NEW ENGLAND CIVIL ENGINEERING CORP.

120 WASHINGTON STREET, SUITE 202E, P.O. BOX 3026, SALEM, MA 01970
PH: 978.741.7401 - FAX: 978.741.7402 – WWW.ENGINEERINGCORPORATION.COM

# HYDRAULIC MODEL BUILD AND ANALYSIS
# HOOD FARM ROAD SERVICE AREA

## IPSWICH WATER DEPARTMENT

**July, 2018**

# TABLE OF CONTENTS


| Letter Report | Pages |
|---|---|
| Executive Summary (Letter) | (1-4) |

| Tables | Table Number |
|---|---|
| Hydraulic Analysis - Options | (1) |
| Cost to Benefit Analysis Maps | (2) |
| Alternate Flushing Locations Results | (3) |

| Maps | Map Number |
|---|---|
| Hood Farm Road Area, Skeletal Hydraulic Model | (1) |
| Existing Ipswich Water System | (1A) |
| Options 1, 1A, 1B, and 1C | (2) |
| Options 2A, 2B, and 2C | (3) |
| Options 3 and 4 | (4) |
| Alternate Hydrant Flushing Locations | (5) |

NEW CIVIL ENGINEERING CORP.

120 WASHINGTON STREET, SUITE 202E, P.O. BOX 3026, SALEM, MA 01970
PH: 978.741.7401 - FAX: 978.741.7402 – WWW.ENGINEERINGCORPORATION.COM

July 13, 2018

Vicki Halmen
Water and Wastewater Manager
Ipswich Water Department
272 High Street, P.O. Box 151
Ipswich, MA 01938

Re: Results from Hydraulic Model Build and Analysis (Addenda 1)
Water Distribution System, Hood Farm Road and Abbott Lane Neighborhood

Dear Vicki,

We appreciated the opportunity to meet with you on July 12, 2018 to review the draft modeling letter report submitted on January 30, 2018. As discussed, the modeling report summarizes the results of hydraulic model simulations to evaluate alternatives to improve the service pressures in the Hood Farm Road and Abbott Lane neighborhoods during periods of high flows or hydrant flushing.
We have prepared this revised letter report (Addenda 1) to include simulations of additional hydrant flushing scenarios and their predicted impacts on the Hood Farm neighborhood.

The Letter Report includes evaluation of various upgrades to the water distribution system including installing a check valve at Hood Farm road, replacing or relining sections of water main, extending water mains to create loops in the distribution system, and installing a storage tank to serve the distribution system West of Route 1.

The model simulations are based on data collected during hydrant flushing completed in April of 2017 in various locations on Boxford Road and side streets West of the Linebrook Road intersection.

Baseline Conditions:
The baseline conditions for this analysis included the existing conditions for the entire water system in Ipswich. Existing conditions were updated to include water work that was performed after the most recent iteration of the hydraulic model was made. This update also expanded the hydraulic model to include all of Ipswich. Demands were redistributed among the added pipe nodes in the model to the west of Route 1. Jeffrey's Neck Road and Linebrook Road water mains were updated to reflect recent updates to the water main. In addition to these changes, roughness coefficients for pipe materials were adjusted to reflect updated mapping and known age of pipe where applicable. Without establishing specific pipe roughness for individual pipe segments, the model utilizes the same roughness coefficient for all pipes of the same material and relative age:

| Pipe Material | Roughness Coefficient |
|---|---|
| Ductile Iron (Older) | 108 |
| Ductile Iron (New) | 118 |
| Cast Iron | 75 |
| Cast Iron (Lined) | 117 |
| Asbestos Cement | 110 |
| PVC | 120 |
| Unknown | 100 |

Modeled Options:
The options below include several scenarios to increase water pressure at the end of Boxford Road and the streets adjacent to Boxford Road including, but not limited to, Hood Farm Road, Newbury Road, and Oakwood Knoll Road. The options incorporated system loops and/or upgrades that may provide additional benefit to other parts of the distribution system. Each of the options described below is proposed to improve static pressures and residual pressures in the Hood Farm Road service area during fire flow conditions. Pressure was analyzed at 5 locations within the model; at the end of Hood Farm Road, in the middle of Hood Farm Road, at the intersection of Linebrook Road and Newbury Road, at the end of Oak Knoll Road, and at the intersection of Route 1 and Linebrook Road. Fire flows were simulated at a hydrant node on Boxford Road between Linebrook Road and Hood Farm Road (See Maps 1 and 1A).

Option 1 includes the installation of a check valve at the end of Hood Farm Road or check valves on individual properties on Hood Farm Road. (Refer to Map 2)

Option 1A includes cleaning and cement lining 4,600 feet of 8-inch main from Howe Street to Route 1. (Refer to Map 2)

Option 1B includes cleaning and cement lining 6,600 feet of 8-inch main from Route 1 to Newbury Road. (Refer to Map 2)

Option 1C is modeled as a combination of Options 1A and 1B; cleaning and lining 11,200 feet of 8-inch main from Howe Street to Newbury Road. (Refer to Map 2)

Option 2A includes installing 4,600 feet of new 12-inch ductile iron main from Howe Street to Route 1. (Refer to Map 3)

Option 2B includes installing 6,600 feet of new 12-inch ductile iron main from Route 1 to Newbury Road. (Refer to Map 3)

Option 2C is modeled as a combination of Options 2A and 2B; installing 11,200 feet of new 12-inch ductile iron main from Howe Street to Newbury Road. (Refer to Map 3)

Option 3 includes installing 700 feet of new 8-inch ductile iron main; connecting Oak Knoll Road and Howard Road. (Refer to Map 4)

Option 4 is modeled as Option 3 with the addition of a new water tank installed between Oak Knoll Road and Howard Road. The proposed tank was input at an elevation of 197 feet, initial level set to 50, max level set to 70, and a 35 foot diameter. (Refer to Map 4)

In addition to these options; two different flushing locations were tested to analyze how these locations affected our simulation points. One flushing location was on Pond Edge Lane. This scenario was run with all pipes open in the system and run again but with the Pond Edge Lane loop closed to our simulation points. The second flushing location was on Linebrook Road at the intersection of Lillian. This scenario was run with all pipes open in the system and run again with the Linebrook branch closed off. (Refer to Map 5)

Results:

We modeled multiple scenarios including average summer and fire flow conditions. For the purposes of comparing the options described above, we ran the model to simulate high flow conditions when low pressure problems are the most likely in the western part of the system.

These model outputs assume the Pinefield tank is at 74', both the Mile Lane well and booster pumps are on, and the water treatment facility is off during these simulations.

Static pressure for each condition and each option is provided on Table 1. Hydrant flushing or fire flows were simulated by applying a demand of 500 gallons per minute was modeled at the selected hydrant node, to represent the location where flushing took place in April 2017. Pressures during fire flows during baseline conditions and each option are summarized on the attached tables 1 and 2.

During Average Daily Flow Conditions:

Almost every option results in a slight increase in static pressures during average daily flow conditions. Options 1A, 1B, 1C, 2A, 2B, and 2C result in significant increase in pressure during fire flow conditions; with option 2C yielding the greatest increase of 46psi. Option 1 would result in a nominal decrease in static pressures due to friction loss through the check valve (1-2 psi depending on the make and model). Option 3 results in a negligible increase in static pressures and a 5-6 psi increase during fire flows. Option 4 results in a decrease in static pressures and a high of 43.6 psi increase during fire flows. This static pressure decrease is the result of the model filling the proposed tank, resulting in a drop in overall static pressure.

Option 1 did not result in any residual pressure increase during fire flow conditions (1-hour extended flushing scenario), but it is anticipated that a common check valve in this location, or individual check valves on buildings of concern, would provide short-term relief during short-term flushing occurrences,

and would prevent any negative pressure conditions from being experienced at the higher elevations in the neighborhood.

The two modified flushing scenarios with different flushing locations improved pressures at the simulation points when the distribution system loops were closed, refer to predicted results in Table 3. We recommend the Town incorporate this modified approach when flushing hydrants between Route 1 and the Linebrook/Pillowlace intersection in the future to reduce the impact to Hood Farm neighborhood. This approach will also enable data to be collected to complete C-factor testing on each leg of the distribution system loop to improve the hydraulic model inputs.

Cost Analysis:
In an effort to provide a cost-to-benefit analysis of the options we factored the project cost and potential benefits during average daily and fire flows and presented the results on Table 2.

Project Cost estimates were developed from a weighted per-foot average using a 2016-2017 water lining project and a 2013 Ipswich water main replacement project.

Based on the dollars per benefit (static pressure and fire flow gpm) we found that Options 1A and 2A were "more cost-effective" in terms of relative cost-to-benefit of the options.

Recommendation:
We recommend the Town pursue installation of check valves on individual properties who experience low or negative pressures in the Hood Farm neighborhood during flushing operations, or in a structure at the lower end of Hood Farm Road to serve the neighborhood. Option 1 will only provide short-term relief from pressure drops during short-term flushing, but should prevent negative pressures from being experienced at the high points, and is the least expensive option. If the check valves are installed on private plumbing instead of in a structure in the street, the cost to the Town would be significantly less than the estimate provided on Table 2.

Both Option 1A and 2A provide comparable results per dollar spent. Option 2A, although relatively cost-effective in terms of results, would require installing new water main underneath a freshly paved Linebrook Road. Option 1A provides very similar results, while eliminating most of the excavation within the road by simply lining the existing main. Option 3 is the least expensive of the construction options but does not result in a significant improvement when not combined with Option 4.

If you have any questions or require additional information, please do not hesitate to contact me at any time on my cell phone at 978-767-5415 or at our Salem office at 978-741-7401. We thank you for the opportunity to work with the Town of Ipswich and look forward to developing a successful and rewarding partnership moving forward.

Sincerely,

William M. Ross, P.E.
Project Manager
New England Civil Engineering Corp.
attachments

Ipswich Water Department
Boxford Road Area Water, Model Projections
12/13/2017

| Results Key |
|---|
| Positive Change |
| Negative Change |
| Very Little Change |

**TABLE 1**

Static Pressure (psi, Summer Flow: Average Day)

| Node # | Description | Existing | CI Pipe Revision | | Cleaning and Lining | | | | | | New 12" DI Pipe | | | | | | Loop and Tank | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Option 1A | | Option 1B | | Option 1C | | Option 2A | | Option 2B | | Option 2C | | Option 3 | | Option 4 | |
| | | Avg Day | Avg Day | Difference | Avg Day | Difference | Avg Day | Difference | Avg Day | Difference | Avg Day | Difference | Avg Day | Difference | Avg Day | Difference | Avg Day | Difference | Avg Day | Difference |
| 627 | End of Hood Farm Road | 67.9 | 67.5 | -0.5 | 68.6 | 1.1 | 67.6 | 0.1 | 68.8 | 1.3 | 69.5 | 2.0 | 67.8 | 0.3 | 69.8 | 2.3 | 67.6 | 0.1 | 61.9 | -5.6 |
| 630 | Middle of Hood Farm Road | 74.9 | 74.4 | -0.5 | 75.6 | 1.2 | 74.6 | 0.2 | 75.7 | 1.3 | 76.4 | 2.0 | 74.7 | 0.3 | 76.7 | 2.3 | 74.5 | 0.1 | 68.8 | -5.6 |
| 609 | Linebrook at Newbury Road | 76.7 | 76.3 | -0.4 | 77.5 | 1.2 | 76.5 | 0.2 | 77.6 | 1.3 | 78.3 | 2.0 | 76.7 | 0.3 | 78.6 | 2.3 | 76.4 | 0.1 | 70.8 | -5.6 |
| 655 | End of Oakwood Knoll Road | 57.2 | 56.8 | -0.4 | 58.0 | 1.2 | 57.0 | 0.1 | 58.1 | 1.3 | 58.8 | 2.0 | 57.2 | 0.3 | 59.1 | 2.3 | 56.9 | 0.1 | 51.1 | -5.7 |
| 500 | Rte 1 at Linebrook | 80.1 | 79.8 | -0.3 | 80.9 | 1.1 | 79.8 | 0.0 | 80.9 | 1.1 | 81.7 | 2.0 | 79.8 | 0.0 | 81.7 | 2.0 | 79.8 | 0.0 | 75.2 | -4.6 |

Residual Pressures for Fire Flow (500 GPM) at J749 (Boxford Road)

| | | Existing | CI Pipe Revision | | Cleaning and Lining | | | | | | New 12" DI Pipe | | | | | | Loop and Tank | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Option 1A | | Option 1B | | Option 1C | | Option 2A | | Option 2B | | Option 2C | | Option 3 | | Option 4 | |
| | | Fire Flow | Fire Flow | Difference | Fire Flow | Difference | Fire Flow | Difference | Fire Flow | Difference | Fire Flow | Difference | Fire Flow | Difference | Fire Flow | Difference | Fire Flow | Difference | Fire Flow | Difference |
| **627** | **End of Hood Farm Road** | 19.6 | 5.2 | -14.4 | 22.6 | 17.4 | 10.8 | 5.6 | 29.7 | 24.5 | 35.8 | 30.7 | 17.7 | 12.5 | 49.9 | 44.7 | 9.0 | 3.8 | 44.7 | 39.5 |
| 630 | Middle of Hood Farm Road | 28.7 | 12.1 | -16.6 | 29.5 | 17.4 | 17.7 | 5.6 | 36.6 | 24.5 | 42.8 | 30.7 | 24.7 | 12.6 | 56.8 | 44.7 | 15.9 | 3.8 | 51.6 | 39.5 |
| 609 | Linebrook at Newbury Road | 40.2 | 26.3 | -13.9 | 45.6 | 19.4 | 33.8 | 7.5 | 52.7 | 26.4 | 58.9 | 32.6 | 40.7 | 14.5 | 72.9 | 46.6 | 32.0 | 5.7 | 67.7 | 41.5 |
| 655 | End of Oakwood Knoll Road | 20.7 | 6.8 | -13.9 | 26.1 | 19.4 | 14.3 | 7.6 | 33.2 | 26.5 | 39.4 | 32.6 | 21.2 | 14.5 | 53.4 | 46.6 | 13.5 | 6.7 | 50.8 | 44.1 |
| 500 | Rte 1 at Linebrook | 55.9 | 45.7 | -10.2 | 64.7 | 19.0 | 45.8 | 0.1 | 64.7 | 19.0 | 78.0 | 32.3 | 45.8 | 0.1 | 78.0 | 32.3 | 45.8 | 0.1 | 74.1 | 28.4 |

**TABLE 2**

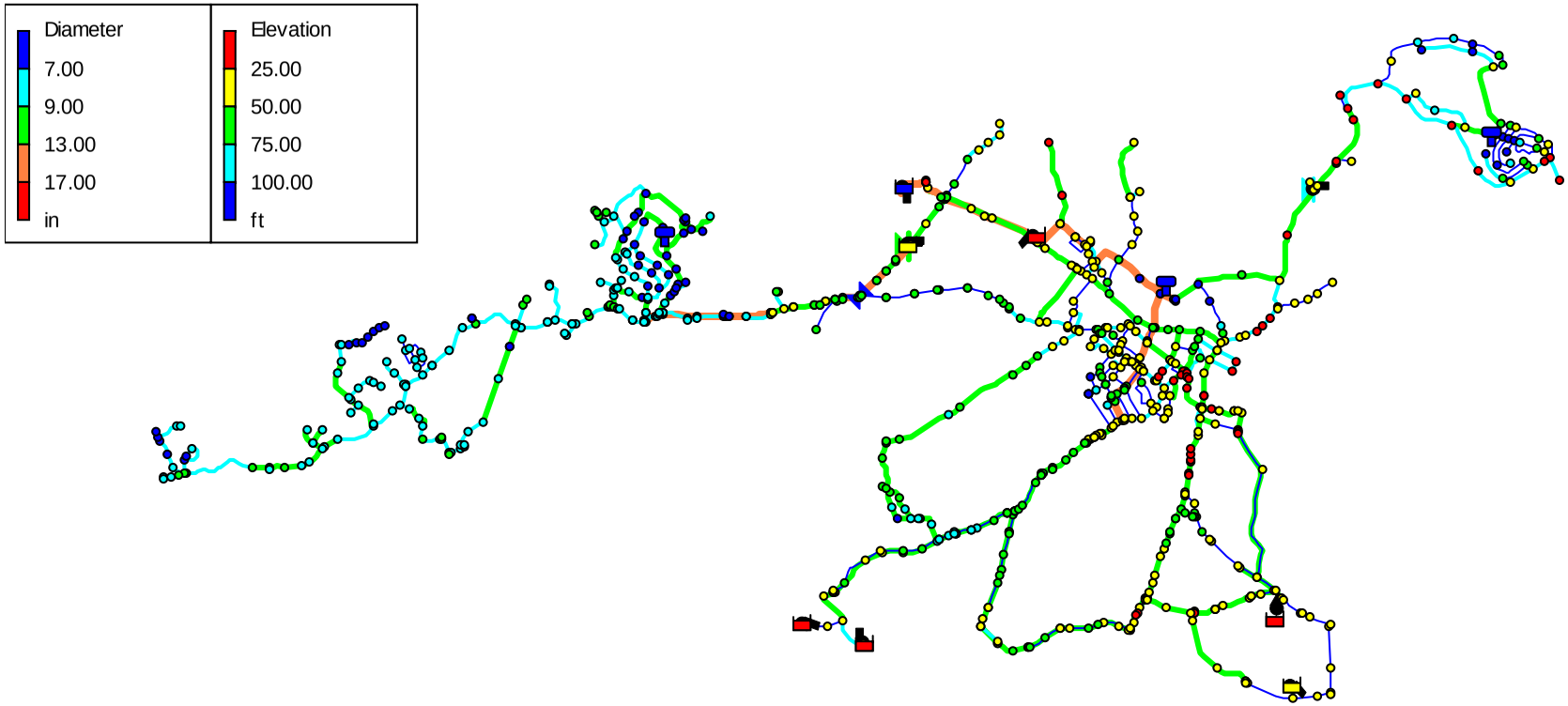
| Project Cost Estimate ($) | Unit Price | Option 1 | Option 1A (4600 FT) | Option 1B (6600 FT) | Option 1C (1A + 1B) | Option 2A (4600 FT) | Option 2B (6600 FT) | Option 2C (2A +2B) | Option 3 (700 FT) | Option 4 |
|---|---|---|---|---|---|---|---|---|---|---|
| C&L 8-inch (per LF) | $125.00 | | $575,000.00 | $825,000.00 | $1,400,000.00 | | | | | |
| New 12-inch DI (per LF) | $200.00 | | | | | $920,000.00 | $1,320,000.00 | $2,240,000.00 | | |
| New 8-inch DI (per LF) | $200.00 | | | | | | | | $140,000.00 | $140,000.00 |
| New Tank | $1,000,000.00 | | | | | | | | | $1,000,000.00 |
| Mill and Overlay (per SY) | $20.00 | | | | | $245,333.33 | $352,000.00 | $597,333.33 | | |
| Private Cheack Valves | TBD | | | | | | | | | |
| Total Project Cost | | $40,000.00 | $575,000.00 | $825,000.00 | $1,400,000.00 | $1,165,333.33 | $1,672,000.00 | $2,837,333.33 | $140,000.00 | $1,140,000.00 |
| Using End of Hood Farm Road (627) as Control | | | | | | | | | | |
| $ per psi fireflow increase, avg. day | | N/A | $33,027.00 | $147,321.43 | $57,142.86 | $38,020.66 | $133,333.33 | $63,489.22 | $37,037.04 | $28,831.56 |

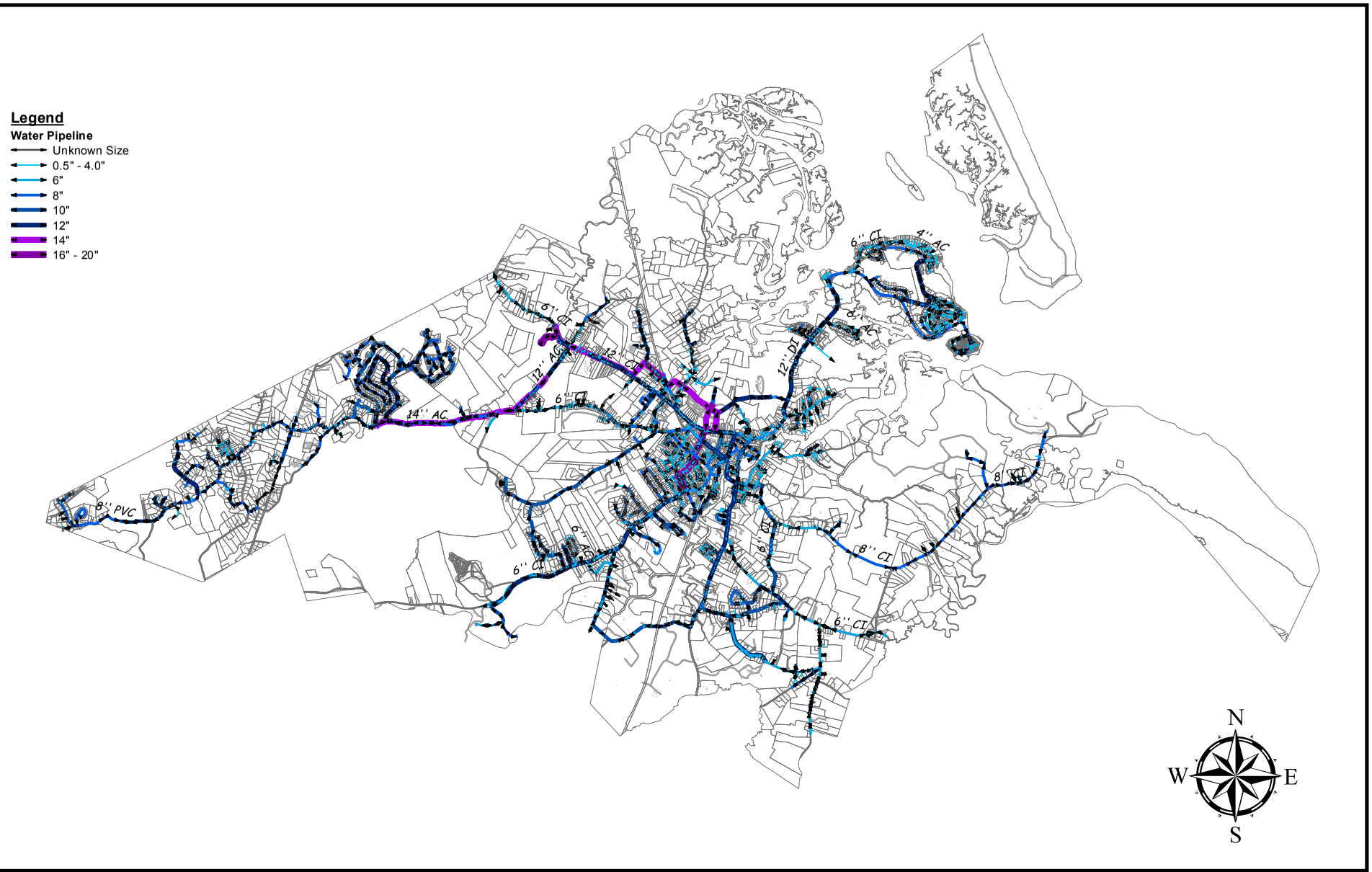
**TABLE 3**

| | Residual Pressures for Fire Flow (500 GPM) at J755 (Pond Edge Lane) | | |
|---|---|---|---|
| | | | |
| | Existing | Closed Pipe 756 | |
| | Fire Flow | Fire Flow | Difference |
| **627 End of Hood Farm Road** | 26.9 | 33.0 | 6.1 |
| 630 Middle of Hood Farm Road | 33.8 | 39.9 | 6.1 |
| 609 Linebrook at Newbury Road | 35.7 | 41.8 | 6.1 |
| 655 End of Oakwood Knoll Road | 16.2 | 22.3 | 6.1 |
| 500 Rte 1 at Linebrook | 45.8 | 45.8 | 0.0 |

| | Residual Pressures for Fire Flow (500 GPM) at J754 (Linebrook at Lillian) | | |
|---|---|---|---|
| | | | |
| | Existing | Closed Pipe 704 | |
| | Fire Flow | Fire Flow | Difference |
| **627 End of Hood Farm Road** | 27.3 | 33.4 | 6.1 |
| 630 Middle of Hood Farm Road | 34.2 | 40.3 | 6.1 |
| 609 Linebrook at Newbury Road | 36.1 | 42.2 | 6.1 |
| 655 End of Oakwood Knoll Road | 16.6 | 22.7 | 6.1 |
| 500 Rte 1 at Linebrook | 45.8 | 45.8 | 0.0 |

# 2017 Updated Hydraulic Model, Ipswich Utilities Department





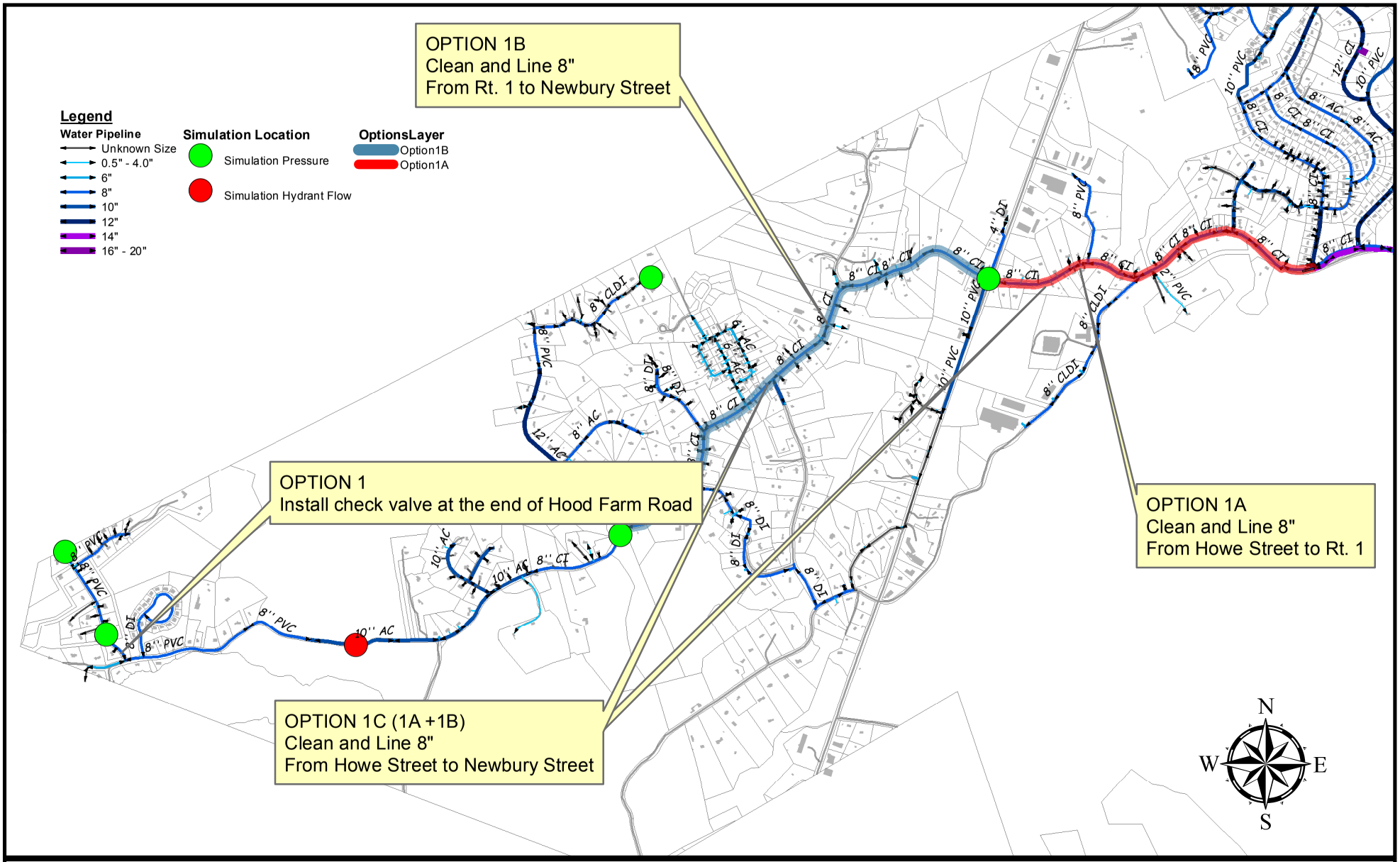

0 3,500 7,000 14,000 Feet

1 inch = 7,000 feet

Town of Ipswich, Massachusetts
Hydraulic Model
Existing Water System

**MAP 1A**

NECE
NEW ENGLAND CIVIL ENGINEERING
SALEM, MA



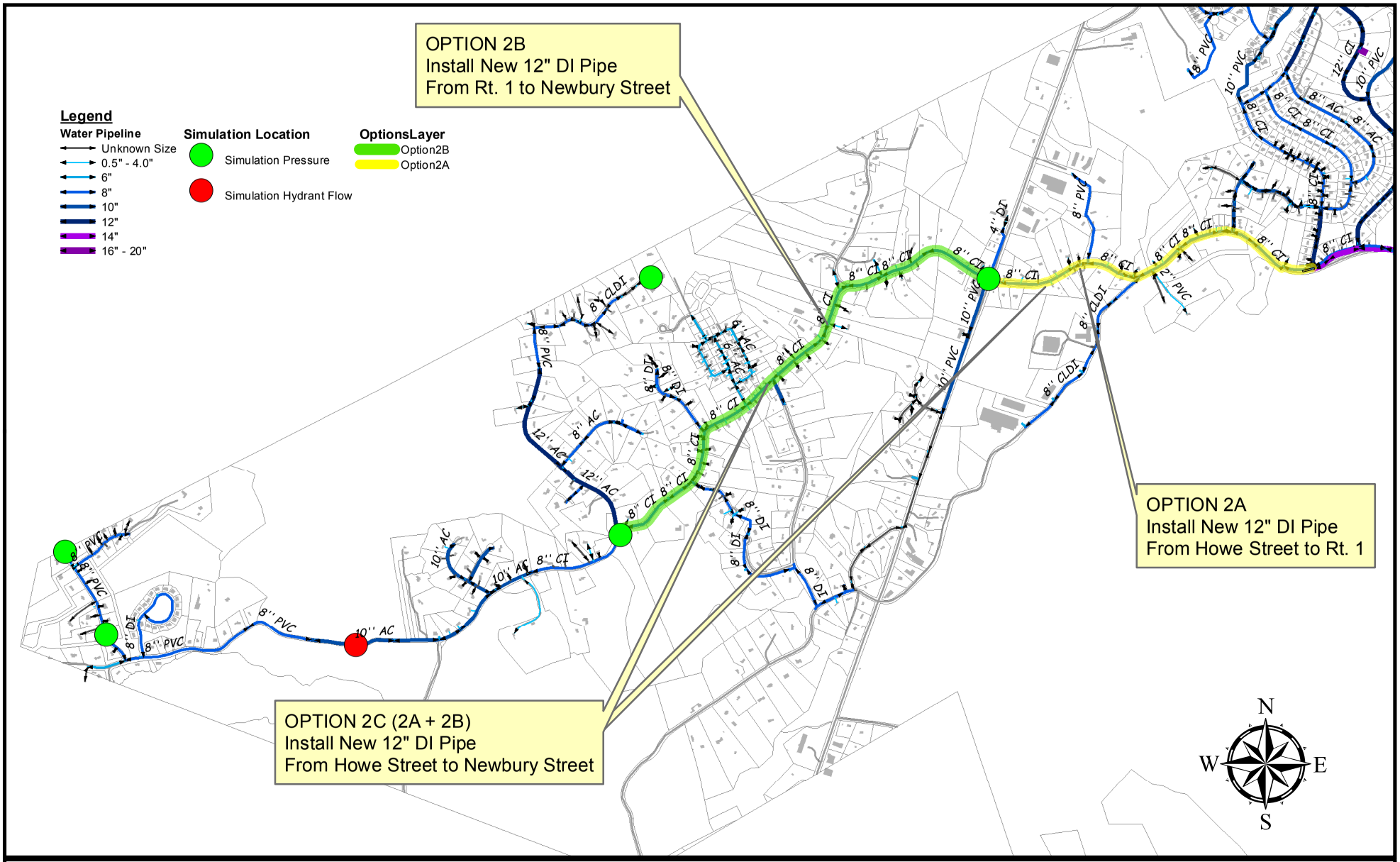

0 500 1,000 2,000 **Feet**

1 inch = 1,749.04 feet

Town of Ipswich, Massachusetts
Hydraulic Model
Proposed Water Main Lining Options

**MAP 2**

NECE
NEW ENGLAND CIVIL ENGINEERING
SALEM, MA



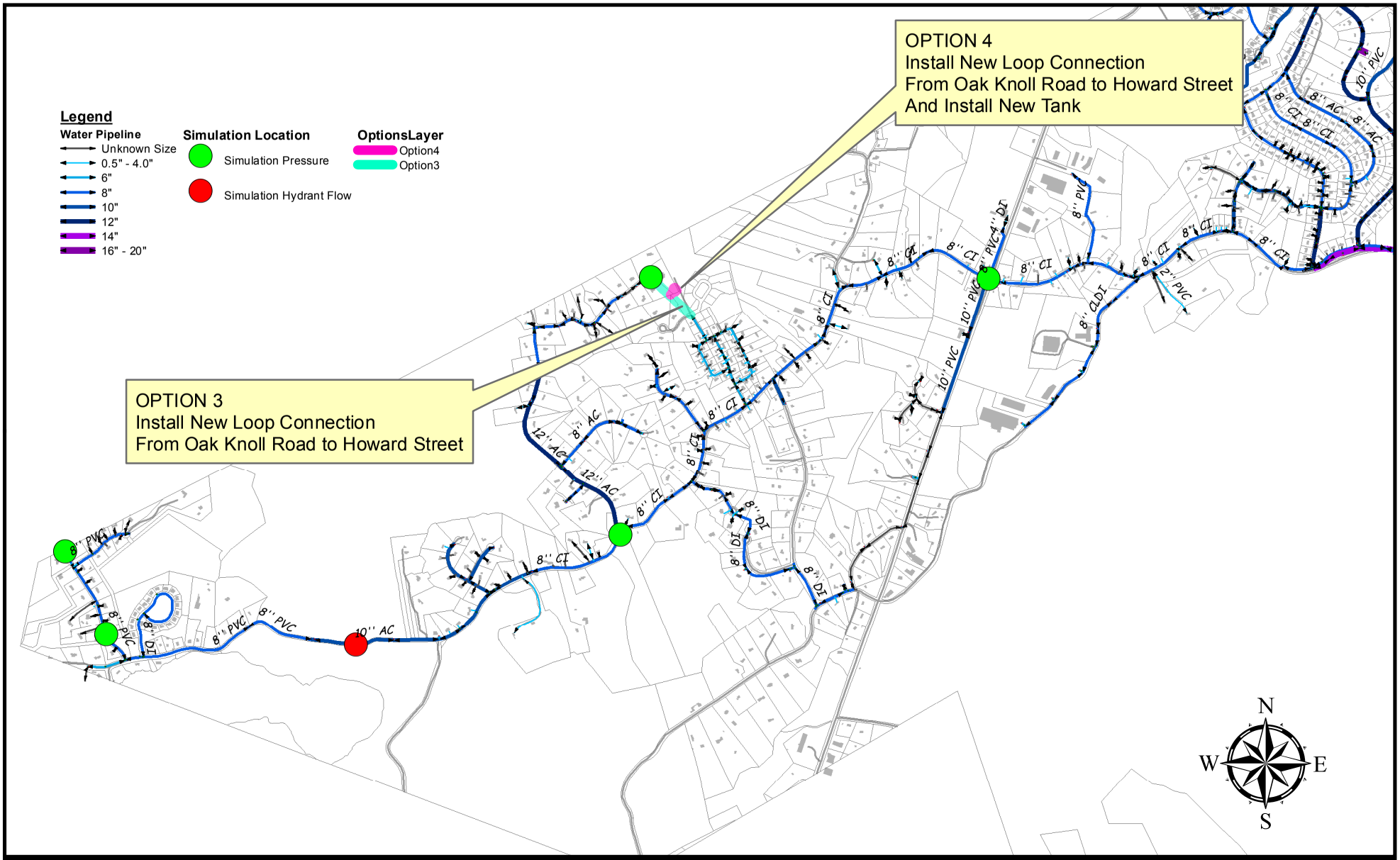

0 500 1,000 2,000 **Feet**

1 inch = 1,749.04 feet

Town of Ipswich, Massachusetts
Hydraulic Model
Proposed Water Main Lining Option 2

**MAP 3**

NECE
NEW ENGLAND CIVIL ENGINEERING
SALEM, MA



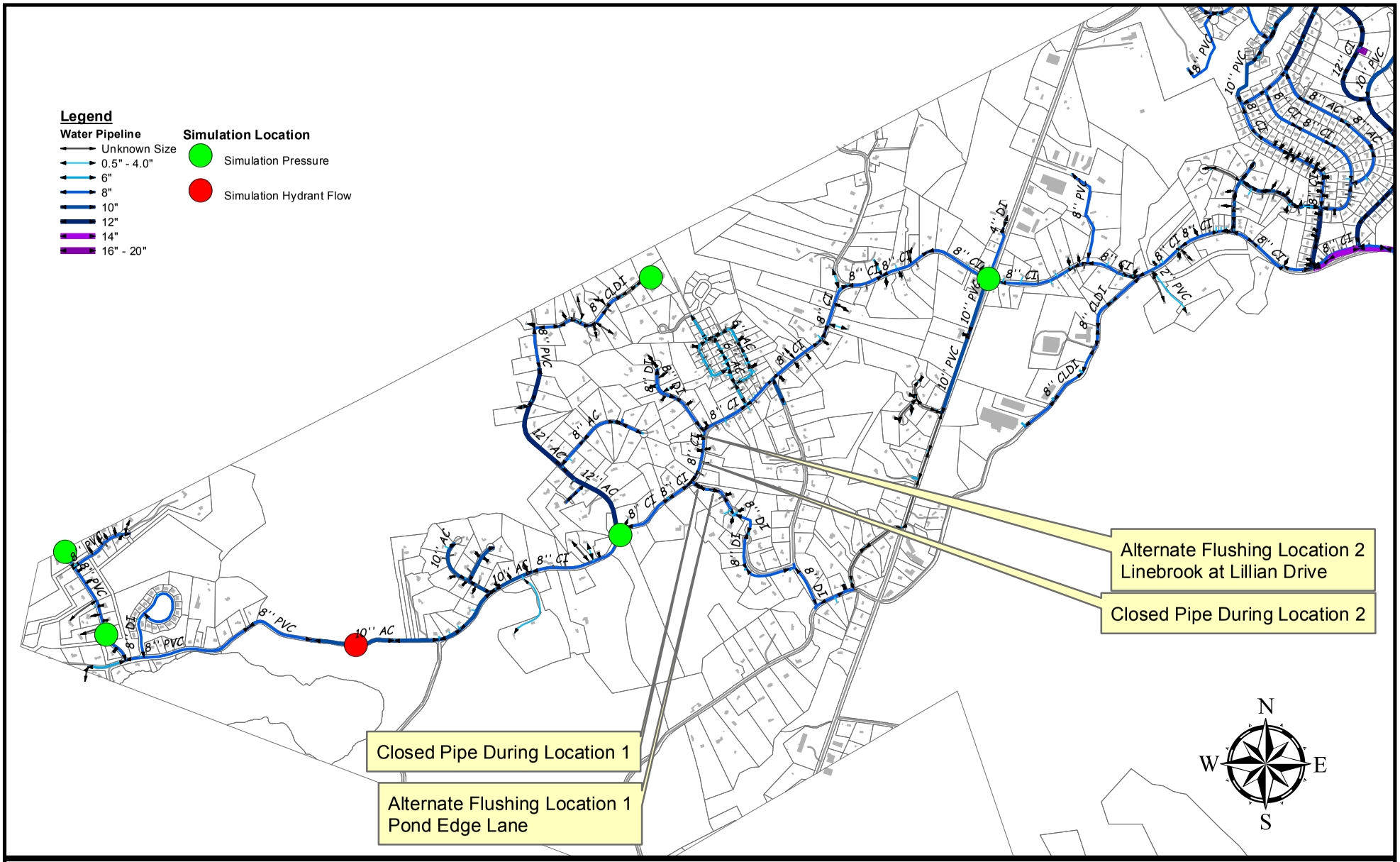

0 500 1,000 2,000 Feet

1 inch = 1,749.73 feet

Town of Ipswich, Massachusetts
Hydraulic Model
Proposed Water Main Lining Options 3 and 4

**MAP 4**

NECE
NEW ENGLAND CIVIL ENGINEERING
SALEM, MA




0 500 1,000 2,000 **Feet**

1 inch = 1,749.04 feet

Town of Ipswich, Massachusetts
Hydraulic Model
Alternate Hydrant Flushing Locations

**MAP 5**

NECE
NEW ENGLAND CIVIL ENGINEERING
SALEM, MA