75 State Street, Suite 701
Boston, Massachusetts 02109
tel: 617 452-6000

September 12, 2022

Mr. John Scenna
Superintendent
Lynnfield Center Water District
83 Phillips Road
Lynnfield, MA 01940

Subject: Hydraulic Modeling Evaluation for Proposed Tie-In at Sagamore Spring Golf Club, 1287 Main Street

Dear Mr. Scenna:

In accordance with Task Order 1.4 of the FY23 Engineering Services Agreement, CDM Smith is pleased to submit this evaluation of the hydraulic impacts associated with the proposed water main tie-in for the proposed housing development within Sagamore Spring Golf Club at 1287 Main Street in the Lynnfield Center Water District (LCWD, the District).

This letter report describes the work performed to assess the distribution system's performance at a proposed development at 1287 Main Street in Lynnfield. A model analysis was performed to evaluate delivery pressures and fire protection results and to determine if any piping improvements are necessary prior to the development connecting to the LCWD.

Hydraulic Model Calibration

The hydraulic modeling analysis was conducted using the most recent version of the LCWD distribution system model, Innovyze InfoWater Version 12.4 that was last updated in February 2022

A hydrant flow test was performed at 1135 Main Street to calibrate the model in the vicinity of the proposed development. Calibration is the process of simulating each field hydrant flow test in the computer model. Then, by comparing field test results against modeled results, and making adjustments to the model variables, as required, the computed system response can be adjusted to closely match the actual field data. The greatest variable in the calibration of the model is the assumed Hazen-Williams C-value of the mains that is sometimes influenced by valves that may be closed or partially closed. The C-values of these mains are adjusted during calibration until the model simulates the approximate head losses (pressure drops) and flow rates in the distribution system that were recorded during the hydrant flow tests.

Hydrant Flow Tests

One hydrant flow test was conducted at 1135 Main Street by The Morin-Cameron Group, Inc. personnel on August 3, 2022. The test utilized a single 2.5-inch hydrant outlet. Hydrant flow test data is included in **Attachment A**, and the test location is shown in **Figure 1** of **Attachment A.**

Calibration Conditions

An assumed system demand of 0.90 million gallons per day (MGD) on the day of the flow test was simulated based on historical August water consumption data. The tank levels and operation of the District's wellfields were operating at the typical levels and flow rates for the season. Station 2 was offline for the field testing and model calibration.

Calibration Results

Calibration was performed by comparing the field measured static and residual pressures and observed hydrant flow at the hydrant flow test location with the corresponding data from the computer model simulations. C-values of the pipes were adjusted to try and achieve calibration to the hydrant field flow tests.

A model is generally considered calibrated when the residual pressure drops (i.e., the difference between static pressure and residual pressure or "deltas") were at least 10 pounds per square inch (psi) and when simulated on the computer model were within 10 percent of the actual field residual pressure drops. In areas where a total of 10 psi pressure drop was not achieved in the field, it is very difficult to calibrate the model to match within these margins. Generally, an agreement of 5 psi or less between simulated pressure drop and the field pressure drop is considered good. To calibrate the model to this flow test, adjusting C-values alone could not achieve calibration. The simulated pressure drop was greater than the observed pressure drop so the water main on Main Street, north of Lowell Street, was adjusted from an 8-inch pipe to a 12-inch pipe with a C-value of 120 to achieve calibration to the hydrant field flow tests. We recommend LCWD verify the size of this water main.

The model results demonstrate that both the pressure drop of within 10 percent and within the 5 psi criteria and thus is considered calibrated. **Table 1** provides a summary of the hydrant flow calibration results.

Table 1 - Flow Test Calibration Results

Hydrant Test ID	*Date*	*Location*	*Field Flow (gpm)*	*Field Pressure Drop "delta" (psi)*	*Modeled Pressure Drop "delta" (psi)*	*Difference between Field and Modeled Pressure Drop (psi)*
1	August 3, 2022	1135 Main Street	1,290	3	3	0

Additionally, during the calibration process the field observed static pressure (66 psi) was compared to the simulated static pressure (64 psi). This indicates good agreement between simulated and field observed pressures in this area.

Alternatives Development and Modeling

CDM Smith used the distribution system hydraulic model to perform an evaluation of post-development conditions at the proposed development within Sagamore Spring Golf Club at 1287 Main Street. Model runs (simulations) were conducted for a 5-day period using the predicted maximum day demand (MDD) for the LCWD, which is 1.5 MGD. An interconnection between LCWD and the Town of Wakefield to wheel Massachusetts Water Resources Authority (MWRA) water to supplement LCWD's water distribution system is currently under design. However, this interconnection may not be online when the proposed Sagamore development ties into the system and cannot be considered a definitive source until the MWRA approval process is complete. Therefore, the development should meet fire flow and pressure requirements through the existing system, prior to the installation of the interconnection.

Two operation conditions were run for each piping scenario – one with the interconnection and one without the interconnection. The following eight scenarios were evaluated in the model:

- Scenario 1A: 3,620-feet of new 8-inch cement lined ductile iron (CLDI) pipe in the proposed development with "low-low" (69.5 ft at Wing Road and 80.5 ft at Knoll Road) initial water storage tank levels. This piping route is the proposed route by the developer.
- Scenario 1B: 3,620-feet of new 8-inch cement lined ductile iron (CLDI) dead end pipe in the proposed development with "low" (74.5 ft at Wing Road and 85.5 ft at Knoll Road) initial water storage tank levels and MWRA interconnection.
- Scenario 2A: 3,620-feet of new 8-inch CLDI pipe in the proposed development with 2,060-feet of additional 8-inch pipe to loop to Main Street (via Friendship Lane) with "low-low" water storage tank levels.
- Scenario 2B: 3,620-feet of new 8-inch CLDI pipe in the proposed development with 2,060-feet of additional 8-inch pipe to loop to Main Street (via Friendship Lane) Street with "low" water storage tank levels and MWRA interconnection.
- Scenario 3A: 3,620-feet of new 8-inch CLDI pipe in the proposed development with 1,740-feet of additional 8-inch pipe to loop to Lowell Street (via Vallis Way) with "low-low" water storage tank levels.
- Scenario 3B: 3,620-feet of new 8-inch CLDI pipe in the proposed development with 1,740-feet of additional 8-inch pipe to loop to Lowell Street (via Vallis Way) with "low" water storage tank levels and MWRA interconnection.
- Scenario 4A: 3,620-feet of new 8-inch CLDI pipe in the proposed development with 2,060-feet of additional 8-inch pipe to loop to Main Street (via Friendship Lane) and 1,740-feet of additional 8-inch pipe to loop to Lowell Street (via Vallis Way) with "low-low" water storage tank levels.

- Scenario 4B: 3,620-feet of new 8-inch CLDI pipe in the proposed development with 2,060-feet of additional 8-inch pipe to loop to Main Street (via Friendship Lane) and 1,740-feet of additional 8-inch pipe to loop to Lowell Street (via Vallis Way) with "low" water storage tank levels and MWRA interconnection.

A demand of 28 gallons per minute (gpm) was applied to the node at the middle of the proposed Friendship Way extension, based on the 37gpm demand estimate for peak hour provided by The Sagamore Group, converted to maximum day demands by utilizing their residential diurnal curve.

Should the proposed Vallis Way not be constructed, an alternative could be a loop to Lowell Street via Mohawk Lane. Although this scenario was not modeled, the results are expected to be very similar to Scenarios 3A and 3B since the length of the loop, existing pipe size and C-values are roughly the same.

Available Fire Flow

Available fire flow is evaluated in the computer model under post development conditions to determine whether fire protection provided from the distribution system is adequate. Generally, available fire flow requirements in residential areas range from 500 to 1,500 gpm at a residual system pressure of 20 psi. The Insurance Services Office (ISO) establishes fire protection guidelines pertaining to needed fire flow based on the type of structure and neighboring building spacing, among other criteria. **Table 2** below shows the ISO fire flow guidelines for 1- and 2-family dwellings not exceeding 2 stories in height. Specific requirements for this development should be confirmed with the fire department.

Table 2 – ISO Fire Flow Requirements

Distance Between Buildings	Needed Fire Flow
More than 30 feet	500 gpm
21 – 30 feet	750 gpm
11 – 20 feet	1,000 gpm
0 – 10 feet	1,500 gpm

The results of the fire flow model run for Scenarios 1A through 4B are shown in **Figures 1 through 8, Attachment B.** Results are shown for 2:00 P.M. on the third day of the model run and correlate to a tank level of 86.3-ft in the Knoll Road Tank, which sets the hydraulic gradeline elevation for the system. As shown in the figures, simulated available fire flow at 20 psi under Scenarios 1A and 1B does not meet the minimum ISO fire flow requirement of 500 gpm, meaning some sort of looping is needed for the proposed development. Simulated available fire flow under Scenarios 2A through 4B exceed 500 gpm, however the proposed development plan shows the distance between houses ranging from 11 to 30 feet, therefore it is expected that the required fire flows will be between 750 gpm and 1,000 gpm. The high point of the proposed development is approximately 188 feet at the end of the proposed Friendship Lane extension where available fire flows are the lowest. **Table 3**

below shows the simulated available fire flow at this location for each of the 4 scenarios without the MWRA interconnection.

Table 3 – Simulated Available Fire Flow at High Point of Proposed Development

Scenario	Available Fire Flow at 20 PSI
1A – Proposed Dead End	451 gpm
2A – Main Street Loop	625 gpm
3A – Vallis Way Loop	667 gpm
4A – Both Loops	946 gpm

As shown in Table 3, the Vallis Way loop provides slightly more fire flow protection than the Main Street loop, yet neither meet the 750 gpm criteria. Implementing both loops would provide the most fire flow protection and meet the ISO fire flow requirement.

Delivery Pressure

The Massachusetts Department of Environmental Protection (MassDEP) provides guidance for public water system design, including a minimum recommended normal working pressure in the distribution system of 35 psi. The results of the delivery pressure model run for Scenarios 1A through 4B are shown in **Figures 9 through 16**, **Attachment B.** Results are shown for the time at which the resulting in a tank level is lowest (85.3-ft) at the Knoll Road water storage tank on the third day of the run. With the MWRA interconnection, that is 7:00 P.M. and without the MWRA interconnection, that is 8:00 AM. As shown in the site plans in **Attachment C**, the expected elevation at the proposed site is 188 ft. This elevation was inputted in the model. Simulated working pressure evaluated under maximum day demands at the high point of the proposed development is approximately 27 psi, missing the minimum requirement of 35 psi for all scenarios.

Conclusions and Recommendations

Model evaluations were conducted with the MWRA interconnection online to assess potential improvements to system performance once the interconnection is online. However, in making conclusions and recommendations for the expansion of the system, it is necessary to design the proposed development without relying on the proposed interconnection (as it is not yet designed, built or approved). Therefore, only the modeling results for Scenarios 1A, 2A, 3A and 4A were evaluated for the development of these recommendations.

The model evaluation results indicate that the simulated fire flow at the proposed development does not meet ISO requirements (minimum of 500 gpm) for Scenario 1A and some sort of looping is necessary. **The water main loop to Lowell Street (via Vallis Way) in Scenario 3A provides greater fire flow (42 gpm at 20 psi) protection throughout the proposed development and is approximately 300 LF shorter than the loop to Main Street (via Friendship Lane) in Scenario 2A, therefore this is the preferred loop**. It should be noted that with the houses spaced approximately 11 to 30 feet apart throughout the proposed development plan, the ISO minimum

fire flow required ranges from 750 gpm to 1,000 gpm. Neither Scenario 2A nor 3A meet this fire flow requirement. Should this level of fire protection be required by the Fire Department, a fire pump or a larger size main would be required.

The pressures on Main Street and through the middle of the proposed development exceed the MassDEP working pressure requirement of 35 psi for all scenarios. However, the pressures towards the end of the Friendship Lane Extension are approximately 27 psi for all scenarios which is slightly lower than 35 psi requirement. It is recommended that home booster pumps be utilized to provide adequate pressure during peak demands.

Scenario 4A yields greater fire flow protection than Scenarios 1A, 2A, and 3A and similar pressures to the other scenarios. Additionally, looping provides the added benefits of redundancy and improved water quality and is recommended as a best practice by MassDEP. CDM Smith recommends that the loop in Scenario 4A should be the long term goal of the District and be considered part of future capital programs.

Sincerely,

Anne Malenfant, P.E., PMP
Project Manager
CDM Smith Inc.

cc: Colleen Heath and Hannah Sullivan, CDM Smith

Attachment A
Hydrant Flow Test

TABLE 1

THE MORIN-CAMERON GROUP, INC
66 Elm Street
Danvers, MA 01923
Tel.: (978) 777-8586

HYDRANT FLOW TEST AND HYDRAULIC SUMMARY - 1,000 GPM

TEST MADE BY:	The Morin-Cameron Group, Inc				
REPRESENTATIVE:	Scott P. Cameron, P.E.	TEST DATE:	August 3, 2022	10:30 AM	
WITNESS:	Lynnfield Center Water Districk Nick and Frank				
PURPOSE OF TEST:	To determine existing flow and pressures in water main in Main Street				

	FIELD DATA TEST	(see hydrant flow test figure for hydrant locations)					
	HYDRANT	**1**					
FLOW HYDRANT 1 1217 Main St	elevation of hydrant	104	feet		HYDRANT 1 DATA		
	nozzle size	2.5	inches		flush	2 Minutes +/-	
	static reading	71	psi		date	1979	
	discharge coefficient	0.80	n/a		type	Kennedy	
	flow rate	1,290	gpm		condition	Good	
	pressure gauge check	n/a	psi		ground el.	104	feet
	static pressure	71	psi				
	HYDRANT	**2**					
PRESSURE (residual) HYDRANT 2 1135 ~~1235~~ **Main St**	elevation of hydrant	116		feet	HYDRANT 2 DATA		
	nozzle size	2.5		inches	flush	1 Minute +/-	
	residual pressure	63		psi	date	1979	
	discharge coefficient	0.8		n/a	type	Kennedy	
	flow rate	0		gpm	condition	Good	
	static pressure	66		psi	ground el.	116	feet

	PROJECTED RESULTS		
PROJECTED RESULTS	FLOW 1 (gpm)	RESIDUAL 2 (psi)	
	1000	64	
	5,634	20	

	FLOW 1 (gpm)	RESIDUAL 2 (psi)	
SUMMARY OF RESULTS	0	66 (field)	
	1,000	64 (calculated)	
	1,290	63 (field)	
	5,634	20 (calculated)	

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Add note describing how/why address changed (maybe refer to a meeting or email date?)

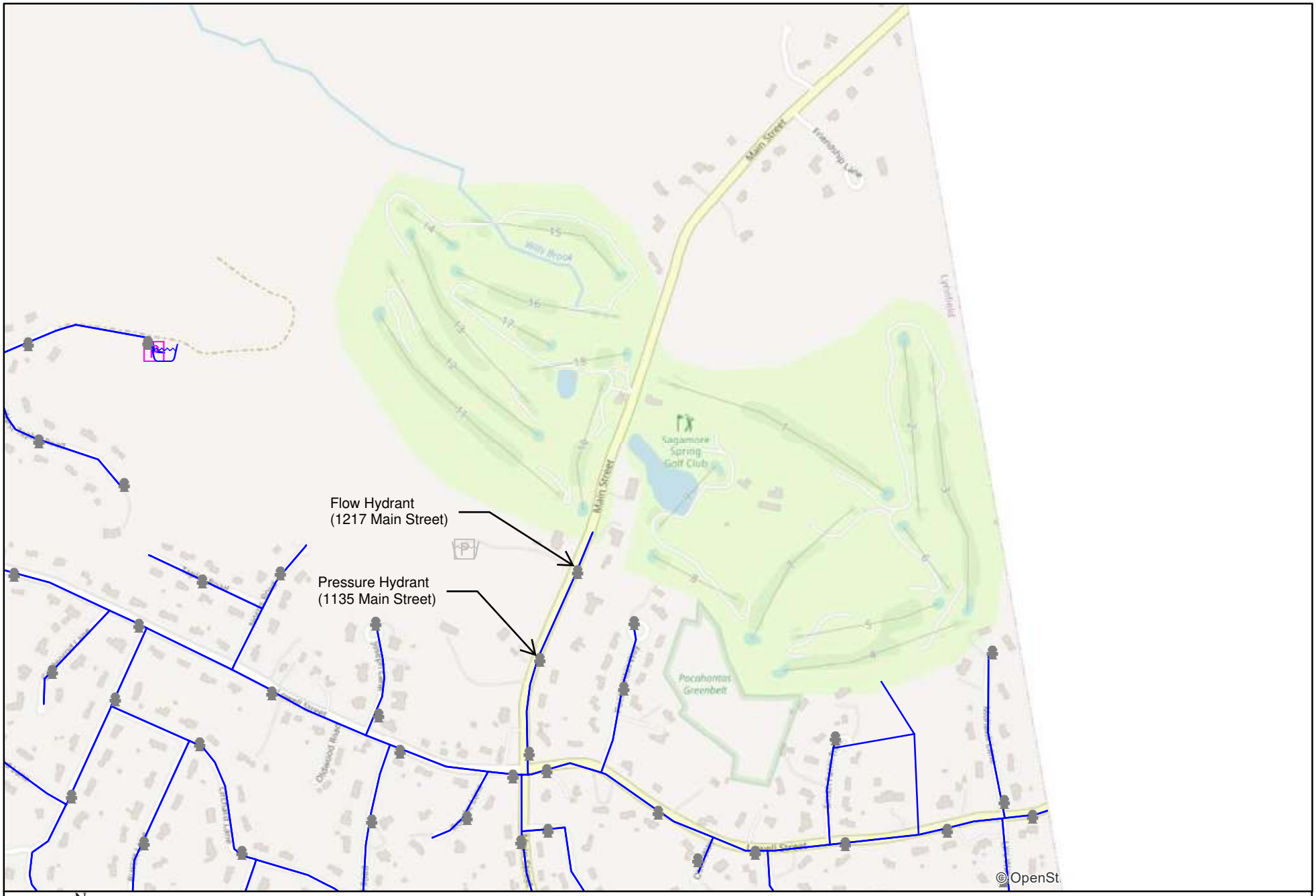
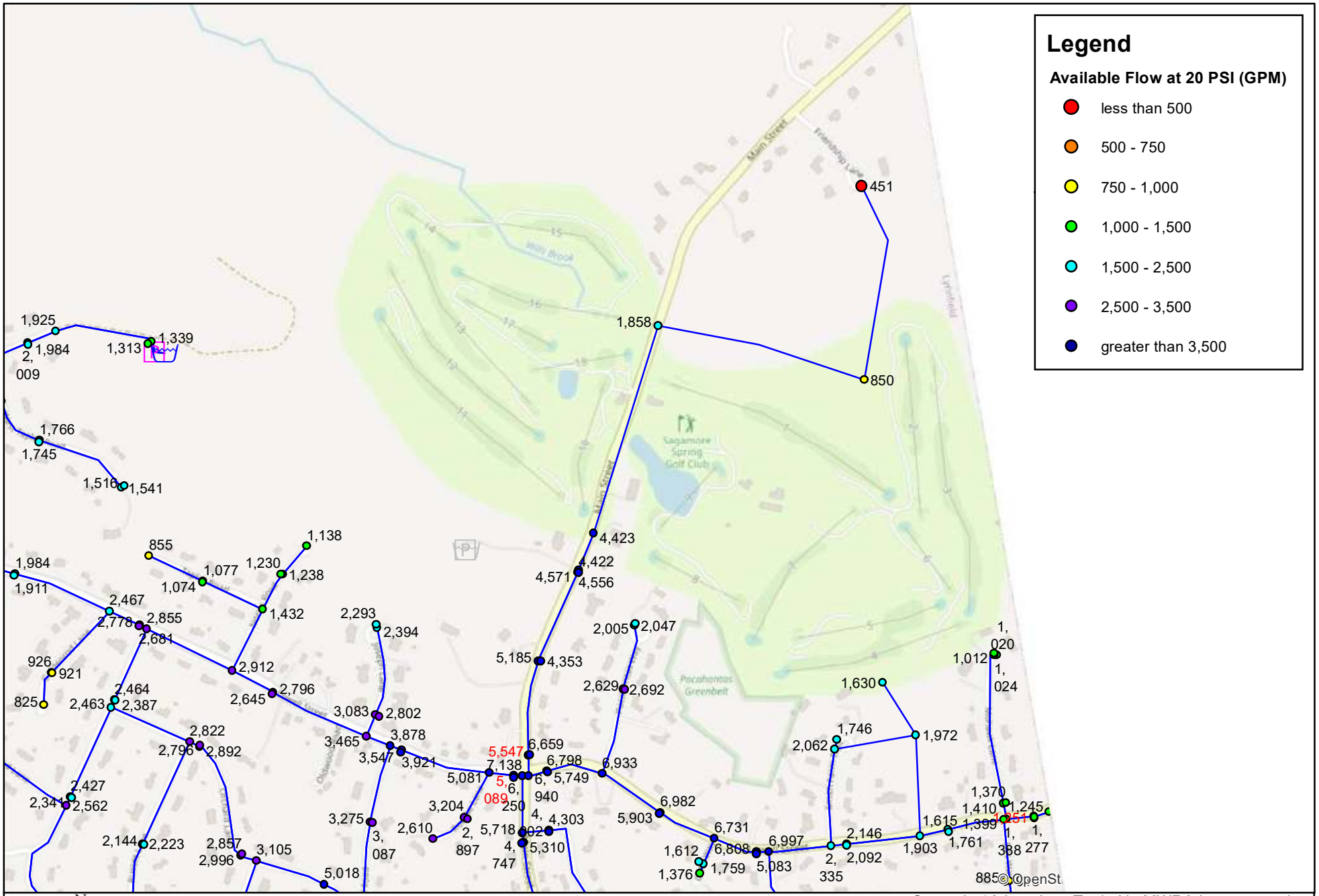


Figure 1
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

CDM Smith

Attachment B
Model Simulation Results


Legend
Available Flow at 20 PSI (GPM)
less than 500
500 - 750
750 - 1,000
1,000 - 1,500
1,500 - 2,500
2,500 - 3,500
greater than 3,500
Main Street
Friendship Lane
Mills Brook
Sagamore Spring Golf Club
Pocahontas Greenbelt
451
1,858
850
4,423
4,422
4,571
4,556
5,185
4,353
2,005
2,047
2,629
2,692
6,659
6,798
6,933
5,547
7,138
5,081
5,749
6,940
6,089
6,250
4,303
4,002
5,310
4,747
5,718
3,204
2,610
3,275
3,087
5,903
6,982
6,731
6,808
6,997
5,083
1,759
1,612
1,376
1,630
1,746
2,062
1,972
1,012
1,020
1,024
2,146
2,092
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1,903
1,615
1,761
1,399
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1,277
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2,394
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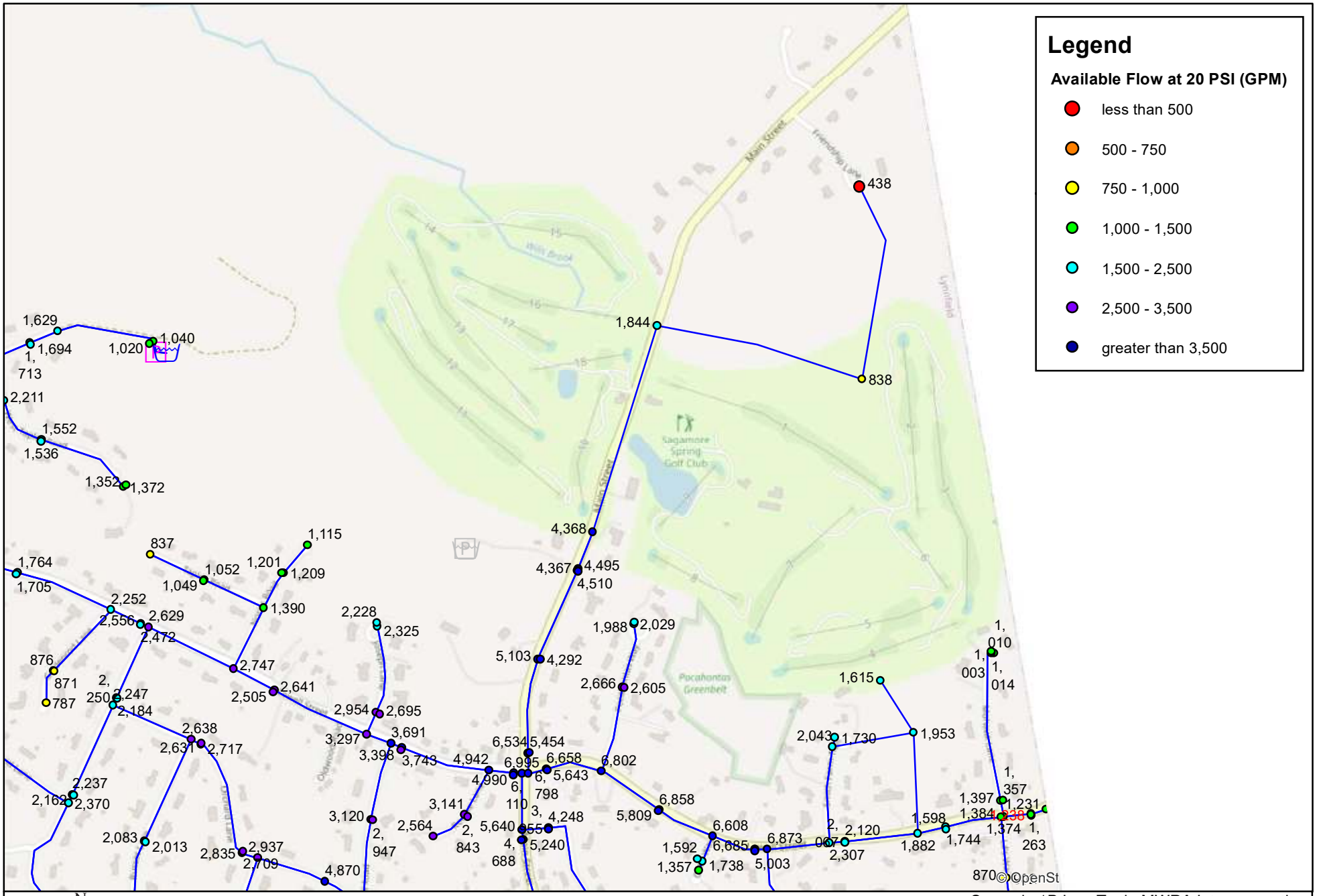
1,238
1,077
1,074
855
1,432
2,912
2,796
2,645
3,083
2,802
3,878
3,921
3,547
3,465
2,822
2,892
2,796
2,427
2,562
2,341
2,144
2,223
2,857
2,996
3,105
5,018
2,467
2,778
2,855
2,681
1,984
1,911
926
921
825
2,464
2,463
2,387
1,925
1,984
2,009
1,313
1,339
1,766
1,745
1,516
1,541
0
215
430
860 Feet
N
Figure 1
Hydraulic Modeling Evaluations for Proposed
Development near Sagamore Springs Golf Club
Lynnfield Center Water District
Scenario 1A Low-Low Tank, No MWRA Interconnection
Simulated Fire Flow at 20 PSI
CDM Smith



N

0 215 430 860 Feet

Figure 2
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 1B Low Tank, MWRA Interconnection
Simulated Fire Flow at 20 PSI

CDM Smith

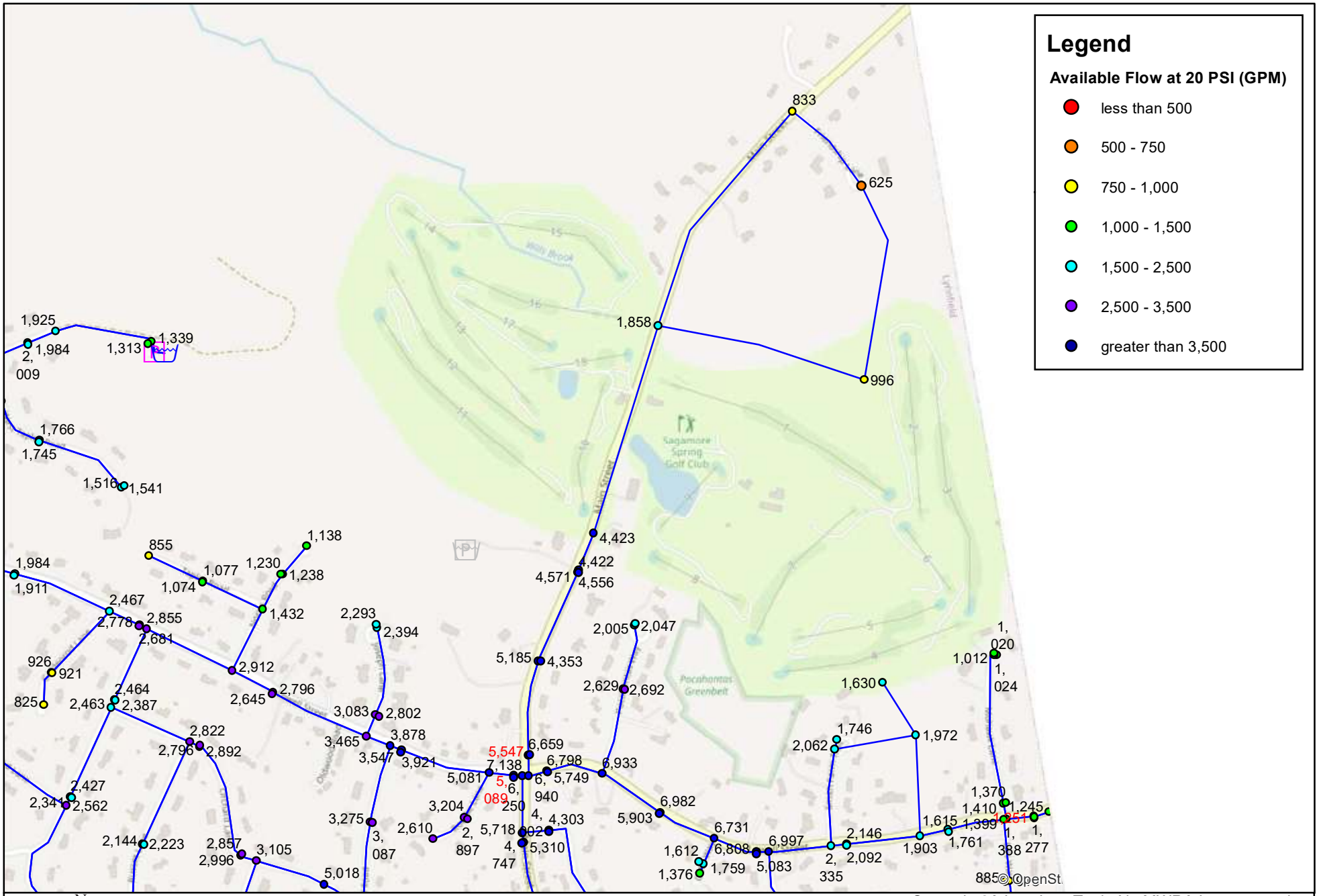
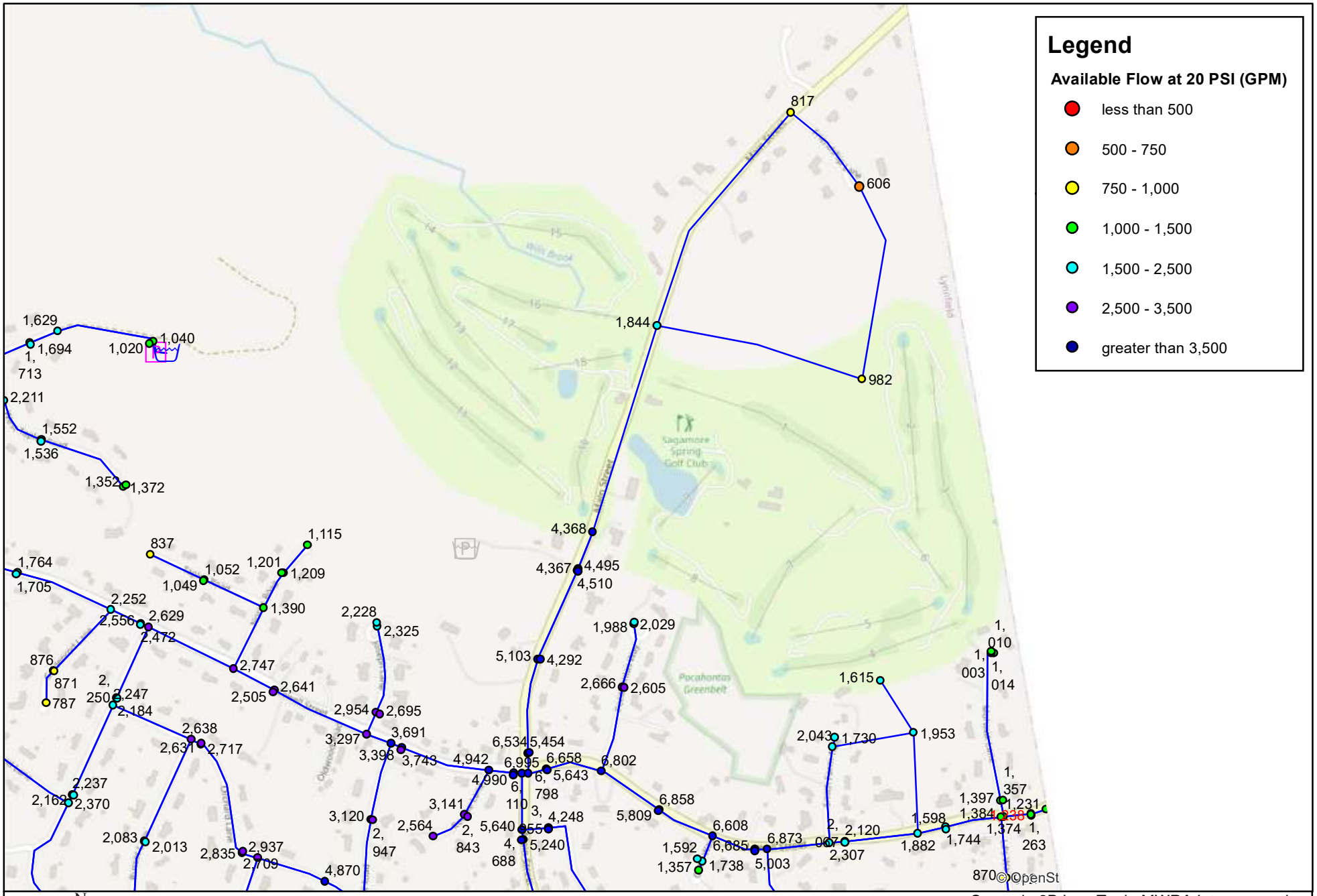


Figure 3
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 2A Low-Low Tank, No MWRA Interconnection
Simulated Fire Flow at 20 PSI

CDM Smith



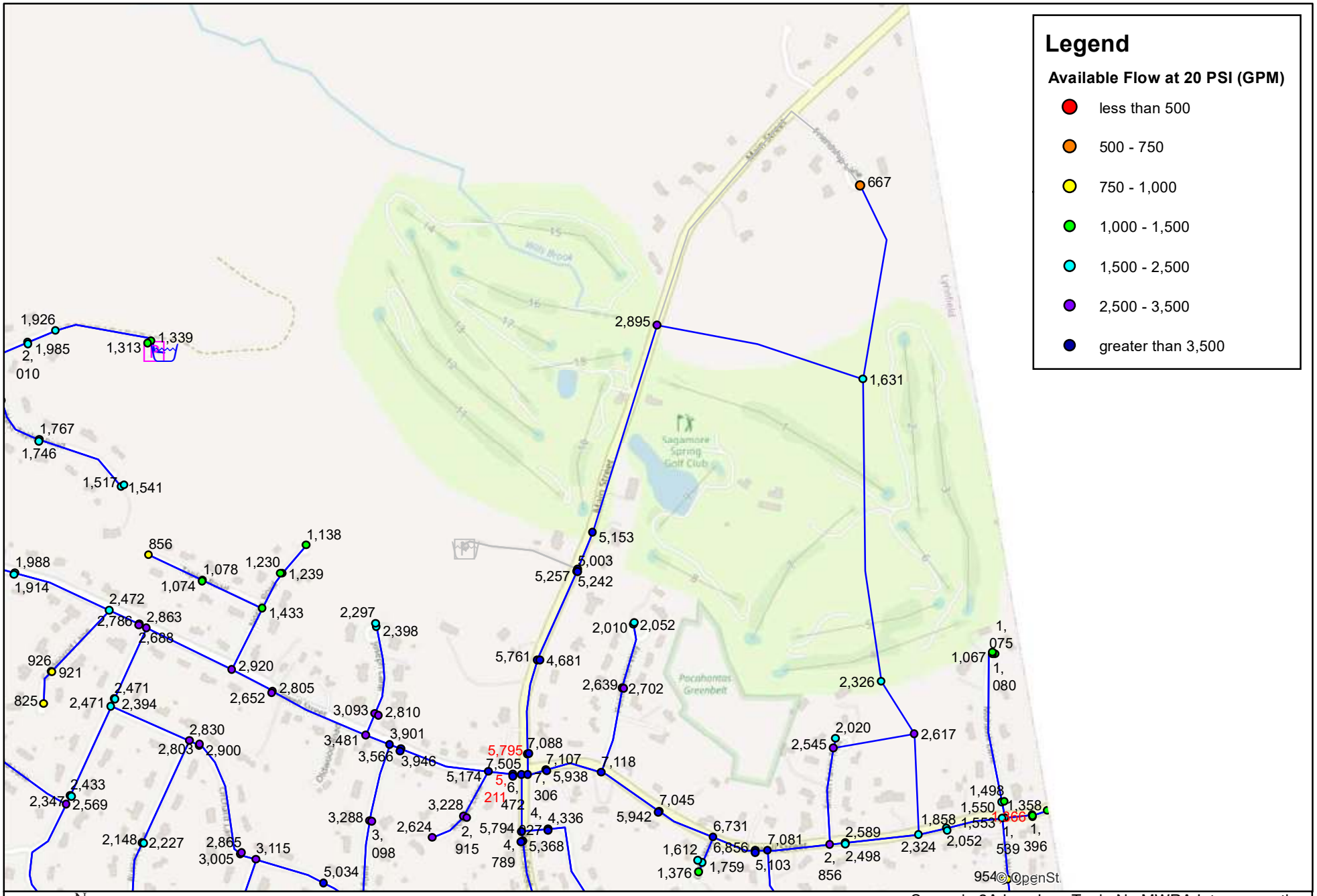
N

0 215 430 860 Feet

Figure 4
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 2B Low Tank, MWRA Interconnection
Simulated Fire Flow at 20 PSI

CDM Smith



N

0 215 430 860 Feet

Figure 5
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 3A Low-Low Tank, No MWRA Interconnection
Simulated Fire Flow at 20 PSI

CDM Smith

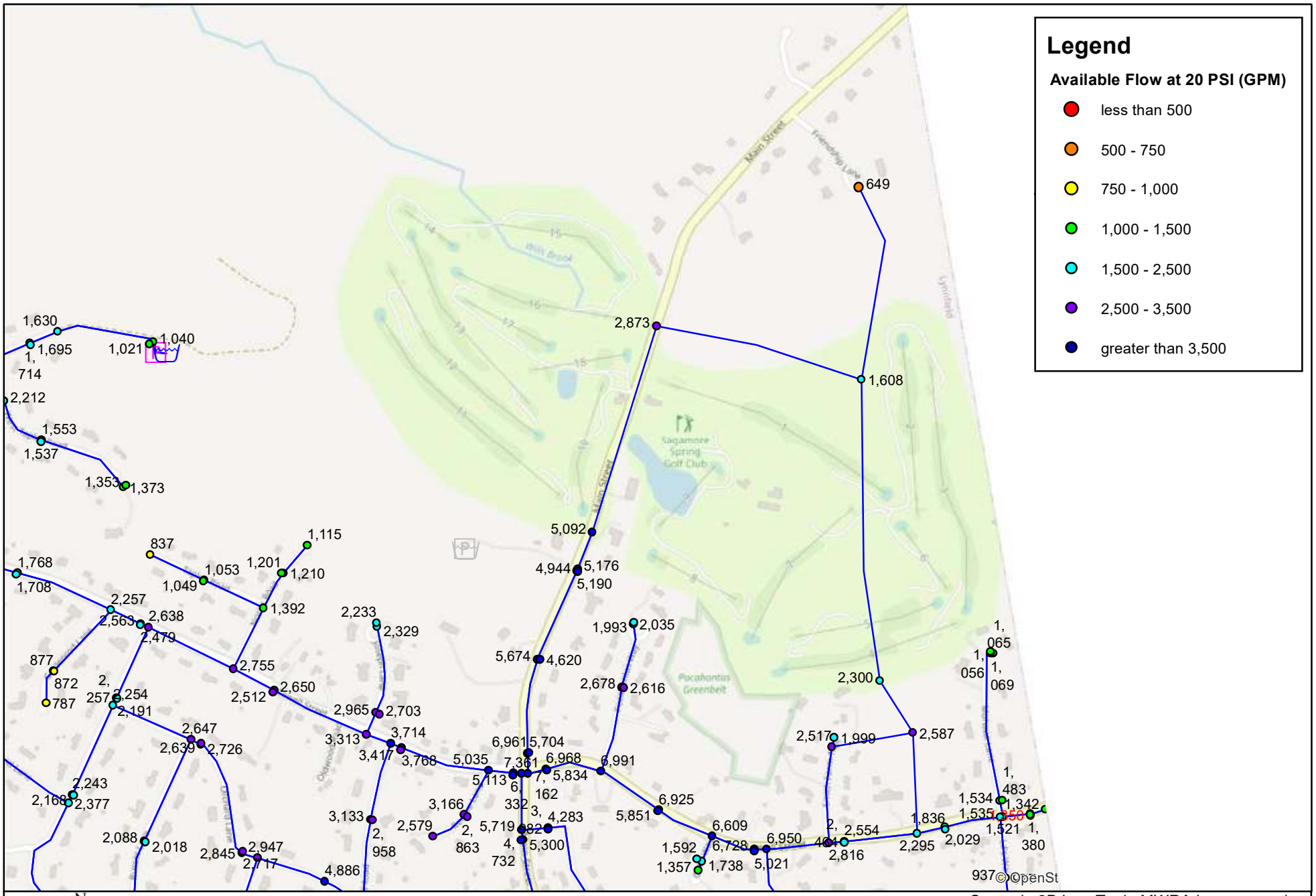


Figure 7
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 3B Low Tank, MWRA Interconnection
Simulated Fire Flow at 20 PSI

CDM Smith

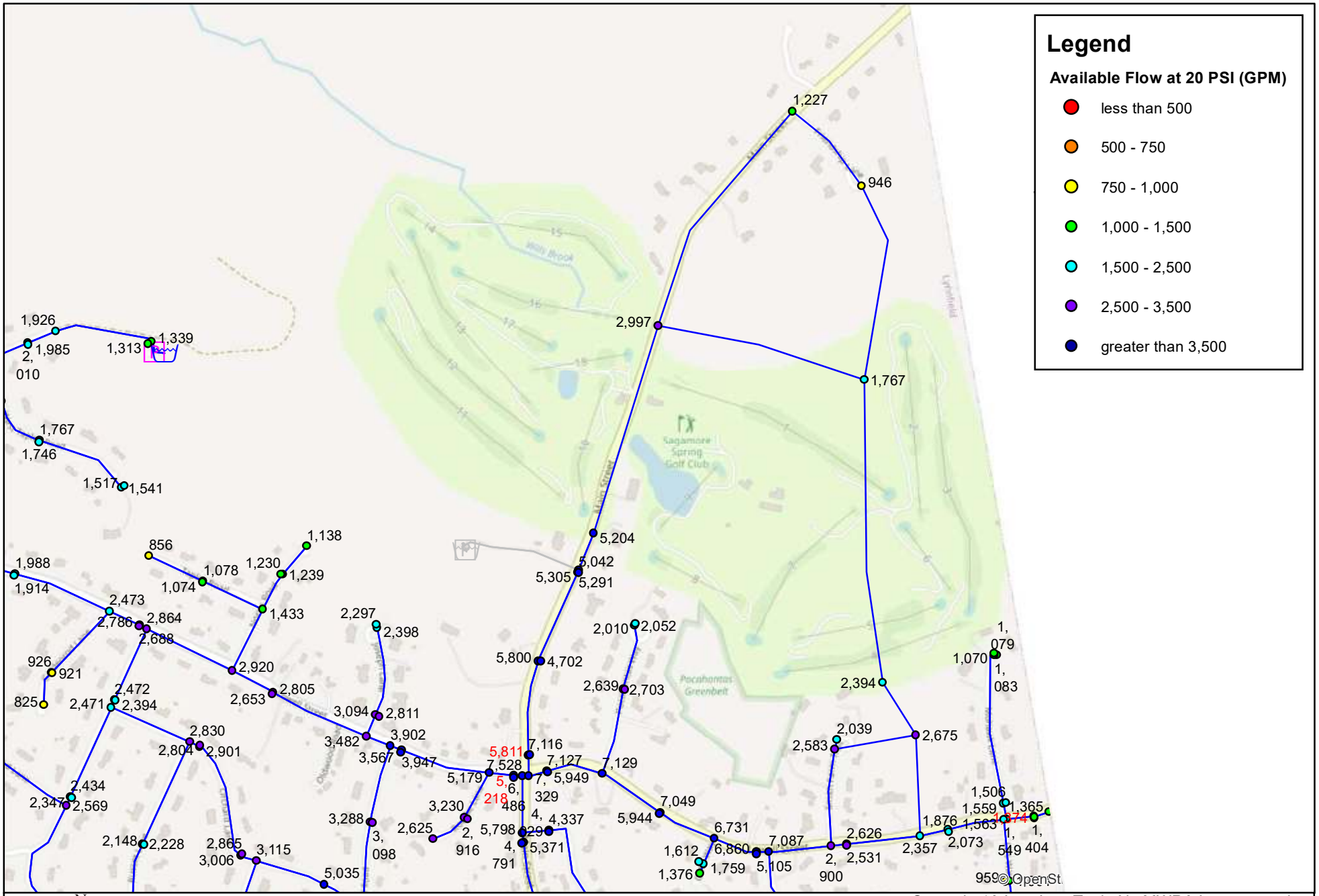


Figure 8
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 4A Low-Low Tank, No MWRA Interconnection
Simulated Fire Flow at 20 PSI

CDM Smith

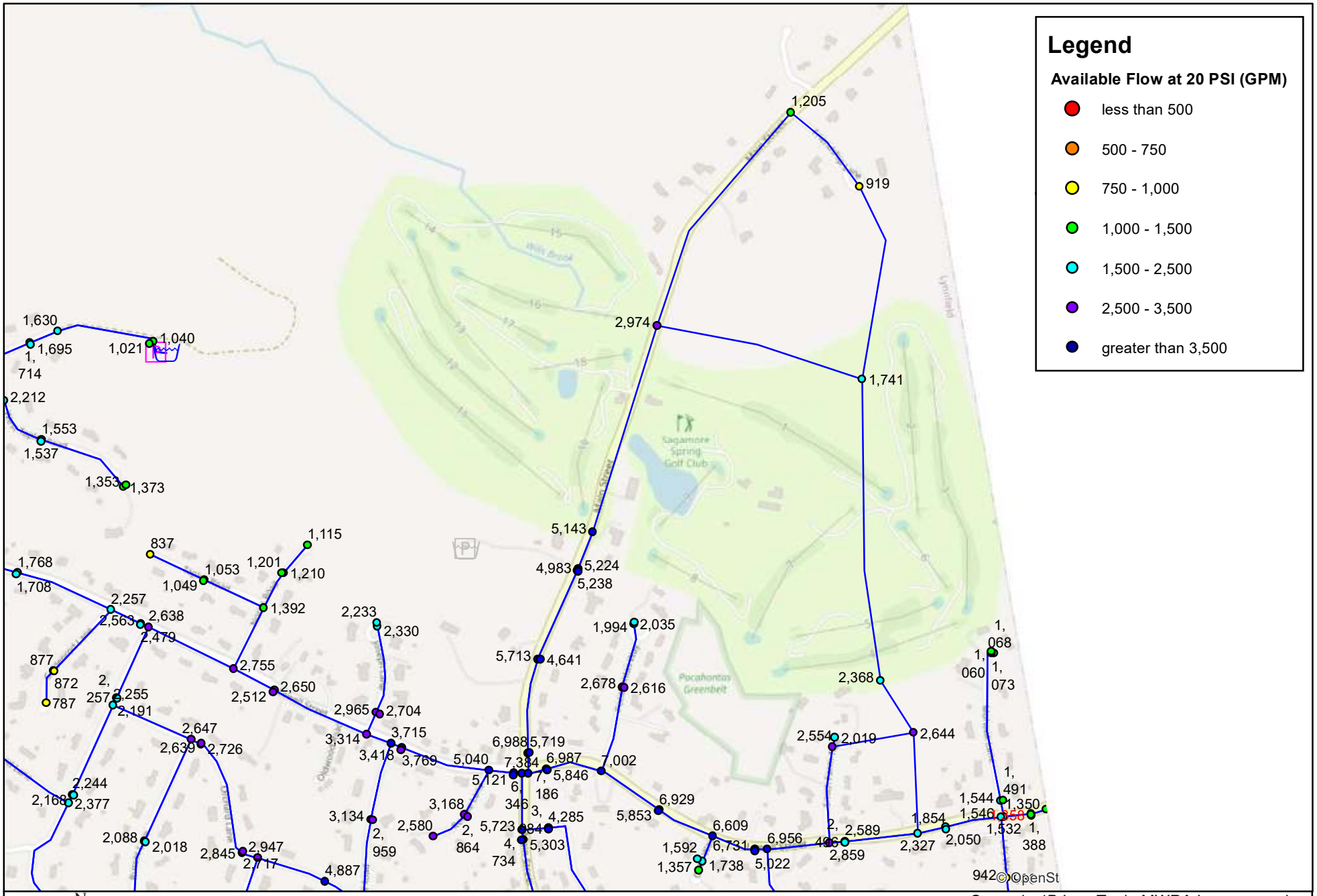


Figure 9
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 4B Low Tank, MWRA Interconnection
Simulated Fire Flow at 20 PSI

CDM Smith

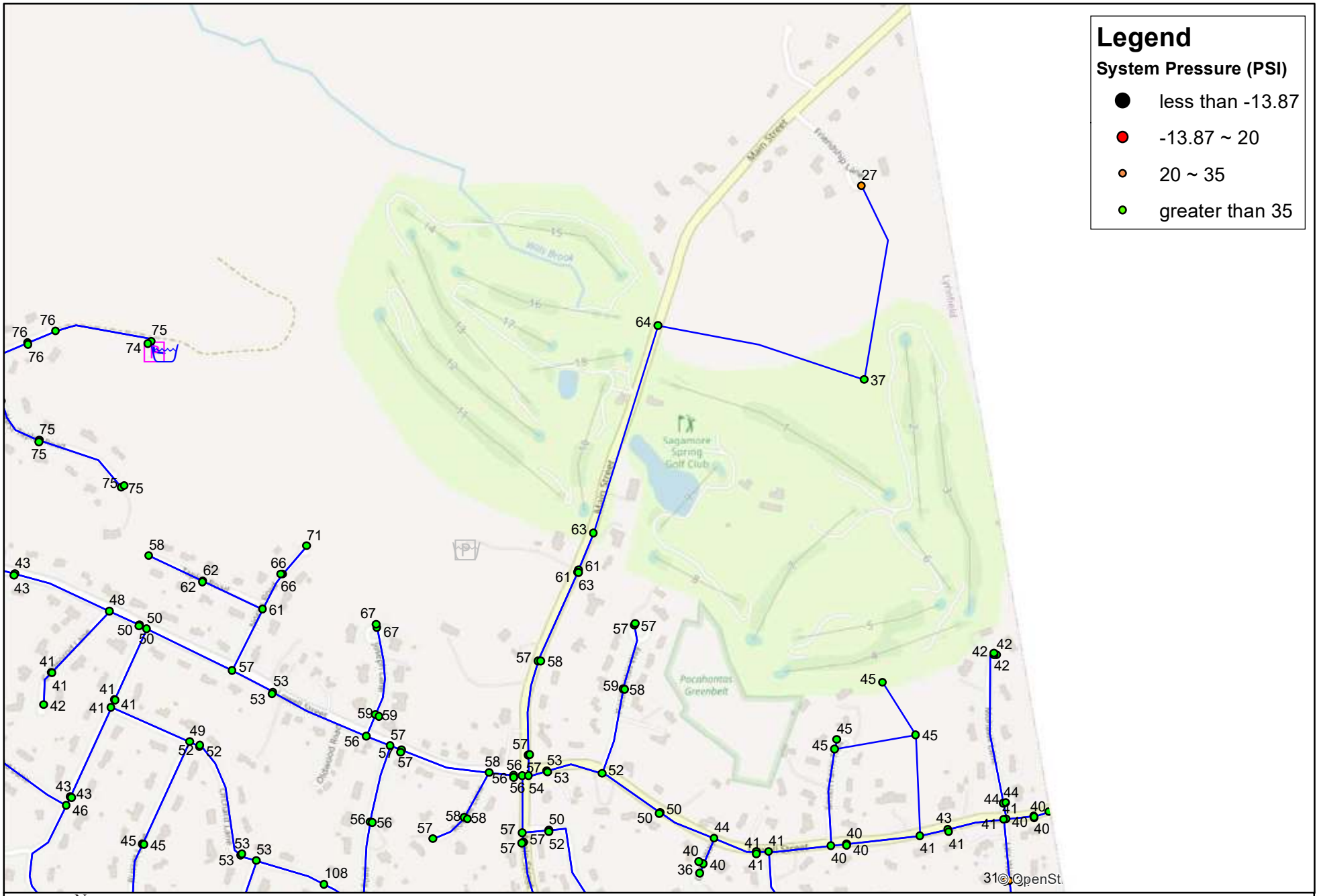


Figure 10
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 1A Low-Low Tank, No MWRA Interconnection
Simulated Delivery Pressure

CDM Smith

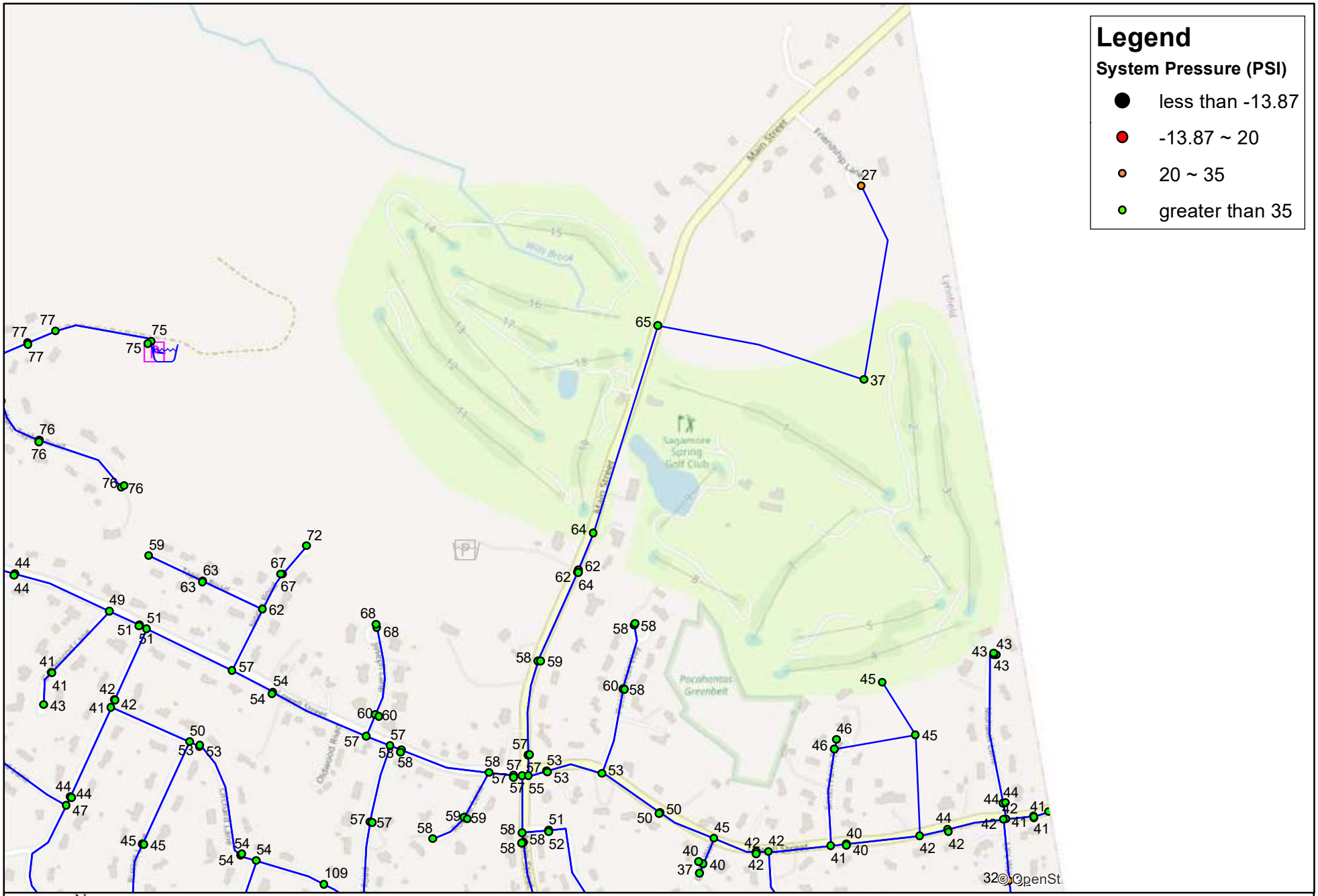


Figure 11
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 1B Low Tank, MWRA Interconnection
Simulated Delivery Pressure

CDM Smith

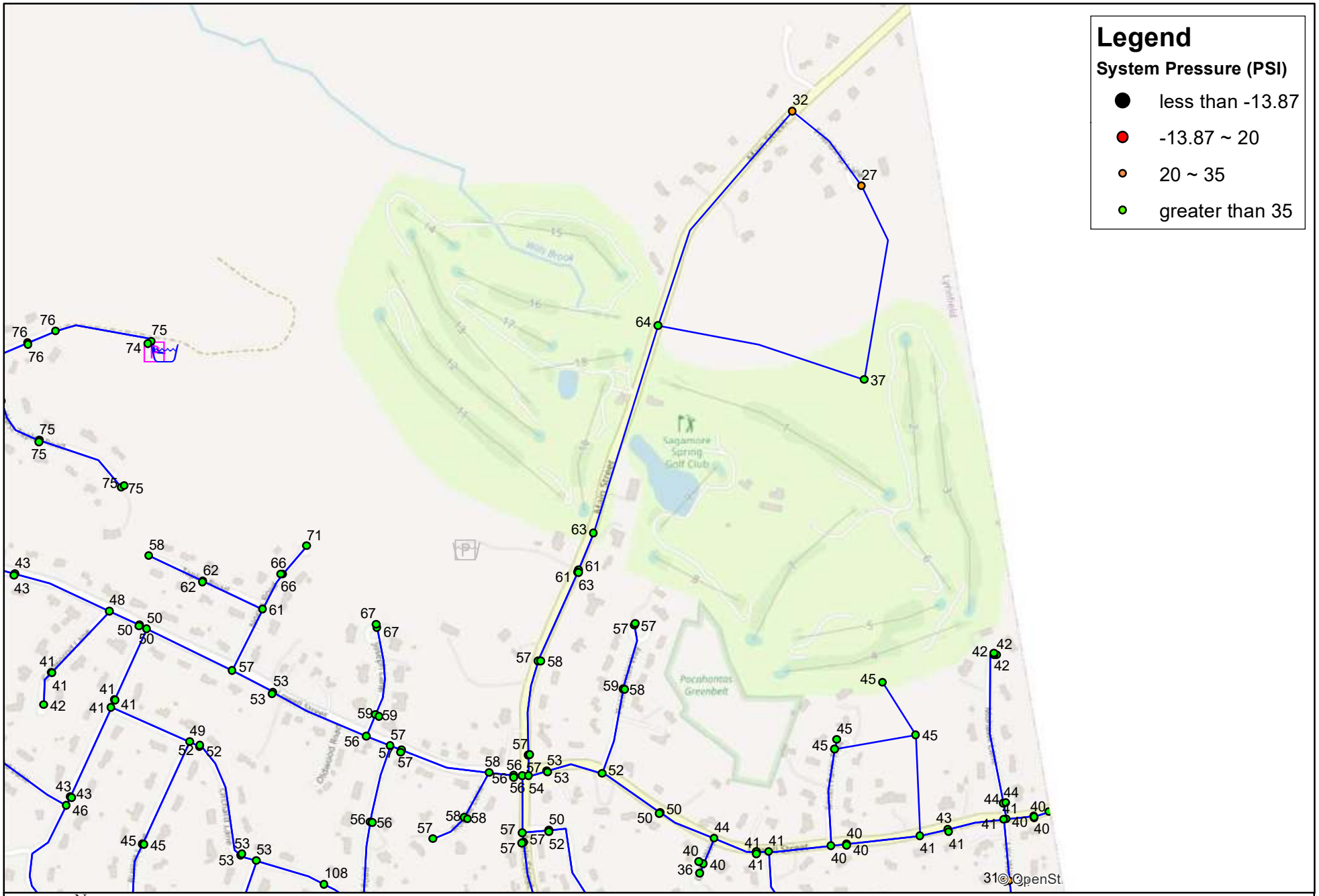


Figure 12
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 2A Low-Low Tank, No MWRA Interconnection
Simulated Delivery Pressure

CDM Smith

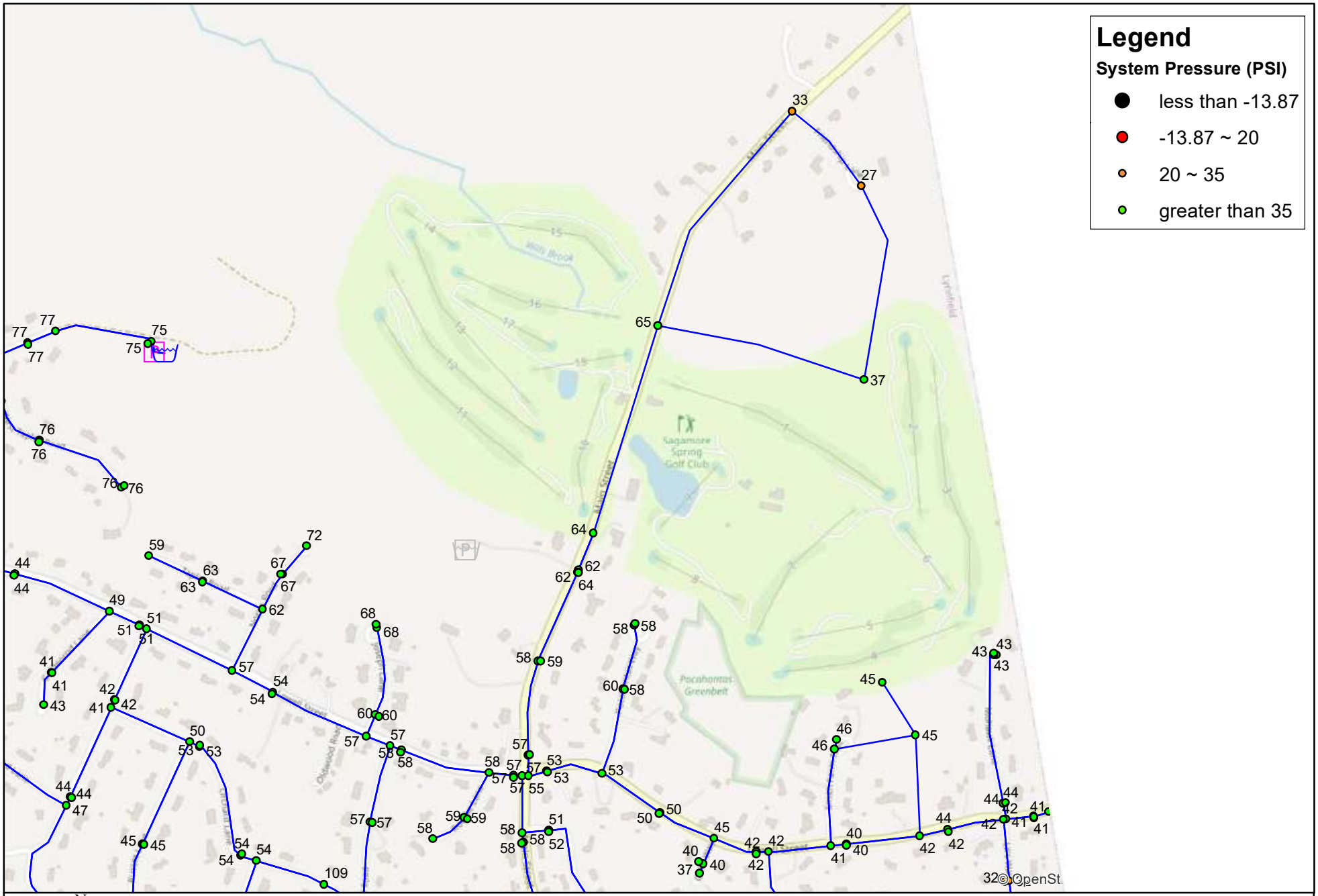


Figure 13
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 2B Low Tank, MWRA Interconnection
Simulated Delivery Pressure

CDM Smith

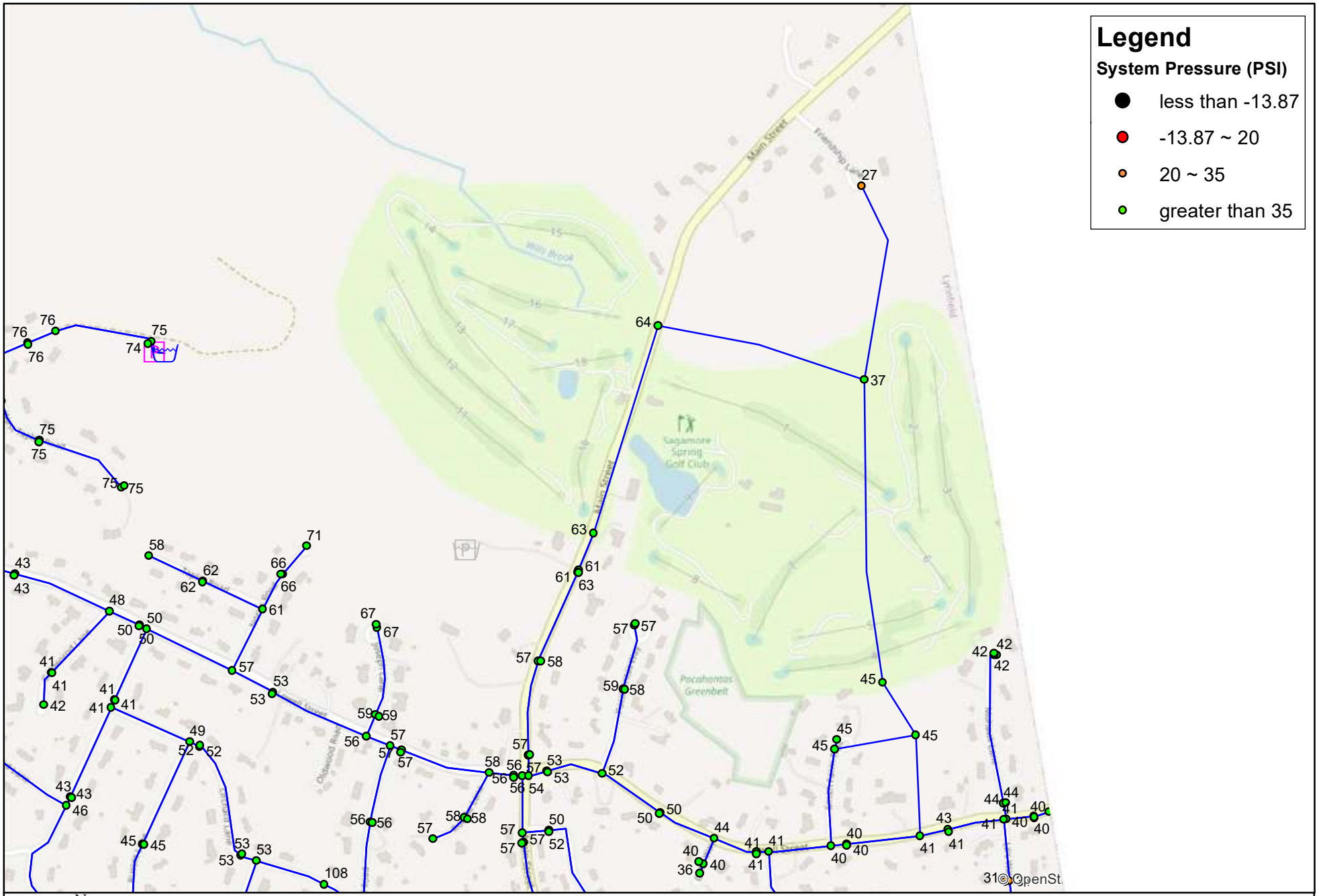


Figure 14
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 3A Low-Low Tank, No MWRA Interconnection
Simulated Delivery Pressure

CDM Smith

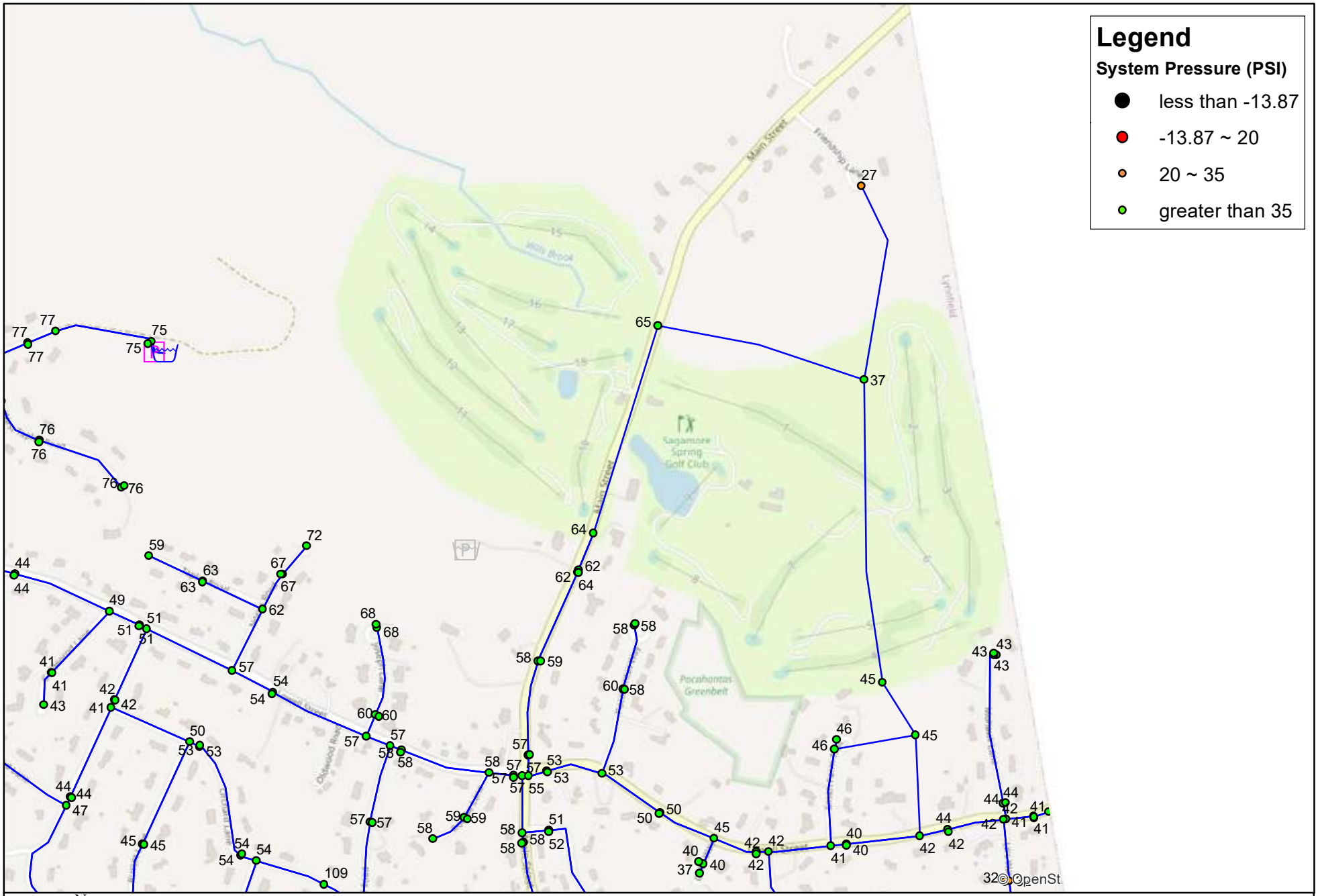


Figure 15
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 3B Low Tank, MWRA Interconnection
Simulated Delivery Pressure

CDM Smith

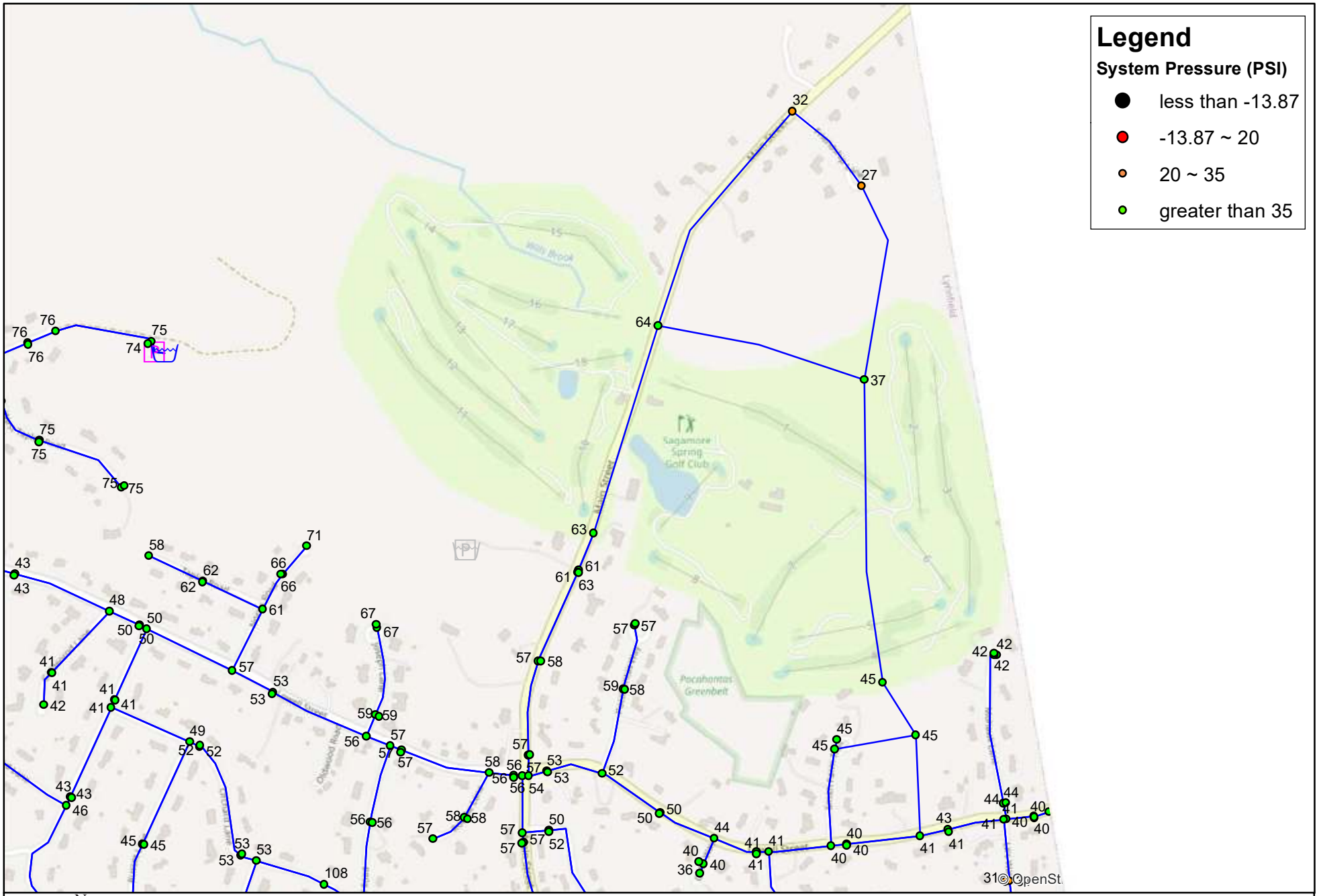


Figure 16
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 4A Low-Low Tank, No MWRA Interconnection
Simulated Delivery Pressure

CDM Smith

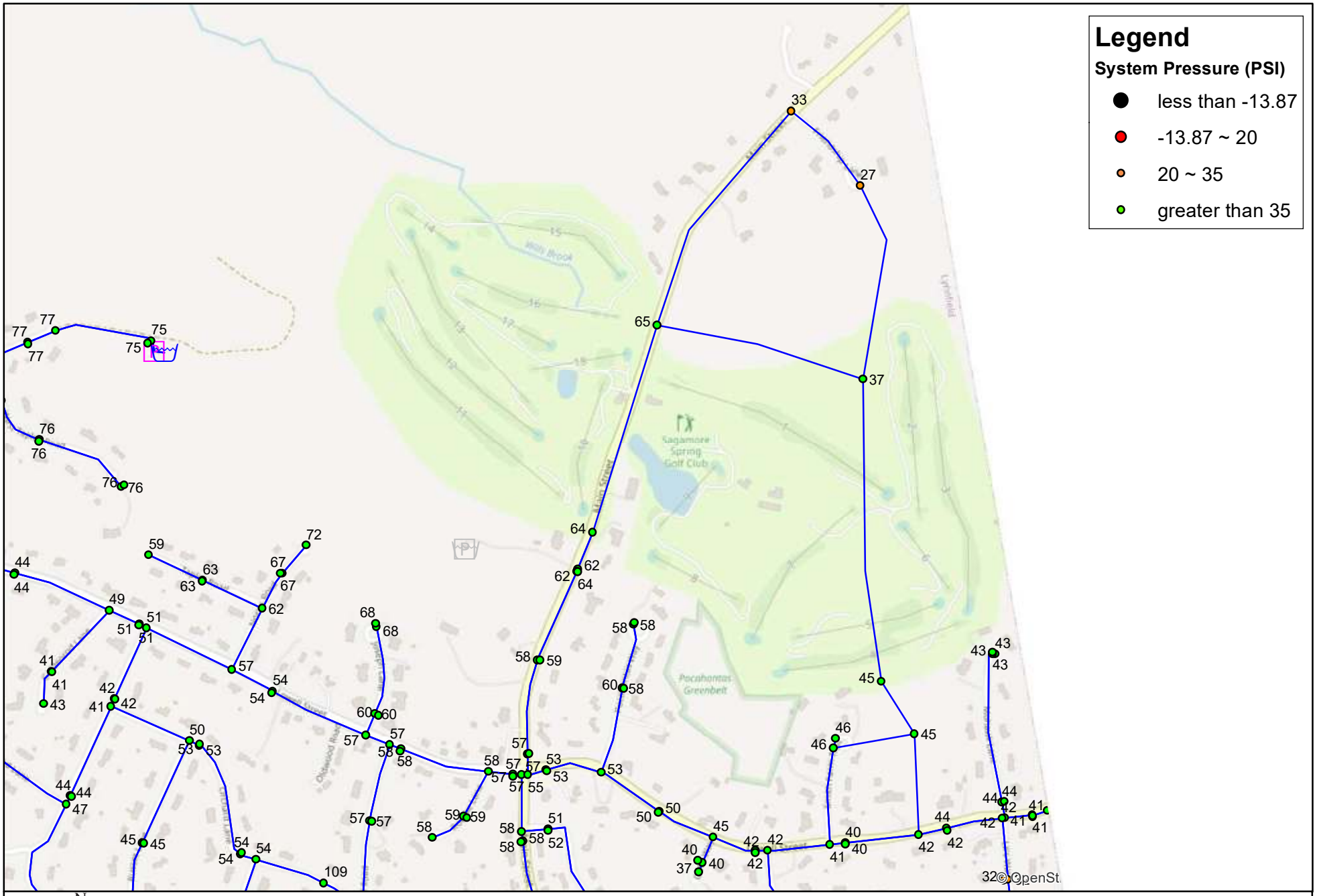


Figure 17
Hydraulic Modeling Evaluations for Proposed Development near Sagamore Springs Golf Club
Lynnfield Center Water District

Scenario 4B Low Tank, MWRA Interconnection
Simulated Delivery Pressure

CDM Smith

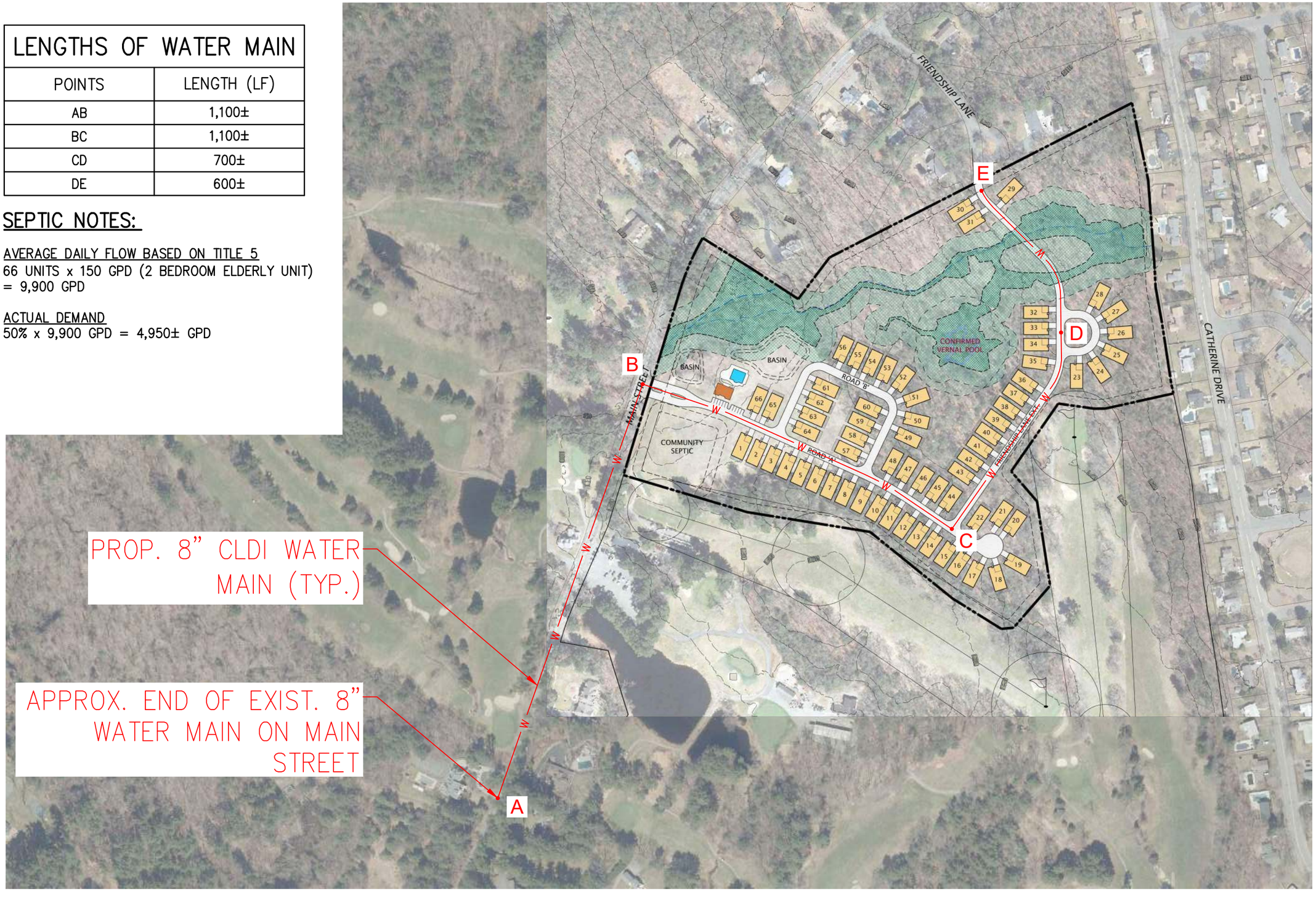
Attachment C
Proposed Site Plan

LENGTHS OF WATER MAIN	
POINTS	LENGTH (LF)
AB	1,100±
BC	1,100±
CD	700±
DE	600±

SEPTIC NOTES:

AVERAGE DAILY FLOW BASED ON TITLE 5
66 UNITS x 150 GPD (2 BEDROOM ELDERLY UNIT)
= 9,900 GPD

ACTUAL DEMAND
50% x 9,900 GPD = 4,950± GPD



The Morin-Cameron GROUP, INC.
CIVIL ENGINEERS | ENVIRONMENTAL CONSULTANTS
LAND SURVEYORS | LAND USE PLANNERS
25 KENOZA AVENUE, HAVERHILL, MASSACHUSETTS 01830
P: 978-373-0310, W: WWW.MORINCAMERON.COM

DATE:
8/16/2022
SCALE:
1"=300'

CONCEPT PLAN
AT:
1287 MAIN STREET
LYNNFIELD, MASSACHUSETTS

PROJ. #4171