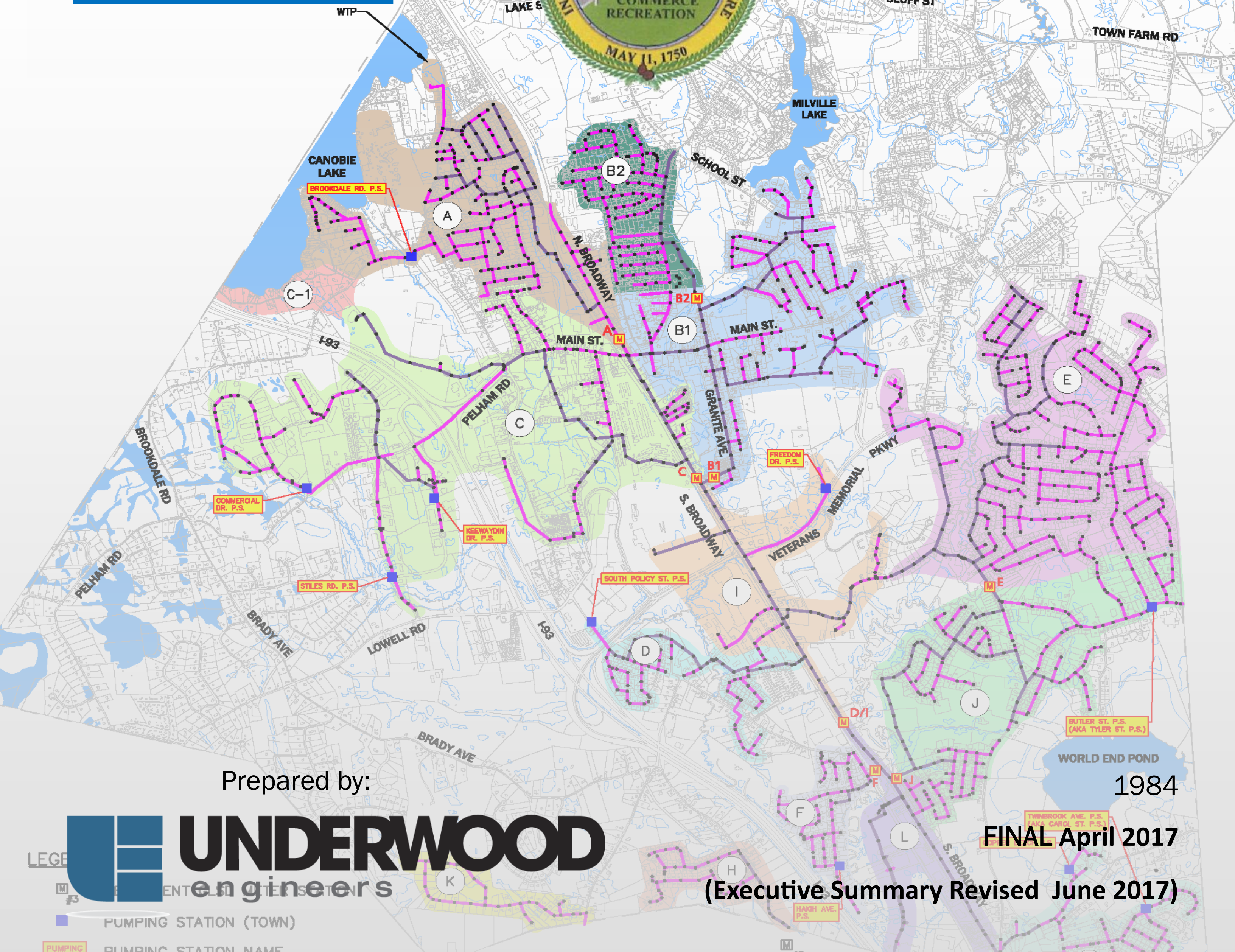
SEWER MASTER PLAN

SALEM,

NEW HAMPSHIRE

VOLUME I



Prepared by:

UNDERWOOD engineers

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FINAL April 2017

(Executive Summary Revised June 2017)

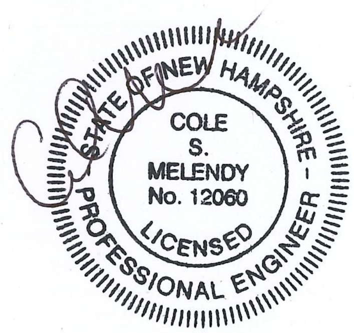
Town of Salem
New Hampshire

Sewer Master Plan

FINAL

April 2017

(Executive Summary Revised June 2017)



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Executive Summary

Purpose and Objectives

The purpose of this Master Plan Update is to build off previous reports to complete an evaluation of the Town of Salem, New Hampshire's (the Town's) wastewater collection system. Objectives include:

- Update the Town's Sewer Master Plan which was last performed in the early 1980s
- Select and create a hydraulic sewer interceptor model to evaluate the existing sewer system capacity under dry weather and peak wet weather conditions
- Evaluate Infiltration and Inflow (I/I) in the system and the ability to reclaim sewer capacity by I/I reduction.
- Evaluate infrastructure needs at pumping stations
- Identify sewer planning and buildout areas
- Evaluate current and future infrastructure needs
- Identify a Capital Improvements Program (CIP)
- Identify next steps

Overview of Existing System

The Town's wastewater and collection and treatment system was originally built and constructed in the 1960's and has been expanded since that time. In the early 1980s the Town abandoned the wastewater treatment facility and entered into an inter-municipal agreement with the Greater Lawrence Sanitary District (GLSD) for treatment and disposal of the Town's wastewater. Under the inter-municipal agreement the Town pays GLSD for an apportionment of the costs to operate, maintain, and improve (when necessary) the GLSD system and the Town is responsible for operating and maintaining the public collector sewers and pumping stations owned by the Town. The Town's inter-municipal agreement with GLSD was renewed in October 2014 for a period of 30 years and included the following flow limitations that will be accepted from the Town:

- Average Daily Flow = 5 Million Gallons per Day (MGD)
- Maximum Daily Flow = 9 MGD
- Peak Hour Flow = 14.5 MGD

The Town's wastewater collection system consists of approximately 72.5 miles of gravity sewer, 3 miles of force main, and ten (10) wastewater pumping stations. Wastewater is conveyed to GLSD through three (3) flow meters and GLSD assesses Salem a charge for wastewater treatment and disposal based on the flow that the Town sends to GLSD. Figure 2-2 shows the extents of the Town's wastewater collection system, pumping stations, as well as the GLSD service area included in the inter-municipal agreement.

Pumping Station Evaluation
UE visited the Town's ten (10) wastewater pumping stations and reviewed operation and maintenance manuals provided by the Town to assess the condition of the stations and provide recommendations. A 10-year CIP was developed with approximately $6.0M in recommended pump station improvements (Table ES-4). Additional improvements beyond 10 years were also identified (Table 9-1).

Wastewater Flows
Recent sewer flows are summarized in Table ES-1 and have been less than the limitations of the GLSD inter-municipal agreement. However, maximum day flow is the most utilized flow limit (74%) and it is believed that these maximum day flows are primarily due to I/I in the system.

Table ES-1. Recent Sewer Flows

	Recent Sewer Flows (2013-2015) (MGD)	GLSD Flow Limitations (MGD)	GLSD Capacity Percent Utilized (%)
Annual Average Day Flow	2.6 to 3.0	5.0	52% to 60%
Maximum Day Flow	5.1 to 6.7	9.0	57% to 74%
Peak Hour Flow	5.6 to 6.9	14.5	39% to 48%

Infiltration and Inflow (I/I) Evaluation
The Town is required to evaluate infiltration and inflow in the system and develop reasonable mitigation programs pursuant to Section 4.f of the Town's inter-municipal agreement with GLSD. Infiltration and inflow evaluations from flow metering performed as part of this evaluation was used to help prioritize recommended sewer replacements in areas of the system exhibiting the highest infiltration and inflow. It was estimated that approximately 60% of average annual flow in the system was I/I and contributed to identified hydraulic limitations during max-day and peak flow conditions.

Continuous flow monitoring was used to evaluate the components of infiltration and inflow within each meter basin and it was estimated that infiltration represented approximately 91% and inflow represented 9% of the annual average I/I in the system. Therefore future I/I investigations should focus on infiltration mitigation to help reduce system flows and recapture "lost" capacity. Excessive infiltration was identified in Basins A, C, D/I, F and G which were estimated to contribute 76% of the average infiltration in the system and represent 42% of the total system piping (Figure 5-3). Furthermore approximately 50% of the system infiltration was concentrated in Basins A and C which represented approximately 24% of the total system piping.

Night time flow isolation was performed in Basins A and C to identify specific sewer reaches with excessive infiltration in the basins (Figures 5-4 and 5-5). It was found that approximately 80% of the infiltration in Basin A was concentrated in approximately 12,500' of sewer and 62% of infiltration in Basin C was concentrated in 7,000' of sewer. Therefore, it is estimated that approximately 36% of the total system infiltration is concentrated in approximately 5% of the system. Future night time flow isolation of Basins D/I, F and G will help identify specific sewer reaches with excessive infiltration in these basins and future closed circuit television (CCTV) can be used to identify specific leaking defects and private I/I so mitigation measures can be designed.

Future phases of I/I reduction work should include evaluation of the cost effectiveness of proposed repairs once identified. A large percentage of Salem's charges from GLSD are based on Salem's contribution of flow relative to the other GLSD member communities, so I/I reduction in the Town's system can help manage those flow-based charges for service. For example, in GLSD FY 2014 Town flow-based 'General Fund' charges were $1.043M. A 20% reduction of I/I from the Town would have potentially saved the Town approximately $140K in flow-based charges that year. It should be noted moving forward that the other GLSD member communities are also required to reduce I/I in their systems so the Town's flow-based charges also have the potential to increase if other GLSD communities have a more effective I/I mitigation program than the Town. For example, we are aware that Lawrence is aggressively reducing I/I.

Sewer Interceptor Modeling

Underwood Engineers used the Town's GIS data as the base to create a steady-state hydraulic model of the Town's sewer interceptors (pipes with diameters 10" and greater) using Bentley Sewer CAD modeling software. Sewer record drawings provided by the Town were used to supplement pipe size, rim/invert elevation, material and other required information not included in the GIS database. Water records and wastewater pumping station flow data provided by the Town were used to estimate and distribute sanitary flows in the model. The model was calibrated using spring 2016 continuous flow monitoring data from the eleven (11) flow meters in the system, eight (8) of which were installed as part of this study and three (3) were existing meters used by the GLSD for billing purposes. Figure 5-2 shows the location of the flow meters used for the flow monitoring evaluation.

Once calibrated, average day flows predicted by the model were within 1% of observed flows during flow monitoring. The model showed that approximately 6,700 linear feet of the sewer interceptor exceeded the hydraulic capacity of the sewer under observed 6.7 MGD maximum day flows (March 31, 2014) whereas average day flows did not predict pipe capacity exceedance. The main areas of the hydraulic restrictions were located along Main St., Granite Ave. and South Broadway. This finding was consistent with hydraulic 'bottlenecks' identified during previous evaluations (UE 2015) and was also consistent with past Town observations during flood events where staff observed surcharging of sewer manholes in this area.

Furthermore, the sewer model was also used to evaluate the hydraulic impacts of infiltration and inflow (I/I), potential flows from 'infill' growth within the existing collection system, and potential flows from sewer buildout/expansion. The model used existing max day flows to evaluate the addition of future buildout and infill flows and recommend alternatives to mitigate hydraulic restrictions to be included in the recommended long-term Capital Improvement Plan (CIP) for the system. Maximum day flows were also the focus of future flow projection evaluations because they were found to be the Town's most utilized GLSD flow limit in recent years (**Table ES-3**).

Sewer Planning and Flow Projections

UE evaluated existing information to project estimated future sewer flows associated with 'infill' development (i.e. additional sewer flows from development or re-development within the limits of the existing wastewater collection system) and from 'buildout' (i.e. additional sewer flows from sewer extensions to service areas not currently served by the public sewer). UE used the following information to estimate the future sewer flows for the Town's Sewer System:

- Hydraulic Modeling-Sewerage System, dated 5/22/89 by Underwood Engineers
- Lakes Area Infrastructure Plan Phase II Draft, dated 11/01/99 by SEA Consultants
- Town of Salem 2001 Master Plan
- Town of Salem 2008 Zoning Map
- Town GIS Data

Planning areas compiled and used for wastewater flow projections are shown on Figure 7-1.

Table ES-2. Projected Additional Sewer Buildout Flows

Area	Estimated Average Day Sanitary Flows (MGD)	Estimated Max. Daily Sanitary Flow (MGD)	Additional I/I Flow Estimates from Sewer Extensions (MGD)	Estimated Average Daily Flow (MGD)	Estimated Max. Daily Flow (MGD)
Arlington/Captains Pond Buildout Area	0.51	1.03	0.058	0.57	1.09
Millville St. Buildout Area	0.02	0.04	0.003	0.02	0.05
Lake St. Buildout Area	0.16	0.32	0.017	0.18	0.34
West Side Buildout Area	0.20	0.41	0.03	0.23	0.44
Subtotal	***0.9***	***1.8***	***0.1***	***1.0***	***1.9***
Existing System	1.1	N/A	N/A	2.7	6.7
			TOTAL	***3.7***	***8.6***

1. I/I estimates were based on an assumed 300 gpd/idm applied to sewer extension size/routing identified in previous reports (SEA 1999 and UE 1986).
2. Buildout sanitary flows based on 148.5 gpd/ house (Average Day) and 300 gpd/house (Max Day) and increased existing house count density associated with an assumed Rural to Residential Zoning Change where sewer service is extended (Salem 2001 Master Plan Chapter XII Land Use Table XII-4)
3. Does not include any flows from Windham.

Sewer infill areas focused on the 'Business Innovation Overlay District' using flow projections based on recent proposed developments in Town. However, it is difficult to predict the uses of future private development so applications should be compared to estimates on a case by case basis. Future buildout and infill flows used in this evaluation are summarized (**Table ES-3**).

Table ES-3. Projected Additional Sewer Buildout Flows with Infill

Area	Estimated Average Daily Flow (MGD)	Estimated Max. Daily Flow (MGD)
Existing System	2.7	6.7
Subtotal Buildout Area Flow Projections	1.0	1.9
Infill Development Estimate	0.2	0.5
TOTAL	***3.9***	***9.1***
GLSD Allowance	***5.0***	***9***

The estimated 9.1 MGD future build-out maximum day flows were slightly above the current 9 MGD GLSD limits. However, the 0.1 MGD difference is within the error of flow estimates and it is believed that flow estimates are generally conservative so the Town should have sufficient GLSD capacity to accommodate the assumed future sewer flows. In addition, there is potential for reducing max day flows through I/I reduction to gain additional capacity to stay below the GLSD allowance. For example, an approximate 5% system wide reduction of max day I/I flow would reduce estimated future max day system flows below the GLSD limit.

Hydraulic sewer modeling showed that projected future maximum day sewer flows, including estimated buildout and infill flows, exceeded the capacity of approximately 9,500 linear feet of the modeled sewer interceptors. The majority of the hydraulic restrictions under future projected maximum day flow scenarios were in the same areas around Main St., Granite Ave., and South Broadway where hydraulic restrictions were observed under existing max day flow conditions. This study evaluated alternatives to mitigate these hydraulic ‘bottlenecks’ in the Town’s sewer interceptors.

Alternatives Evaluations

Four alternatives were evaluated to mitigate the hydraulic ‘bottlenecks’ of the sewer interceptors in the vicinity of Main St., Granite Ave., and South Broadway including:

- Alternative #1 – I/I Reduction
- Alternative #2 – West Side Interceptor Flow Shedding
- Alternative #3 – Sewer Interceptor Replacement
- Alternative #4 – South Broadway Flow Shedding and Sewer Interceptor Replacement

The advantages, disadvantages, and costs of each alternative was evaluated. Alternative #4 was the recommended lowest cost alternative to mitigate Main St., Granite Ave. and South Broadway hydraulic bottlenecks.

The long-term cost effectiveness of an alternative to install the West Side Interceptor to eliminate the Keewaydin and Stiles Road pumping stations was also evaluated. It was also found that the long-term cost benefits of eliminating the Keewaydin and Stiles Road pumping stations did not offset the capital costs of the West Side Interceptor. However, the West Side Interceptor would be needed for the future buildout of the West Side due to anticipated system routing.

Recommended Improvements

Recommended improvements included the following areas of the system:

- Existing hydraulic bottleneck improvements
- Improvements to the existing pumping stations to mitigate identified deficiencies and help budget for pump and entire station replacements
- Additional studies and evaluations related to the Town's sewer system
- Long-term sewer replacement and buildout capital reserve program

Recommendations were prioritized based on a scale of 1 to 3, with priority 1 projects being the most critical to maintain the current level of service to the existing system and Town objectives for sewer service. This ranking put a higher priority on fixing existing deficiencies rather than expansion into build-out areas since they are not yet part of the system. However, future needs such as failing septic systems in the Lakes Area and water quality considerations may make sewer buildout higher priority in the future so are recommended to be included in annual planning and budgeting.

Capital Improvements Plan (CIP)

The recommended ten-year Capital Improvement Plan (10-Year CIP) includes specific projects and evaluations recommended to be performed within the next 10-years. Additional reserve contributions needed to be set aside for the future replacement of the existing infrastructure as they reach the end of their expected useful life is also provided. The expected asset replacement reserve contribution is expected to begin at the end of the near-term, 10-year CIP.

Table ES-4. Ten Year Capital Improvements Plan.

Project	Notes/References	Priority	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Annual Long
System Hydraulic Improvements[1]													
South Broadway Sewer Replacement Project (Alt #4)[3]	The replacement of approximately 7,200' of sewer pipe along South Broadway from the intersection of Main Street to Cluff Road to mitigate approximately 78% of hydraulic bottlenecks. Phase I (2018) and Phase II (2019)	1	$200,000	$3,700,000	$1,900,000								
Pumping Station Improvements[2]													
Brookdale Road PS	Modifications and improvements to the existing PS	1										$220,000	
Butler Street PS	Complete pumping station replacement and electrical modifications	1					$760,000						
Commercial Drive PS	Pump replacements and electrical modifications	1	$120,000	$180,000									
Copper Beach PS	Pumping station improvements	1		$15,000				$501,000					
Freedom Drive PS	Complete pump station replacement	1									$780,000		
Haigh Avenue PS	Pumping station improvements	1							$960,000				
Keewaydin Drive PS	Pump replacements, site work, and electrical improvements	1	$10,000			$320,000							
South Policy Street PS	Pump replacements and pumping station modifications	1										$390,000	
Stiles Road PS	Pump replacements, site work, and electrical improvements	1		$15,000		$870,000							
Twinbrook Avenue PS	Pumping station improvements	1								$850,000			
Additional Studies and Evaluations													
Infiltration and Inflow Identification and Removal Program	Additional evaluations in and mitigation projects to target infiltration reductions	1	$200,000	$100,000	$100,000	$100,000	$100,000						
I/I Program Implementation	Implementation Efforts based on the findings of I/I evaluations	2		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
Sewer Rate Study	Additional evaluations to determine appropriate user rates.	1	$15,000	$5,000	$5,000	$15,000	$5,000	$5,000	$15,000	$5,000	$5,000	$15,000	
Sewer System Asset Management Program	Develop an in depth asset management program for the entire wastewater collection system.	2		$30,000	$30,000								
Long Term Sewer Funding Reserve													
Long Term Capital Improvement Program[4]	Annual reserve funding to be set aside for existing asset replacement and future sewer buildout.	2, 3					$600,000	$900,000	$500,000	$600,000	$600,000	$800,000	$1,507,000
		TOTAL[5]	**$545,000**	**$4,045,000**	**$2,035,000**	**$1,305,000**	**$1,465,000**	**$1,406,000**	**$1,475,000**	**$1,455,000**	**$1,385,000**	**$1,425,000**	**$1,507,000**

1. Preliminary costs are for planning purposes only.
2. Further information on specific pumping station projects are provided within the Pumping Station Recommended Projects table
3. South Broadway Sewer costs do not include possible $3M costs for management of limited re-use soils and groundwater to be refined during project design
4. Reserves needed for existing asset replacement and future sewer buildout recommended to be included within Annual CIP
5. Costs are in 2016 dollars.

1. Introduction

1.1. Background

The Town of Salem, New Hampshire's (the Town's) wastewater and collection and treatment system was originally built and constructed in the 1960's. The original system included a Wastewater Treatment Facility (WWTF) that discharged treated effluent to the Spickett River. In the early 1980s the Town faced a significant upgrade of the aging WWTF and increasingly stringent WWTF discharge limits. The cost of WWTF upgrades compounded with the long-term challenges associated with WWTF discharge to a water body with low dilution factors such as the Spickett River led the Town to abandon the WWTF and enter into an inter-municipal agreement with the Greater Lawrence Sanitary District (GLSD) for treatment and disposal of the Town's wastewater. The initial agreement with GLSD began in 1986 and was renewed in October 2014 for a period of an additional 30 years until year 2044.

With the abandonment of the WWTF and transference of wastewater treatment and disposal responsibilities to GLSD, the Town's wastewater infrastructure responsibilities currently consist of payments to GLSD for wastewater treatment and disposal, and operation and maintenance of the Town's wastewater collection system. Over time, the Town's wastewater collection system has expanded to provide municipal wastewater service to different areas of Town and the current collection consists of approximately 72.5 miles of gravity sewer, three miles of force main, and ten wastewater pumping stations. The Town is responsible to operate and maintain the wastewater collection system and this Sewer Master Plan update endeavors to serve as a planning document to assist the Town plan for wastewater collection system infrastructure needs.

1.2. Purpose and Objectives

The purpose of this Master Plan Update is to build off previous reports to complete an evaluation of the Town of Salem, New Hampshire's (the Town's) wastewater collection system. The objectives of this Sewer Master Plan Update include:

- Update the Town's Sewer Master Plan which was last performed in the early 1980s
- Select and create a hydraulic sewer interceptor model to evaluate the existing sewer system capacity under dry weather and peak wet weather conditions
- Evaluate Infiltration and Inflow (I/I) in the system and the ability to reclaim sewer capacity by I/I reduction.
- Evaluate infrastructure needs at pumping stations
- Identify sewer planning and buildout areas
- Evaluate current and future infrastructure needs
- Identify a Capital Improvement Program (CIP)
- Identify next steps.

1.3. Previous Reports

The last Sewer Master Plan for the Town's wastewater system was the *201 Facilities Plan Update* dated October 1, 1981 (Facilities Plan). The Facilities Plan focused on evaluating wastewater treatment alternatives and recommended abandoning the Town's Wastewater Treatment Facility (WWTF) and participating with the GLSD. However, a comprehensive master plan has not been completed since 1981 and a sewer master plan focusing on the Town's wastewater collection system had never been done. Nonetheless the Town has continued to evaluate and improve its wastewater collection system over the past 30 years and this report intends to assimilate some of the past work into a single document. To that end the following past reports were referenced for this evaluation:

201 Facilities Plan Update, G/Underwood Engineers, October 1, 1981

Five Year Sewer Construction Program Capital Costs and Rate Impact Presentation, Board of Selectmen Meeting, G & Underwood Engineers, November 19, 1984

Sewer System Map, Town of Salem, N.H., Rockingham County, G & Underwood, 1986

Hydraulic Modeling – Sewerage System, Salem, New Hampshire, Underwood Engineers, Inc., May 22, 1989 (Updated July 24, 1989)

Lakes Area Infrastructure Study, Town of Salem, NH, SEA Consultants Inc., December 1997

Phase I – Infiltration and Inflow Analysis, Salem, New Hampshire, SEA Consultants Inc., December 1998

Lakes Area Infrastructure Plan, Phase II for Town of Salem, NH, SEA Consultants Inc., October 1999

Salem Master Plan, 2001, Prepared for the Town of Salem Planning Board, Woodward Planning Consultants, Inc., adopted November 13, 2001

Phase II Sewer System Evaluation Survey for Salem, New Hampshire, SEA Consultants Inc., May 2004

Windham/Salem Sewer Line Interconnection Feasibility Study, Windham, New Hampshire, Underwood Engineers, Inc., November 30, 2009

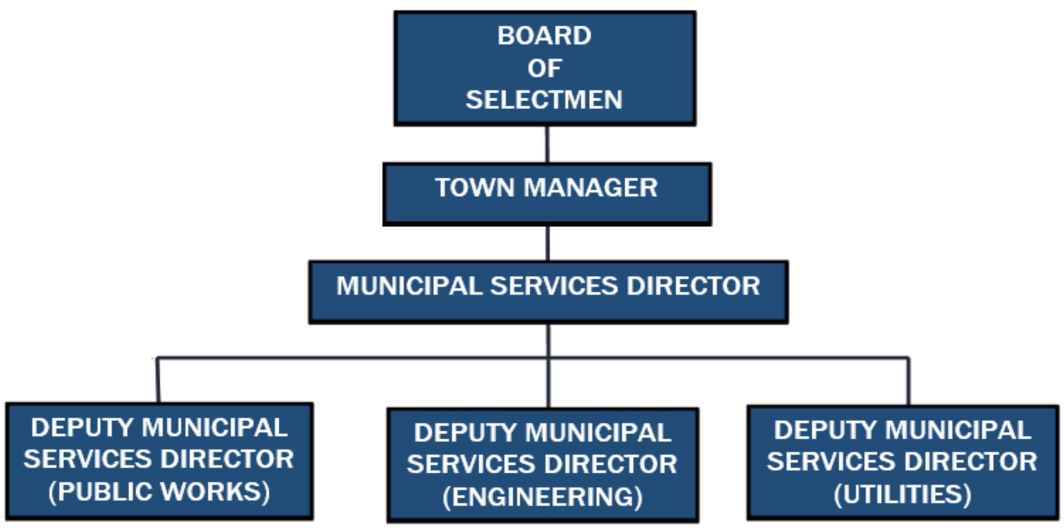
Sewer Flow Path Capacity Evaluation, Salem, New Hampshire, Underwood Engineers, June 11, 2015

2. Description of the Existing System

2.1. Town Organizational Structure

The Town of Salem is governed by a five-member board of selectmen and Town Manager. The Town's Municipal Services Director oversees the public works, engineering and utilities divisions. The Town's sewer system is operated by the Deputy Municipal Services Director (Utilities) and support staff with support from engineering. The Town's DPW operates under the following organizational structure:

Figure 2-1. Salem Municipal Services Organizational Chart



2.2. Town Sewer Standards

The Town has two Town ordinances which govern the disposal of wastewater. Chapter 398 of the Town's Regulations govern use of users connected the Town's public sewers and Chapter 391 governs sewage disposal, primarily related on-site wastewater disposal systems (i.e. septic systems).

2.3. Sewer Revenue and User Rates

The 2016 sewer department budget was $2.6M. To support this budget, the Town has established a rate structure to raise revenues to fund operating expenses, as well as debt service and capital improvements for the sewer system. The expenses for the Town's system include payments to GLSD for wastewater treatment and disposal and for the operation and maintenance of the Town-owned wastewater collection system. Sewer user billings include flat administrative charges and sewer usage charges based on water consumption from meter records. Users that do not have a water meter are charged a flat fee in lieu of sewer usage charges.

The Town periodically reviews sewer user rates and the Town's most recent sewer usage charge update was on January 1, 2012. It is recommended that rates be evaluated no less than every two years and updated no less than every five years because revenue/expense projections beyond those timeframes become less reliable. Based on the most recent New Hampshire Department of Environmental Services (NHDES) sewer rate survey in 2015, the Town's average annual residential sewer rate of $292.83 were approximately half of the $593.52 New Hampshire state average (Appendix A).

2.4. Wastewater Treatment and Disposal

2.4.1. GLSD Service Area for Salem

The GLSD regional wastewater system service area for the Town includes the Salem, NH municipal town boundary and also includes a portion within the Town of Windham, NH around Canobie Lake (Figure 2-2). The Town's GLSD Agreement includes this area of Windham to protect water quality around Canobie Lake and the Town's 2001 Master Plan indicates that Windham has *a reservation of 300,000 gallons per day at the Greater Lawrence Treatment Facility*. However, we understand that the Town of Windham would need to execute an inter-municipal agreement with the Town of Salem and/or GLSD prior to connection to the system.

2.4.2. GLSD Flow Limitations

The Agreement with GLSD from the service areas includes the following flow limitations:

- Average Daily Flow = 5 Million Gallons per Day (MGD)
- Maximum Daily Flow = 9 MGD
- Peak Hour Flow = 14.5 MGD

The Town must notify GLSD in writing when flows exceed 90% of the any of the flow limitations indicated above. It is understood that the GLSD flow limitations include flow from the entire service area (including Windham). Sewage flow allocations in Salem's 201 Facilities plan included 310,500 gals/day from Windham (UE 1981). However, it is expected that Windham would need to buy-in to the system with a separate inter-municipal agreement prior to connecting so future flows from Windham have not been considered in this evaluation.

2.4.3. GLSD Meter Locations and Entry Points

Flow from Salem is metered through three (3) meter sites located along the southern Town boundary (Figure 2-2). A summary of the meter locations is as follows:

- Meter #1: Located along interceptor along Garabedian Drive between Interstate I-93 and South Broadway and provides flow data in 15-minute increments. The meter is located in a 42-inch diameter pipe and the majority of the flow from the Town passes through this meter.

- Meter #2: Located on South Broadway and provides flow data in 15-minute increments. This meter is located in a ten-inch diameter pipe and services the sewered area in the south east corner of Town.

- Meter #3: Located on Cross Street and services a neighborhood in that area. GLSD manually records the totalizer flows from this meter on an approximately weekly basis. This meter is located in a 24-inch diameter pipe.

- Unmetered Area: There is a small sewered area in the vicinity of Silverbrook Road that does not pass through Meters 1, 2 or 3. We understand that wastewater flow from this area is monitored by GLSD under separate agreement.

The GLSD Agreement requires that the Town pay GLSD for a portion of GLSD annual operating costs proportional to the Town's flow. The Agreement also requires that the Town pay 10.8% of the GLSD's annual debt service and 10.8% of GLSD's annual contribution to capital projects. The Town raises the funds required to make these payments through sewer user rates and fees. GLSD indicated that flows from Salem can enter GLSD in any proportion at the meter locations, so appear to only be limited by the hydraulics of the Town's system.

2.5. Town Owned Collector Sewers and Interceptors

Based on the Town's GIS system, the wastewater collection system consists of approximately 72.5 miles of gravity sewer, approximately 1,630 manholes, 3 miles of force main, and ten (10) wastewater pumping stations. The following tables summarizes the infrastructure associated with the Town's collector gravity sewers and sewer interceptors:

Table 2-1. Gravity Sewer Material Summary

Gravity Sewer Interceptor/Collector Material	Length (ft)
Asbestos Concrete (AC)	69
Reinforced Concrete Pipe (RCP)	41,581
Concrete	2,678
Cast Iron (CI)	1,592
Ductile Iron (DI)	1,173
High Density Polyethylene Pipe (HDPP)	748
Polyvinyl Chloride (PVC)	115,979
Vitrified Clay (VC)	79,639
Unknown	139,333
TOTAL	**382,792**

Table 2-2. Gravity Sewer Diameter Summary

Gravity Sewer Interceptor/Collector Diameter (inches)	Length (ft)
4	1,347
6	5,383
8	254,933
10	23,820
12	30,878
15	27,609
16	44
18	7,772
21	8,543
24	12,340
30	5,395
42	4,348
UNKNOWN	380
TOTAL	**382,792**

2.6. Town Owned Pumping Stations

The Town owns and operates 10 wastewater pumping stations within the Town's wastewater collection system including:

- Brookdale Road (can/dry pit)
- Butler Street (suction lift)
- Commercial Drive (suction lift)
- Copper Beach (suction lift)
- Freedom Drive (ejector)
- Haigh Avenue (can/dry pit)
- Keewaydin Drive (suction lift)
- South Policy Street (flooded suction)
- Stiles Road (suction lift)
- Twinbrook Avenue (can/dry pit)

Underwood Engineers and our electrical engineer performed a site visit to each station in the Spring of 2016 to identify deficiencies and incorporate recommended improvements into the CIP. These evaluations and recommendations are discussed in later sections of this report.

3. Pumping Station Evaluation

UE evaluated the existing pumping station infrastructure to develop a plan for future evaluations and infrastructure replacement planning for capital improvement planning purposes. A detailed asset management plan was outside the scope of this Sewer Master Plan update and is recommended as a future task in later sections of this report.

Table 3-1 identifies the ten Town owned pumping stations evaluated in this report based on O&M manuals and/or pump nameplate information provided by the Town. Additional supporting information can be found in Appendix E.

Table 3-1. Town Owned Pumping Stations

Pumping Station	Station Installation Date	Design Flow (gpm)	TDH (ft)
Brookdale Road PS	1998	120	70
Butler Street Road PS	1980s	400	71
Commercial Drive PS	1987	250	51
Copper Beach PS	1990	120	35
Freedom Drive PS	1969 relocated in 1980s	100	15
Haigh Avenue PS	1972	240	38
Keewaydin Drive PS	1990	650	82
South Policy Street PS	1991	400	37.5
Stiles Road PS	1987	260	50
Twinbrook Ave PS	1972	250	42

3.1. Pumping Station Evaluation and Identified Deficiencies

A summary of observed electrical conditions at each station was provided in the Electric Review of Ten Waste Water Pumping Stations in Salem, NH by Lee F. Carroll, P.E. (Appendix C). A summary of UE's field observations, photos, observed deficiencies to the requirements of NH Code of Administrative Rules Env-Wq 705, and 2016 drawdown test results for each station are also provided (Appendix D). The *Copper Beach Road Pumping Station Evaluation* by Underwood Engineers dated February 13, 2014 is included for reference (Appendix E). It should be noted that the pump station site visits only include observing visible items. No exploratory work was performed.

The following is a brief narrative summary of the existing conditions and deficiencies observed at each pumping station evaluated. Section 9 of this report includes a general description of recommended improvements and engineer's opinions of probable costs.

3.1.1. Brookdale Road Pumping Station

The Brookdale Road Pumping Station is an approximately 18-year-old (1998 vintage) USEMCO-type concrete wetwell/dry pit package located on the eastern side of Brookdale Road. A wooden stockade fence surrounds the pumping station site and a paved driveway provides access and parking. An 18-year-old pad-mounted diesel generator supplies emergency power to the site. This pumping station conveys wastewater from the southeast section of Canobie Lake to the forcemain discharge to the gravity sewer located at North Policy Street.

The existing precast concrete of the visible portion of the wetwell appeared to be in good condition. There were no bar racks, comminutors, or other influent screening on influent flows. No apparent signs of hydrogen sulfide corrosion were observed on the structure walls (i.e. exposed aggregates) and limited grease was observed around the waterline of the structure.

The existing underground dry pit houses the vertical centrifugal pumps, controls and alarms. An exhaust fan is used to vent the space and a ladder affixed to the wall is used to access the pit. The can walls visually appeared to be in good condition. Minor surface rust was observed on the floor of the structure and near the force main exit and also by the domestic water service entrance. The paint on the floor of the structure was peeling. Much of the equipment appeared to be original. The pumps were reportedly overhauled approximately 10 years ago and the drives were replaced this year. A domestic water service with a backflow preventer is located in the dry pit for pump cooling/lubrication. The original bubbler level control system was changed to a pressure transducer. The dry pit is a confined space.

Observed NHDES Env-Wq 705 Compliance Deficiencies

- Env-Wq 705.03.e: Pumps are not protected from damage due to large solid objects.
- Env-Wq 705.04.d: Dry pit is accessed by a vertical ladder that is steeper than the required 75-degree slope.
- Env-Wq 705.07.c: Backup float switch has no apparent intrinsically safe barrier device.
- Env-Wq 705.07.d: Control modifications have voided any UL label on control panel.
- Env-Wq 705.08.j: No hazardous/confined space warning signs present.

- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include high water in pump room, pump malfunction, level sensing malfunction, loss of ventilation, intrusion, temperature, independent low water alarm, visible/audible enunciators.
- Env-Wq 705.10 & 705.11: Pumping station O&M manual is missing required information including: design assumptions, detailed unit process information, emergency operating plan, staffing requirements, etc.

3.1.2. Butler Street Pumping Station

The Butler Street Pumping Station is an approximately 32-year-old (1984 vintage) Gorman-Rupp above ground fiberglass enclosure with duplex self-priming pumps and a concrete wetwell located at the intersection of Butler Street and Wheeler Street. This station was relocated from another location in Town to its current location in the 1980's (estimated). The pumping station site is bounded by Butler Street to the west and north and trees and plantings to the east of the site. The site is not enclosed by any fence. A guardrail runs along the corner of Butler Street and steel bollards are located around the perimeter of the enclosure. A 10-year-old pad-mounted diesel generator supplies emergency power to the site. This pumping station conveys wastewater from the sewers on the eastern end of Butler Street to the Town's wastewater gravity collection system on the western end of Butler Street.

The existing concrete of the visible portion of the wetwell appeared to be in good condition. There were no bar racks, comminutors, or other influent screening on influent flows. No apparent signs of hydrogen sulfide corrosion were observed on the structure walls (i.e. exposed aggregates). No equipment to bulkhead portions of the wetwell for maintenance are present.

The existing above ground fiberglass enclosure houses the duplex self-priming vertical centrifugal pumps, controls, run time meter, and alarms. An exhaust fan is used to vent the space. The electrical service is located adjacent to the enclosure. Much of the equipment appeared to be original with the exception of the pumps which appeared to have been replaced and the pressure transducer and alarm system have been upgraded. The fiberglass enclosure makes access to the pumps and equipment within difficult without disassembly of the enclosure walls.

Observed NHDES Env-Wq 705 Compliance Deficiencies

- Env-Wq 705.02.e: There are no division walls present in the wetwell and no bypass connection observed.
- Env-Wq 705.03.e: Pumps are not protected from damage due to large solid objects.
- Env-Wq 705.05.a: Continuous flow recording or totalizer capability not provided.
- Env-Wq 705.07.c: Backup float switch has no apparent intrinsically safe barrier device.
- Env-Wq 705.07.d: Enclosures on exterior of electrical equipment severely rusted.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include pump malfunction, level sensing malfunction, intrusion, temperature, independent low water alarm, visible/audible enunciators, silencing of audible enunciator.
- Env-Wq 705.10 & 705.11: Pumping station O&M manuals and emergency operation procedures are required.

3.1.3. Commercial Drive Pumping Station

The Commercial Drive Pumping Station is an approximately 30-year-old (1987 vintage) suction lift type pumping station located on the southern end of Commercial Drive at the intersection of Pelham Road. The wetwell is accessed through a manhole cover on the southern side of the building. This pumping station conveys wastewater from the sewers in the industrial park in the Commercial Drive area to the gravity discharge on Pelham Road.

The existing concrete of the visible portion of the wetwell appeared to be in fair condition. There were no bar racks, comminutors, or other influent screening on influent flows. Early signs of hydrogen sulfide corrosion were apparent in the upper sections of the concrete structure walls but exposed aggregate was not visible at the time of inspection. No equipment to bulkhead portions of the wetwell for maintenance was present. The original bubbler level control system was changed to a pressure transducer. Cracked concrete around the frame of the wetwell access manhole was observed.

The existing single story precast concrete building houses the duplex self-priming centrifugal pumps, controls, electrical, and alarms. The bottom of the entry door to the station is rusted and in poor condition. The station is equipped with an auxiliary propane fueled engine that can manually operate one of the pumps during a power failure. If the pump operated by the auxiliary motor is out of service during a power failure, there is no way to operate the other back-up pump and there are no provisions to connect a portable generator. Modifications and repairs have been made to the pump control panel. The air release valves on the pumps reportedly clog frequently. Temperature operated louvers provide ventilation within the building. Much of the equipment appeared to be original with the exception of the newer pressure transducer and alarm system.

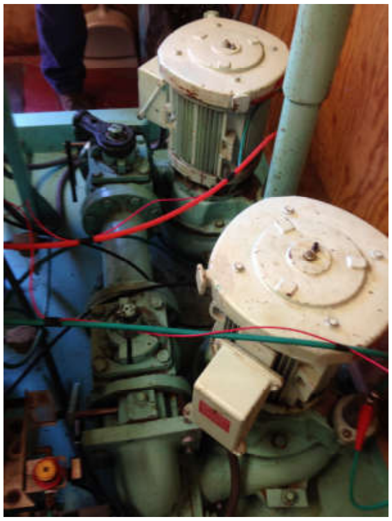
Observed NHDES Env-Wq 705 Compliance Deficiencies

- Env-Wq 705.02.e: There are no division walls present in the wetwell and no bypass connection observed.
- Env-Wq 705.03.h: The system's available net positive suction head (NPSH) shall be at least 6 feet greater than the required NPSH. The system's available NPSH does not meet these requirements. Per O&M information available, this systems NPSH is 3 ft. greater than the required NPSH.
- Env-Wq 705.07.c: Backup float switch has no apparent intrinsically safe barrier device.
- Env-Wq 705.07.d: Controls modifications have voided any UL label on the control panel.
- Env-Wq 705.08.h: There is no ventilation provided for the wet well.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include high water in pump room, pump malfunction, level sensing malfunction, loss of ventilation, intrusion, temperature, independent low water alarm, visible/audible enunciators, silencing of audible enunciator.
- Env-Wq 705.10 & 705.11: Pumping station O&M manual is missing required information including staffing requirements, utility emergency contact information, etc.
- Env-Wq 705.11.b through i: There is no standby emergency generator.
- Env-Wq 705.11.j: The standby engine drive system that is designed to start on loss of power does not start automatically and has to be turned on manually.

3.1.4. Copper Beach Pumping Station

The Copper Beach Pumping Station is an approximately 25-year-old (circa 1990) suction lift pumping station. It is located in a residential neighborhood on the southern end of Town. The pumping station site is accessed via a paved driveway located between two residential lots. The rear of the building abuts wetlands surrounding World End Pond to the north. Plantings at the rear of the building make access to the electric utility difficult. This pumping station collects wastewater from Copper Beach Road residents and conveys it to the gravity sewer on South Broadway Street.

The existing building is a single-level pumping station with a wooden dividing wall separating the wetwell access from the pumps and controls. Overall, the building is in poor condition with deteriorating wood, aged roofing, holes going underneath the concrete slab at the front and rear of the building and signs of insect and rodent infestation. The wetwell is accessed through a hatch. The existing concrete of the visible portion of the wetwell structure appeared to be in good condition. There were no bar racks, comminutors, or other influent screening on influent flows.



The pumps, controls, run hour meter, electrical, and alarms are installed in a separate room that also houses the emergency standby generator. Louvers provide ventilation within the building while the generator is running. Much of the equipment appeared to be original with the exception of the newer pressure transducer and alarm system. Underwood Engineers completed a detailed evaluation of this station with recommended improvements in 2014 (Appendix E).

Observed NHDES Env-Wq 705 Compliance Deficiencies

- 705.02.b: The pumping station superstructure and the wetwell are not separated and the wood divider wall is not explosion proof Class 1, Division 1, Group D.
- Env-Wq 705.03.e: Pumps not protected from damage due to large solid objects.
- Env-Wq 705.07.c: Wood divider wall is not compliant as noted above. No intrinsically safe barrier device on backup float switch.
- Env-Wq 705.07d: Control modifications have voided any UL label on control panel. Utility meter access poor due to plant/brush growth.
- Env-Wq 705.08.a: Mechanical ventilation is not provided.
- Env-Wq 705.08.j: No hazardous/confined space warning signs present.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include pump malfunction, level sensing malfunction, loss of ventilation, intrusion, temperature, independent low water alarm, visible/audible enunciators, silencing of audible enunciator.
- Env-Wq 705.10: Pumping station O&M manual is missing required information including emergency operation plan, staffing requirements, checklists for systems maintenance, utility emergency contact information, etc.

3.1.5. Freedom Drive Pumping Station

The Freedom Drive Pumping Station is believed to be an approximately 30-year-old ejector style pumping station located at the intersection of Freedom Drive and Veterans Memorial Parkway. The pumping station site is surrounded by a chain link fence. This pumping station was reportedly relocated from another location in Town to its current location. This pumping station collects wastewater from residences on Freedom Drive and conveys it to the Town's gravity wastewater collection system.

The existing precast concrete building appeared to be in fair condition. Corrosion was observed on the bottom of the door and paint is peeling on the interior floor in the building. Rust was observed on the bottom of the entry door. The existing compressors were reported to be in satisfactory condition and serviceable. The ejector pot count for each of the two pots showed a significantly different value, indicating that alternation is not always successful. There is an emergency standby generator located within the building. Controls, electric and alarms are located within the building. The compressors have been removed from their original below grade location in the can and relocated at grade within the building for maintenance reasons.

Mechanical equipment within the building includes electric wall mount unit heater, electrically actuated louvers that operate when the generator is running, and a domestic water service. With the exception of the generator and alarm system, the equipment appeared to be original.

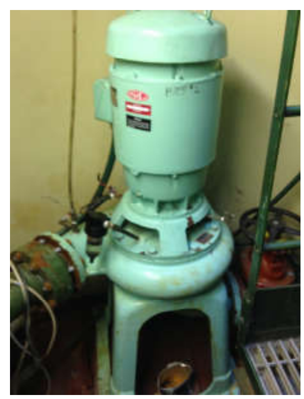
Observed NHDES Env-Wq 705 Compliance Deficiencies

- Env-Wq 705.02 – Wetwell and Drywell Construction: The criteria described in this section is not applicable to an ejector style station.
- Env-Wq 705.03 – Allowable Pump Types, Pump Controls and Pump Size: An ejector style station is not an allowable type of sewage station per 705.03.a. The Freedom Drive station does not meet criteria in this section or it is not applicable,
- Env-Wq 705.07.d: Propane fuel tank is too close to utility service and doesn't meet code. Generator radiator is not ducted to exterior of building.
- Env-Wq 705.08.a: Mechanical ventilation is not provided.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include pump malfunction, level sensing malfunction, loss of ventilation, intrusion, temperature, independent low water alarm, visible/audible enunciators, silencing of audible enunciator, etc.
- Env-Wq 705.10: Pumping station O&M manuals are required.
- Env-Wq 705.11.a: Emergency operation procedures are required.

3.1.6. Haigh Avenue Pumping Station

The Haigh Avenue Pumping Station is an approximately 44-year-old (circa 1972) Smith & Loveless-type concrete wetwell/dry pit package located on Haigh Avenue. A cast in place concrete wall surrounds the pumping station site and a paved driveway provides access and parking. This area is subject to flooding and the concrete wall around the perimeter is intended to protect the station. An 44-year old (circa 1972) propane generator located in a building supplies emergency power to the site. This pumping station conveys wastewater from Haigh Avenue in the southern portion of Town to the forcemain discharge to the gravity sewer that flows to South Broadway Street

The existing precast concrete of the visible portion of the wetwell appeared to be in good condition. There is a secondary cover under the manhole cover on the wetwell to prevent water from entering. An influent tee and valves allows the flow to be directed to either side of the wet well divider wall. There are no bar racks, comminutors, or other influent screening on influent flows. Limited signs of hydrogen sulfide corrosion were apparent in the upper sections of the concrete structure walls where some exposed aggregate was visible. Grease was observed in the wet well.



The existing underground dry pit houses the vertical centrifugal pumps and controls. An exhaust fan is used to vent the space and an elevator is used to access the pit. The structure walls visually appeared to be in satisfactory condition. However, surface rust was observed on the floor of the structure below pump 2 and also at various locations at the joints of the different can sections. The paint on the floor of the structure was peeling in areas. Town records indicate that the pumps were replaced in 2004 and it appeared that gate valves on the discharge had also been replaced. The original bubbler level control system was changed to a pressure transducer. The dry pit is a confined space.

The existing building houses the standby generator, alarms and pump run time meters. The exterior brick façade was in fair condition and the mortar showed signs of deterioration, exposing brick. The piping for the wetwell vent is routed through the building. The vent enters through the building floor and exits through the roof. The ceiling in the area of the vent showed signs of leakage. Electric unit heaters are provided in the building and louvers are provided for ventilation when the generator is running.

Observed NHDES Env-Wq 705 Compliance Deficiencies

- Env-Wq 705.03.e: Pumps not protected from damage due to large solid objects.
- Env-Wq 705.04.g: The power elevator in the dry pit has inadequate capacity. The existing elevator has a capacity of 440 lbs. and the regulations require a minimum capacity of 600 lbs.
- Env-Wq 705.07.c: Backup float switch has no apparent intrinsically safe barrier device.
- Env-Wq 705.07.d: Control modifications have voided panel UL label.
- Env-Wq 705.08.j: No hazardous/confined space warning signs present.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include high water level in pump room, pump malfunction, level sensing malfunction, loss of ventilation, intrusion, temperature, independent low water alarm, visible/audible enunciators, silencing of audible enunciator.
- Env-Wq 705.10: Pumping station O&M manual is missing required information including organizational structure and administrative procedures, utility emergency contact information, etc.

3.1.7. Keewaydin Drive Pumping Station

The Keewaydin Drive Pumping Station is an approximately 26-year-old (circa 1990) suction lift pumping station. It is located on Keeywaydin Drive in an industrial park on the western end of Town. A chain link fence surrounds the pumping station site and a paved driveway provides access and parking. The rear of the building abuts wetlands to the west. Equipment from the former pumping station (abandoned) is adjacent to the building and confined within the limits of the chain link fence. This pumping station receives wastewater from the Commercial Drive Station, the Stiles Road Station, and surrounding area and conveys it to the gravity sewer on Pelham Road.

The existing building is a single-level pumping station with wooden clapboard siding and trim. Overall, the building is in fair condition. Signs of insect infestation were observed in the wooden trim boards and areas of deteriorated wood. The building does not have any ventilation other than two small windows, which were open at the time of inspection. The wetwell is accessed through a hatch located on the eastern side of the building. The existing concrete of the visible portion of the wetwell structure appeared to be in good condition. There were no bar racks, comminutors, or other influent screening on influent flows. There is no divider wall present to separate flows.

The self-priming duplex centrifugal pumps, controls, run hour meter, electrical, and alarms are installed inside the building. It was indicated that present pump controls do not allow for lag pump operation. Much of the equipment appeared to be original with the exception of the newer pressure transducer, alarm system, and soft starters for pump motors. The emergency standby generator is located outside on the northern side of the building. Significant surface rust was observed on the exterior of the weatherproof generator enclosure. The pumping station uses an 8-inch diameter HDPE forcemain to discharge wastewater to the corner of South Policy St. and Main St.

Observed NHDES Env-Wq 705 Compliance Deficiencies

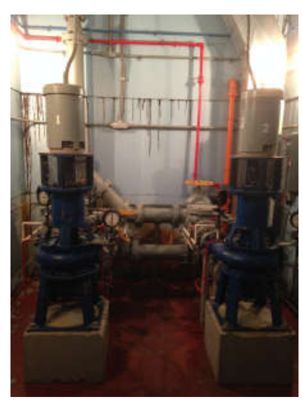
- Env-Wq 705.02.e: There are no division walls present in the wetwell and no bypass connection observed.
- Env-Wq 705.03.e: Pumps not protected from damage due to large solid objects.
- Env-Wq 705.03.j: Lag pump does not start if the lead pump loses suction and does not effectively pump.
- Env-Wq 705.05.a: No continuous flow recording or totalizer capability present.
- Env-Wq 705.07.c: Backup float switch has no apparent intrinsically safe barrier device.
- Enq-Wq 705.07.d: Service backboard needs discontinued equipment removed and backboard rebuilt. Outdoor dry type transformer should be replaced and relocated. Control panel modifications have voided UL label and resulted in control function issues.
- Env Wq 705.08.a: No mechanical building ventilation is provided.
- Env-Wq 705.08.j: No hazardous/confined space warning signs present.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include high water level in pump room, pump malfunction, level sensing malfunction, intrusion, temperature, independent low water alarm, no audible enunciators, silencing of audible enunciator.
- Env-Wq 705.10: Pumping station O&M manuals are required.

3.1.8. South Policy Pumping Station

The South Policy Pumping Station is a 25-year-old (circa 1991) flooded suction pumping station. It is located on the east side of South Policy Street and surrounded by the parking lot for the Mall at Rockingham Park. A chain link fence surrounds the pumping station site and a paved driveway provides access and parking. Buffer plantings surround the pump station. This pumping station collects wastewater from the Mall at Rockingham Park and conveys it to the gravity sewer on South Broadway Street.

The existing building is a three-level pumping station constructed of precast concrete panels with a split face CMU block veneer on the exposed upper level. Overall, the building is in good condition. The different levels of the building are accessed by a spiral staircase. Accessing the pump station is very difficult due to the close proximity of the chain link fence gate to the roadway. There is not enough space for a vehicle to park in front of the gate and open it without protruding into the roadway.

The wetwell is accessed through a hatch located on the northern side of the building. The existing concrete of the visible portion of the wetwell structure appeared to be in good condition. Influent flow enters through a channel and can be split between wet wells that are separated by a common wall. Mechanical equipment inside the wetwell included a muffin monster, lighting, and ventilation system. The mechanical equipment showed signs of corrosion. Grease and debris was observed in the wet well.



The vertical centrifugal pumps, controls, run hour meter, flowmeter (defunct), electrical, and alarms are located on various levels of the building. Much of the equipment appeared to be original with the exception of the newer pressure transducer, alarm system, and mechanical ventilation system. The original bubbler level control system was changed to a pressure transducer. It was observed that the ventilation system is very loud when in operation.

Observed NHDES Env-Wq 705 Compliance Deficiencies

- Env-Wq 705.05.b: The flow meter and chart recorder are reportedly defunct.
- Env-Wq 705.07.c: Backup float switch has no apparent intrinsically safe barrier device.
- Env-Wq 705.07.d: Inadequate working space at service and distribution. Control modifications have voided panel UL label. Non GFCI receptacles in dry well.
- Env-Wq 705.08.j: No hazardous/confined space warning signs present.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include level sensing malfunction, loss of ventilation, intrusion, temperature, and independent low water alarm.
- Env-Wq 705.10: Pumping station O&M manuals are required.

3.1.9. Stiles Road Pumping Station

The Stiles Road Pumping Station is an approximately 30-year-old (circa 1987) Gorman-Rupp above ground fiberglass enclosure with duplex self-priming pumps and a concrete wetwell located on the Southern end of Stiles Road. The pumping station site is bounded by Stiles Road to the east and Porcupine Brook to the west. The pumping station site is located within the 100-year flood zone. The site is enclosed by a chain link fence. A 30-year-old pad-mounted propane generator supplies emergency power to the site. This pumping station conveys wastewater from the Stiles Road industrial park area to the Town's gravity system on Pelham Road.

The existing concrete of the visible portion of the wetwell appeared to be in fair condition. No apparent signs of hydrogen sulfide corrosion were observed on the structure walls (i.e. exposed aggregates). The wetwell has a passive PVC pipe vent. There were no bar racks, comminutors, or other influent screening on influent flows. No equipment to bulkhead portions of the wetwell for maintenance was present.

The existing above ground fiberglass enclosure houses the duplex self-priming vertical centrifugal pumps, controls, run time meter, electrical, and alarms. An exhaust fan is used to vent the space. Much of the equipment appeared to be original, with the exception of the pressure transducer for level control and the alarm system. The pumps were reportedly the original pumps installed with the station in 1987. The fiberglass enclosure makes access to the pumps and equipment stored within difficult without disassembly of the enclosure walls.

Observed NHDES Env-Wq 705 Compliance Deficiencies

- Env-Wq 705.01.a: P.S. site located within 100-year flood zone. Wetwell, fiberglass pump enclosure and the generator may be below 100-year flood levels.
- Env-Wq 705.02.e: There are no division walls present in the wetwell and no bypass connection observed.
- Env-Wq 705.03.e: Pumps are not protected from damage due to large solid objects.
- Env-Wq 705.05.a: The pumps do not have continuous flow recording or totalizer capability.
- Env-Wq 705.07.b: P.S. site located within 100-year flood zone and there were no apparent provisions to protect electrical systems from flooding and flood damage.
- Env-Wq 705.07.c: Backup float switch has no apparent intrinsically safe barrier device. The level control cables from the wetwell to the fiberglass enclosure are not sealed properly.
- Env-Wq 705.07.d: Control modifications have voided UL label on control panel. Wiring and accessibility issues at panel.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include pump malfunction, level sensing malfunction, intrusion, temperature, independent low water alarm, no audible enunciators/silencing capability.
- Env-Wq 705.10.b: Pumping station O&M manual did not include emergency contact information.

3.1.10. Twinbrook Avenue Pumping Station

The Twinbrook Avenue Pumping Station is an approximately 44-year-old (circa 1972) Smith & Loveless concrete wetwell/dry pit package located on Twinbrook Avenue. A chain link fence surrounds the pumping station site and a paved driveway provides access and parking. A propane generator located in a building supplies emergency power to the site. This pumping station conveys wastewater from the southern portion of Town to the forcemain discharge to the gravity sewer that ultimately discharges to South Broadway. This station is of similar vintage and type as the Haigh Ave. station.

The existing precast concrete of the visible portion of the wetwell appeared to be in good condition. No apparent signs of hydrogen sulfide corrosion were observed on the structure walls (i.e. exposed aggregates). There were no bar racks, comminutors, or other influent screening on influent flows. Grease and small debris was observed in the wet well.

The existing underground dry pit houses the vertical centrifugal pumps and controls. An exhaust fan is used to vent the space and a ladder mounted to the structure wall is used to access the pit. The structure walls visually appeared to be in good condition. The paint on the floor of the structure was peeling in areas. Much of the equipment appeared to be original with the exception of the pumps which the Town indicated may have been replaced. The seal water system on pump 1 was observed to be leaking. The original bubbler level control system was changed to a pressure transducer. The dry pit is a confined space.

The existing building houses the standby generator, alarms dialer and electrical. The exterior brick façade was in fair condition and the mortar showed signs of deterioration that exposed brick. The piping for the wetwell vent enters through the floor of the building and exits through the roof. Electric unit heaters are provided in the building.

Observed NHDES Env-Wq 705 Compliance Deficiencies

- Env-Wq 705.02.e: There are no division walls present in the wetwell and no bypass connection observed.
- Env-Wq 705.03.e: Pumps are not protected from damage due to large solid objects.
- Env-Wq 705.04.d: Dry pit is accessed by a vertical ladder that is steeper than the required 75-degree slope.
- Env-Wq 705.07.c: Backup float switch has no intrinsically safe barrier device.
- Env-Wq 705.07.d: Control modifications have voided the UL label for the control panel.
- Env-Wq 705.08.j: No hazardous/confined space warning signs present.
- Env-Wq 705.09: Insufficient alarms provided. Lacking alarms include high water in pump room, pump malfunction, level sensing malfunction, loss of ventilation, intrusion, temperature, independent low water alarm, visible/audible enunciators, silencing of audible enunciator.
- Env-Wq 705.10 & 705.11: Pumping station O&M manual is missing required information including: checklists for systems and components and utility emergency contact information.

4. Population and Sewer Flows

Town population estimates summarized herein were based on information contained in the Town's 2001 Master Plan and information provided by the State of New Hampshire Office of Energy and Planning (OEP).

4.1. Recent Population

The Town's 2001 Master Plan estimated the 2000 population of 28,112. This is similar to the NH OEP population estimate of 28,776 based on the 2010 census, and shows a <1% annual population growth for the Town between 2000 and 2010.

4.2. Population Projections

The NH OEP projects a 2040 Town population of 29,813. This represents <1% annual population growth from existing 2010 Census population estimates. These limited projected population growth rates indicate that Town population growth alone should have limited impact to future wastewater flows over the next 25 years. However, zoning changes and development may impact population growth in Town so population projections should be periodically evaluated for impact to the wastewater flow projections described in later sections of this report.

4.3. Recent Sewer Flows and Water Records

4.3.1. Total Sewer Flow

Table 4-1 summarizes total wastewater flows from Town measured by the GLSD flow meters over the past three years. Over the past three years wastewater flows have been within the flow limits thresholds established by the GLSD inter-municipal agreement. The Town has utilized between 39% and 74% of the GLSD annual average day, maximum day, and peak hour flow reserve capacity. The Town's maximum day flow allowance has been the most utilized (up to 74% utilized) and the peak hour flow allowance was the least utilized (less than 50% utilized). Peak hour flows over the past three years were only slightly elevated above maximum day flows indicating elevated flow conditions persist for over 24-hours. Max day and peak hour flows during 2013-2015 occurred on March 31, 2014 following several days of prolonged rain that lead to regional flooding. This indicates that high flows are likely due to I/I entering the system. Because peak hour and max day flows were very similar it is believed that infiltration and private inflow (as opposed to direct inflow which would result in short duration flow spikes) contribute a significant portion of the flow peaks. However, a more detailed I/I evaluation to support this observation is provided in later sections of this report.

Table 4-1. Sewer Flow Summary 2013-2015

	Town Total Sewer Flows (2013-2015) (MGD)	GLSD Flow Limits (MGD)	GLSD Capacity Percent Utilized (%)
Annual Average Day Flow	2.6 to 3.0	5.0	52% to 60%
Maximum Day Flow	5.1 to 6.7	9.0	57% to 74%
Peak Hour Flow	5.6 to 6.9	14.5	39% to 48%

4.3.2. Metered Sanitary Usage and Annual Average I/I Estimates

The Town's annual metered sanitary usage from 2013-2015 was estimated to be approximately 1.1 mgd based on metered water consumption of sewer accounts, assuming 90% of metered water usage becomes sanitary flow. When compared to the total wastewater flow measured by GLSD, approximately 60% of the total annual flow metered and billed to the Town by GLSD is estimated to be I/I that enters the wastewater collection system. I/I is clean water (stormwater and groundwater) that enters the wastewater collection system that does not need to be treated like sanitary wastewater. Annual average I/I estimates for 2013-2015 are tabulated (Table 2).

Table 4-2. Annual Average I/I Estimates

Year	Town Total Sewer Flows (2013-2015) (MGD)	Average Annual Daily Metered Sanitary Usage (MGD)	Estimated Average Annual I/I (MGD)	Annual Average Daily Flow Percent I/I (%)
2013	2.7	1.1	1.6	59%
2014	3.0	1.1	1.9	63%
2015	2.6	1.1	1.5	57%
3-Year Average	***2.7***	***1.1***	***1.6***	***60%***

5. Infiltration and Inflow Evaluation

5.1. Flow Monitoring

UE performed a continuous flow metering program in the spring of 2016. This data was used to calibrate the distribution of flows in the Town's sewer model and also to evaluate I/I throughout the Town's wastewater collection system.

5.1.1. Flow Meter Locations

For this study, flow monitoring was conducted for ten basins within the sewer system. Continuous flow meters collected flow data in 15 minute intervals for approximately 12 weeks from March 15, 2016 to June 13, 2016. Eight flow meters installed by Flow Assessment Services, LLC for this study, two existing GLSD flow meters and a temporary rain gauge were used to continuously monitor flow in the system and response to rainfall. Meter locations were chosen to represent a basin (i.e. an area where all sewer flow in that area travels through the same flow meter) so that separate I/I analyses can be performed for each basin to estimate the contributions of infiltration and inflow to the system in response to precipitation events. Basin names and locations were based off of pervious reports, GIS data provided by the Town, and discussions with the Town.

The following names were chosen for the 12 basins: A, B1, B2, C, D/I, E, F, G, H, J, K, and L. One (1) meter was set up in each basin without an existing meter (A, B1, B2, C, D/I, E, F and J). Existing GLSD flow meters were used to collect fifteen (15) minute flow data in Basins G and L. Limited flow data (collected approximately each week) was available for Basin H. No flow data was available for Basin K. A routing schematic of the flow meters and pumping stations are provided (Figure 5-1) and the locations of these flow meters can be found on Figure 5-2. Flow meter data is provided (Appendix F).

A nighttime flow analysis was performed using the flow data to estimate infiltration flows in each basin. Data collected before, during and after a storm event was used to estimate inflow responses to a storm event in each basin.

5.1.2. Infiltration Evaluation Criteria

Continuous flow monitoring data was used to estimate infiltration and inflow for each basin in the system. To further characterize infiltration, the following criteria can be used to evaluate whether infiltration is excessive:

The Commonwealth of Massachusetts Department of Environmental Protection (MADEP)

- *The MADEP Guidelines for Performing Infiltration/Inflow Analysis and Sewer System Evaluation Survey, Revised January 1993*, indicates 4,000 gallons per day per inch-diameter-mile (gpd/idm) may be used as the threshold for determining whether or not infiltration is excessive based on dry weather flows attributable to infiltration.

Federal Criteria

- The Environmental Protection Agency (EPA) indicates in 40 CFR Part 133 that 1,500 gpd/idm may be used as the threshold value for determining whether or not infiltration is excessive based on dry weather flows attributable to infiltration.

5.1.3. System-Wide Infiltration Evaluation

The 1993 MADEP *Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Surveys* provides guidance on how to estimate infiltration using flow monitoring data. Since nighttime flows, typically between on 12AM-6AM, have limited a limited sanitary component, these nighttime flows can be used as a basis for estimating infiltration. For this study, night-time water meter consumption data provided by the Town indicated that approximately 4% to 8% of the night time flow may be sanitary flow, so estimated infiltration rates were reduced by 5% to account for the estimated nighttime sanitary component of flow.

The infiltration analysis was performed for the date ranges of 4/18/16-4/22/16 and 6/10/16-6/12/16. These dates were chosen to represent high and low groundwater conditions. April (high groundwater conditions) and June (low groundwater conditions) were used to help evaluate infiltration at different times of the year. The dates also follow at least three days with little to no rain to mitigate the effects of inflow to the analysis. Computations for the infiltration analysis can be found in Appendix G.

Average infiltration for April and June in each basin can be found for each basin in the following table (Table 5-2):

Table 5-2. Nighttime Flow Analysis- Infiltration Estimates

Basin	Average April Infiltration (MGD)	Average June Infiltration (MGD)	Average April & June Infiltration (MGD)	Average April Infiltration Rate (gpd/idm)	Average June Infiltration Rate (gpd/idm)	Average April & June Infiltration Rate (gpd/idm)
A	0.542	0.424	0.483	**7,433**	**5,820**	6,627
B1	0.044	0.035	0.040	477	385	431
B2	0.097	0.057	0.077	2,256	1,324	1,790
C	0.397	0.221	0.309	**4,245**	2,365	3,305
D/I	0.244	0.310	0.277	3,252	**4,131**	3,691
E	0.212	0.130	0.171	1,535	942	1,238
F	0.096	0.043	0.070	**4,206**	1,876	3,041
G	0.130	0.066	0.098	**3,810**	1,947	2,878
H	0.012	0.001	0.007	504	45	275
J	0.078	0.054	0.066	860	596	728
L	0.023	0.023*	0.023*	327	327	327
Total	**1.876**	**1.367**	**1.621**	**2,478**	**1,805**	**2,141**

*Note: April infiltration used twice because June infiltration calculated was negative

Highlighted basins are those with an infiltration rate within 10% (and higher) of the 4,000 gpd/idm excessive infiltration threshold during either the April 2016 or June 2016 infiltration evaluation periods performed as part of this study. Basins with excessive infiltration are shown (**Figure 5-3**).

5.1.4. Inflow Evaluation

An inflow analysis was also performed for Salem's sewer system based on the MADEP guidelines. This type of analysis provides insight into how a sewer system will react to a storm event by estimating the amount of water that enters the system during that event. The analysis involves metering flow both before and after a storm event, and finding the difference between the pre and post storm flow. The difference in flows calculated during the storm event can be attributed to inflow, while continued elevated flows following the storm can be attributed to delayed inflow and rainfall induced infiltration.

The analysis was based on a storm that took place on Sunday 6/5/16 that lasted approximately fifteen (15) hours and produced 1.26 inches of rain. Direct and delayed inflow were measured in each basin, and then the total inflow was scaled up to estimate how much water would enter each system during a design storm (based on a one-year, six-hour, 1.72-inch storm event for Boston, MA from the MADEP guidelines). The peak inflow rate was also found for each basin. Computations for the inflow analysis can be found in Appendix H. The following table lists the basins in order of highest total inflow to lowest total inflow.

Table 5-3. Inflow Estimates for Each Basin for Storm on 6/5/16

Basin	Total Inflow (Gal)	Direct Inflow (Gal)	Delayed Inflow (Gal)	Total Inflow (Des. Storm) (Gal)	Peak Inflow Rate (MGD)
D/I	1,195,772	70,825	1,124,947	1,632,323	0.329
L*	129,640	75,184	54,456	176,968	0.339
G	73,050	30,842	42,208	99,719	0.169
A	39,585	-1,438	41,023	54,036	0.154
B2	32,849	19,848	13,001	44,842	0.060
B1	23,599	23,599	0	32,214	0.135
J	20,026	19,787	239	27,337	0.099
C	14,875	13,436	1,439	20,306	0.138
E	6,752	6,752	0	9,216	0.049
F	1,541	-665	2,206	2,104	0.026
Total	**1,537,688**	**258,169**	**1,279,519**	**2,099,066**	

* The results from L are not considered to be reliable due to the variability in the data and negative flows used in the analysis (see Appendix H).

The analysis indicates that delayed inflow (rainfall induced infiltration) is a greater problem than direct inflow, as the delayed inflow made up approximately 83% of the total inflow. The majority of the delayed inflow (88%) was found in Basin D/I.

5.2. Infiltration and Inflow Annual Summary

Inflow appears to represent a small portion of the total estimated annual I/I in the system. Assuming 50 inches of annual average precipitation approximately 60 million gallons/year of total annual inflow is estimated. When compared to the 1.62 MGD estimated average infiltration, inflow makes up approximately 9% of the total I/I within the system. Furthermore a large portion of the total inflow is delayed inflow which could be influenced by infiltration and private I/I. Therefore to effectively mitigate I/I in the system, it is recommended that infiltration and private I/I removal programs be prioritized over direct inflow mitigation programs.

5.3. Pumping Station Collection Area Infiltration Estimates

An infiltration (nighttime flow) analysis was also performed for several pump station basins to evaluate if areas of high infiltration could be narrowed down within each basin. Flows were estimated using pump runtime data provided by the Town and pump flow estimates from drawdown tests performed by UE. Infiltration (gpd/idm) calculations are summarized (Table 5-4).

Table 5-4. Pump Station April and June gpd/idm Estimates

Pump Station	Basin	April gpd/idm	June gpd/idm
Keewaydin Dr.	C	5,602	4,972
Haigh Ave.*	F	5,270	2,253
Brookdale Rd.	A	4,804	2,180
Twinbrook Ave	G	3,232	1,434
Commercial Dr.	C	1,775	638
Butler St.	J	667	1,003
Stiles Rd.	C	103	319
Copper Beech	G	0	332
South Policy St.**	D/I	ND	ND

*Basin boundary was unclear and assumed using GIS
** South Policy Street does not have a basin associated with it, so a gpd/idm value could not be calculated at that station.

The results identify the Keewaydin Dr., Haigh Ave., Brookdale Rd., and Twinbrook Ave. pump station basins to have excessive infiltration of approximately 1,500 gpd/idm or greater. This data is consistent with the excessive infiltration estimates for the larger meter basin in which each pumping station was located. Only the June 2016 Keewaydin Pumping Station infiltration estimate (4,972 gpd/idm) was noticeably higher than the June 2016 Basin C infiltration estimate (2,365 gpd/idm) indicating that future infiltration investigations should include additional attention to the Keewaydin Pumping station basin.

5.4. Targeted Basins A and C Infiltration Evaluation (Flow Isolation)

Flow isolation is a technique that can be used to identify specific sewer reaches with the highest infiltration within sewer basins. This technique isolates sections of pipe so that no flow may enter except that due to infiltration and private inflow, which is measured using a calibrated weir. These measurements are performed during dry weather (no inflow) and in the middle of the night when sanitary usage is typically low to help assure that the measured flow is infiltration and not sanitary flow.

Flow isolation for Basins A and C was performed as part of this study on 5/17/16 and 5/19/16, respectively based on an early assessment of meter data. The report generated by Flow Assessment Services can be found in Appendix I. Flow was measured for approximately 87,000 ft. of pipe, with 42,000 ft. in Basin A and 45,000 ft. in Basin C. Flow isolation measured approximately 0.363 MGD of infiltration in basin A and 0.180 MGD of infiltration in Basin C. A summary of some of the findings include:

- A total of approximately 0.363 MGD of infiltration was measured in basin A
  - Excessive infiltration over 4,000 gpd/idm was measured in approximately 12,500 ft. of sewer (~30% of Basin A). Approximately 291,000 gpd (80% of Basin A's infiltration) was measured in these areas.
  - Potentially excessive infiltration between 1,500 gpd/idm and 4,000 gpd/idm was measured in approximately 12,000 ft. (~29% of Basin A). Approximately 51,000 gpd (14% of Basin A's infiltration) was measured in these areas.
- A total of approximately 0.180 MGD of infiltration was found in basin C
  - Excessive infiltration over 4,000 gpd/idm was measured in approximately 7,000 ft. of sewer (~16% of Basin C). Approximately 111,000 gpd (62% of Basin C's infiltration) was measured in these areas.
  - Potentially excessive infiltration between 1,500 gpd/idm and 4,000 gpd/idm was measured in approximately 14,000 ft.of sewer (~31% of Basin C). Approximately 52,000 gpd (29% of Basin C's infiltration) was measured in these areas.

Sewer reaches with infiltration (above 4,000 gpd/idm and between 1,500 and 4,000 gpd/idm) can be found on Figures 5-4 and 5-5.

It was noted that infiltration estimates for the continuous flow monitoring analysis (0.483 MGD for Basin A and 0.309 MGD for Basin C) differed from the flow isolation infiltration estimates (0.363 MGD for Basin A and for 0.180 MGD for Basin C). These differences could be because some areas were not able to be flow isolated and because some flow during flow isolation could not be differentiated from pump station action. Also, force mains from private sewers were not included during flow isolation.

6. Hydraulic Sewer Interceptor Modeling

Sewer modeling can be an effective tool to evaluate wastewater collection systems. Sewer modeling software creates a virtual representation of a municipality's collection system to evaluate the hydraulics of the system. Models can evaluate existing conditions of a system including hydraulic flows, velocities, and capacity to better understand what, if any, deficiencies exist (i.e. hydraulic restrictions and the potential for sewer backups and overflows). This helps to identify and prioritize cost effective ways to improve the system's performance. Sewer modeling is also an effective way to evaluate the potential impacts that future growth, sewer expansion, and rehabilitation projects might have to the system prior to implementation.

6.1. Sewer Model Selection

Underwood Engineers evaluated the following sewer modeling software packages to meet the Town's objectives that the model can be integrated with the Town's Geographic Information System (GIS) and that the model can evaluate impacts of future buildout to the existing system under dry and wet weather conditions.

- EPA-SWMM (US EPA)
- HYDRA (Pizer)
- InfoSewer (Innovyze)
- SewerCAD (Bentley)
- PCSWMM (Chi)
- XP-SWMM (XP Software)
- Storm and Sanitary Analysis (Autodesk)

It was found that the capabilities of each of the evaluated software packages were similar and any of the programs would be able to meet the Town's objectives for the modeling. SewerCAD by Bentley was selected for the Town's hydraulic sewer model because it was used on previous Town projects, is user friendly, provides good technical support and the Town has used similar Bentley software in the past.

6.2. Sewer Model Preparation

Underwood Engineers used the following data to create the virtual model of the Town's existing sewer collection system:

- Town GIS data
- Record Drawings
- Existing models
- Previous reports by Underwood Engineers
- Metering Data
- Pump Station Testing
- Town Water Records

Once the base physical attributes were generated and the assumed sanitary flows were added, the model was calibrated using metering data that was installed in the spring of 2016 within the Town's sewer system.

6.2.1. Sewer Interceptor Information

Underwood Engineers used the Town's GIS data as the base for the physical attributes of the sewer model to create a virtual representation of the Town's existing sewer system. Interceptors (pipes with diameters 10" and greater) and sewer manhole information was imported from GIS into SewerCAD. During this process it was noted that portions of the GIS data necessary for modeling was incomplete (pipe inverts, missing manholes, etc.). UE used record drawings provided by the Town and information in previous sewer models (Salem Interceptor Evaluations dated 4/30/15, and the Hydraulic Modeling Evaluation dated 5/22/1989) by UE to fill in the missing GIS data.

6.2.2. Pumping Stations

The Town owns and operates 10 pumping stations within its sanitary collection system. UE modeled the pumping stations using average daily flows at their corresponding entry points into the gravity system as recommended for steady-state hydraulic models.

The following exceptions were made to the pump station modeling:
Keewaydin Pump Station: The flows from the Commercial Dr. PS and Stiles Rd. PS were not modeled since they did not directly discharge to the modeled sewer interceptor. Instead their flows were assumed to be a part of the Keewaydin Dr. PS flows which is where they end up.
South Policy Street Pump Station: Commercial flows from the Mall at Rockingham Park were used instead of PS data since the metered water data was considered more reliable than the pumping station runtime data.
Freedom Drive PS: No flow data was available for the Freedom Drive PS (ejector) so residential flow estimates were used for this area.

6.2.3. Sanitary Flow Estimates

Estimated average sanitary flows were applied to the model at the nearest manhole where they were understood to enter the interceptor. Residential flows were based on an average 2015 metered residential water consumption of 165 gpd/unit and building counts provided by the Town. Commercial/industrial contributions for accounts with average daily flow >165 gpd were based on individual metered consumption and were modeled entering the system at the nearest interceptor manhole to the account address. Ninety percent of the metered residential and commercial/industrial water consumption was assumed to become sanitary flow in the sewer.

6.2.4. Infiltration and Inflow Estimates

UE modeled the system's infiltration by using the data recorded by flow meters that were installed in the spring of 2016 as part of this study. The average of the April 2016 and June 2016 infiltration estimates from each basin was modeled as being distributed evenly within modeled interceptors of each basin. The average of the high and low infiltration estimates were used to better represent typical/average conditions.

6.3. Sewer Model Confirmation

Flow meter data from the spring of 2016 was used to confirm the sewer flow outputs/estimates from the hydraulic sewer model. The average daily flow predicted by the model at each of the ten meter locations used for this study was compared to the 3-month average daily flow measured by the meter during the spring 2016 metering period. The total average daily flows predicted by the model were within 1% of the of the total system flows measured by the meters. Hydraulic sewer model output files and graphics are provided in a separate volume (Appendix J).

6.4. Maximum Day Flow Estimate Modeling

UE used the sewer model to evaluate the hydraulic effect of maximum daily flows to the system interceptors. The observed (2013-2015) maximum day flow of 6.7 mgd occurred on March 31, 2014 following a time of extended rainfall and it is believed that the elevated flows at that time were attributed to I/I rather than peak sanitary flows in the system. Model inputs to evaluate the hydraulic effects of 6.7 mgd max day flows included typical average annual daily sanitary flow conditions (1.1 mgd) and an elevated I/I flow (5.6 mgd). The estimated 5.6 mgd I/I was proportionally distributed throughout the model by meter basin based on the average infiltration estimate for each basin observed during the spring 2016 flow metering performed as part of this study.

6.5. Existing Hydraulic Limitations in the Modeled Sewer Interceptors

Hydraulic modeling was used to identify areas of the sewer interceptor with existing hydraulic limitations under existing average day and max day flow conditions. Sewer interceptors that were surcharged under different flow conditions were identified as limiting because they have the potential to back up wastewater into service connections and or cause sanitary sewer overflows (SSOs). Sewer modeling indicated that no significant areas of the sewer interceptor were limiting during existing average day flow. This finding was expected because the Town has not had a history of surcharge and back-up under normal daily conditions. However, hydraulic sewer modeling under existing max day flow conditions (March 31, 2014) showed that approximately 6,700 linear feet of the interceptor were limiting. These limiting areas were concentrated along South Broadway north of Cluff Road, Granite Avenue, and Main Street between South Broadway and Granite Avenue. Model output maps of the limiting interceptor reaches under average day and max day flow conditions are provided (Appendix J). Hydraulic limitations identified through modeling while incorporating projected flows from development and sewer expansion are provided in later sections of this report.

7. Future Sewer Flow Planning Estimates

The Sewer Master Plan update includes an update of the Town's Sewer Buildout Plan to provide sewer service to areas where wastewater service is not currently provided. The Master Plan update also includes estimates of future flows from infill development projects within the existing sewer system service area. UE used the following information to estimate the future sewer flows for the Town's Sewer System:

- 201 Facilities Plan Update, dated October 1, 1981 by G/Underwood Engineers
- Sewer System Map, dated 1986 by Underwood Engineers
- Hydraulic Modeling-Sewerage System, dated 5/22/89 by Underwood Engineers
- Lakes Area Infrastructure Plan Phase II Draft, dated 11/01/99 by SEA Consultants
- Town of Salem 2001 Master Plan
- Town of Salem 2008 Zoning Map
- Town GIS Data

7.1. Sewer Expansion and Planning Areas

Areas for planned sewer expansion were based on previous planning documents. The 201 Facilities Plan Update (1982) focused on providing wastewater service to the 'Lakes Area' of Town and an industrial-commercial corridor in the southwest corner of Town (Appendix K). The Lakes Area sewer planning areas are generally intended to help protect sensitive areas around Arlington Pond and Canobie Lake which are used for the Town's municipal water supply as well as other environmentally sensitive areas around Shadow Lake, Captains Pond, Millville Lake and Hittytity Brook. The west side planning area encompasses the southwest corner of Town to service commercial-industrial zoned areas. Planned sewer build-out areas identified in the 201 Facilities Plan Update (1982) identified six distinct sewer expansion planning areas including:

- Salem Center Interceptor Area
- Millville Lake Area
- Arlington Lake Area
- Green Acres Area
- Canobie, Shadow Lake Area
- Industrial-Commercial Zone

These planning areas were refined through specific sewer sizing and routing on the Sewer System Map (1986), Hydraulic Sewer Modeling (1989) and the Lakes Area Infrastructure Plan (1999). Town has also expanded sewer into portions of the planning areas since 1982 so sewers no longer need to be planned for those areas. This study endeavors to update the sewer expansion planning areas to incorporate changes to the system, refined sewer routing planning (1986), and the Town's objectives since the 201 Facilities Plan Update (1982).

Current sewer build-out planning areas used for this study are shown on Figure 7-1 and the following sections discuss each sewer planning area in more detail.

7.1.1. Arlington/Captains Pond Areas

The Arlington/Captains Pond Area encompasses the previously identified Arlington Lake Area plus portions of the previously identified Millville Lake Area (1982) that are east of Millville Lake and area surrounding Captains Pond. The previous planning areas delineations from the 201 Facility Plan were adjusted to accommodate subsequent sewer routing recommendations to best service these areas and expanded to include protection of Captains Pond (1986). Generally this service area includes the densely developed area surrounding Arlington Lake and Captains Pond and the developed area south of Bluff St./Town Farm Rd. Municipal sewer extensions to service the Arlington/Captains Pond sewer planning area is consistent with the goals of the Town's Master Plan to protect water resources in Town. Arlington Lake is the Town's drinking water reservoir and Captains Pond includes a poplar recreational beach area where high bacteria levels are often detected during routine NHDES water quality sampling. Planned sewer extensions to this area would help remove the nutrient and bacteria loads associated with subsurface wastewater disposal systems around ponds and help improve water quality in this area.

7.1.2. Millville Street Area

The Millville St. Area is a small area of the previously identified Millville Lake Area identified in the 201 Facilities Plan. Updated sewer routing recommendations (1986) re-routed the majority of the previous Millville Lake Area so that only a small portion of the Millville Lake Area (Along Millville St.) remains.

7.1.3. Lake Street Area

The Lake St. Area encompasses portions the west side of Millville Lake, portions of Lake St., the densely developed area on the east side of Shadow Lake, and a small portion of Zion Hill Rd. This area includes portions of the Millville Lake Area and Canobie, Shadow Lake Area identified in the 201 Facilities Plan. These previously identified planning areas were modified to accommodate recommended sewer routing to service these areas (1986) and to include subsequent sewer extensions to provide municipal wastewater service to areas around Canobie Lake. Planned municipal sewer extensions to service the Lake St. sewer planning area is consistent with the goals of the Town's Master Plan to protect water resources in Town. Lake St. follows Hittytity Brook which is used to help convey the Town's drinking water supply to Canobie Lake; and Shadow Lake and Millville Lake include poplar recreational beach areas where high bacteria levels are sometimes detected during routine NHDES water quality sampling. Planned sewer extensions to this area would help remove the nutrient and bacteria loads associated with subsurface wastewater disposal systems around ponds and help improve water quality in this area.

7.1.4. West Side Area

The West Side Area includes an area in the southwest corner of Town along Brady Ave. This area encompasses the previously identified Industrial-Commercial Zone and Green Acres Areas delineated in the 201 Facilities Plan (1982). These previously identified planning areas were modified to accommodate recommended sewer routing to service these areas (1986) and to include subsequent sewer extensions that currently provide municipal wastewater service to the area in the vicinity of Green Acres Drive. This area has historically been planned to be serviced by the West Side Interceptor which would link the existing sewers on Keewaydin Drive and Stiles Road to the existing collection system on Cross St. As identified in the Town's Master Plan the West Side Interceptor was intended to help restore capacity to the commercial and industrial users on the west side of Town. However, much of the commercial/industrial area on the west side of town originally identified in the *201 Facilities Plan (1982)* has subsequently been rezoned to Rural so the previously-identified benefits of the proposed West Side Interceptor to commercial/industrial users in this area are reduced. Note that the sewer model assumes the west side area is routed through the west side interceptor to GLSD meter #3.

7.1.5. Buildout Sanitary Estimate Summary

UE used existing Town zoning and recommendations of the Town's Master Plan to project future sewer buildout flows within the aforementioned sewer planning areas. Areas in town that do not have municipal wastewater service are generally zoned Rural which requires a lower development density than areas with municipal sewer service which are generally zoned Residential. The Town Master Plan allows for an increased development density in areas where municipal sewer service is extended resulting in transitions from Rural to Residential zoning within the sewer planning area. UE projected build-out flows based on an increased 1.8 unit/acre density allowed by the Town Master Plan (2001) in sewer planning areas and are summarized as follows (**Table 7-1**).

Table 7-1. Projected Additional Sewer Buildout Flows Without Infill

Area	Estimated Average Day Sanitary Flows (MGD)	Estimated Max. Daily Sanitary Flow (MGD)	Additional I/I Flow Estimates from Sewer Extensions (MGD)	Estimated Average Daily Flow (MGD)	Estimated Max. Daily Flow (MGD)
Arlington/Captains Pond Buildout Area	0.51	1.03	0.058	0.57	1.09
Millville St. Buildout Area	0.02	0.04	0.003	0.02	0.05
Lake St. Buildout Area	0.16	0.32	0.017	0.18	0.34
West Side Buildout Area	0.20	0.41	0.03	0.23	0.44
Subtotal	***0.9***	***1.8***	***0.1***	***1.0***	***1.9***
Existing System	1.1	N/A	N/A	2.7	6.7
			TOTAL	***3.7***	***8.6***
			GLSD Allowance	***5.0***	***9.0***

1. I/I estimates were based on an assumed 300 gpd/idm applied to sewer extension size/routing identified in previous reports (SEA 1999 and UE 1986).
2. Buildout sanitary flows based on 148.5 gpd/ house (Average Day) and 300 gpd/house (Max Day) and increased existing house count density associated with an assumed Rural to Residential Zoning Change where sewer service is extended (Salem 2001 Master Plan Chapter XII Land Use Table XII-4)
3. Does not include any flows from Windham.

7.2. Sewer Infill Evaluation

At the onset of this study, the Town identified a goal to maximize usage of the Town's sewer capacity from development and re-development within the limits of the existing wastewater collection system. This type of development would not require extension of the collection system, possibly at the Town's expense to unsewered areas of the Town (such as to the sewer planning areas previously discussed). For the purposes of this study, this type of increased sewer demand from within the current municipal wastewater service area will be referred to as 'infilling'.

7.2.1. Existing Zoning

The Town's existing zoning ordinance was updated in 2012 and includes 13 different municipal zones. The areas that appear to have the greatest potential for increased wastewater flows as a result of infill growth within the existing sewer service area are in Commercial/Industrial zoned areas and in the Business Innovation Overlay District which was adopted by the Town in 2015 (Overlay District). A map of current zoning is provided (Appendix L).

The Overlay District generally straddles either side of US Interstate 93 between Exits 1 and 2, and also includes tracts of land greater than 10 acres in the Industrial District. The Overlay District is located in upstream portions of the existing wastewater collection system, so increased sewer flows from this area from infill development will affect more downstream sewers (and existing hydraulically limited sewers identified in previous sections of this report) than infill development in lower reaches of the system. In addition, much of the areas in the lower sections of the collection system with current commercial/industrial/Town Center zoning have been developed and/or contain prime wetlands (Appendix L) limiting the potential for increased sewer flows in those areas. It is for these reasons that UE used the Overlay District and developments along the northern sections of South Broadway as the basis for estimating sewer flows from infill development (**Figure 7-1**).

7.2.2. Infill Sanitary Estimate Summary

UE evaluated recent planning board applications and conceptual site plans to try to project the types of infill projects (and associated wastewater flows) that may occur in the future. While it is difficult to predict what future private re-development may occur, UE estimated wastewater flows from several large proposed developments based on conceptual proposed land uses to develop estimated average day and max day infill flows for the Town. These flows are estimated over two areas: Infill Area #1 and Infill Area #2 (Table 7-2). However, future proposed developments should be incorporated into the model for hydraulic impact evaluations and allocation toward the allowance.

Table 7-2. Projected Town Infill Flows

Area	Estimated Average Daily Sanitary Flow (MGD)	Estimated Max. Daily Flow (MGD)
Infill Area #1	0.072	0.18
Infill Area #2	0.128	0.32
TOTAL	***0.2***	***0.5***

7.3. Future Sanitary Estimates Compared to GLSD Agreement Limitations

Existing flows, projected future buildout flows, and the flow estimates for future infill development as compared to the flow limitations of the Town's GLSD intermunicipal agreement are summarized (**Table 7-3**). As previously discussed, recent maximum day flows in the existing system are the most limiting when compared to GLSD flow limits (57% to 74% utilized), so projected max day flows have been provided for evaluation. Although the 9.1 mgd projected future max day flows are slightly higher than the 9 mgd GLSD max day flow limit, the 0.1 mgd difference is within the level of uncertainty of flow estimates. In addition, since approximately 60% of the average flow in the system appears to be I/I, it is believed that there is opportunity for the Town to recapture some of the 'lost' capacity in the system through I/I mitigation efforts.

Table 7-3. Projected Additional Sewer Buildout Flows With Infill

Area	Estimated Average Daily Sanitary Flow (MGD)	Estimated Max. Daily Flow (MGD)
Existing System	2.7	6.7
Subtotal Buildout Area Flow Projections	1.0	1.9
Infill Development Estimate	0.2	0.5
TOTAL	***3.9***	***9.1***
GLSD Allowance	***5.0***	***9.0***

7.4. Projected Interceptor Hydraulic Limitations with Buildout and Infill

Although projected total future sewer flows appear to be at GLSD flow limits, hydraulic sewer modeling shows that the addition of buildout and infill flows to the system exacerbate existing hydraulic limitations in the sewer interceptors. The locations where flows from the buildout planning basins and infill areas enter the sewer model are indicated by arrows (**Figure 7-1**). Infill flows were assumed to enter the system in the vicinity of the Overlay District (Infill Area #1) since this area appeared to have the largest potential for additional infill flows and the sewer routing from this area has a greater impact to the collection system than areas downstream of the system. Currently proposed large developments (Infill Area #2) were also modeled along the northern portion of South Broadway. As previously discussed future development projects should be incorporated into the model for hydraulic impact evaluations.

Hydraulic sewer modeling under existing max day flow plus projected sewer flows associated with infill and buildout conditions showed that approximately 9,500 linear feet of the interceptor were limiting (**Figure 7-2**). These limiting areas were concentrated along South Broadway north of Cluff Road, Granite Avenue, and Main Street between South Broadway and Granite Avenue. Model output maps of the limiting interceptor are provided (Appendix J). Alternatives for mitigating hydraulic bottlenecks are discussed in later sections of this report.

8. Alternatives Evaluations

UE evaluated several alternatives to mitigate the hydraulic bottlenecks identified in Section 7 and also the long-term cost benefits of eliminating the Stiles Road and Keewaydin Pumping Stations by installing the 'West Side Interceptor'. Present day budgetary engineer's opinions of probable costs were developed for each alternative (Appendix M) and alternatives that included projected long-term cost avoidance benefits (pumping station elimination, reduced GLSD treatment costs from I/I reduction, etc.) were evaluated as present value using a 4% annually compounding interest rate over a 50-year planning period.

8.1. Existing Interceptor Bottleneck Mitigation

Four alternatives to mitigate existing hydraulic restrictions under max day buildout and infill conditions identified in Section 7 were evaluated and focused on mitigating the bottlenecks identified on South Broadway, Granite Ave., and Main St. where past sewer overflow issues were reported by the Town. The alternatives included in this analysis were:

- Alternative #1 – I/I Reduction
- Alternative #2 – West Side Interceptor Flow Shedding
- Alternative #3 – Granite Ave. and South Broadway Sewer Interceptor Replacement
- Alternative #4 – South Broadway Flow Shedding Sewer Interceptor Replacement

8.1.1. Alternative #1 - I/I Reduction

Description

This alternative included mitigation of I/I in sewer basins A and C which contribute sewer flow to the Granite/South Broadway bottleneck (**Figure 8-1**). Basins A and C were identified to have excessive infiltration during the system-wide flow monitoring and flow isolation evaluations described in previous sections of this report. Hydraulic modeling of this alternative (Appendix J) showed that an approximate 70% reduction of total basin infiltration would be needed to reduce enough flow to mitigate a significant portion of the Granite/South Broadway bottlenecks for all modeled conditions (i.e. infill and buildouts).

Elimination of 70% of the total infiltration within entire sewer basins is a very aggressive objective near the limits of what any I/I removal program could possibly achieve. In our experience this level of I/I reduction is generally not cost effective and difficult to implement because it typically requires significant mitigation of private sources of I/I. To develop present value budgetary opinions of probable costs for this alternative we assumed that a comprehensive sewer replacement, rehabilitation, and private I/I mitigation program would be required for I/I elimination. This conceptual I/I reduction program focused on the approximate 45,500 linear feet of sewers identified to exhibit potentially excessive infiltration during flow isolation (>1,500 gpd/idm) in Basins A and C and included:

- Replacement of VC sewers
- Rehabilitation of AC, RCP, and sewers of unknown material

- Private sewer separation and lateral rehab/replacement in sewer replacement/rehab project areas

Present Value Budgetary Opinion of Probable Cost = $22,000,000

Advantages

- Eliminates most of the Granite/South Broadway bottlenecks
- Eliminates other identified interceptor bottlenecks in Basin A
- Reduces total system max day flow freeing up additional capacity for sanitary flow
- Reduces total system flow to reduce Town payments to GLSD for treatment
- Eliminates approximately 93% of max day with infill and buildout bottlenecks

Disadvantages

- High capital costs
- Difficult to implement because it will likely require significant private I/I mitigation and work on private property

8.1.2. Alternative #2 - West Side Interceptor Flow Shedding

Description

This alternative included shedding sewer flows from the sewer planning areas located on the west side of US Route 93 away from the Granite/South Broadway bottlenecks. West side sewer flows were assumed to be re-routed to the conceptual West Side Interceptor, an approximate three-mile-long, 21 to 24-inch gravity interceptor that the Town has considered for decades to service Commercial/Industrial and Residential users on the west side of Town. It also appears that the addition of this interceptor has the potential to eliminate the need for the existing Stiles Rd. and Keewaydin Pumping Stations (**Figure 8-2**). Hydraulic modeling of the effects of this alternative (Appendix J) show that it did not shed enough flow to eliminate the Granite/South Broadway Bottlenecks so significant pipe replacements along Granite/South Broadway would be required (and were assumed for budgeting) to eliminate bottlenecks for it to be a complete viable alternative.

Present Value Budgetary Opinion of Probable Cost = $7,300,000

Advantages

- Eliminates the need for two existing pumping stations and their associated long-term operation and maintenance costs
- Provides additional reserve capacity for development on the west side of town.
- Provides additional sewers in buildout area.
- Eliminates approximately 78% of the max day with infill and buildout bottlenecks

Disadvantages

- Does not shed enough flow to eliminate the Granite/South Broadway bottlenecks

- Requires significant pipe replacement/enlargement on Granite Ave. and South Broadway to mitigate bottlenecks
- Higher capital cost than other alternatives

8.1.3. Alternative #3 - Granite Ave. and S. Broadway Sewer Interceptor Replacement

Description

This alternative included replacement of the Granite/South Broadway bottleneck sewers with larger diameter PVC pipes to improve hydraulics and eliminate the bottleneck (**Figure 8-3**). Conceptual pipe sizing for budgetary purposes and hydraulic modeling (Appendix J) was based on existing interceptor slope and so that larger pipes were not routed to smaller diameter pipes. Trench restoration and replacement of service laterals to the edge of the roadway ROW were included in the budgetary estimate. The following is a summary of the length/diameter interceptors used for budgetary purposes for this alternative:

- 800 LF of 18-inch sewer on Main St. and Granite Ave.
- 1,500 LF of 24-inch sewer on Granite Ave.
- 6,400 LF of 30-inch sewer around Granite Ave. and South Broadway

Present Value Budgetary Opinion of Probable Cost = $6,300,000

Advantages

- Improves hydraulics and eliminates the Granite/South Broadway bottlenecks
- Provides additional capacity for growth
- Eliminates approximately 78% of the max day with buildout and infill bottlenecks.

Disadvantages

- Higher capital cost than other alternatives
- Replaces larger diameter RCP interceptors on Granite Ave. that still have remaining useful life
- Does not reduce sewer flows or other long term O&M costs
- Potential environmental contamination may increase construction costs

8.1.4. Alternative #4 – South Broadway Flow Shedding and Sewer Interceptor Replacement

Description

This alternative included re-routing of flows from North Broadway down South Broadway, away from the bottlenecks along Granite Ave. Hydraulic modeling (Appendix J) indicated that this alternative requires replacement of the sewers on South Broadway between Main St. and Cluff Rd. with larger diameter pipes to eliminate the Granite/South Broadway bottlenecks (**Figure 8-4**). However, because this alternative sheds flow away from Granite Ave., the sewers on Granite Ave. do not need to be replaced to eliminate the bottleneck. Conceptual pipe sizing for budgetary purposes was based existing interceptor slope and so that larger pipes were not routed to smaller diameter pipes. Trench restoration and replacement of service laterals to the edge of the roadway

ROW were included in the budgetary estimate. The following is a summary of the length/diameter interceptors used for budgetary purposes for this alternative:

- 2,100 LF of 15-inch sewer on South Broadway
- 1,000 LF of 24-inch sewer on South Broadway
- 4,000 LF of 30-inch sewer on South Broadway

Present Value Budgetary Opinion of Probable Cost = $5,600,000

Advantages

- Lower budgetary cost than other alternatives
- Improves hydraulics and eliminates the Granite/South Broadway bottlenecks
- Replaces existing VC sewers on South Broadway that exhibited high I/I during flow isolation
- Current planned improvements/construction in this area may help reduce costs
- Provides additional capacity for growth
- Eliminates approximately 78% of the max day with infill and buildout bottlenecks.

Disadvantages

- Does not reduce sewer flows or other long term O&M costs
- Additional work on South Broadway may be more challenging compared to Alternative #3
- Requires two crossings of Policy Brook which may require deeper sewers
- Potential environmental contamination may increase construction costs

8.2. Westside Interceptor and Pumping Station Elimination

This alternative included evaluation of the long term (50-year) cost avoidance benefits of the West Side Interceptor through elimination of the Stiles Rd. and Keewaydin Pumping Stations. It was found that the budgetary present day capital costs of the West Side Interceptor ($5,200,000) were higher than the cost avoidance from pumping station O&M and capital improvements ($4,260,000) over the next 50-years indicating that elimination of the pumping stations is not a cost-effective justification for building the West Side Interceptor. However, it should be noted there may be other justifications to construct the West Side Interceptor including expanding the sewer service into the west side of Town (a buildout area), accommodate flow requests from Windham, and provide additional sewer capacity to the Business Overlay District. As development continues to grow within the Overlay District, the ability of the Keewaydin Pumping Station to handle max day/peak hour flow will need to be evaluated. Cost sharing opportunities for construction of the West Side Interceptor may arise if these other considerations develop in the future that may make this alternative more cost effective in the future, so this alternative should be re-evaluated at key decision points (such as replacement of the Keewaydin and Stiles Road Pumping Stations).

9. Recommended Projects and Priority Ranking

Recommended projects were characterized as near term improvements (10-years) to the existing system to maintain or improve the level of service to the existing users, long term improvements (<10 years) to maintain or improve the level of service to the existing users, or buildout projects that expands the existing system to provide municipal wastewater service to new users. These priority ranking criteria are biased towards servicing the existing users on the system and against sewer expansions. However, additional considerations such as failing septic systems, protection of water supply, land use zoning changes, proposed revenue-generating development, etc. may make sewer system expansions of higher priority. It is recommended that the Town should periodically confirm that the priority of sewer system expansion projects are consistent with other Town planning documents and objectives.

9.1. Recommended Near-Term Improvements to the Existing System (10-Year)

Recommended near-term improvements are considered Priority 1 to maintain the current level of service to the existing users. These improvements included interceptor bottleneck mitigation, pumping station deficiency mitigation, infiltration and inflow identification and mitigation, and sewer system planning studies and reports.

9.1.1. Recommended Interceptor Bottleneck Mitigation

Alternative #4 – South Broadway Flow Shedding and Sewer Interceptor replacement is the recommended alternative to mitigate the existing bottlenecks in the vicinity of Main St., Granite Ave., and South Broadway under max day flow conditions. It is recommended that the replaced interceptor pipes associated with this project be sized to handle projected final buildout flows because buildout may occur within the assumed 100-year design life for the new sewers. Therefore, the assumed buildout flow projections should be reviewed and confirmed by the Town since the design flows will affect interceptor pipe sizing and that the feasibility of this alternative be evaluated due to the challenges of crossing Policy Brook (which will also be affected by pipe sizing). As previously discussed this alternative will be designed to mitigate the majority of the identified interceptor bottlenecks. Other identified interceptor bottlenecks located in the cross country sewer west of North Broadway under existing max day flow conditions, are recommended to be improved with I/I mitigation which will also help recover 'lost' sewer capacity due to I/I.

9.1.2. Existing Pumping Station Deficiency Mitigation

The age, condition, and deficiencies at each station described in earlier sections of this report were used to develop the basis of recommended improvements **(Table 9-1)**. Planning level costs and schedule for anticipated expenditures were based on the following assumed design life for existing equipment:

- Pumps: 20 to 30 Years
- Fiberglass Enclosures: 20 to 30 Years
- Buildings: 50 Years
- Dry pit can structures: 50 Years*

*It is difficult to estimate design life for the can structure due to unknown factors such as expiration of buried sacrificial anodes as noted in the electrical report.

Additional recommended considerations included in planning level costs included:

- Replacing existing fiberglass suction lift pumping station enclosures (Butler Street and Stiles Road) with new buildings to house pumps, controls, generators, etc. at the time of station replacement in-lieu of fiberglass enclosure. This is recommended because the typical design life of a building is greater than a fiberglass enclosures and equipment is better protected from the elements.

- The addition of Supervisory Control And Data Acquisition (SCADA) to the pumping stations is recommended as a future consideration to be included as a separate item or incorporated into future pumping station replacement projects. We understand that the Town has incorporated SCADA to improve the operation and control of the Town's water system and the same benefits would apply if the wastewater pumping stations are also incorporated into the Town's SCADA system.

- A list of near term pumping station improvement recommendations are provided in Table 9-1 and 10-1.

Table 9-1. Pumping Station Recommended Projects

STATION	ITEM	BUDGETARY COSTS	2017-2020s[1]	2030s	2040s	2050s	2060s	2070s	2080s	2090s	2100s	2110s
Brookdale Road												
Station Vintage = 1998	Relocate pump controls to an above grade enclosure											
Pump Vintage = 1998 (Overhauled 2006 +/-)	Provide intrinsically safe isolation barrier for high water float											
	Repair rust on weather enclosure for generator											
	Add low temperature alarm input											
	Seal conduits to eliminate rodent access. See Electrical Report.											
	Replace media in odor control unit											
	Monitor integrity of dry pit can for deterioration annually and evaluate target date for pump station replacement											
	Plan for pump replacement (2016 drawdown tests indicate existing pumps operating at 75% design capacity, see design considerations above and opinion of cost). Target year 2026.	$220,000	$220,000					$120,000				
	The site is in close proximity to the 100 year flood elevation. Perform evaluations and/or modeling to identify 100 year flood levels prior to design of station replacement.											
	Demo and abandon the existing pumping station dry pit and construct replacement station. Budget for above grade, self-priming centrifugal pumps and controls.											
	Plan for pumping station replacement (see design considerations above). Target year 2048	$840,000			$840,000					$840,000		
Butler Street												
Station Vintage= 1980's estimated	We recommend budgeting for a pump station replacement that includes a new building to house pumps, generator, controls, etc. in lieu of an in-kind replacement (fiberglass enclosure). The design life of a building is approximately 50 years whereas the fiberglass enclosures have a recommended design life of 20-30 years.											
Pump Vintage = 1985	Repair rust deterioration on generator weather enclosure and top of diesel fuel tank											
	Repair or replace rust on electrical boxes (annunciator cover) to permit access if needed.											
	Plan for pumping station replacement (see design considerations above). Target year 2021.	$760,000	$760,000					$760,000				
	Plan for pump replacement. Target year 2046.	$120,000			$120,000					$120,000		
Commercial Drive												
Station Vintage = 1987	Permanent standby generator with automatic transfer switch and perform electrical upgrade including new control panel with intrinsically safe barrier device for backup float.											
Pump Vintage = 1987	Add low temperature alarm input											
	Repair cracked mortar on wetwell manhole frame											
	Replace rusted entry doors											
	Rehabilitate the existing wetwell to remove defunct equipment											
	Evaluate building maintenance repairs needed due to age, replace roof											
	Plan for pump replacement (2016 drawdown tests indicate existing pumps operating at 75% design capacity, see design considerations above). Target year 2017.	$300,000	$300,000				$125,000					$125,000
	Plan for in-kind pumping station replacement. Target year 2037.	$840,000		$840,000					$840,000			
Copper Beach												
Station Vintage= 1990	See report by Underwood Engineers dated February 13, 2014											
Pump Vintage = 1990	Individual component upgrades per report recommendations (Immediate life safety needs per previous report, confirm previous work performed)	$15,000	$15,000									
	Add surge protection device on electrical service per Electrical Report.											
	Plan for pumping station replacement (see design considerations above). Target year 2022.	$501,000	$501,000					$501,000				
	Plan for pump replacement. Target year 2047.	$120,000			$120,000					$120,000		
Freedom Drive												
Station Vintage= 1969 Relocated in the 1980's	Demo existing ejector station and construct replacement station. Evaluate feasibility of keeping existing station in service while constructing new station.											
Compressor Vintage = 1980's estimated	Provide duct adapter for generator to prevent overheating when running on generator power											
	Relocate location of propane tank to correct code violation											
	Plan for pumping station replacement (see design considerations above). Target year 2025.	$780,000	$780,000					$780,000				
	Plan for pump replacement. Target year 2050.	$120,000				$120,000					$120,000	
Haigh Avenue												
Station Vintage = 1972	Relocate pump controls to an above grade cabinet or within the existing generator building.											
Pump Vintage = 2004	Renovate the existing generator building: repoint brick masonry, replace the asphalt shingle roof											
	Remove defunct equipment in the wetwell											
	Demo and abandon the existing pumping station dry pit and construct replacement station. Budget for above grade, self-priming centrifugal pumps and controls.											
	Perform evaluations and/or modelling to confirm the 100-year flood levels and if the existing protection is adequate prior to design.											
	Plan for pumping station replacement (see design considerations above). Target year 2023.	$960,000	$960,000					$960,000				
	Plan for pump replacement. Target year 2048.	$120,000			$120,000					$120,000		

Table 9-1. Pumping Station Recommended Projects

STATION	ITEM	BUDGETARY COSTS	2017-2020s[1]	2030s	2040s	2050s	2060s	2070s	2080s	2090s	2100s	2110s
Keewaydin Drive												
Station Vintage= 1990	Configure lead/lag pump operation in event of malfunction, evaluate downstream impacts. **Target Year 2017.**	$10,000	$10,000									
Pump Vintage = 1990	General site cleanup, including; demo abandoned equipment from former pump station, equipment no longer in use											
	Electric service backboard needs discontinued equipment removed and backboard rebuilt. Outdoor dry type transformer should be replaced and relocated.											
	Repair rusted generator enclosure. Evaluate if existing enclosure can be repaired or if a new enclosure is required.											
	Evaluate feasibility of eliminating station and connecting to a new Stiles Road Pump Station by gravity sewer											
	Replace wooden siding with a lower maintenance façade material, roof replacement											
	Plan for pump replacement (2016 drawdown tests indicate existing pumps operating at design capacity, see design considerations above). Target year 2020.	$320,000	$320,000				$165,000				$165,000	
	Plan for in-kind pumping station replacement. Target year 2040.	$1,060,000			$1,060,000					$1,060,000		
South Policy Street												
Station Vintage = 1991	Add secondary driveway access from Rockingham Mall parking lot											
Pump Vintage = 1991	Repair defunct flow meter and chart recorder and remove existing bubbler system no longer in service											
	Provide float type battery charger for generator											
	Evaluate and repair motor for electrically actuated generator louver that makes a loud humming sound.											
	Replace non GFCI receptacles in dry well											
	Replace muffin monster in the wetwell											
	Rehab corroded mehcanical equipment in wetwell and improve ventilation system if necessary											
	Plan for pump replacement (unable to complete drawdown tests in 2016 due to debris in wetwell). Pumps should be evaluated annually due to age (see additional design considerations above). Target year 2026.	$390,000	$390,000				$120,000					$390,000
	Plan for in-kind pumping station replacement. Target year 2041.	$1,500,000			$1,500,000					$1,500,000		
Stiles Road												
Station Vintage = 1987	**Preliminary Design:** Evaluate feasibility of connecting Keewaydin Dr. Pump Station to a new Stiles Road Pump Station located outside of the 100 year flood zone and existing apparent poor pump performance. **Target year 2018.**	$15,000	$15,000									
Pump Vintage = 1987	Properly seal control cables at wet well											
	Modify locations of apparent load side breakers and panelboard connected to the automatic transfer switch. The breaker to the pump control panel is not adequately accessible in accordance with NEC requirements.											
	Perform evaluations and/or modelling to confirm the 100-year flood levels and potential hazard mitigation measures in advance of planned station replacement.											
	We recommend budgeting for a pump station replacement that includes a new building to house pumps, generator, controls, etc. in lieu of an in-kind replacement (fiberglass enclosure). The design life of a building is approximately 50 years whereas the fiberglass enclosures have a recommended design life of 20-30 years.											
	Plan for pumping station replacement with provisions for flood protection (2016 drawdown tests indicate existing pumps operating at 35% design capacity, see additional design considerations above). Target year 2020.	$870,000	$870,000					$870,000				
	Plan for pump replacement. Target year 2045.	$130,000			$130,000					$130,000		
Twinbrook Avenue												
Station Vintage = 1972	Relocate pump controls to an above grade cabinet or within the existing generator building.											
Pump Vintage = 1972	Renovate the existing generator building: repoint brick masonry, replace the asphalt shingle roof											
	Demo and abandon the existing pumping station dry pit and construct replacement station. Budget for above grade, self-priming centrifugal pumps and controls.											
	Plan for pumping station replacement (see additional design considerations above). Target year 2024.	$850,000	$850,000					$850,000				
	Plan for pump replacement. Target year 2049.	$120,000			$120,000					$120,000		
SCADA												
	Consider installation of SCADA system at all ten (10) pump stations. Estimate includes the total cost for remote terminal units (1 per site, 10 required), master terminal unit (1), and preliminary path study per Electrical Report plus contingency. SCADA improvement costs and feasibility should be considered and evaluated during design of station replacements.	$185,000				$185,000						
		TOTAL	***$5,991,000***	***$840,000***	***$4,010,000***	***$305,000***	***$410,000***	***$4,841,000***	***$840,000***	***$4,010,000***	***$285,000***	***$515,000***

1. Costs in 2016 dollars

2. 50 year assumed design life for pumping stations and 25 years for pumps

3. Pump replacement costs after pumping station upgrades based on pump costs plus an assumed 35% installation, 30% contingency, 25% engineering costs

9.1.3. Infiltration and Inflow Identification and Removal Program

The I/I evaluations performed during this study revealed significant I/I in the Town's collection system. Approximately 60% of the Town's average daily flow that the Town sends (and pays for) to GLSD for treatment and disposal is estimated to be I/I and I/I flow peaks contribute to the hydraulic bottlenecks identified during sewer modeling. Approximately 91% of the total annual average I/I in the system was estimated to be infiltration and private inflow (9% was estimated to be inflow) and infiltration represents a significant contributor to the limiting max day flows with respect to the Town's agreement with GLSD. Although a comprehensive I/I removal program was not cost effective to mitigate the Granite/South Broadway bottlenecks, it is believed that targeted I/I could improve other interceptor bottlenecks. In addition, targeted I/I identification and removal is consistent with good wastewater collection system operation and maintenance, is required by the GLSD NPDES permit, eliminating I/I in the system may help recapture 'lost' capacity, and sewer rehabilitation projects may help defray long-term sewer replacement costs discussed in later sections of this report.

It is recommended that the first phase of the I/I identification and mitigation program focus on identifying and removing infiltration and private inflow (as opposed direct inflow). Based on the continuous flow monitoring evaluation, UE recommends the following basins for flow isolation to identify the sewer reaches with the highest infiltration:

- Basin A (flow isolation already performed)
- Basin C (flow isolation already performed)
- Basin F
- Basins D/I
- Basin G

The flow isolation performed in Basins A and C as part of this study was used to compile a list of recommended sections of pipe targeted for Closed Circuit Television (CCTV) and manhole inspection to observe/identify specific leaking defects. Once CCTV and manhole inspections are performed cost effective rehabilitation and repairs can be recommended.

The recommended areas for CCTV and manhole inspections were broken into priority A recommendations and priority B recommendations. Priority A includes areas where infiltration in excess of 4,000 gpd/idm was observed, while priority B includes areas where infiltration between 1,500 and 4,000 gpd/idm was observed. Tables outlining priority A and priority B recommendations for further evaluation can be found in Appendix N.

Overall, a total of 491,000 gpd of infiltration and private inflow was identified in Basins A and C based on the flows measured during the two nights of flow isolation. However, these infiltration rates vary over time with groundwater levels and were likely higher during max day flows and are likely lower in the summer. An overview of the amount of infiltration and private inflow in areas targeted for CCTV and manhole inspections in each basin can be found in **Tables 9-2 and 9-3** below.

Table 9-2. Basin A Infiltration and Private Inflow Observed During Flow Isolation

Basin	Priority	Infiltration in Recommended CCTV Areas (gpd)	% of Total Basin Infiltration in CCTV Areas	Length of Pipe Targeted for CCTV (ft)	% of Basin Targeted for CCTV
A	Priority A	291,000	80%	12,500	30%
	Priority B	51,000	14%	12,000	29%
	Total	**342,000**	**94%**	**24,500**	**59%**

Table 9-3. Basin C Infiltration and Private Inflow Observed During Flow Isolation

Basin	Priority	Infiltration in Recommended CCTV Areas (gpd)	% of Total Basin Infiltration in CCTV Areas	Length of Pipe Targeted for CCTV (ft)	% of Basin Targeted for CCTV
C	Priority A	111,000	62%	7,000	16%
	Priority B	52,000	29%	14,000	31%
	Total	**163,000**	**91%**	**21,000**	**47%**

UE recommends CCTV and manhole inspections in these areas to identify specific locations for repairs that may reduce infiltration in the system and to identify the presence of private I/I in the system. Several CCTV recommendations have been provided by the flow assessment crew due to conditions encountered during flow isolation:

- Perform CCTV at night due to high flow rates in certain areas
- CCTV areas that could not be reached during flow isolation
- Manipulate pump stations so they are not running during CCTV
- Opinion of costs: $200,000 (2017) and $100,000 annually for budgetary planning.

Following CCTV, home inspections may be necessary to identify potential sources of private I/I.

9.1.4. Recommended Sewer System Planning Studies and Reports

Proper planning is recommended for all wastewater systems and the following evaluations are recommended to incorporate the findings of this sewer master plan update:

- Develop an asset management plan to refine budgets and schedule for asset replacements. A major component of the asset management plan should be to inventory the age/material of approximately 26.5 miles of unknown sewer in the collection system and additional components of the wastewater pumping stations (Opinion of costs $60,000)

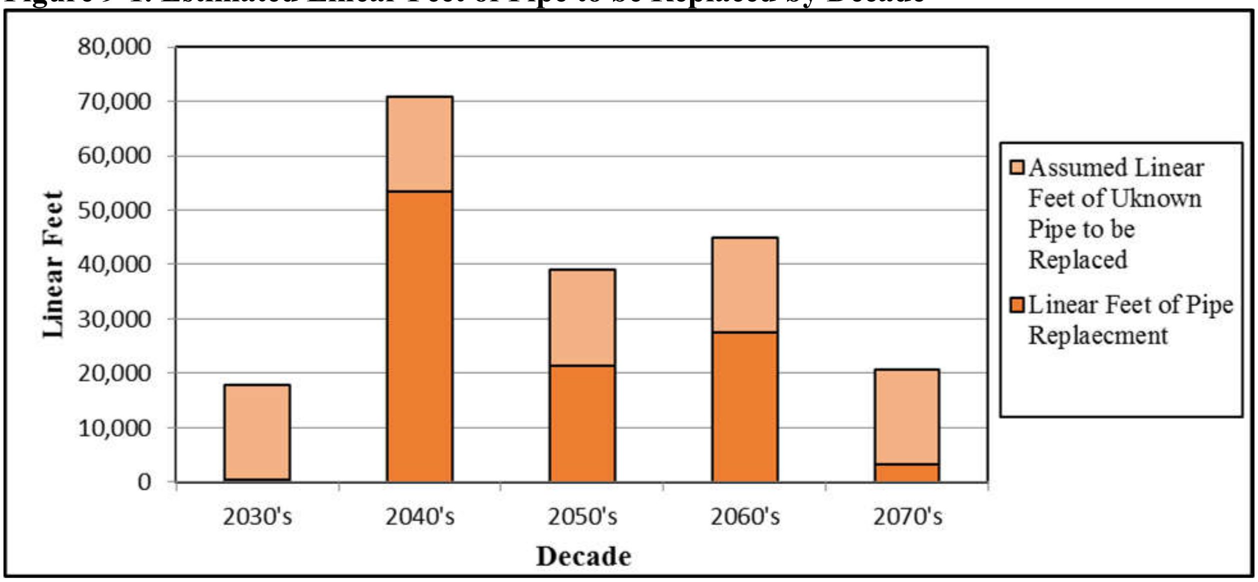
- Perform a sewer rate study to incorporate budgetary elements of this report as well as budgets developed through the recommended asset management planning document (Opinion of costs $15,000 with annual updates)

9.2. Recommended Long Term Improvements to the Existing System

9.2.1. Age/Material-Based Sewer Replacement Planning

UE used sewer age and material to estimate a decade of replacement for each reach of the wastewater collection system for long-term planning and budgeting purposes for this study. Vitrified Clay (VC) pipe was assumed to have a useful life of 70 years and other pipe (PVC, RCP, AC, DI, etc.) was assumed to have a useful life of 100 years and the pipe in the system was assigned a decade of replacement based on its age and material based on information provided in the Town's Geographic Information System (GIS). Approximately 140,000 feet of sewer (36% of the system) was of unknown material/age and the planned decade of replacement for those pipes was assumed to be evenly distributed throughout the planning period. The following bar chart figure shows the distribution of the estimated decade of the Town's gravity sewers for planning purposes (**Figure 9-1**).

Figure 9-1. Estimated Linear Feet of Pipe to be Replaced by Decade



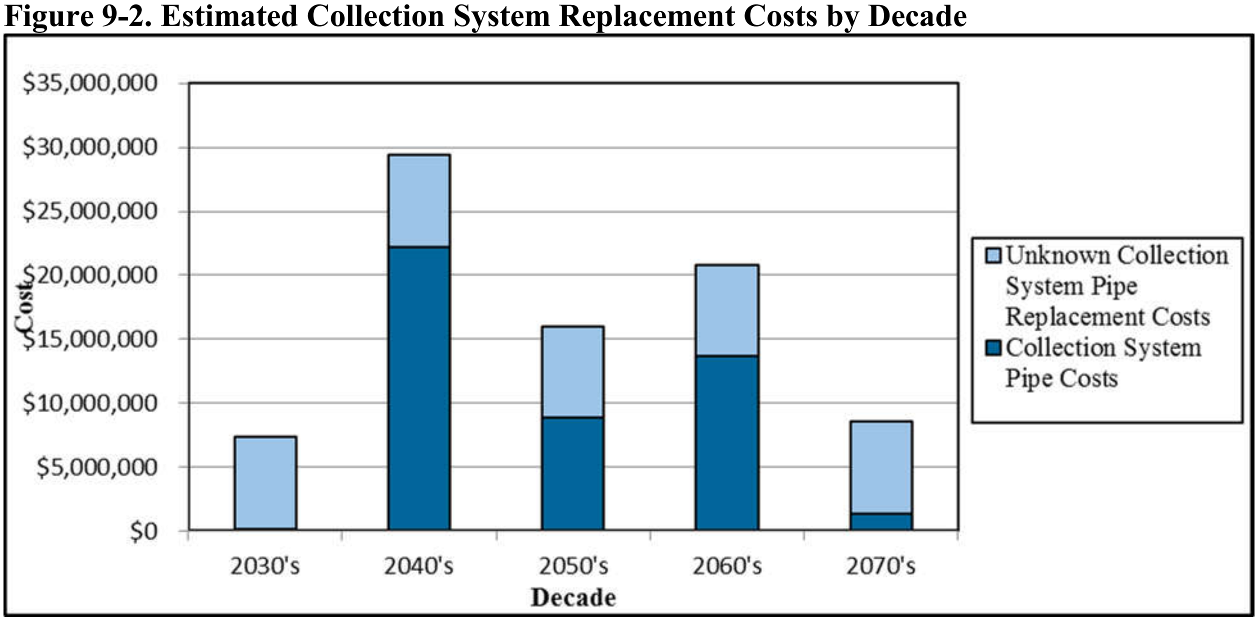
UE assigned a budgetary total pipe replacement cost to each reach of sewer system based on pipe diameter (**Table 9-4**). These budgetary average total project costs assume trench pavement repair, engineering and contingency based on recent projects for system-wide planning purposes. However, this approach is not a surrogate for project-specific opinions of cost for pipe replacement projects that includes the project specific details. For example, the challenges of replacing pipe on South Broadway will have higher total project cost than replacement of a cross country sewer. The budgetary prices included herein do not take into account that project-specific variability so project-specific opinions of probable cost must be performed for each future sewer project.

Table 9-4. Pipe Replacement Cost Summary

Pipe Diameter	Assumed Budgetary Replacement Total Project Costs ($/ft)
4" & 6"	$410
8" and Unknown	$410
10"	$420
12"	$430
15"	$440
16"	$440
18"	$450
21"	$550
24"	$580
30"	$660
42"	$750

Combining the planning level decade of replacement with assumed budgetary pipe replacement cost by pipe diameter results in the following planning level decade of replacement cost distribution for sewer improvements (**Figure 9-2**).

Figure 9-2. Estimated Collection System Replacement Costs by Decade



It should be noted that Figure 9-2 only shows the amount of pipe expected to be replaced over a 50 year period and not the entire system. Table 9-5 below breaks down each decade with the expected costs of pipe replacement and provides a preliminary total for future planning. Costs for hydraulic improvement projects within the 10-year CIP (South Broadway Sewer Replacement Program) were removed from the age-based long term reserve fund 50-year planning period.

Table 9-5. Collection System Pipe Replacement Reserves Summary

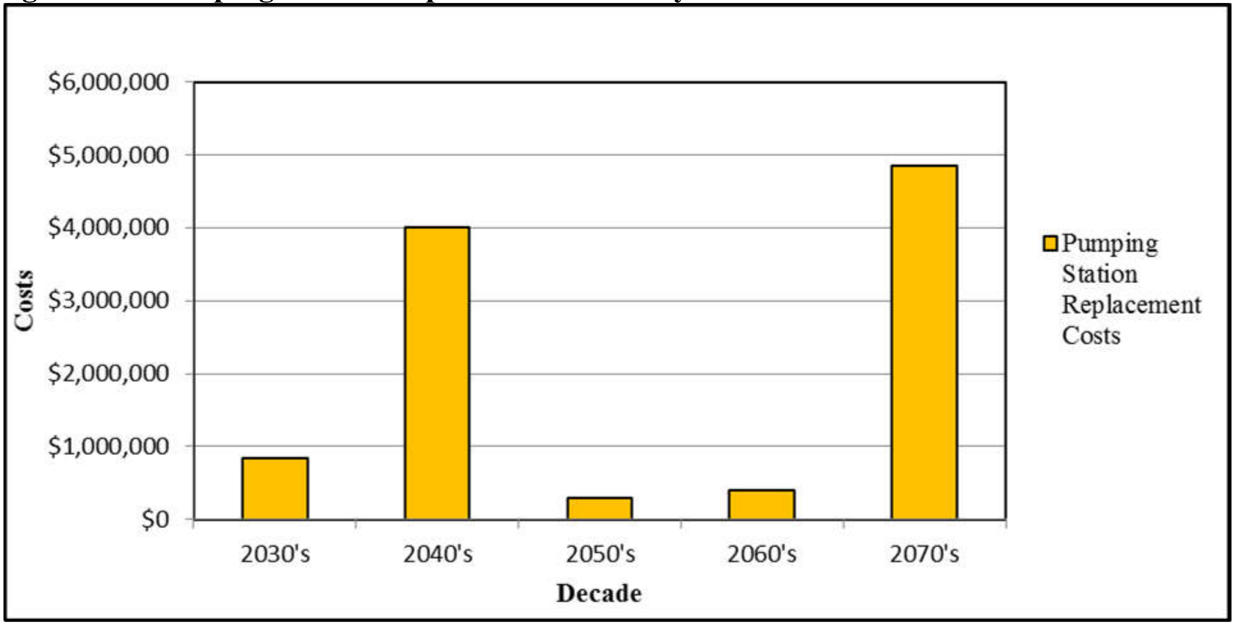
	2030's	2040's	2050's	2060's	2070's	Total
Pipe Replacement Costs per decade	$191,000	$22,200,000	$8,860,000	$13,650,000	$1,359,000	**$46,260,000**
Assumed Replacement costs of Unknown Pipe	$7,163,000	$7,163,000	$7,163,000	$7,163,000	$7,163,000	**$35,815,000**
					Subtotal	**$82,075,000**
Near Term South Broadway Sewer Replacement Project (10-Year CIP)						**($5,800,000)**
PIPE REPLACEMENT RESERVE FUND TOTAL:						**~ $76,275,000**

It should be noted that this approach should be considered a first step for long-term planning and budgeting, and a thorough evaluation of the collector sewers through I/I evaluations, CCTV and other inspection methods is required to refine budgets and prioritize replacements under a recommended comprehensive asset management plan.

9.2.2. Pumping Station Improvements and Replacement Planning

The process used to develop long-term pumping station planning was discussed earlier and a summary of recommended projects, planning schedule, and budgetary estimates was previously provided (Table 9-1). Combining the planning level decade of replacement with assumed budgetary long-term pumping station improvements results in the following planning level decade of replacement cost distribution for pumping station improvements/replacements (**Figure 9-3**).

Figure 9-3. Pumping Station Replacement Costs by Decade



As shown in Figure 9-3, Table 9-6 below identifies the total capital cost for Pumping Stations over a 50 year period recommended for future planning. As with the Pipe Replacement Reserve, 10-year CIP projects are not included in the long term Pumping Station Reserve Fund because they are expected to be completed prior to the beginning of the 50-year planning period.

Table 9-6. Pumping Station Reserve Fund Summary

	2030's	2040's	2050's	2060's	2070's	Total
Pumping Station Costs per Decade	$840,000	$4,010,000	$305,000	$410,000	$4,841,000	**$10,406,000**
PUMPING STATION RESERVE FUND TOTAL:						**$10,406,000**

9.2.3. On-Going I/I Identification and Mitigation Program

I/I identification and removal is a process which evolves as evaluations and mitigation measures are performed, so while the specific measures for the long term program are not yet defined, it is still included a long-term recommendation.

9.2.4. Long Term Sewer System Planning Studies and Reports

It is recommended that revenue and asset inventory be reviewed annually with rate model updates every 2 years and periodic asset management program updates following changes to the system. It is also recommended that the sewer master plan is updated no less than every 20 years to incorporate changes to the Town and changing objectives for the wastewater system.

It is also recommended that total system flows be evaluated as infill and buildout projects progress to monitor the utilization of the Town's capacity limitations with GLSD. Actual flows should be compared to the sewer flow projections/estimates included in this report and flow projections/estimates should be updated if needed based on future conditions. It is recommended that average, max day, and peak hour system flows be monitored annually compared to GLSD flow limitations and sewer flow projections/estimates should be updated approximately every 5-years.

9.3. Sewer Service Extension Planning

Sewer service extension planning areas included extensions to service existing development around the lakes area of Town and also to service the area of town located west of US Route 93 (**Figure 7-1**). These sewer build out projects are consistent with previous sewer planning documents as well as the Town's Master Plan.

9.3.1. Lakes Area Sewer Extensions

The Lake St. and Arlington/Captains Pond sewer extension planning areas are intended to service the lakes area of Town. These areas include the surface waters used for the Town's water supply and recreational beach areas. We recommend that the Town make it a priority to protect these areas from contamination associated with leachfields from the existing relatively dense housing around the lakes. In addition, the existing tight development and proximity of residences to the lakes will likely limit the feasibility of replacing the existing private leachfields when they fail. For these reasons we recommend that the Town plan and budget for extension of the collection system to service these areas. We have included the following budgetary estimates (**Table 9-7**) based on project costs from SEA's Lakes Area Improvements Plan increased to present day costs using the Engineering News Record (ENR) Boston construction cost index factors.

Table 9-7. Buildout Area Costs

Buildout Planning Area	SEA Budgetary Costs (1999)	ENR Correction Factor	Updated Present Day Budgetary Cost (2016)
Lake St. Area	$6,400,000	1.86	$12,000,000
Arlington/Captains Pond Area	$18,700,000	1.86	$35,000,000

9.3.2. West Side and Millville St. Area Sewer Extensions

Planning level costs for the Millville St. and West Side Area were developed based on sewer routing/sizing from UE's 1986 sewer buildout maps. Budgetary conceptual planning costs were based on the linear foot unit costs previously discussed (**Table 9-8**) and project specific opinions of costs are recommended to refine budgets during preliminary design of these projects.

Table 9-8. Westside and Millville Buildout Costs

Buildout Planning Area	UE Planning Level Budgetary Costs
Millville St. Area	$3,000,000
West Side Interceptor Service Area	$14,000,000

Table 9-9. Buildout Area Capital Reserve Summary

Buildout Planning Area	UE Planning Level Budgetary Costs
Lake St. Area	$12,000,000
Arlington/Captains Pond Area	$35,000,000
Millville St. Area	$3,000,000
West Side Interceptor Service Area	$14,000,000
Total	**$64,000,000**
Annual (50-Year Period) Reserves at 50%	**$640,000**

If the Town wishes to pursue sewer buildout in the areas described in Table 9.9, a reserve fund of $640,000 would need to be set aside over a 50 year period to fund a recommended 50% of the project.

9.3.3. Windham Considerations

Possible future flows from Windham have not been included in this evaluation because Windham is not party to the Town's agreement with GLSD. However, as previously discussed a portion of Windham around Canobie Lake is within the GLSD service area. There may be cost sharing opportunities between the Town and Windham for the West Side Interceptor should Windham approach the Town for participation in the future and Town desires to incorporate flow from Windham into the Town's GLSD reserve capacity.

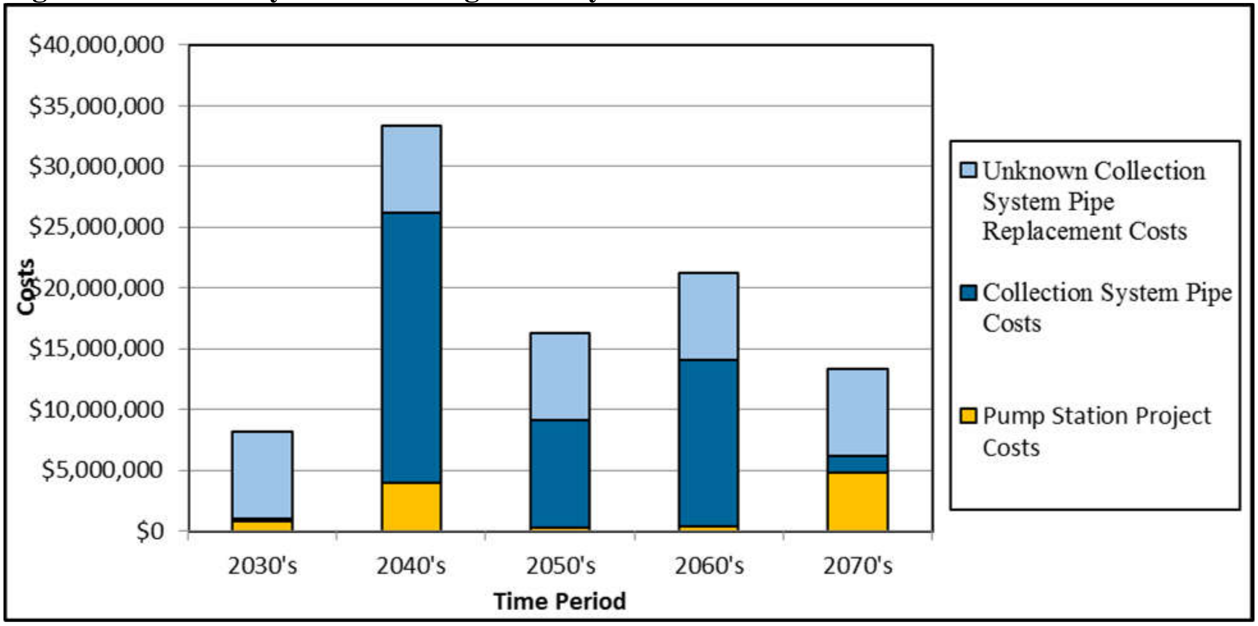
9.4. Summary of Long Term Recommendations for Capital Reserve Planning

It is recommended that the Town incorporate long term infrastructure budgetary planning estimates into an annual capital reserve program. The long term infrastructure recommendations previously discussed included:

- Long-Term Sewer Replacement Planning
- Long-Term Pumping Station Improvements and Replacement Planning

The estimated decade of replacement costs for these long-term planning programs is provided (**Figure 9-4**). As shown, capital expenditures are not projected to be evenly distributed by decade. For example, the large collection system pipe replacement costs projected for the 2040's occurs when the oldest VC pipe in the system reaches the end of its useful design life. Similarly, long term pumping station capital improvements may be necessary before the sewer pipe replacement program because mechanical equipment has a shorter design life than sewer pipes.

Figure 9-4. Sewer System Planning Costs by Decade



It is recommended that the long term asset replacement costs be incorporated into annual capital reserve budgets to help distribute the variability of annual costs over time (**Table 9-10**). For planning purposes we recommend that 50% of the annual average budgetary costs be included to account for the time value of money and bonding for capital projects. Recommended annual long-term capital reserve funding is summarized (**Table 9-10**). Note that costs for short term recommendations (South Broadway Sewer, etc.) have been deducted from the long term program. However, all long term planning level costs should be refined as part of a future asset management plan for the system.

Table 9-10. Recommended Asset Replacement Reserve Fund

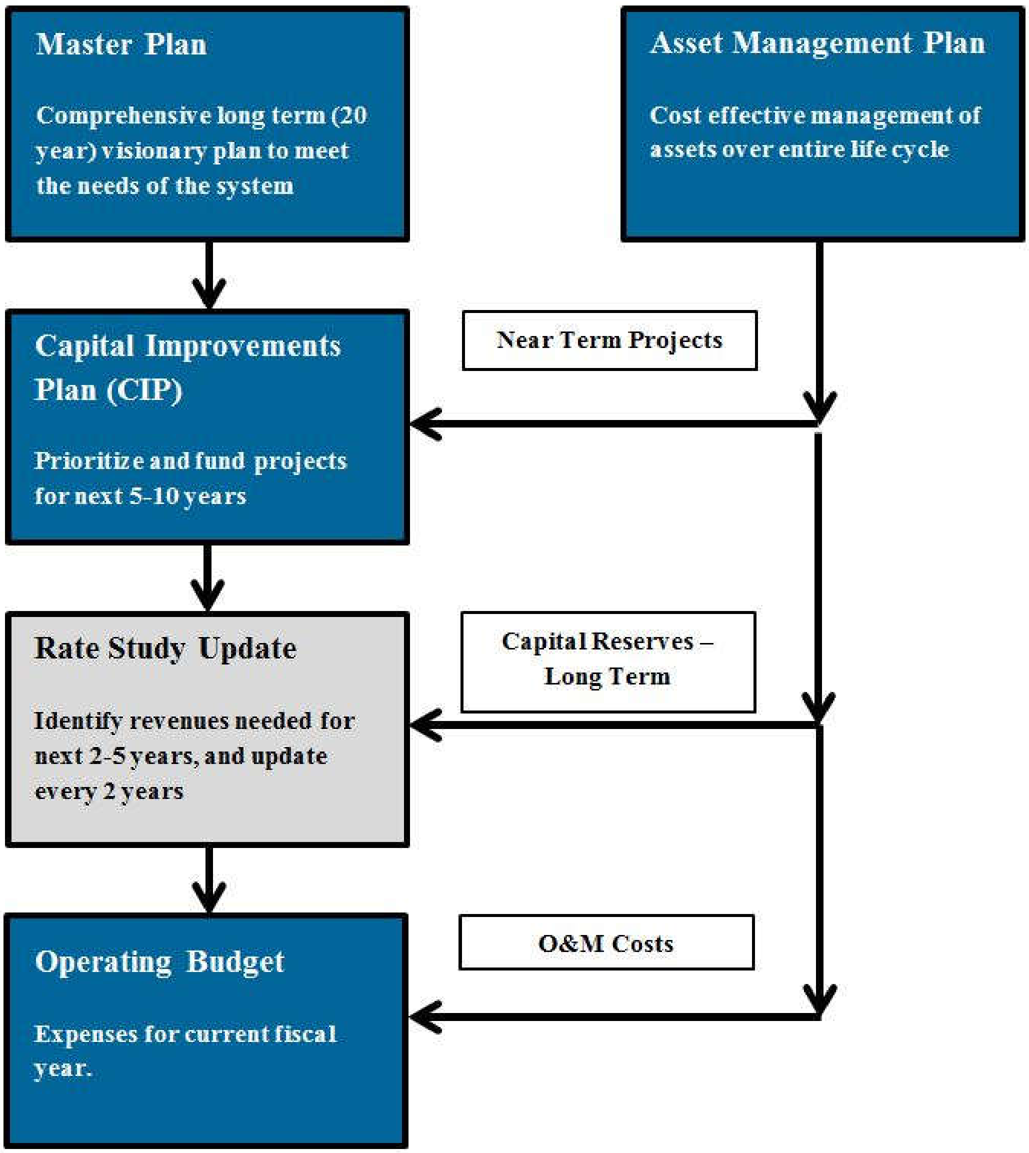
	Total 50-Year Long Term Planning Costs	Total Annual Long Term Reserves	Capital Reserve Annual Funding (50%)
Long Term Sewer Replacement Planning	$76,275,000	$1,526,000	$763,000
Long Term Pumping Station Improvement Program	$10,406,000	$208,000	$104,000
		Total	**$867,000**

10.Recommended Capital Improvements Summary

10.1. Phasing of Improvements

The Master Plan relates to other financial planning documents for the Town as illustrated in Figure 10-1. The projects identified in the Master Plan and other planning studies are summarized in the Capital Improvements Plan. The near term (up to 5 year) funding strategy for the CIP should be considered in the next Rate Update. The Rate Model should continue to be updated as the CIP is further refined.

Figure 10-1. Financial Planning Flow Chart



10.2. Ten (10) Year Recommended Capital Improvements

Recommended projects for the Ten Year Capital Improvements Plan (CIP) are summarized in Table 10-1. These include renewals of existing assets and the projects for growth or enhancement identified in the Master Plan.

The CIP should be updated as the scope, cost, and schedule of these projects are further refined and after completion of an asset management plan. The highest priority projects in the CIP should receive further evaluation first. Basic levels of priority were assigned to each project based on the following criteria:

Priority 1 = High Priority (needed in near term to maintain service)
Priority 2 = Medium Priority (needed in the next 5 to 20 years to maintain service)
Priority 3 = Low Priority (not critical in near to mid-term to maintain service)

Table 10-1. Ten Year Capital Improvements Plan.

Project	Notes/References	Priority	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Annual Long
System Hydraulic Improvements[1]													
South Broadway Sewer Replacement Project (Alt #4)[3]	The replacement of approximately 7,200' of sewer pipe along South Broadway from the intersection of Main Street to Cluff Road to mitigate approximately 78% of hydraulic bottlenecks. Phase I (2018) and Phase II (2019)	1	$200,000	$3,700,000	$1,900,000								
Pumping Station Improvements[2]													
Brookdale Road PS	Modifications and improvements to the existing PS	1										$220,000	
Butler Street PS	Complete pumping station replacement and electrical modifications	1					$760,000						
Commercial Drive PS	Pump replacements and electrical modifications	1	$120,000	$180,000									
Copper Beach PS	Pumping station improvements	1		$15,000				$501,000					
Freedom Drive PS	Complete pump station replacement	1									$780,000		
Haigh Avenue PS	Pumping station improvements	1							$960,000				
Keewaydin Drive PS	Pump replacements, site work, and electrical improvements	1	$10,000			$320,000							
South Policy Street PS	Pump replacements and pumping station modifications	1										$390,000	
Stiles Road PS	Pump replacements, site work, and electrical improvements	1		$15,000		$870,000							
Twinbrook Avenue PS	Pumping station improvements	1								$850,000			
Additional Studies and Evaluations													
Infiltration and Inflow Identification and Removal Program	Additional evaluations in and mitigation projects to target infiltration reductions	1	$200,000	$100,000	$100,000	$100,000	$100,000						
I/I Program Implementation	Implementation Efforts based on the findings of I/I evaluations	2		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
Sewer Rate Study	Additional evaluations to determine appropriate user rates.	1	$15,000	$5,000	$5,000	$15,000	$5,000	$5,000	$15,000	$5,000	$5,000	$15,000	
Sewer System Asset Management Program	Develop an in depth asset management program for the entire wastewater collection system.	2		$30,000	$30,000								
Long Term Sewer Funding Reserve													
Long Term Capital Improvement Program[4]	Annual reserve funding to be set aside for existing asset replacement and future sewer buildout.	2, 3					$600,000	$900,000	$500,000	$600,000	$600,000	$800,000	$1,507,000
		TOTAL[5]	**$545,000**	**$4,045,000**	**$2,035,000**	**$1,305,000**	**$1,465,000**	**$1,406,000**	**$1,475,000**	**$1,455,000**	**$1,385,000**	**$1,425,000**	**$1,507,000**

1. Preliminary costs are for planning purposes only.
2. Further information on specific pumping station projects are provided within the Pumping Station Recommended Projects table
3. South Broadway Sewer costs do not include possible $3M costs for management of limited re-use soils and groundwater to be refined during project design
4. Reserves needed for existing asset replacement and future sewer buildout recommended to be included within Annual CIP
5. Costs are in 2016 dollars.

Table 10-2. Long Term Capital Improvements Considerations.

Project	Notes/References	Priority Ranking	Needed Annual Reserve
Existing System Asset Replacement Program			
Existing Wastewater Asset Replacement Reserves Program	Annual funding program for future wastewater asset replacement including pumping station replacements and collection system replacements.	1	$867,000
		Subtotal	**$867,000**
Future System Buildout Projects			
Lake Street Buildout	Sewage collection system expansion into the Lake Street Basin.	2	$120,000
Arlington Pond and Captains Pond Buildout	Expanding the sewage collection system to include the areas around Arlington Pond and Captains Pond	2	$350,000
Millville Area Buildout Projects	Sewage collection system expansion into the Millville Basin	2	$30,000
Westside Basin Buildout	Sewage collection system expansion into the Westside including the Westside Interceptor	2	$140,000
		Subtotal	**$640,000**
TOTAL*			**$1,507,000**

1. Preliminary costs are for planning purposes only.
*Costs are in 2016 dollars

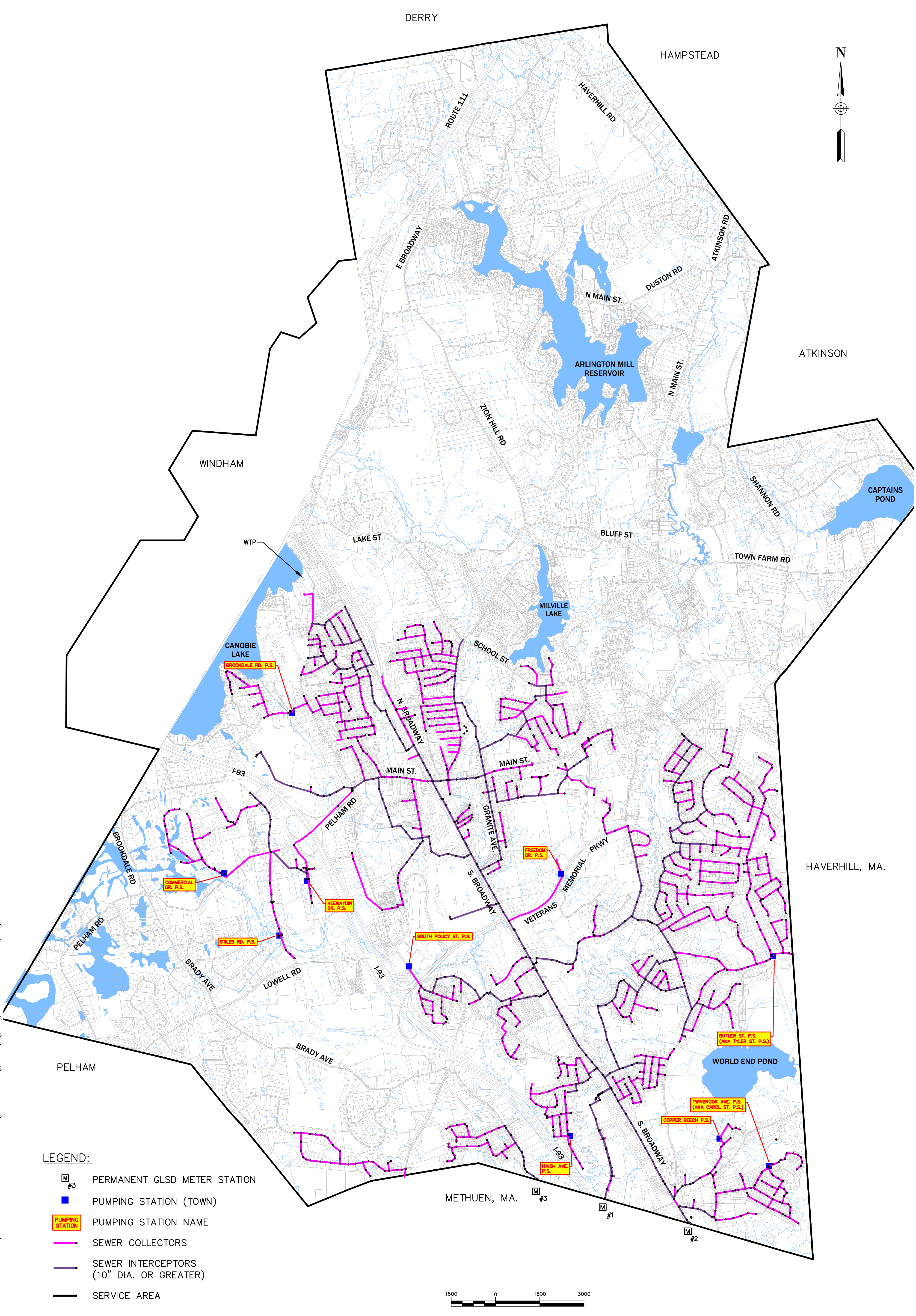
10.3. Funding Sources

Potential funding sources for the CIP program include:

- Revenues: Sewer Rates, System Development Charges (SDC)
- Capital Reserve Funds: Set aside by budget or surpluses.
- Debt: Bonds or State Revolving Funds (SRF)
- Grants: e.g., Asset Management, Source Water Protection

The combination of funding sources that best suits the needs of the Town must be made at the local level.

FIGURES



DATE		EXISTING WASTEWATER COLLECTION SYSTEM	FIG.
4/17	UNDERWOOD engineers	SEWER MASTER PLAN UPDATE	2-2
PROJECT 1984	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	SALEM, NEW HAMPSHIRE	

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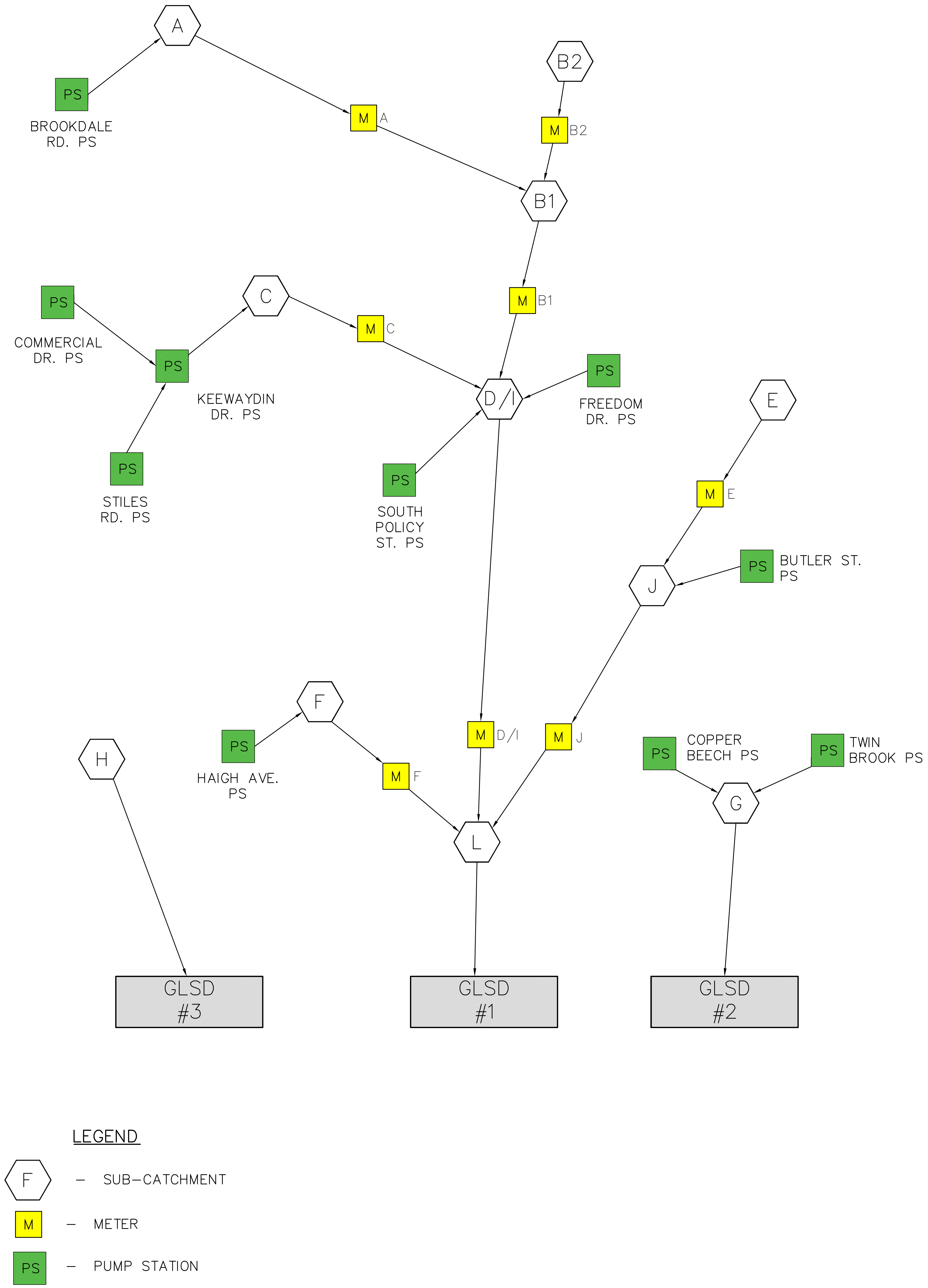
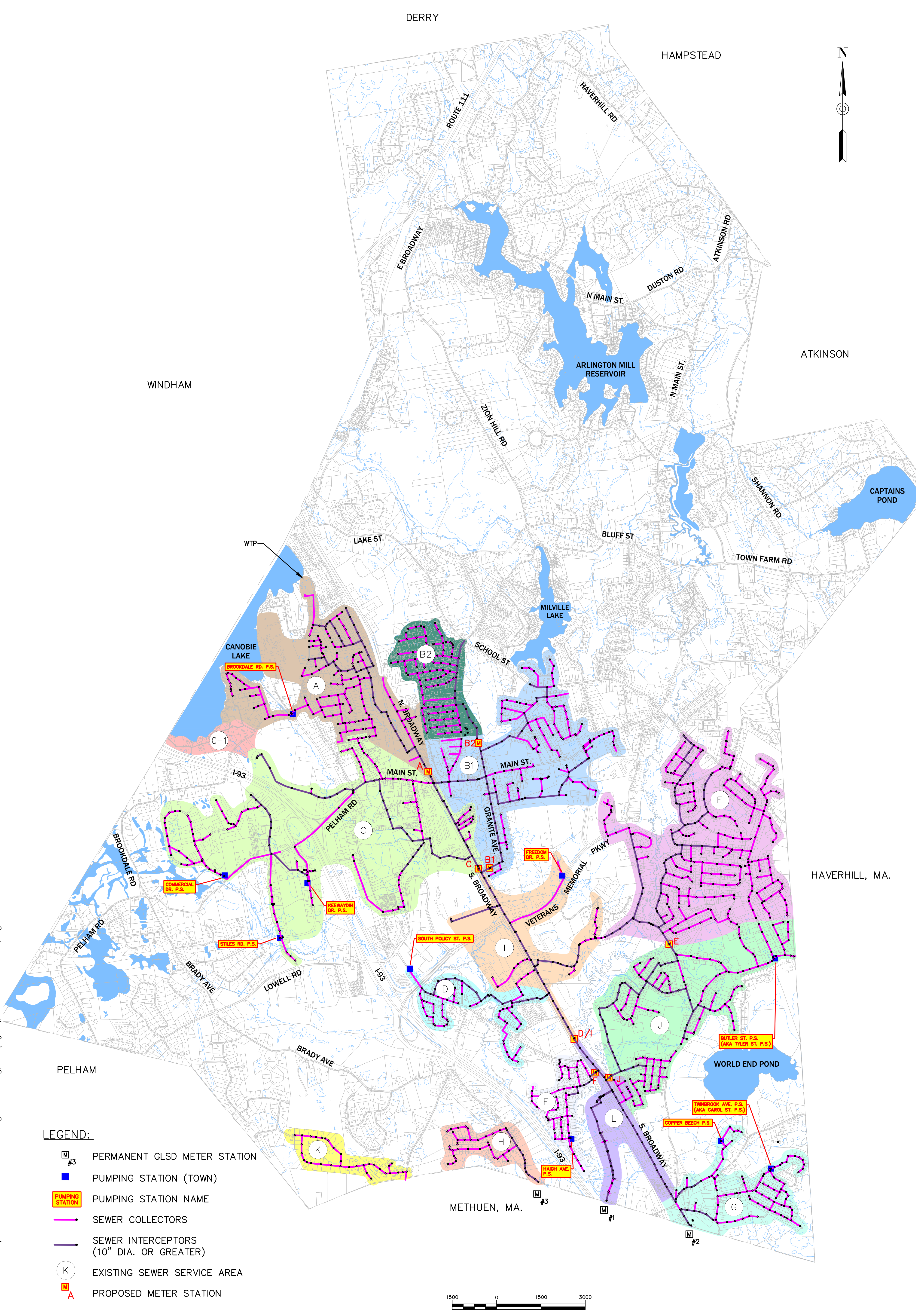
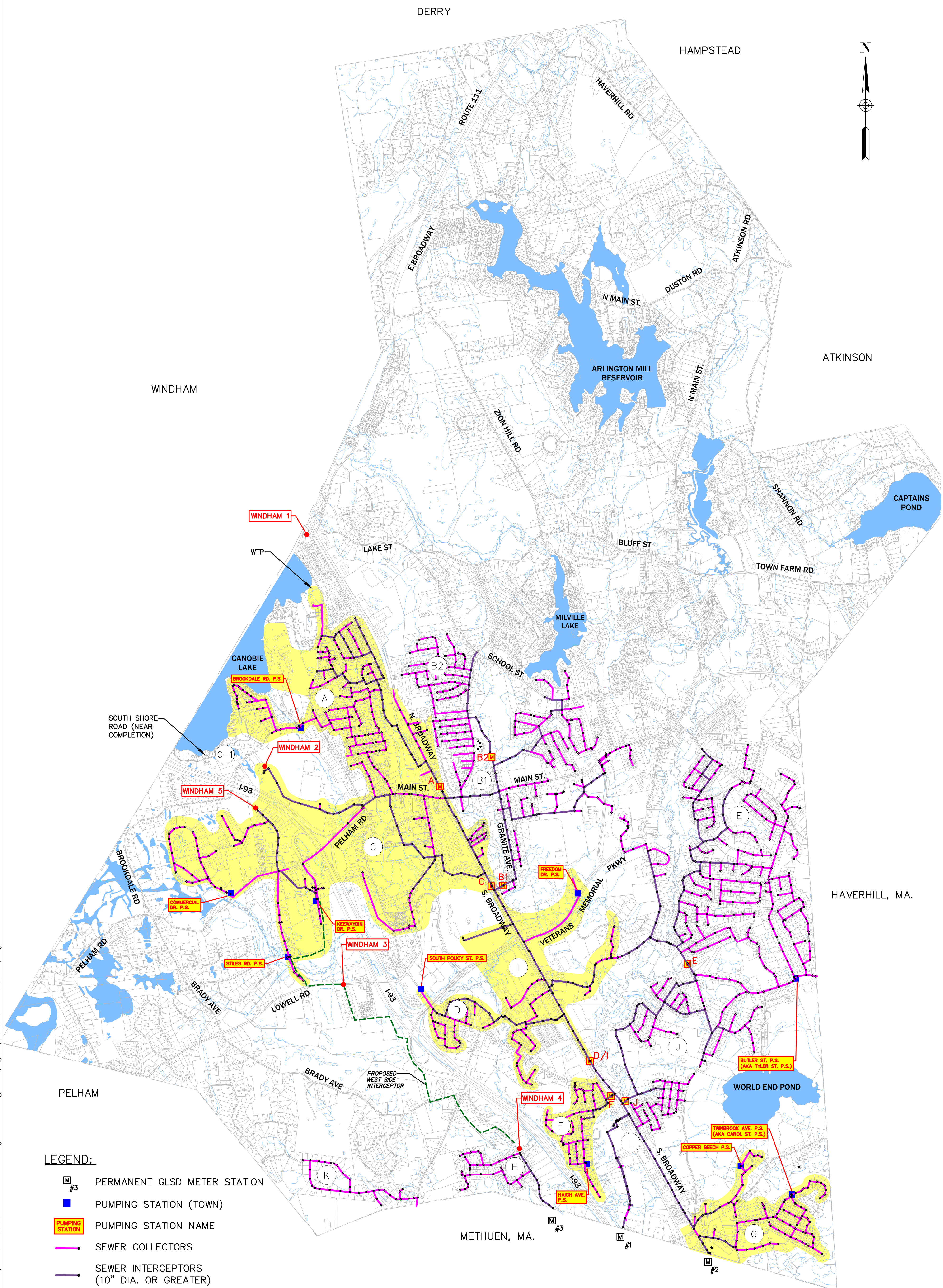


DATE		SEWER SUB–BASIN METER ROUTING SCHEMATIC	FIG.
4/17	UNDERWOOD engineers	SEWER MASTER PLAN UPDATE	5–1
PROJECT	25 Vaughan Mall, Portsmouth, N.H. 03801	SALEM, NEW HAMPSHIRE	
1984	Tel. 603–436–6192 Fax. 603–431–4733		



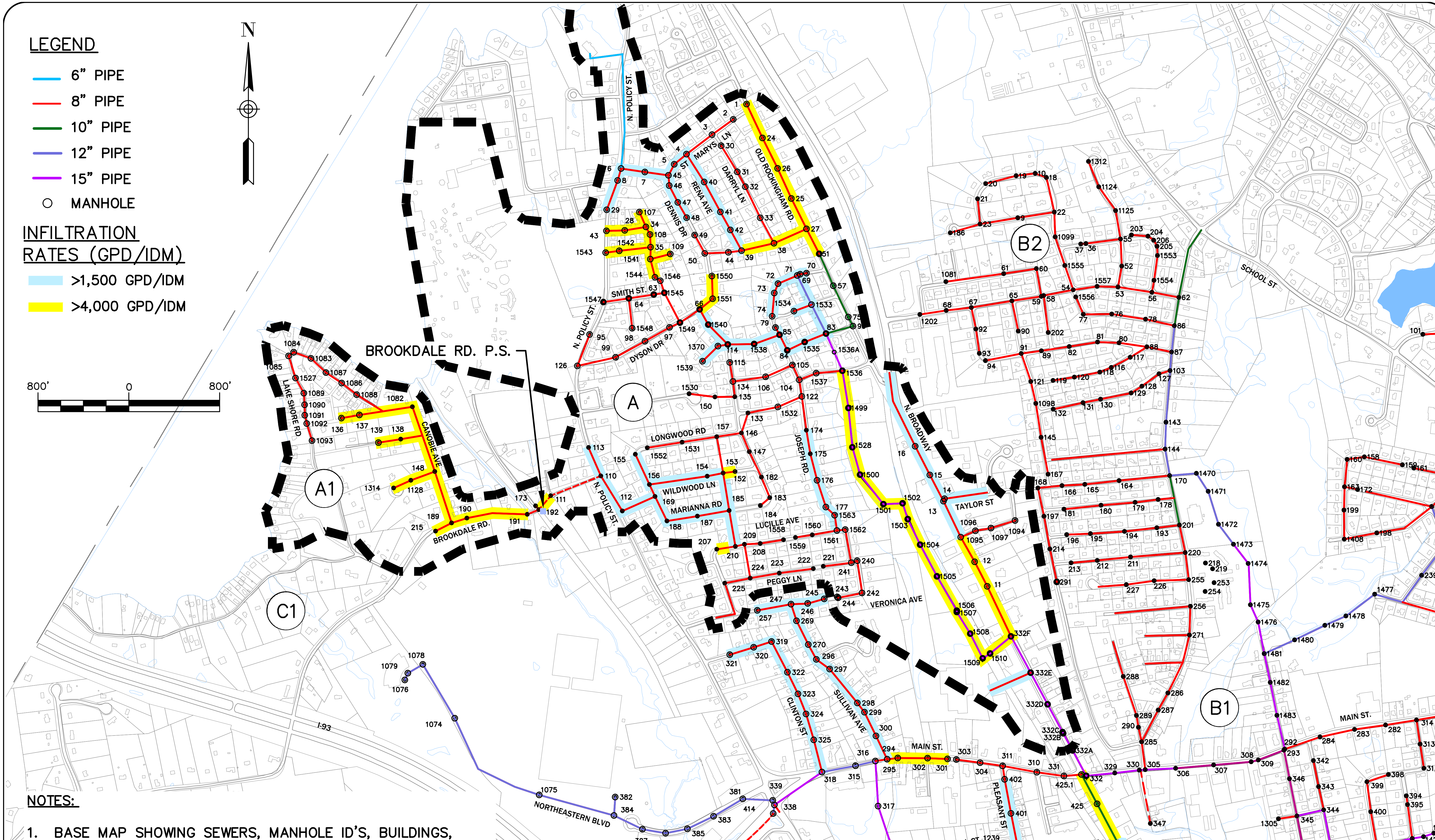
DATE	UNDERWOOD engineers	METERED BASINS	FIG.
4/17	25 Vaughan Mall, Portsmouth, N.H. 03801	SEWER MASTER PLAN UPDATE	5-2
PROJECT	Tel. 603-436-6192 Fax. 603-431-4733	SALEM, NEW HAMPSHIRE	
1984			



LEGEND:

- #3 PERMANENT GLSD METER STATION
- PUMPING STATION (TOWN)
- PUMPING STATION: PUMPING STATION NAME
- SEWER COLLECTORS
- SEWER INTERCEPTORS (10" DIA. OR GREATER)
- FUTURE SEWER (PROPOSED)
- K: EXISTING SEWER SERVICE AREA
- A: METER STATION
- BASINS WITH > 4000 GPD/IDM

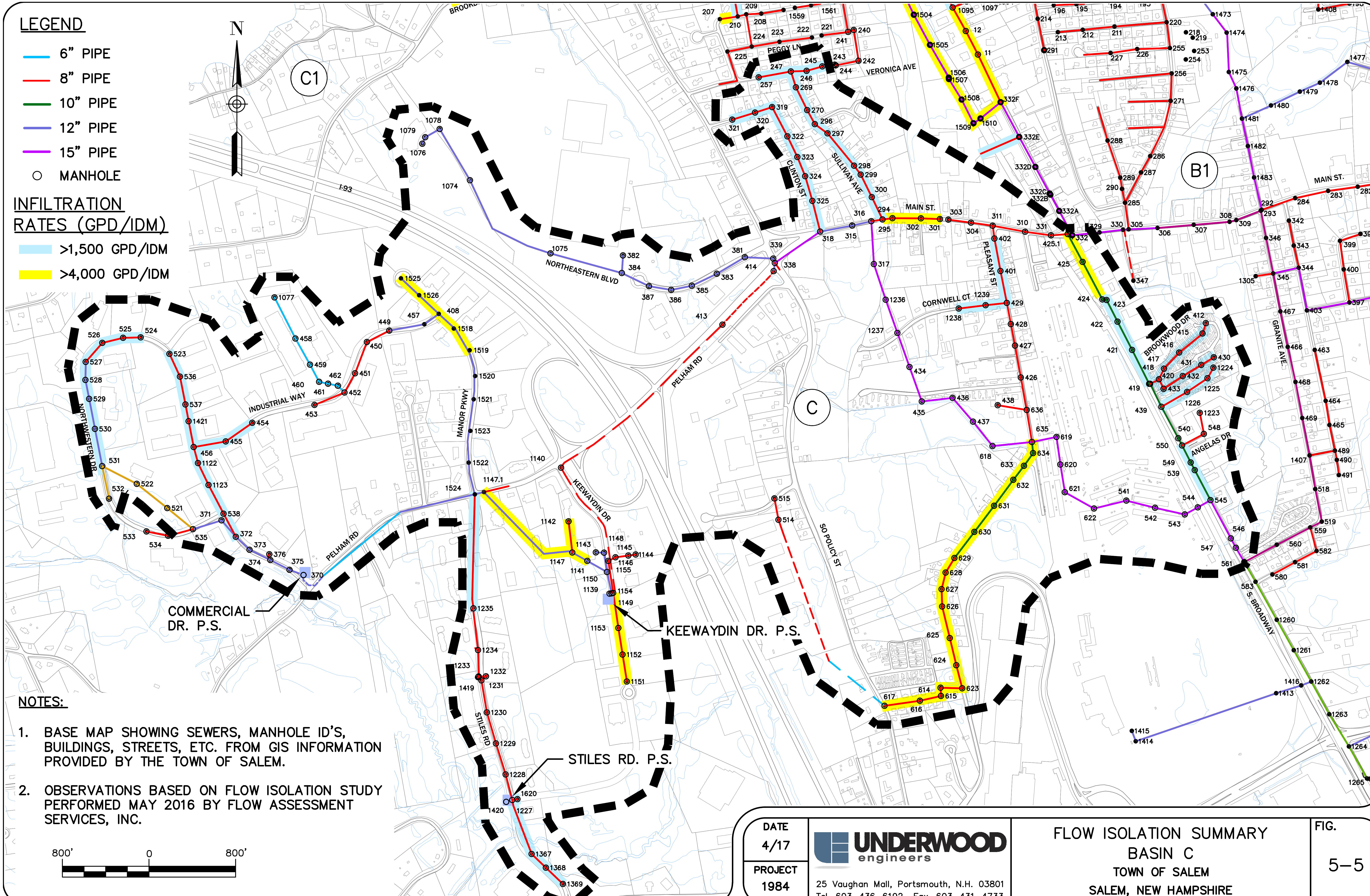
DATE	UNDERWOOD engineers	BASINS WITH EXCESSIVE INFILTRATION	FIG.
4/17			5–3
PROJECT	25 Vaughan Mall, Portsmouth, N.H. 03801	SEWER MASTER PLAN UPDATE	
1984	Tel. 603–436–6192 Fax. 603–431–4733	SALEM, NEW HAMPSHIRE	



NOTES:

1. BASE MAP SHOWING SEWERS, MANHOLE ID'S, BUILDINGS, STREETS, ETC. FROM GIS INFORMATION PROVIDED BY THE TOWN OF SALEM.
2. OBSERVATIONS BASED ON FLOW ISOLATION STUDY PERFORMED MAY 2016 BY FLOW ASSESSMENT SERVICES, INC.

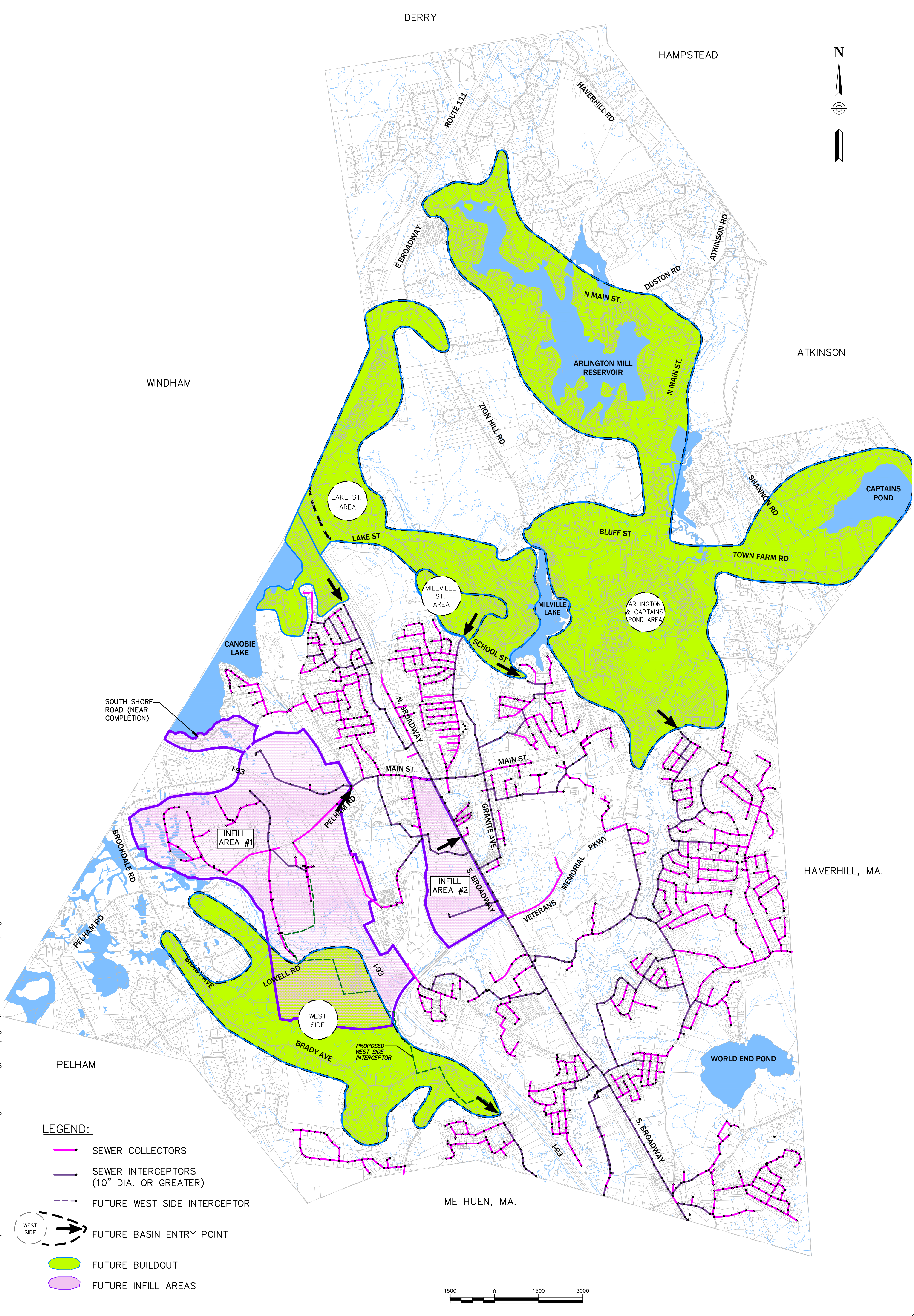
DATE		FLOW ISOLATION SUMMARY	FIG.
4/17	UNDERWOOD engineers	BASIN A	5-4
PROJECT	25 Vaughan Mall, Portsmouth, N.H. 03801	TOWN OF SALEM	
1984	Tel. 603-436-6192 Fax. 603-431-4733	SALEM, NEW HAMPSHIRE	



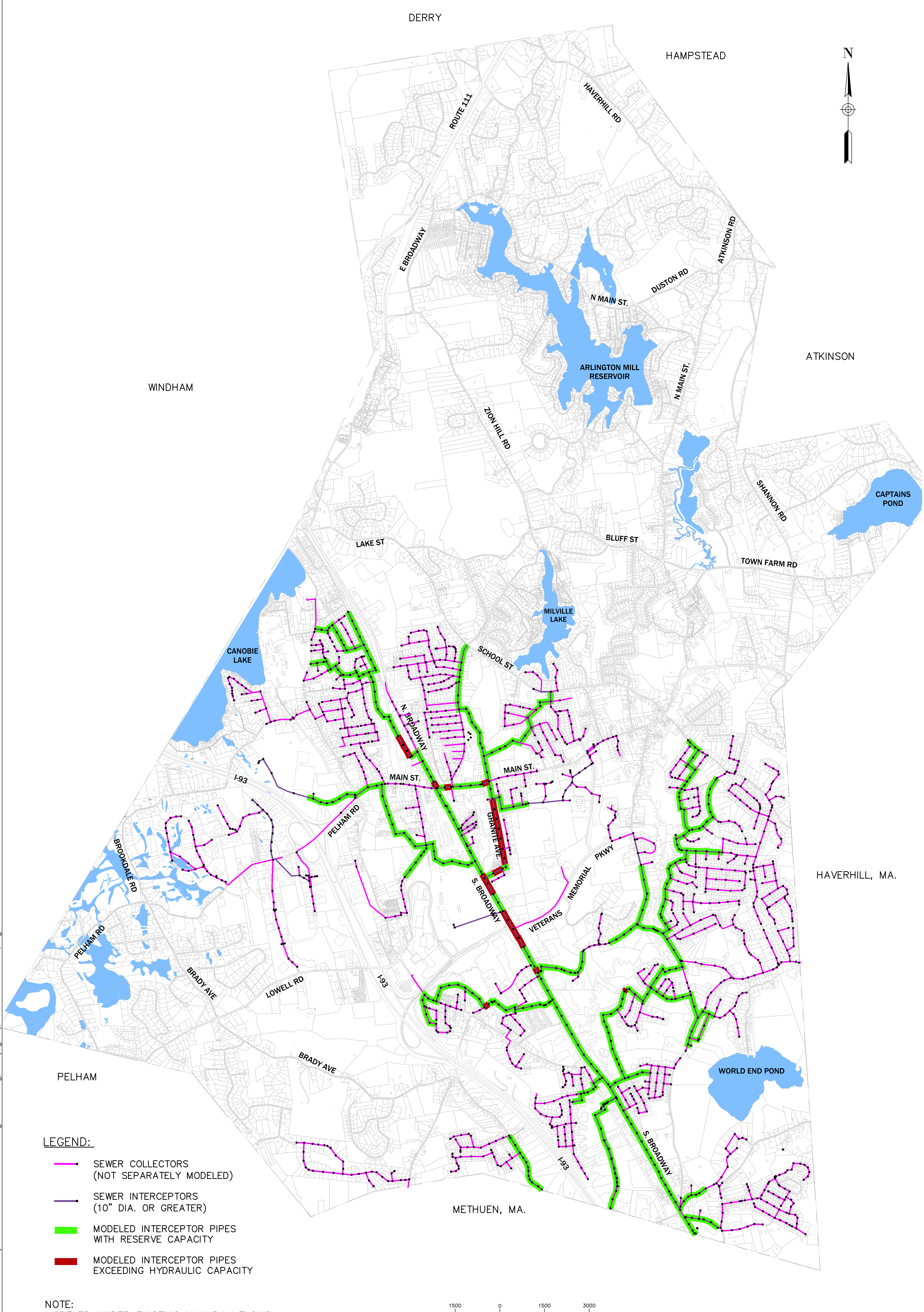
NOTES:

1. BASE MAP SHOWING SEWERS, MANHOLE ID'S, BUILDINGS, STREETS, ETC. FROM GIS INFORMATION PROVIDED BY THE TOWN OF SALEM.
2. OBSERVATIONS BASED ON FLOW ISOLATION STUDY PERFORMED MAY 2016 BY FLOW ASSESSMENT SERVICES, INC.

DATE		FLOW ISOLATION SUMMARY	FIG.
4/17	UNDERWOOD engineers	BASIN C	5-5
PROJECT		TOWN OF SALEM	
1984	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733	SALEM, NEW HAMPSHIRE	



DATE	UNDERWOOD engineers	SEWER PLANNING AREAS	FIG.
4/17			7–1
PROJECT	25 Vaughan Mall, Portsmouth, N.H. 03801	SEWER MASTER PLAN UPDATE	
1984	Tel. 603–436–6192 Fax. 603–431–4733	SALEM, NEW HAMPSHIRE	

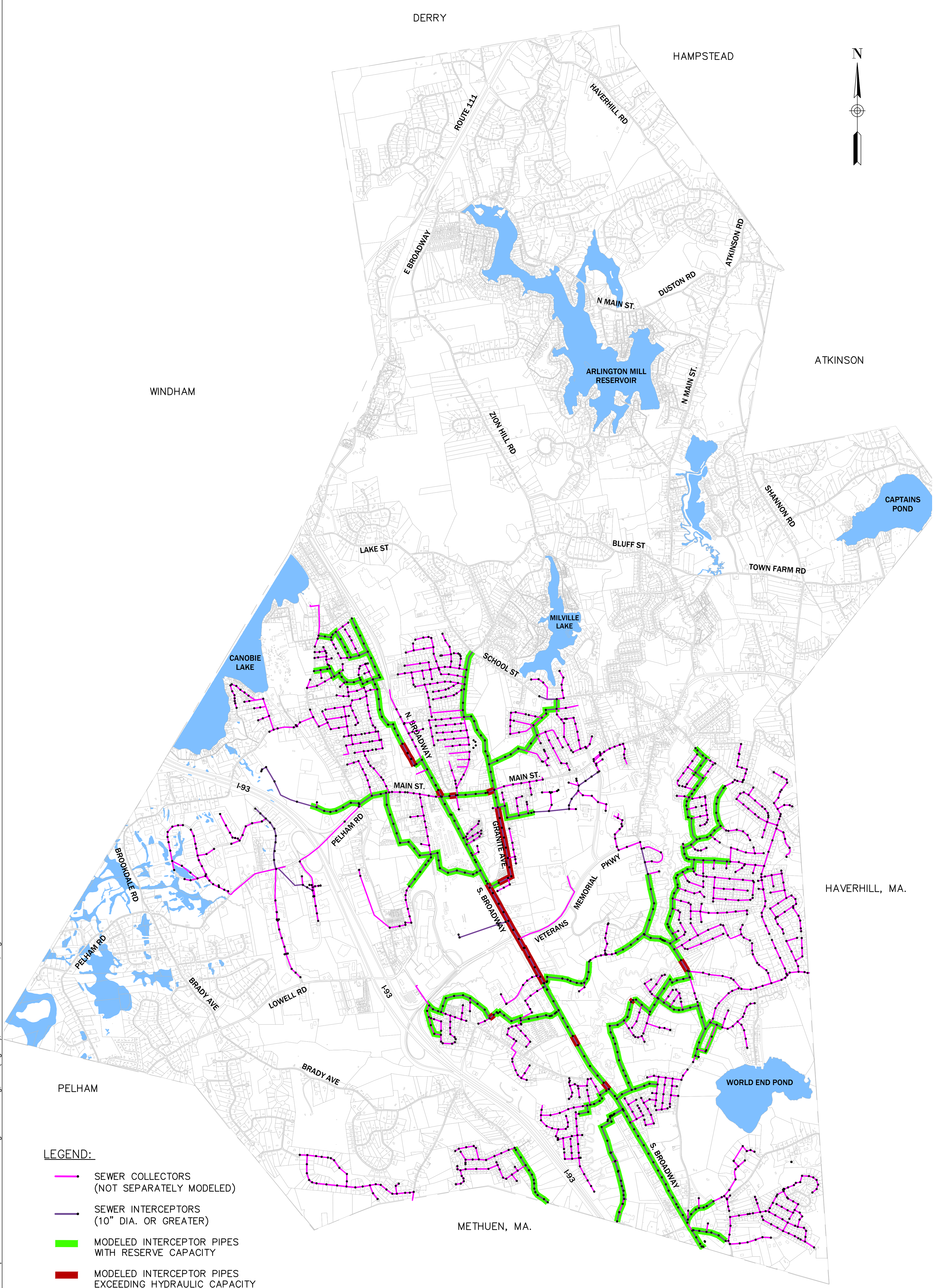


LEGEND:

- SEWER COLLECTORS (NOT SEPARATELY MODELED)
- SEWER INTERCEPTORS (10" DIA. OR GREATER)
- MODELED INTERCEPTOR PIPES WITH RESERVE CAPACITY
- MODELED INTERCEPTOR PIPES EXCEEDING HYDRAULIC CAPACITY

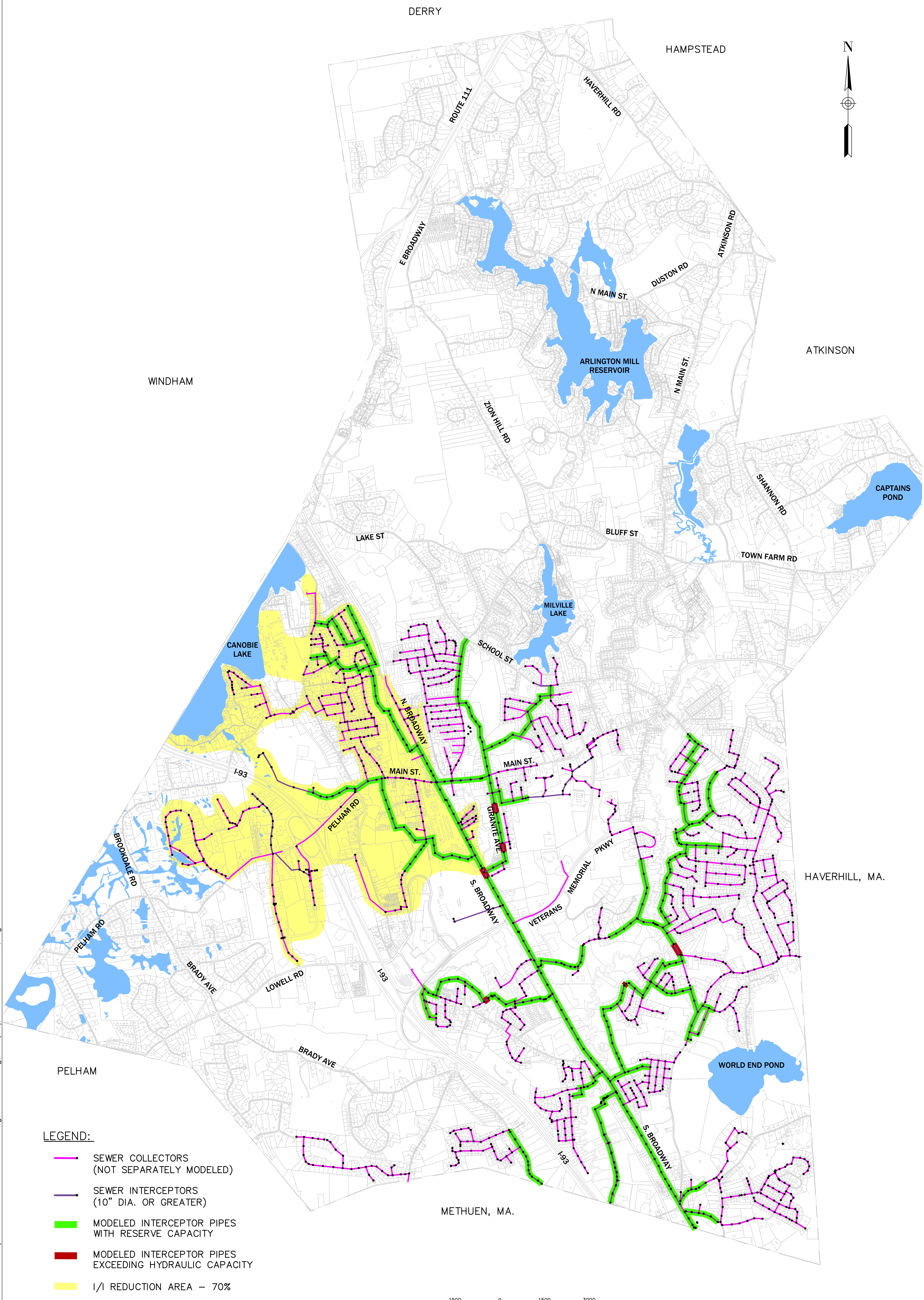
NOTE:
MODELED UNDER EXISTING MAX DAY FLOWS OBSERVED MARCH 31, 2014.

DATE			FIG.
4/17	UNDERWOOD engineers	HYDRAULIC MODEL SUMMARY EXISTING MAX. DAY SEWER MASTER PLAN UPDATE SALEM, NEW HAMPSHIRE	7-2
PROJECT 1984	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733		



NOTE:
MODELED UNDER MAX DAY SCENARIO WITH
FUTURE INFILL AND BUILDOUT.

DATE	UNDERWOOD engineers	HYDRAULIC MODEL SUMMARY MAX DAY W/INFILL & BUILDOUT SEWER MASTER PLAN UPDATE SALEM, NEW HAMPSHIRE	FIG.
4/17			7-3
PROJECT	25 Vaughan Mall, Portsmouth, N.H. 03801 Tel. 603-436-6192 Fax. 603-431-4733		
1984			

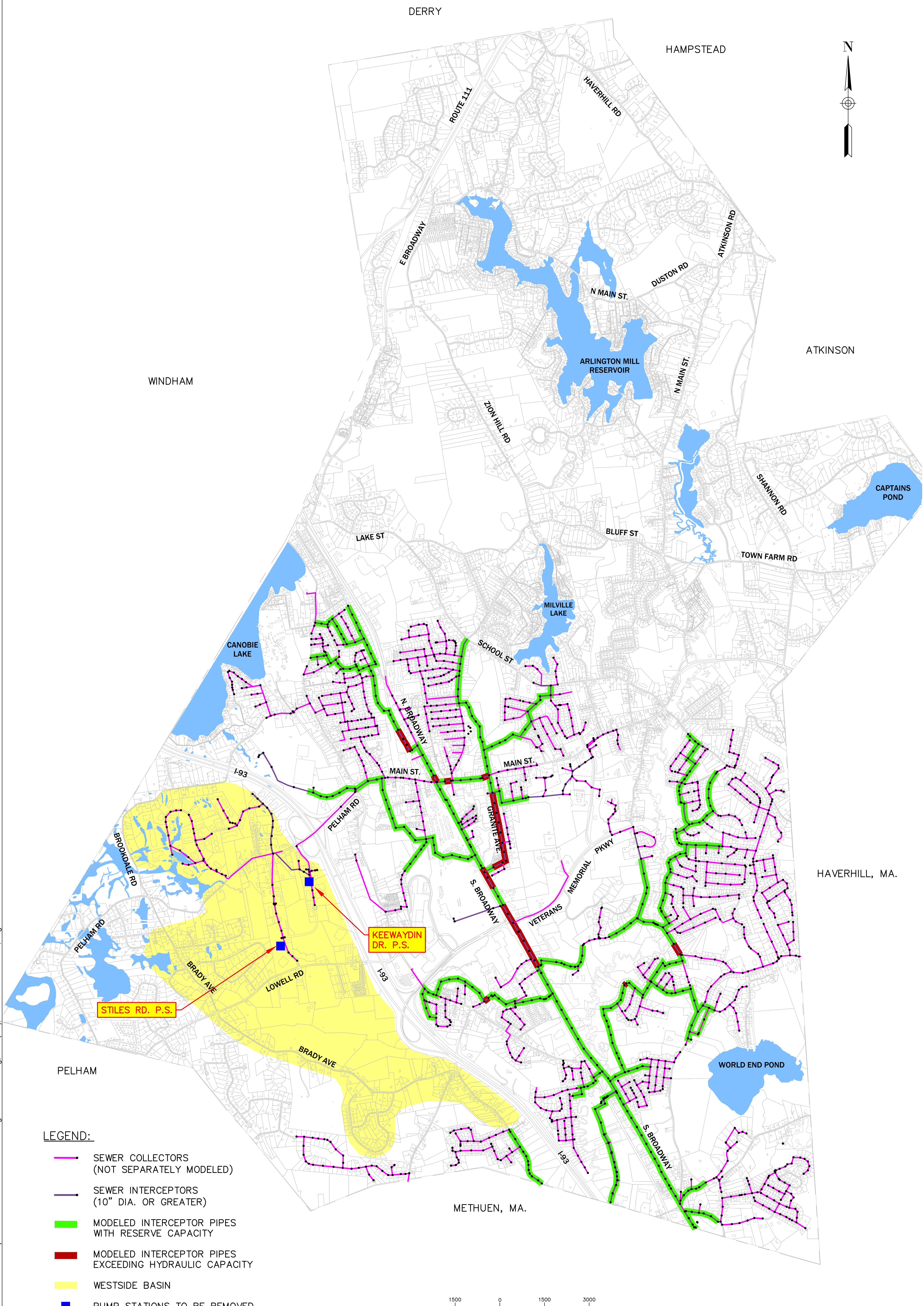


LEGEND:

- SEWER COLLECTORS (NOT SEPARATELY MODELED)
- SEWER INTERCEPTORS (10" DIA. OR GREATER)
- MODELED INTERCEPTOR PIPES WITH RESERVE CAPACITY
- MODELED INTERCEPTOR PIPES EXCEEDING HYDRAULIC CAPACITY
- I/I REDUCTION AREA – 70%

NOTE:
MODELED UNDER MAX DAY SCENARIO WITH FUTURE INFILL AND BUILDOUT.

DATE	UNDERWOOD engineers	ALTERNATIVE #1: I/I REDUCTION	FIG.
1/17			8-1
PROJECT	25 Vaughan Mall, Portsmouth, N.H. 03801	SEWER MASTER PLAN UPDATE	
1984	Tel. 603-436-6192 Fax. 603-431-4733	SALEM, NEW HAMPSHIRE	

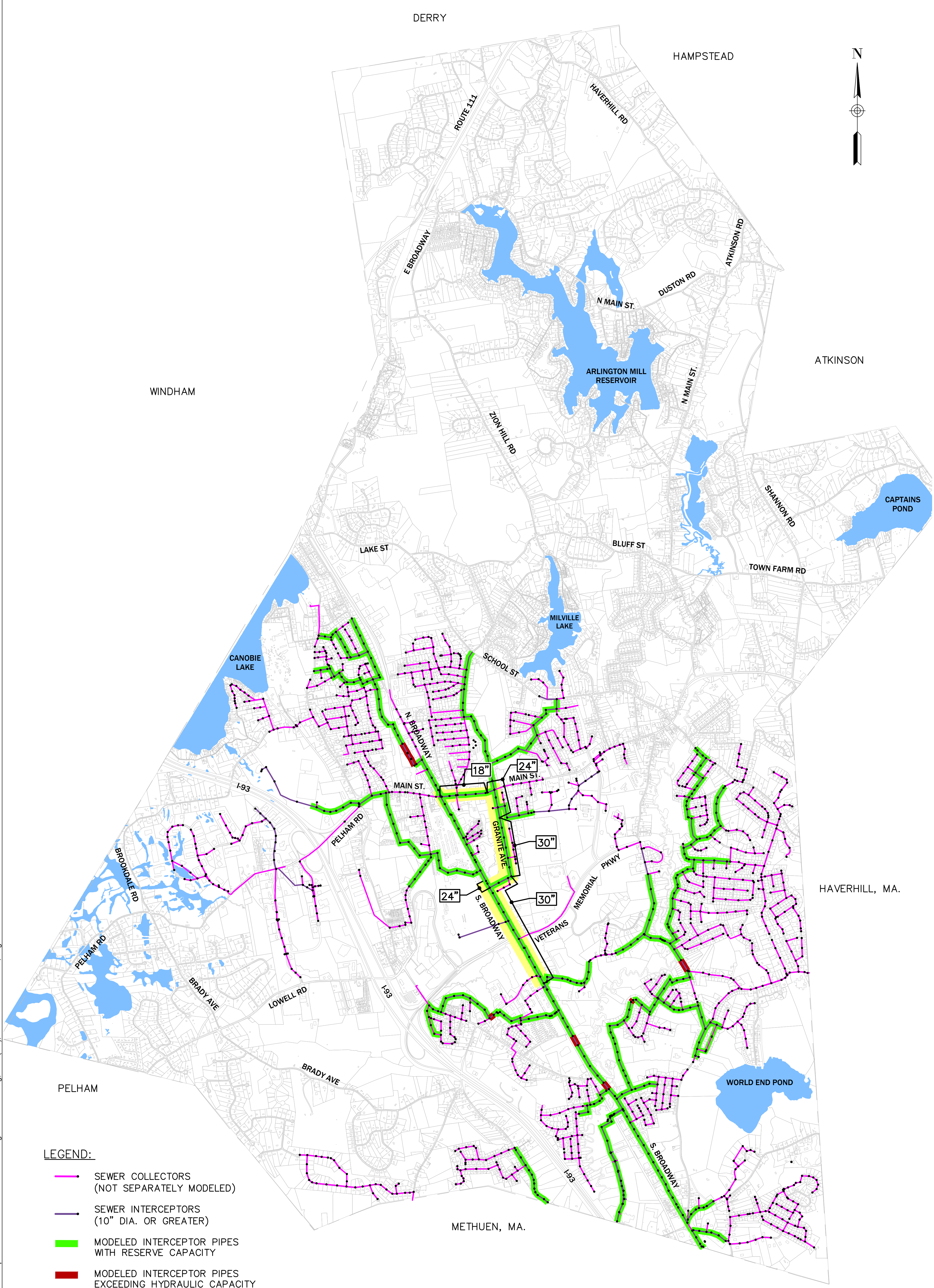


LEGEND:

- SEWER COLLECTORS (NOT SEPARATELY MODELED)
- SEWER INTERCEPTORS (10" DIA. OR GREATER)
- MODELED INTERCEPTOR PIPES WITH RESERVE CAPACITY
- MODELED INTERCEPTOR PIPES EXCEEDING HYDRAULIC CAPACITY
- WESTSIDE BASIN
- PUMP STATIONS TO BE REMOVED

NOTE:
MODELED UNDER MAX DAY SCENARIO WITH FUTURE INFILL AND BUILDOUT.

DATE	UNDERWOOD engineers	ALTERNATIVE #2: WESTSIDE INTERCEPTOR	FIG.
4/17	25 Vaughan Mall, Portsmouth, N.H. 03801	SEWER MASTER PLAN UPDATE	8-2
PROJECT 1984	Tel. 603-436-6192 Fax. 603-431-4733	SALEM, NEW HAMPSHIRE	



NOTE:
MODELED UNDER MAX DAY SCENARIO WITH FUTURE INFILL AND BUILDOUT.

DATE	UNDERWOOD engineers	ALTERNATIVE #3: GRANITE AVENUE & SO. BROADWAY SEWER REPLACEMENT	FIG.
4/17		SEWER MASTER PLAN UPDATE	8–3
PROJECT	25 Vaughan Mall, Portsmouth, N.H. 03801	SALEM, NEW HAMPSHIRE	
1984	Tel. 603–436–6192 Fax. 603–431–4733		

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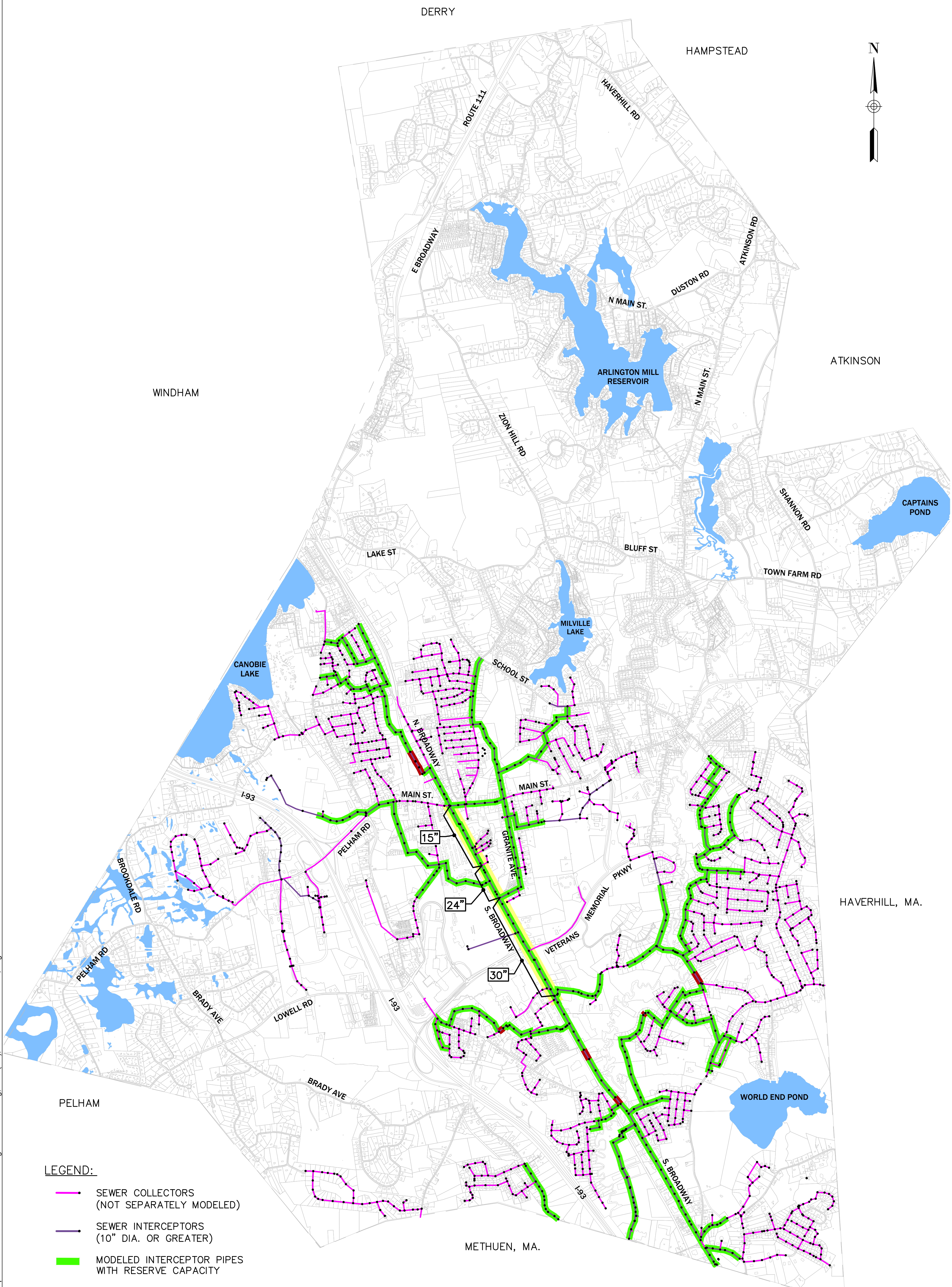

LEGEND:

- SEWER COLLECTORS (NOT SEPARATELY MODELED)
- SEWER INTERCEPTORS (10" DIA. OR GREATER)
- MODELED INTERCEPTOR PIPES WITH RESERVE CAPACITY
- MODELED INTERCEPTOR PIPES EXCEEDING HYDRAULIC CAPACITY
- SEWER REPLACEMENT AREA

NOTE:
MODELED UNDER MAX DAY SCENARIO WITH FUTURE INFILL AND BUILDOUT.

DATE	UNDERWOOD engineers	ALTERNATIVE #4: SOUTH BROADWAY SEWER REPLACEMENT	FIG.
4/17	25 Vaughan Mall, Portsmouth, N.H. 03801	SEWER MASTER PLAN UPDATE	8-4
PROJECT 1984	Tel. 603-436-6192 Fax. 603-431-4733	SALEM, NEW HAMPSHIRE	

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