure 2-4
Hydrant Test Locations and Fixed Telog Locations

To verify model performance, an average day simulation was made to compare model predictions to field data at the five locations. In the simulation, the model was configured to operate the 211 WTP from 3 AM (concurrent with observed irrigation start-up) to 11 PM each day at a discharge pressure of about 65 psi. Other system features have less impact on the local area but were set up to operate as determined in discussions with County operators during development of the County's water master plan. **Figure 2-5** shows a comparison of the model predicted pressures to the observed data at the five locations. As evidenced, the model provides a reasonable representation of field conditions across the Town service area. Of particular importance is that the model captures and approximates the system pressure drop.

2.4 Demand Projection Summary

This study does not have a defined task for demand projections, but the area was evaluated for the potential for additional growth, so that recommended solution(s) will provide a buffer to accommodate additional growth in the area.

The Town is largely built out, with about 375 available lots remaining based on conversations with Town staff. Additionally, there is the possibility for up to 1,394 additional units to develop, based on a development agreement. To date, 125 of these have been constructed. In the last five years, the Town has averaged a little more than 200 new residential development permits per year. It is safe to assume that the remaining development will build out prior to 2040. These units are mostly located along or close to Highway 211 and have been accounted for in the existing demand projections.

There is a large tract opposite the Town, west of E. F. Middleton Boulevard, that is projected to develop and eventually encompass 7,200 single family homes. This tract is alternatively known as the Timmons Tract or the Oak Island development.

Most of the analysis conducted herein is based on existing 2020 conditions. However, the recommended solution was tested for the 2040 maximum day demand condition with additional demands considered. These additional local demands included:

- Assuming all available lots in the Town are developed.
- Inclusion of all remaining lots by the development agreement.
- Construction of 2,000 units in the Timmons Tract.

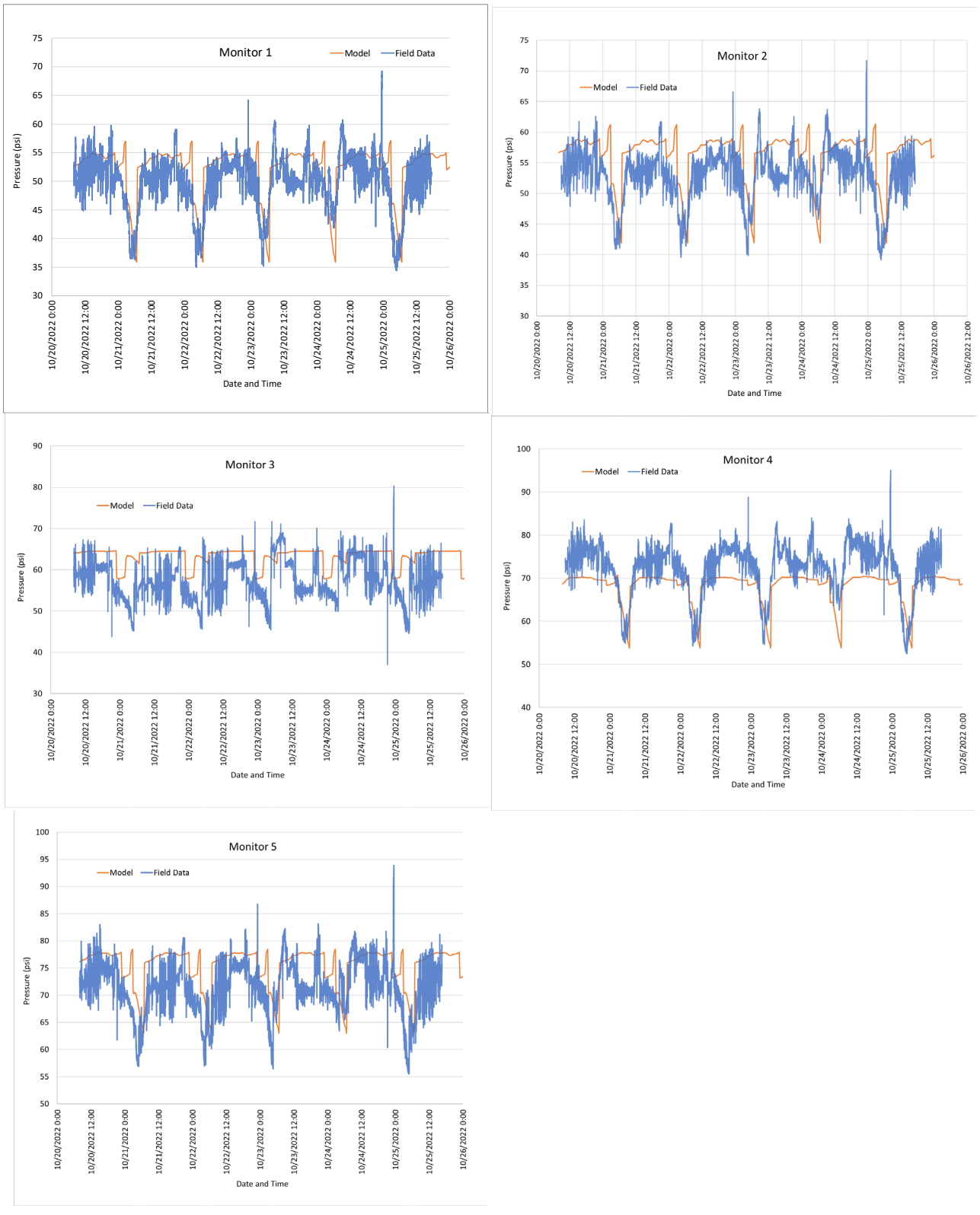

Figure 2-5. Model Prediction versus Field Measurements for Telog Monitoring Period

2.5 Existing Deficiencies

The existing system in the Town was tested under simulated MDD conditions, including irrigation demands, and MDD plus fire flow conditions, to determine system deficiencies. The following conclusions were made:

- Water pressure within the Town is insufficient during peak demand periods at the higher elevations in the north central and northwestern area. Lower than desirable pressures occur due to the combination of very high concurrent irrigation demands, the prevalence of 6-inch diameter piping, and insufficient supply points. **Figure 2-6** shows predicted minimum pressures across the Town system for current conditions.
- Fire flow availability was also evaluated within the Town. Fire flow conditions were assumed to occur outside of the peak irrigation period, using maximum day demands, with the 211 WTP set at a discharge output pressure of 65 psi. Under these conditions, several areas exhibit available fire flow under 1,000 gpm. **Figure 2-7** shows hydrant flow availability based on the conditions described above.

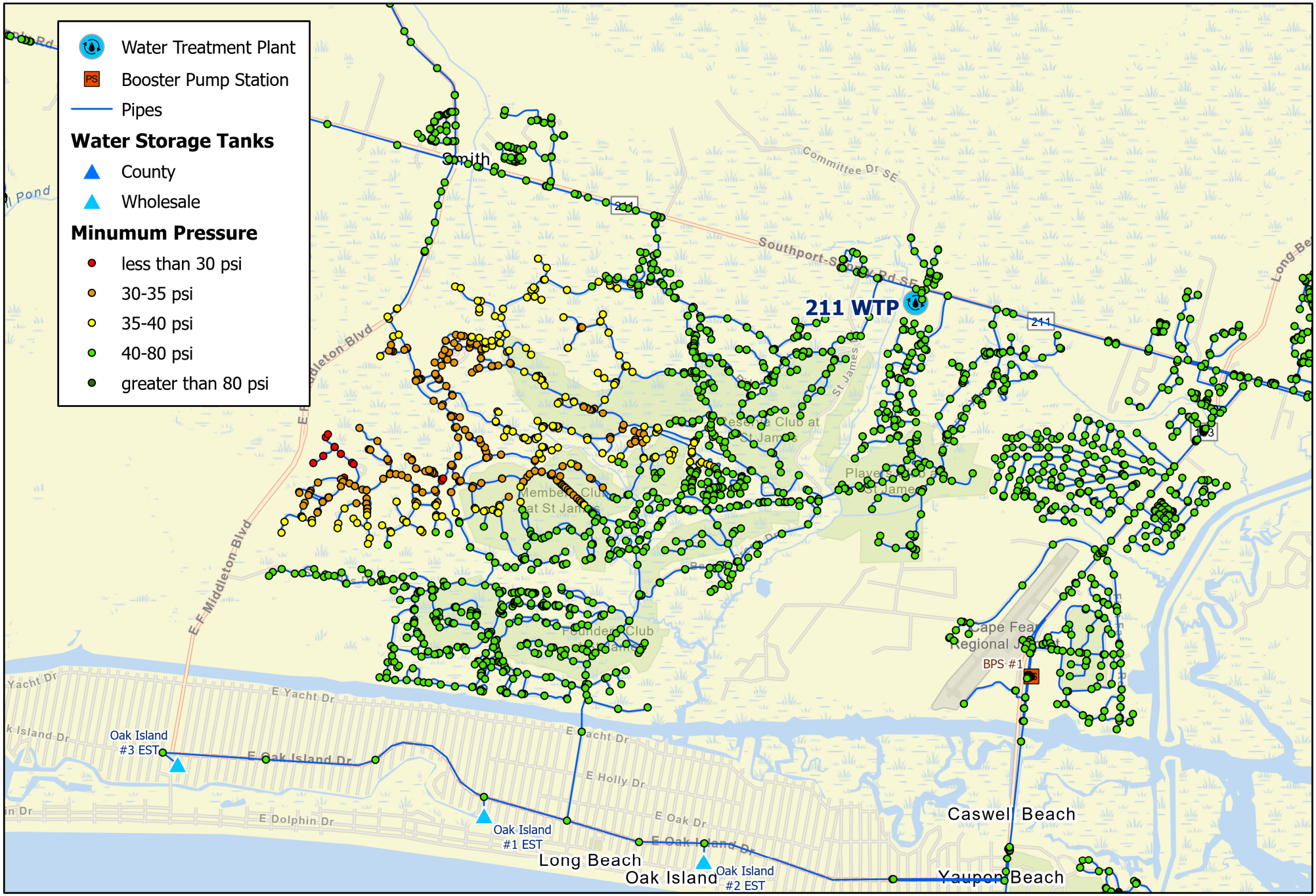

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Figure 2-6
Existing MDD Conditions
Minimum Pressure

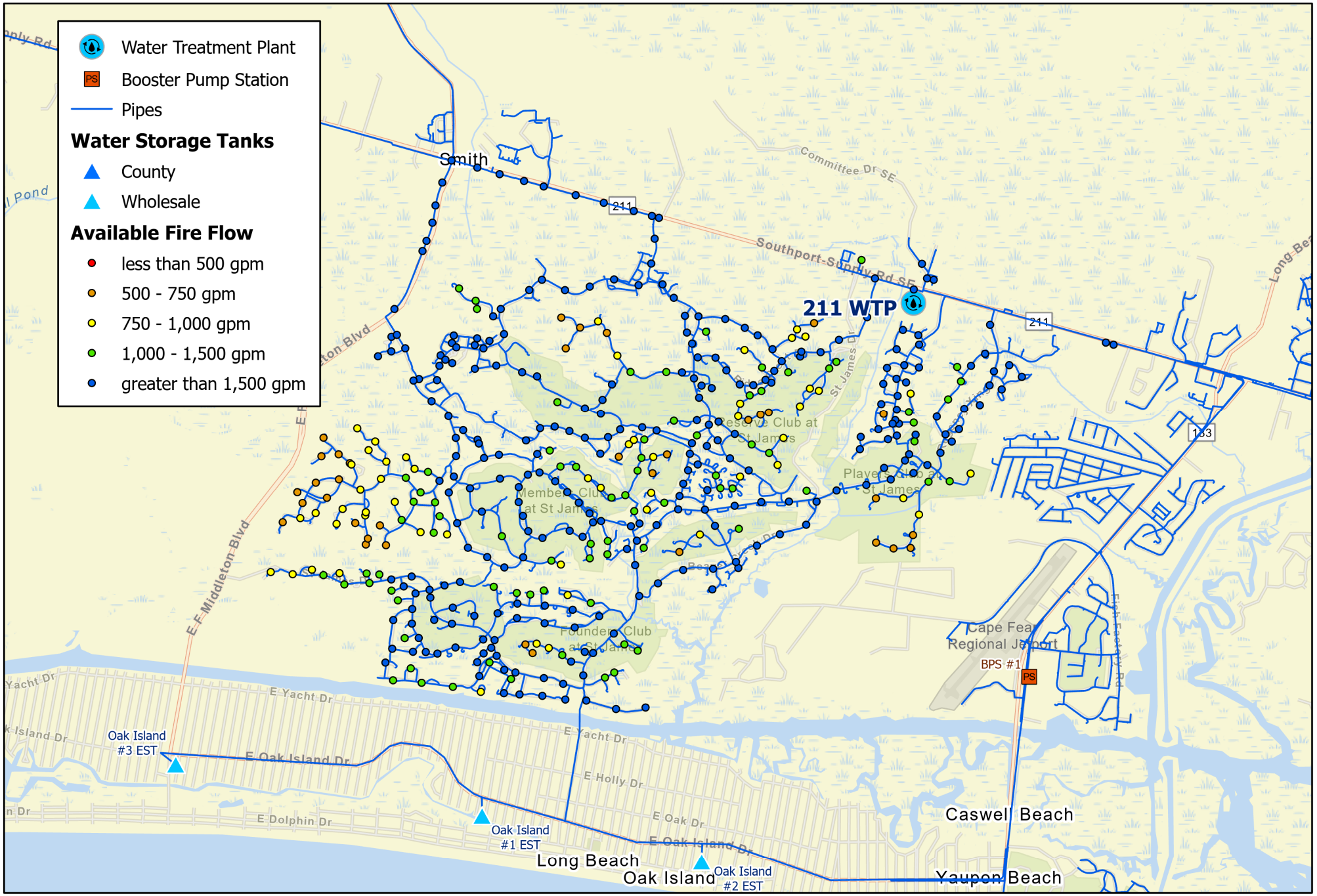

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Figure 2-7
Existing MDD Conditions
Fire Flow Available

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Section 3
Improvement Alternatives

This section described the types of alternatives that were considered to evaluate improvements to the local service area.

3.1 Control Valve Alternatives

Control valves refer to specialty valves that can be leveraged to control flow and/or pressure in a water system. Control valves are more expensive and less common than standard isolation valves.

The County is in the process of installing a pressure sustaining valve (PSV) and check valve assembly in the Highway 211 corridor east of the 211 WTP, near the intersection of Regency Crossing Drive. The intent of the PSV is to control pressure on the east (211 WTP) side of the valve so that flow toward the Southport and Boiling Springs Lake area is controlled. The check valve would allow reverse flow from the Southport area if the water pressure on the west side of valve (211 WTP side) is lower than the east side. The check valve would only supply flow when the 211 WTP is not operational. This alternative is referred to as "**Alternative A**" in the remainder of this report.

The County also desires to evaluate the St. James area as a closed system or separate pressure zone that would be fed from the 211 WTP at increased pressure. The means to configure this pressure zone would be to install a check valve with by-pass piping at the intersection of Midway Road and Highway 211 that allows flow toward St. James and Oak Island but checks flow in the other directions. A schematic of this arrangement is shown in **Figure 3-1**.

With both the PSV and this new configuration in place, the Town water system would operate on pressure supplied via 211 WTP when the plant is in operation, and from the overall system beyond the 211 WTP via check valves when the 211 WTP is off-line. The 211 WTP would require modifications to the existing chemical feed systems to operate at increased pressure to significantly impact the pressures within the new pressure zone.

An existing control valve is located on the water main that allows flow across the intracoastal waterway to Oak Island. This valve would provide a similar function to the Highway 211 PSV but does not allow reverse flow from Oak Island. The operational settings of this valve will depend on the impacts of service to Oak Island, which currently is supplied from two locations. Currently, due to the pressure settings this connection to Oak Island is normally closed. This control valve should be evaluated upon any modifications to the Southeast Area (St. James) water system.

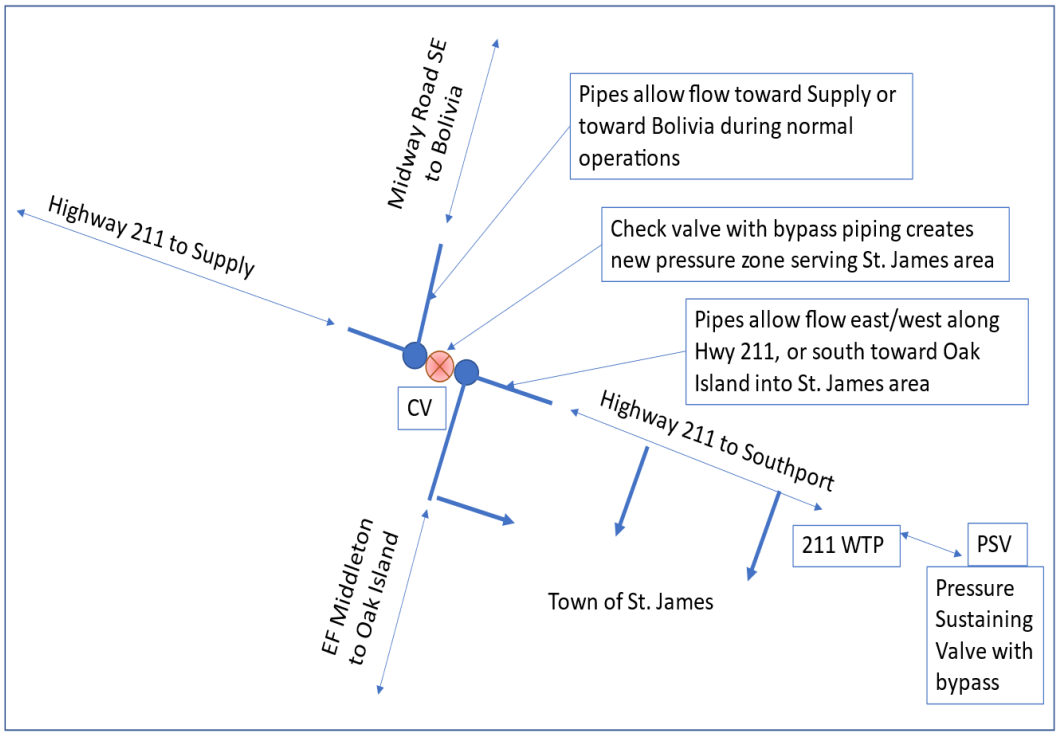

Figure 3-1. Schematic of Control Valve Alternative with Pressure Zone Piping (Alternative G)

3.2 Piping Alternatives

One means of improving service in the Town is through the installation of new or upsized pipes in strategic locations. Since much of the Town piping within neighborhoods is single-feed (meaning the pipe is not looped to another location) 6-inch pipe, upsizing all the piping is not feasible. For any new development within the Town, looping is strongly recommended to allow flow from more than one direction.

Piping alternatives evaluated seek to make redundant connections within or to the Town piping to improve overall flow. Piping alternatives to be evaluated include:

- Addition of two interior loops within the existing Town water system (**Alternative B**).
- Extension of the 16-inch main on E. F. Middleton Boulevard, and a cross-country connection to the existing Town system at Holly Harbor Drive (**Alternative C**).
- Further extension of the 16-inch main on E. F. Middleton Boulevard, and a connection to the existing Town system at Maxwell Drive (St. James Drive SE), and a connection to White Spruce Glen (**Alternative D** – with the White Spruce Glen also included as one of the interior loops in Alternative B).
- Completion of the gap in the 12-inch main on Highway 211 (**Alternative F**).

3.3 Storage Alternatives

Storage alternatives would involve the construction of an elevated storage tank (EST) within or near the Town. An EST could help dampen out demand fluctuations and provide more consistent pressure by providing water into the system during high demand periods and filling from the system during lower demand periods.

The recently completed Brunswick County comprehensive water system master plan recommends a 1.0-million gallon (mg) EST at an unspecified site in the vicinity of Highway 211 and Midway Road intersection. This EST would be brought online as demands dictate. An EST outside the Town boundary would be most effective if it were constructed in conjunction with system piping improvements in the vicinity. Within the Town, the most promising tank sites would be on higher ground and close to larger existing water mains. The most promising sites based on these criteria would be along Seafield Drive, the western portion of Oceanic Drive, or along Park Ridge Drive. A 1.0 MG EST within the Town with no additional piping improvements was evaluated as **Alternative E**.

3.4 Pumping Alternatives

Pumping alternatives would include constructing a new pump station to boost pressure within the Town. Pumping could also be in conjunction with storage. Booster pumping was evaluated and determine unfeasible during system analysis as increasing the pumping pressures as 211 WTP is essentially a booster pumping alternative and more desirable and easier to implement.

3.5 Operational Alternatives

In addition to the alternatives listed above, continued focus on water usage modifications will make positive impacts on pressures and flows. It is recommended that the Town reevaluate periodically the water usage recommendations/guidance to consider several options such as: odd/even watering schedules, increased public education on resource management and/or landscape requirements, etc.

Additionally, another operational alternative to improve systems pressures might be to modify the chemical feed system to allow the high service pumping at the 211 WTP to produce a higher discharge pressure on a regular operational basis. This option was investigated as part of this study in conjunction with a closed system approach (**Alternative G**).

3.6 Internal Connections

The following internal connections are suggested in areas of the Town based upon review of pipe size, number of domestic and irrigation meters and customer complaints previously logged. Several areas were further reviewed for internal connections based upon pipe size, number of domestic and irrigation meters connected. Projects that are feasible and will have the greatest impact to customers service are listed below and further summarized in **Table 3-1**. Additionally, each project is graphically illustrated for reference as **Figures 3-2**.

- **Somerdale Court** – This area recommended a 4-inch connection from the existing 8-inch. The area feeds 21 customer meters total, 9 of which are irrigation meters (near lower pressure area). The proposed line can connect from Somerdale Ct to Oceanic Drive via a

200 ft pipeline. This would require an installation between lots. This area is higher elevation and a significant distance from 211 WTP. It is also in an area with high demand.

- **Worthington Place/Brookfield Way** – This area will require a 4-inch pipe connecting Worthington Place and Westland Lane, which will provide a loop to Brookfield Way. This requires approximately 800 feet of waterline connection to an 8-inch pipe.
- **Medina Court** – The recommendation is a 4-inch pipe connection from the existing 8-inch pipe on Members Club Blvd.. The area feeds 12 customer meters total, 6 of which are irrigation meters (located at the edge of lower pressure area). The proposed line can connect from Medina Ct to Members Club Blvd via a 400 ft pipe installed along the edge of the golf course green.

Table 3-1. Suggested Internal Connections Summary

No.	Street 1	Street 2	Diameter (in)	Pipe Length (ft)
1	Somerdale	Oceanic Dr	2	200
2	Worthington Pl	Westland Lane	4	800
3	Medina Ct	Members Club Blvd	4	400

3.7 Evaluation of Alternatives

The location of the various known alternatives described above is shown in **Figure 3-3.** The approach to evaluating alternatives was as follows:

- The control valve alternative was evaluated to determine its effectiveness against current conditions. This alternative, and all alternatives are measured in part by the resulting lowest pressure, average pressure, and effectiveness in increasing low pressures throughout the Town.
- Piping alternatives were initially evaluated individually with the control valve alternative to see which piping alternatives have the greatest impact on minimum pressures.
- For piping alternatives, combinations were evaluated to determine the system impacts and effectiveness.
- Storage alternative was added for offsite and onsite (i.e., in the Town) options to determine the system impacts and effectiveness.
- Closed system (pressure zone) alternative was evaluated for the potential to improve pressure by increasing the discharge pressure from the 211 WTP and creating an isolated pressure zone in the Town.
- The most feasible alternative was evaluated for effectiveness on improving fire flow availability, for serving buildout conditions in the Town, and for long-term effectiveness based on the year 2040 projected demands within the hydraulic model.

CDM Smith

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Figure 3-2
Suggested Internal Connections

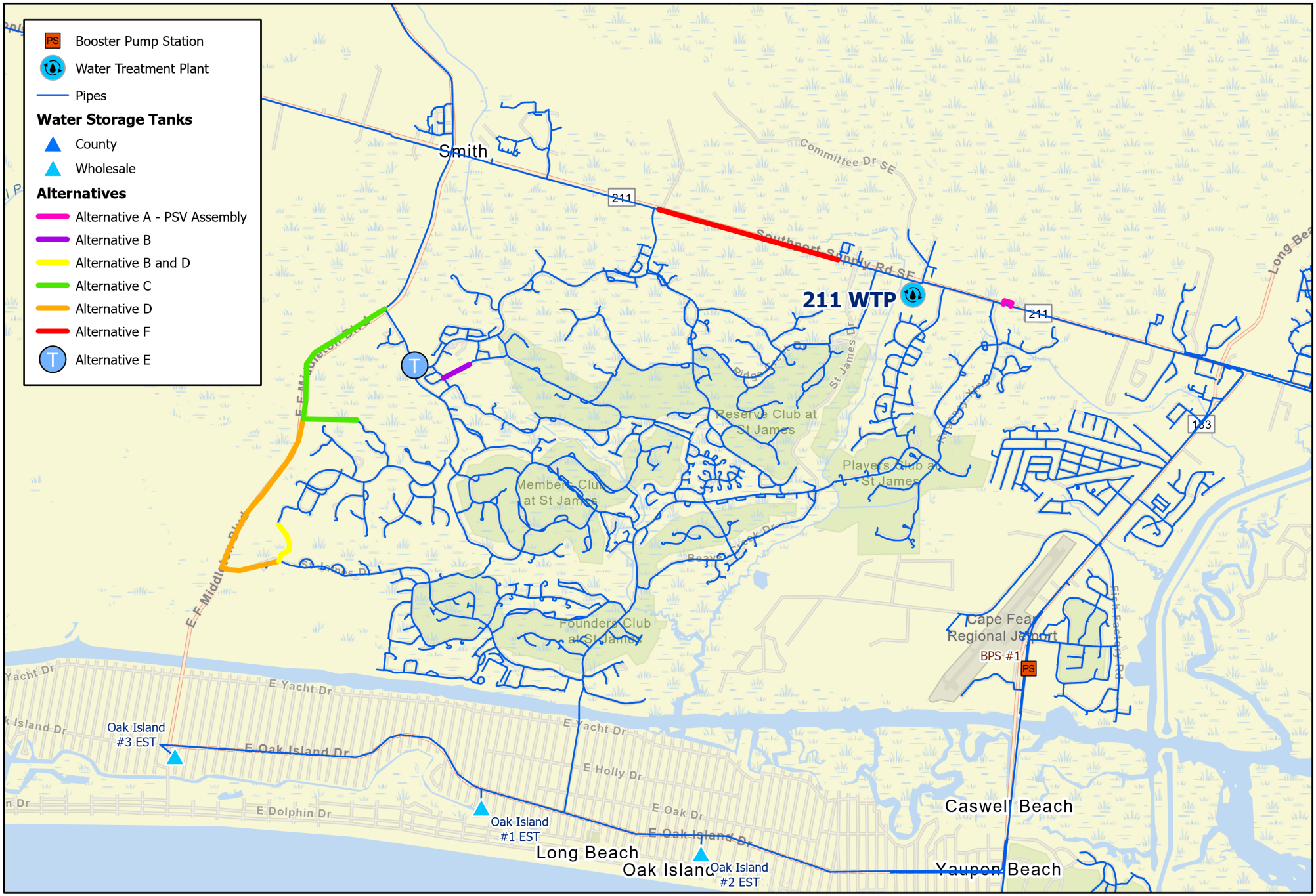

Figure 3-3
Location of Evaluated Alternatives

3.8 Evaluation Criteria

The evaluation criteria used to assess the Southeast area (St James) of the water system included system pressure, water main velocity, water main headloss, and available fire flow. The evaluation criteria served as triggers for identifying the potential need for infrastructure and/or operational improvements. **Table 3-2** summarizes the evaluation criteria for each parameter.

Table 3-2. Summary of Evaluation Criteria

Parameter	Condition	Evaluation Criteria
Pressure	Minimum	40 psi for average, maximum, and peak hour demand
		20 psi for fire flow[1]
	Peak Hour	40 psi
Velocity	Maximum	10 feet per second (ft/sec), with less than 5 ft/sec desirable
Headloss	Maximum[2]	10 feet/1,000 feet for pipes < 16 inches in diameter
		3 feet/1,000 feet for pipes ≥ 16 inches in diameter
Fire Flow	Minimum[3]	500 gpm minimum based on prior code applied in Town 1,000 gpm desirable for 1 and 2 family dwellings
		1,500 gpm for 12-inch and larger pipe and other than 1 and 2 family dwellings

1. Based on North Carolina Administrative Code Title 15A, Subchapter 18C.
2. Headloss was checked, but projects are only recommended if headloss is persistent and results in other issues such as low pressure.
3. As noted in Appendix B of the North Carolina State Building Code: Fire Prevention Code, the fire chief is authorized to reduce the fire-flow requirements for isolated buildings or a group of buildings in rural areas or small communities where the development of full fire-flow requirements is impractical. Additionally, for one- and two-family dwellings not exceeding two stories in height that are more than 100 feet between buildings, the Insurance Service Office's (ISO) "Guide for Determination of Needed Fire Flow" lists a needed fire flow of 500 gpm.

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Section 4
Alternatives Analysis

4.1 Initial Alternatives

The initial alternatives include the proposed pressure sustaining valve (PSV) on Highway 211, and combination alternatives involving both the control valve and different piping alternatives.

The PSV was evaluated at a setpoint pressure of 71 psi and found to have little impact on minimum pressure within the Town. This is because the 211 WTP is currently operated to discharge at approximately 65 psi and placing a PSV decreases the flow to the east (toward Southport) and will not allow that pressure to be increased – consequently reducing the total flow out of the 211 WTP.

A potential drawback of the PSV alternative is that this operation also appears to result in lower pressures and tank levels in the southeast portion of the system, especially Boiling Springs Lake. This is because with the PSV, the 211 WTP is not providing water into the Southport area during peak demand conditions. However, this impact could be overcome by increasing pumping from the Bell Swamp #8E pump station.

At a setting of 71 psi, the PSV was found to block any water into the southeast under normal operating conditions, and the check valve would only allow flow back toward the Town when the 211 WTP is off-line.

The control valve alternative (Alternative A) was tested with each of the individual piping alternatives (B, C, D and F), and with an EST in the area (Alternative E).

Alternative G was tested, using both the PSV east of the 211 WTP and reconfiguration of the Midway Road/Highway 211 intersection to create a closed system (pressure zone) and increasing the 211 WTP discharge pressure in 10 psi increments (G1, G2 and G3).

The predicted impact of Alternatives A through G on Town-wide pressures is indicated in **Table 4-1**.

Table 4-1. Alternatives A through G – Effect on Low Pressures

Alternative	Minimum Pressure (psi)	Average Pressure (psi)	# Locations Below Pressure Threshold		
			30 psi	35 psi	40 psi
Base (No Improvements)	27.8	64.4	18	377	677
A – PSV Only	26.8	65.8	39	429	736
B – PSV and Interior Loops	27.8	65.9	22	422	739
C – PSV and Holly Harbor Dr piping	31.9	66.3	0	277	638
D – PSV and Maxwell Dr piping	31.6	66.4	0	308	655
E – PSV and EST in Vicinity	38.5	66.2	0	0	8
F – PSV and Highway 211 Main	32.3	66.8	0	28	397
G1 – Closed System (211 @ 70 psi)	29.4	68.7	8	205	595
G2 – Closed System (211 @ 80 psi)	33.1	75.7	0	15	359
G3 – Closed System (211 @ 90 psi)	37.2	81.9	0	0	31

All alternatives evaluated and listed in Table 4-1 had at least some overall positive impact, except for Alternative A. All alternatives except for A, B and G1 predicted to eliminate pressures below 30 psi using the previously discussed demand factors.

Alternatives E and G3 predicted eliminated all pressures below 35 psi, leaving only a few locations below 40 psi. The difference between Alternative E and G3 is that Alternative E would involve construction of an elevated storage tank, which takes several years to implement, is be the mostly costly alternative, and does not fit within the funding constraints.

Alternative G involves minimal pipeline work and improvements at the 211 WTP to be able to increase system pressure, but is dependent upon NCDOT completing their work to install the PSV.

Of the pipeline alternatives, Alternative F was found to be the most effective. Alternative F would also have relatively low cost, a relatively short implementation timeline, and remains consistent with the County's comprehensive water system master plan. This pipeline work would be within an active NCDOT project and can be a challenge to coordinate.

4.2 Combination Alternatives

Based on the analysis of the individual alternatives listed in Table 4-1, combination alternatives were developed and analyzed, the following combinations alternatives were developed for further evaluation:

- Combination Alternative H – the combination of alternative C (PSV and Holly Harbor piping) and F (PSV and Hwy 211 piping).
- Combination Alternative I – the combination of alternatives C, E and F, with the EST simulated in the Town for this alternative. Basically, combination Alternative H with EST in place.
- Combination Alternative J – the combination of Alternatives C, F and G1.
- Combination Alternative K – the combination of Alternatives F and G1.
- Combination Alternative L - the combination of Alternatives B (interior loops), C, F and G2.

Table 4-2 shows the impacts of these combinations against the best individual alternatives.

From Table 4-2, combination alternatives I, J1, and K2 predicts increase of all pressures within the Town above 40 psi. Alternatives J and K are the easiest to implement, and Alternative K2 would be the least capital cost but most overall operating cost (211 WTP discharge pressures at or above 80psi). Combination alternative I is the most expensive and longest to implement. Alternative L includes several complementary elements that would increase both pressure and fire flow but also includes the most piping improvements.

Table 4-2. Combination Alternatives – Effect on Low Pressures

Combination Alternatives	Minimum Pressure (psi)	Average Pressure (psi)	# Locations Below Pressure Threshold		
			30 psi	35 psi	40 psi
Individual Alt F – PSV and Highway 211 Main	32.3	66.8	0	28	397
Individual Alt G3 – Closed System (211 @ 90 psi)	37.2	81.9	0	0	31
H – Alternatives C and F	37.6	67.0	0	0	189
I – Alternatives C, E and F	42.1	67.0	0	0	0
J1 – Alternatives C, F and G1	40.6	69.9	0	0	0
J2 – Alternatives C, F and G2	45.9	76.7	0	0	0
K1 – Alternatives F and G1	35.3	69.8	0	0	150
K2 – Alternatives F and G2	41.4	77.0	0	0	0
K3 – Alternatives F and G3	45.9	84.8	0	0	0
L – Alternatives B, C, F and G2	45.9	77.4	0	0	0

4.3 Alternatives Evaluation

All the alternatives (individual and combination) were evaluated for implementation cost and other factors. This comparison is presented in **Table 4-3**.

Table 4-3. Southeast Area Alternative Evaluation Matrix

Alternative	Opinion of Probable Project Cost	Estimated Pressure Improvements			Land Requirement	Permit Requirements
		Minimum Pressure	Average Pressure	# Locations Below 30 psi		
A – PSV Only	Included in NCDOT STIP R-5021	27.8	65.8	18	Inside ROW	Included in NCDOT STIP R-5021
B – PSV and Interior Loops	$438,000	26.8	65.9	39	Land Required for One Loop	PWS/Erosion Control
C – PSV and Holly Harbor Dr piping	$2,300,000	27.8	66.3	22	Inside SJ ROW	NCDOT/PWS/Erosion Control
D – PSV and Maxwell Dr piping	$3,300,000	31.6	66.4	0	Inside SJ ROW	NCDOT/PWS/Erosion Control
E – PSV and 1.0 MG EST in Vicinity	$6,500,000	38.5	66.2	0	Land (0.5 ac) Required for EST	PWS/Erosion Control/FAA
F – PSV and Highway 211 piping	$1,580,000	32.3	66.8	0	Easement adjacent to Controlled Access ROW	NCDOT/PWS/Erosion Control
H – Alternatives C and F	$3,880,000	37.6	67.0	0	Easement adjacent to Controlled Access ROW	NCDOT/PWS/Erosion Control
I – Alternatives C, E and F	$10,380,000	42.1	67.0	0	Land Required for EST	NCDOT/PWS/Erosion Control/FAA
J1 – Alternatives C, F and G1	$3,945,000	40.6	69.9	0	Easement adjacent to Controlled Access ROW	NCDOT/PWS/Erosion Control
K2 – Alternatives F and G2	$1,645,000	41.4	77.0	0	Easement adjacent to Controlled Access ROW	NCDOT/PWS/Erosion Control
L – Alternatives B, C, F and G2	$4,383,000	45.9	77.4	0	Easement adjacent to Controlled Access ROW	NCDOT/PWS/Erosion Control
Three Internal Connections	$451,000	n/a	n/a	n/a	Internal Town and Homeowners' Easements	PWS/Town approval

4.4 Recommended Alternative

Recommend designing and implementing Combination Alternative J1.

- Combination Alternative J1 includes the following in order of priority from ease to implement and estimated cost to construct.

1. Continue with installation of Pressure Sustaining Valve within NCDOT project, (Alt A).
2. Modify operations and pumping conditions at 211 WTP as well as install check valve and bypass at Hwy 211 and Midway Rd intersection (Alt G). Creating a closed system (pressure zone).
3. Design and construction of approximately 5, 900 feet (1.1 miles) of 12-inch water main on Hwy 211 (Alt F). This water main would be planned open cut installation.
4. Design and construction of extension of the existing 16-inch main on E. F. Middleton Boulevard about 4,850 feet (0.9 miles of open cut installation), then construction of 12-inch water main east cross-country to Holly Harbor Drive approximately 1,900 feet (0.4 miles). It is assumed that this water main will need to be a horizontal directional drill (HDD) (a special type of pipe construction that is more costly) to avoid environmental impacts.
5. Design and construction of the small internal connections per listing below:

No.	Street 1	Street 2	Diameter (in)	Length (ft)
1	Somerdale	Oceanic Dr	2	200
2	Worthington Pl	Westland Lane	4	800
3	Medina Ct	Members Club Blvd	4	400

These recommended improvements when implemented together should increase the minimum pressure observed for most customers to above 40 psi and allow the discharge pressures at the 211 WTP to operate at an elevated but reasonable level.

Combination Alternative K2 was not chosen due to the required 211 WTP operating pressures at or above 80 psi). Operating the 211 WTP at pressures higher than normal can lead to additional leakage within the system as well as increased flows during normal irrigation durations (i.e. higher pressures, same irrigation duration, more usage) and can stress homeowner facilities.

Water system operational pressures at 85 psi and above is considered the upper limit.

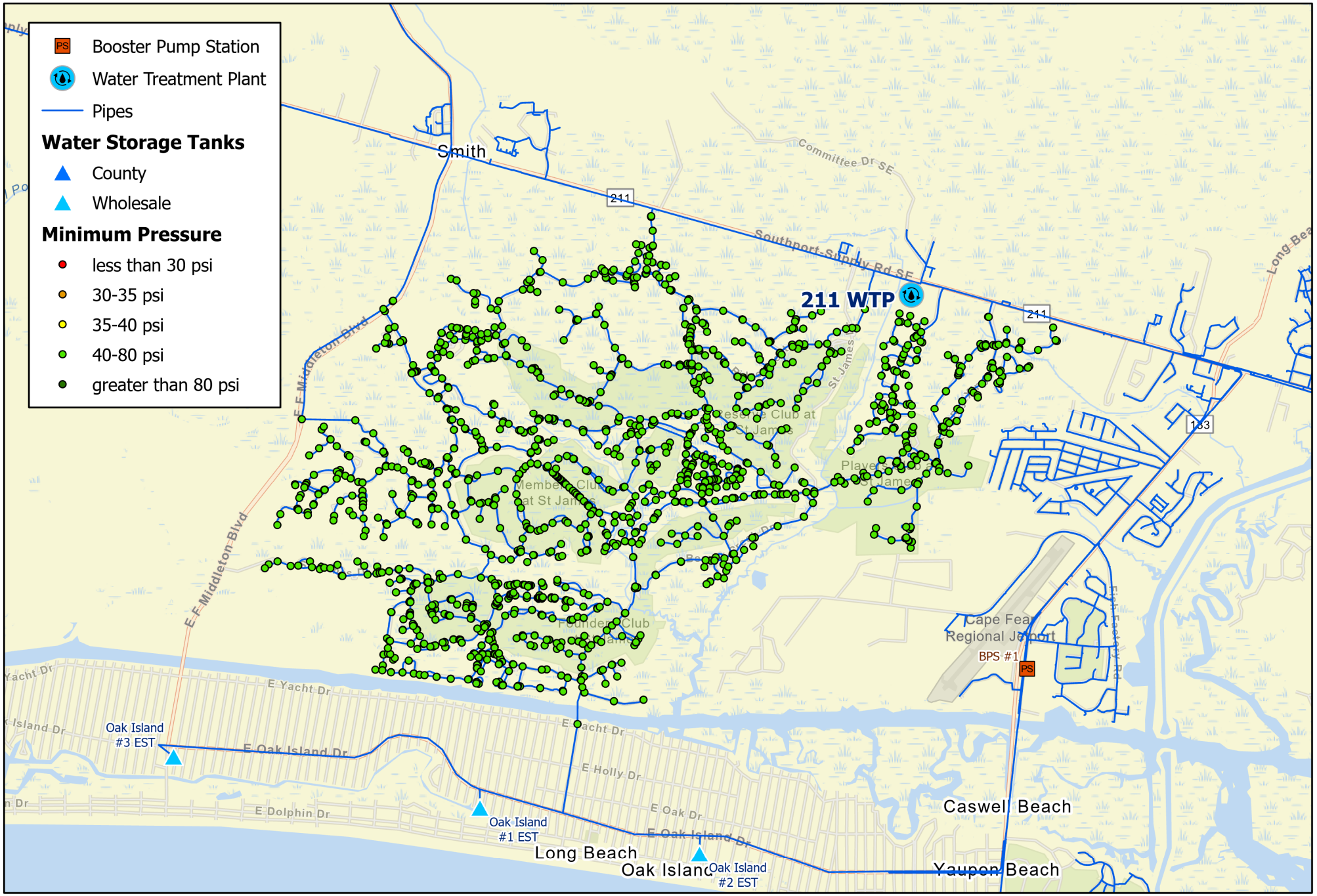
4.5 Predicted System Conditions

As indicated in previous tables and discussion the combination alternatives tested modify the system pressures and operations. Predicted minimum pressures and predicted available fire flow was simulated using the recommended alternatives implemented within the existing system and results provided illustratively below in **Figure 4-1 and Figure 4-2.**

4.6 Fire Hydrants

The Town has requested review of additional fire hydrants at the following locations.

1. Main entrance along St James Blvd from POA gate to Chapel – no water main nor buildings exist.
2. Mulch Shredding area – proposed as connection to existing pipe and is proposed.
3. Along Beaver Creek Rd near tennis center and club house – proposed as connection to existing pipe and is proposed.
4. Near the Troon Storage area at end of Marsh Winds Circle – these pipes are existing 2-inch water mains, addition of fire hydrant on 2-inch pipes is non-compliant with against Brunswick County system standards. Therefore, this hydrant is not proposed as additional Fire Hydrant.



1:48,000

0 0.5 1 1.5 2 Miles

N

Figure 4-1
MDD Conditions
Predicted Minimum Pressure with Improvements

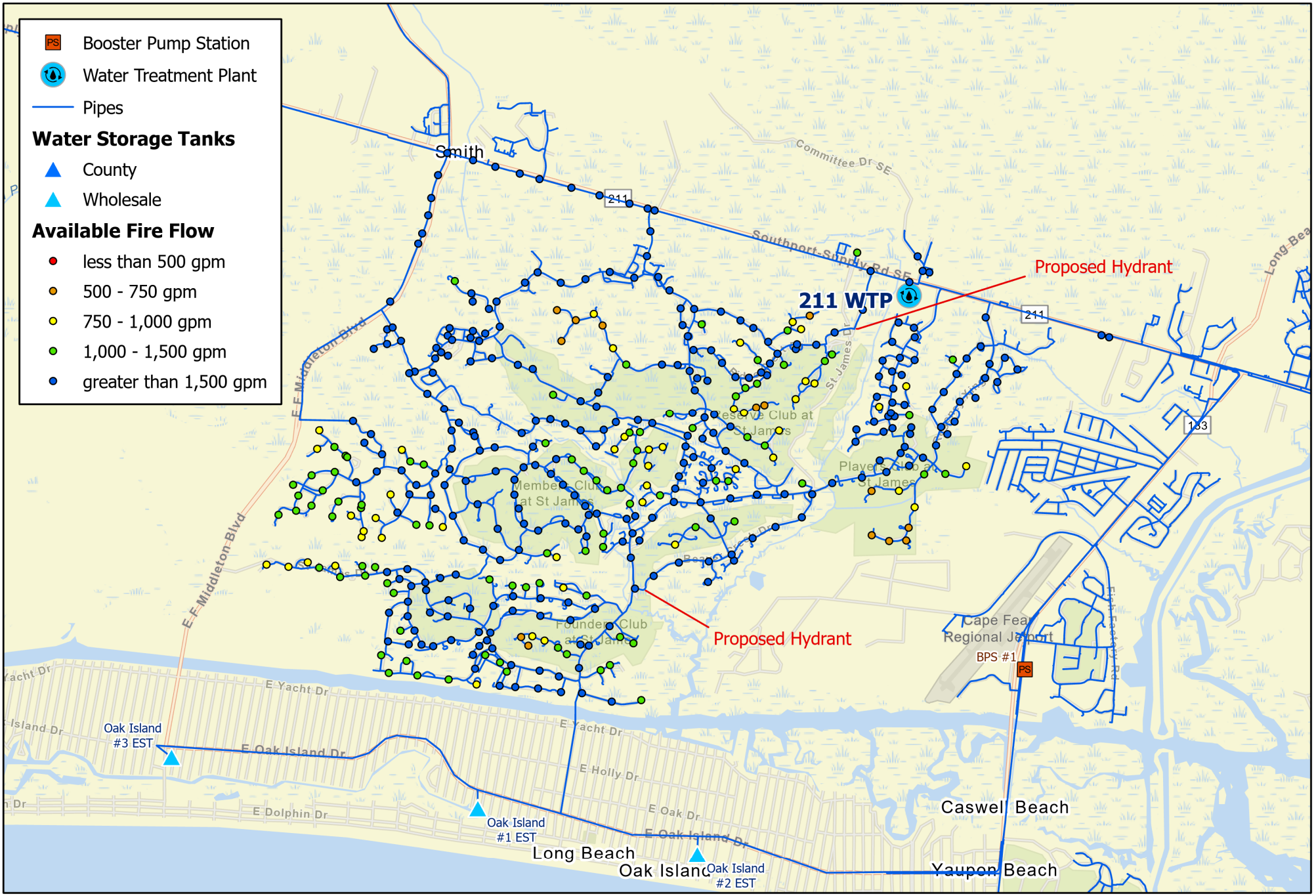


Figure 4-2
Predicted Hydrant Fire Flow Availability with Improvements

Section 5
Capital Improvement Plan

5.1 Capital Improvement Plan

Based on the recommendations in Section 4, a capital improvement plan (CIP) was developed consisting of the recommended projects.

Total Project costs were established and represent April 2023 dollars. Total project cost consists of Engineering, Easements, Permits and Construction cost. Total project costs were escalated at 8.3 percent per year for three-year period of funding (i.e., through 2026). The design and permitting need to begin in 2023 with bidding and construction to follow, if projects are to be completed by 2026. It is our understanding that current budget is approximately $4 million and the funds have strict deadlines stipulated for use by December 2026.

The resulting system improvements in order of priority and showing escalated costs as indicated shown in **Table 5-1**. It should be noted that bidding the overall project with construction alternatives can allow for selecting construction work as budgets allow. Additionally, the total project cost consist of approximately 20% contingencies per discussions with Brunswick County.

In order to include construction of the check valve ($65,000) at Midway Road intersection within a Capital Project we have included this work as part of the Hwy 211 12-inch water main project (Alt F) for Capital Improvement Planning in the below table.

Table 5-1. Southeast Area Improvements - CIP

Transmission/ Distribution Projects	Type	Diameter (in)	Length (ft)	Est of total Project2023 Cost	Future (2026) Cost Total
Alternative G – modifications to 211 WTP	Operational	na	na	O&M	O&M
Alternative F – Highway 211 Main (open cut) with CV ($65,000)	Distribution	12	5,900	$1,645,000	$2,089,000
Alternative C – EF Middleton Extension and Connection to Holly Harbor Drive (HDD)	Transmission	12, 16	6,500	$2,300,000	$2,920,000
Medina Ct - Connection No. 3	Distribution	4	400	$137,000	$174,000
Worthington Pl -Connection No. 2	Distribution	4	800	$235,000	$298,500
Somerdale Ct - Connection No. 1	Distribution	2	200	$79,000	$100,300

Figure 5-1 shows the recommended project locations.

Appendix A provides the costs in County CIP format.

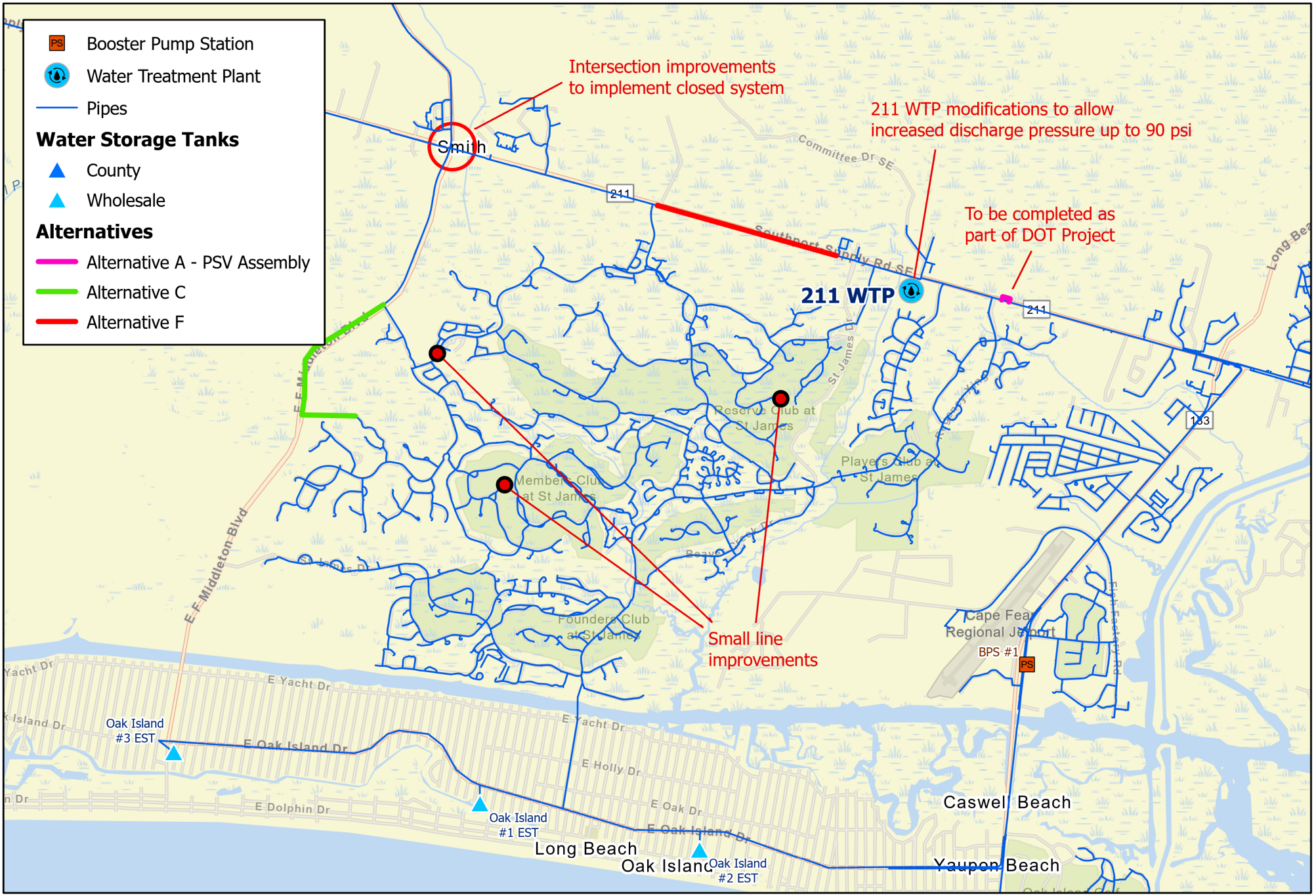


Figure 5-1
Location of Recommended Alternatives

Appendix A

CIP Project Locations and Summary Sheets

Capital Improvement Plan

County of Brunswick | **Capital Project Request Report** | **For FY 2023 Capital Planning**

Name: 211 WTP West Transmission (TR-13A)
Category: Capital Improvement
Type: Transmission Lines
Cost (2023 $): $ 1,581,000
Cost (Escalated $):
Year Needed:

Prior 2023 Costs:	$ -
FY 2023 Costs:	$ 1,581,000
FY 2024-2027 Costs:	
Project Manager:	CIP Manager
Responsible Department:	Public Utilities

Project Description:

Approximately 1.1 miles of 12-inch main by open cut. The alignment follows Southport Supply Road SE (NC 211) from the existing 12" main approximately 1.3 miles from the 211 and NE Middleton Avenue to the existing 12" main located southeast of the St. James Drive SE entrance.

Justification:

The expansion is needed to meet the increased water demands of our residential customers, commercial customers, wholesale customers, and industrial customers. This project will help to shift the service area of the 211 WTP more to the west while improving the pressure and flow in portions of the Town.

Impact if Cancelled or Delayed:

Water restrictions to customers and areas of water pressure below 30 psi during days of high water demands. Inability to deliver sufficient water to high growth areas in the south central and southwestern portions of the County.

County of Brunswick, North Carolina (TR-13A)

211 WTP West Transmission

Southport Supply Road SE (NC 211) Connect Existing 12-inch Main along NC 211

Alt F with Check Valve at Midway Rd intersection

Item Description	Quantity	Unit	Unit Price	Total Cost
Right of Way Prep	5,900	LF	$ 3.50	$ 20,650
Erosion Control	5,900	LF	$ 4.75	$ 28,025
Trench Safety	5,900	LF	$ 4.75	$ 28,025
12-inch Water Line (Open cut)	5,900	LF	$ 150.00	$ 885,000
Fire Hydrants Assy (every 1000 LF)	6	EA	$ 4,700.00	$ 27,730
Gate Valves	10	EA	$ 2,000.00	$ 20,000
Alt G- Check Valve, Vault and By-pass	-	LS	$ 65,000.00	$ -
Dewatering	5,900	LF	$ 3.50	$ 20,650
Revegetation	5,900	LF	$ 7.00	$ 41,300
Subtotal				$ 1,071,380
Mobilization/Demobilization			5%	$ 53,500
Contingency			20%	$ 214,250
Construction Subtotal				$ 1,339,130
Professional Services			15%	$ 200,750
Easement Acquisition	4.1	acres	$ 10,000.00	$ 40,634
Project Total				$ 1,580,514

Note: Alt G (CheckValve) is $65,000 in Table 4-3 of main document, is not included in total of CIP sheet for consistency.

Capital Improvement Plan

County of Brunswick | **Capital Project Request Report** | **For FY 2023 Capital Planning**

Name: Oak Island and St. James Reinforcement (TR-15A)
Category: Capital Improvement
Type: Transmission Lines
Cost (2023 $): $ 2,308,000
Cost (Escalated $):
Year Needed:

Prior 2023 Costs:	$ -
FY 2023 Costs:	$ 2,308,000
FY 2024-2027 Costs:	
Project Manager:	CIP Manager
Responsible Department:	Public Utilities

Project Description:

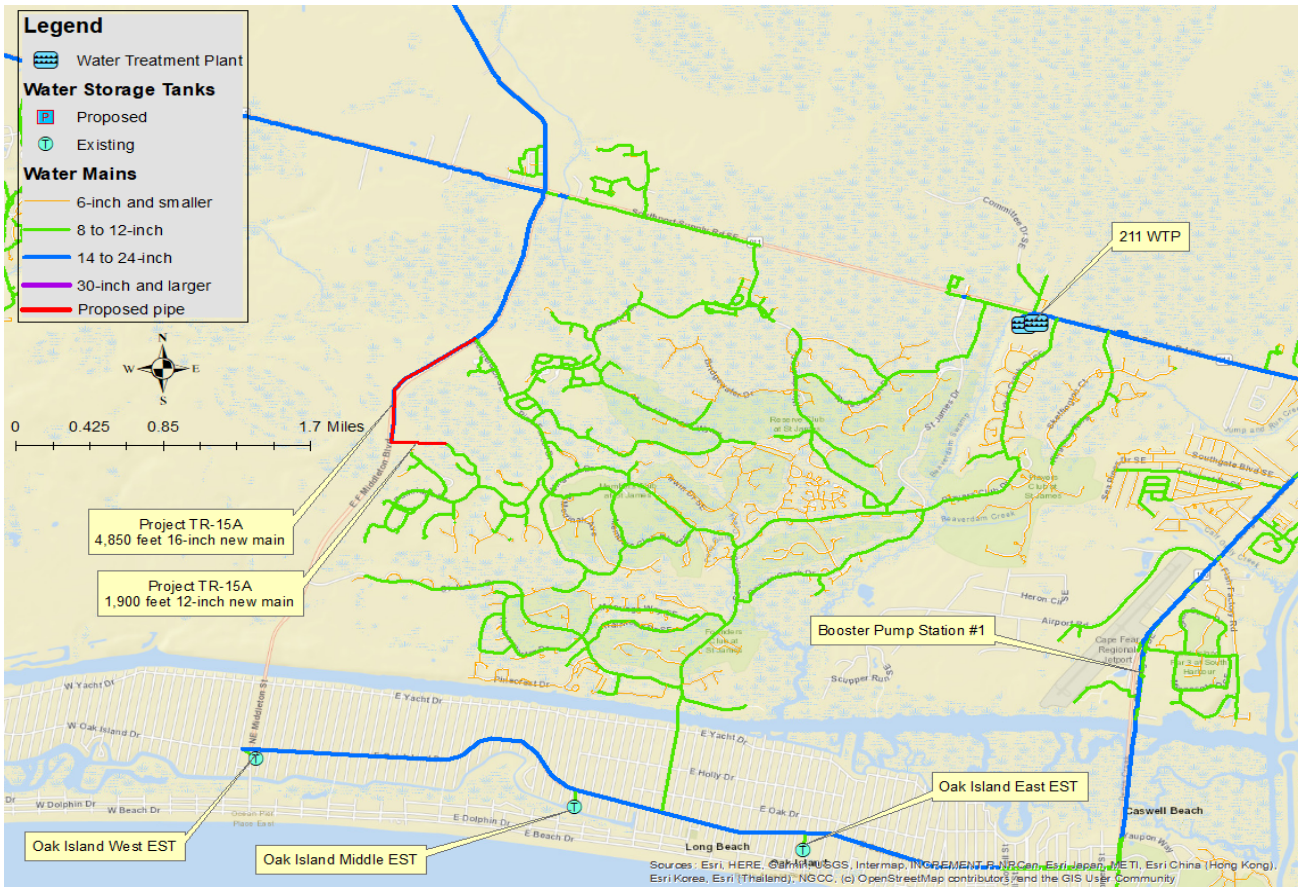
Approximately 0.9 miles of 16-inch main, and 0.4 miles of 12-inch main. The 16-inch main will extend the NE Middleton Avenue main from Seafield Drive south approximately 4,850 feet. The main will be reduced down to a 12-inch main and travel east through cross country to Holly Harbor Drive approximately 1,900 feet and connect to the existing 12-inch main.

Justification:

The expansion is needed to meet the increased water demands of our residential customers, commercial customers, wholesale customers, and industrial customers. This project will extend the existing main on NE Middleton Avenue to a connection into the Town of St. James to improve pressure and flow in portions of the Town.

Impact if Cancelled or Delayed:

Water restrictions to customers and areas of water pressure below 30 psi during days of high water demands. Inability to deliver sufficient water to high growth areas in the south central and southwestern portions of the County.



County of Brunswick, North Carolina (TR-15A)

Oak Island and St. James Reinforcement

NE Middleton Avenue from Seafield Drive to Holly Harbor Drive

Item Description	Quantity	Unit	Unit Price	Total Cost
Right of Way Prep	4,850	LF	$ 3.50	$ 16,975
Erosion Control	4,850	LF	$ 4.75	$ 23,038
Trench Safety	4,850	LF	$ 4.75	$ 23,038
16-inch Water Line	4,850	LF	$ 180.00	$ 873,000
12-inch Water Line (Trenchless)	1,900	LF	$ 295.00	$ 560,500
Fire Hydrants	5	EA	$ 4,700.00	$ 22,795
Gate Valves	6	EA	$ 2,000.00	$ 12,000
Dewatering	4,850	LF	$ 3.50	$ 16,975
Revegetation	4,850	LF	$ 7.00	$ 33,950
Subtotal				$ 1,582,270
Mobilization/Demobilization			5%	$ 79,000
Contingency			20%	$ 316,500
Construction Subtotal				$ 1,977,770
Professional Services			15%	$ 296,750
Easement Acquisition	3.3	acres	$ 10,000.00	$ 33,402
Project Total				$ 2,307,922

County of Brunswick, North Carolina (TR-15B)

Oak Island and St. James Reinforcement

Small internal connections with St James

Somerdale to Oceanic

No. 1	Item Description	Quantity	Unit	Unit Price	Total Cost
Somerdale	Right of Way Prep	200	LF	$ -	$ -
	Erosion Control	200	LF	$ 4.75	$ 950
	Trench Safety	200	LF	$ 4.75	$ 950
	2-inch Water Line (Trenchless)	200	LF	$ 120.00	$ 24,000
	Fire Hydrants	-	EA	$ 4,700.00	$ -
	Gate Valves	2	EA	$ 1,000.00	$ 2,000
	Paving/Curbing	1	LS	$ 25,000.00	$ 25,000
	Revegetation	200	LF	$ 7.00	$ 1,400
	Subtotal				$ 54,300
	Mobilization/Demobilization			5%	$ 2,750
	Contingency			20%	$ 10,750
	Construction Subtotal				$ 67,800
	Professional Services			15%	$ 10,250
	Easement Acquisition	0.1	acres	$ 10,000.00	$ 1,377
	Project Total				$ 79,427

County of Brunswick, North Carolina (TR-15C)

Oak Island and St. James Reinforcement

Small internal connections with St James

Worthington to Westland Lane

No. 2	Item Description	Quantity	Unit	Unit Price	Total Cost
Worthington Pl	Right of Way Prep	800	LF	$ -	$ -
	Erosion Control	800	LF	$ 4.75	$ 3,800
	Trench Safety	800	LF	$ 4.75	$ 3,800
	4-inch Water Line (Trenchless)	800	LF	$ 150.00	$ 120,000
	Fire Hydrants	-	EA	$ 4,700.00	$ -
	Gate Valves	2	EA	$ 1,000.00	$ 2,000
	Paving/Curbing	1	LS	$ 25,000.00	$ 25,000
	Revegetation	800	LF	$ 7.00	$ 5,600
	Subtotal				$ 160,200
	Mobilization/Demobilization			5%	$ 8,000
	Contingency			20%	$ 32,000
	Construction Subtotal				$ 200,200
	Professional Services			15%	$ 30,000
	Easement Acquisition	0.6	acres	$ 10,000.00	$ 5,510
	Project Total				$ 235,710

County of Brunswick, North Carolina (TR-15D)

Oak Island and St. James Reinforcement

Small internal connections with St James

Medina Ct to Members Club

No. 3	Item Description	Quantity	Unit	Unit Price	Total Cost
Medina Ct	Right of Way Prep	400	LF	$ -	$ -
	Erosion Control	400	LF	$ 4.75	$ 1,900
	Trench Safety	400	LF	$ 4.75	$ 1,900
	4-inch Water Line (Trenchless)	400	LF	$ 150.00	$ 60,000
	Fire Hydrants	-	EA	$ 4,700.00	$ -
	Gate Valves	2	EA	$ 1,000.00	$ 2,000
	Paving/Curbing	1	LS	$ 25,000.00	$ 25,000
	Revegetation	400	LF	$ 7.00	$ 2,800
	Subtotal				$ 93,600
	Mobilization/Demobilization			5%	$ 4,750
	Contingency			20%	$ 18,750
	Construction Subtotal				$ 117,100
	Professional Services			15%	$ 17,500
	Easement Acquisition	0.3	acres	$ 10,000.00	$ 2,755
	Project Total				$ 137,355

Appendix B

Hydraulic Model Data Summary

Appendix B

Southeast Area Water System Improvements – Model Summary

- Actual Billing Data and GIS meter point features.
- Max Day Demand Peaking Factor estimated using 2020 Average Day Demand and 2019 Max Day Demand to offset effects of COVID-19 data influence.
- Diurnal patter Coastal Utility
- Irrigation Patter 3am to 7 am
- Overall Peaking Factor calculated = 4.6

DEMANDS

- Overall water system 2040 Demands
- All lots in St. James developed.
- 2000 units in Timmons Tract- Oak Island developed.

FIRE FLOW

- 500 gpm minimum
- 1000 gpm desirable
- All fire hydrants connected to 6-inch or greater pipeline

PRESSURE

- Minimum 40 psi at Peak Hour

CDM Smith