



December 18, 2024
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To: Brad Kosco, PE, PS – City of
Hudson

From: GPD Group

Cc:

No. of Pages: 12 (not including attachments)

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Technical Memorandum: Brandywine Creek Watershed Flood Reduction Study

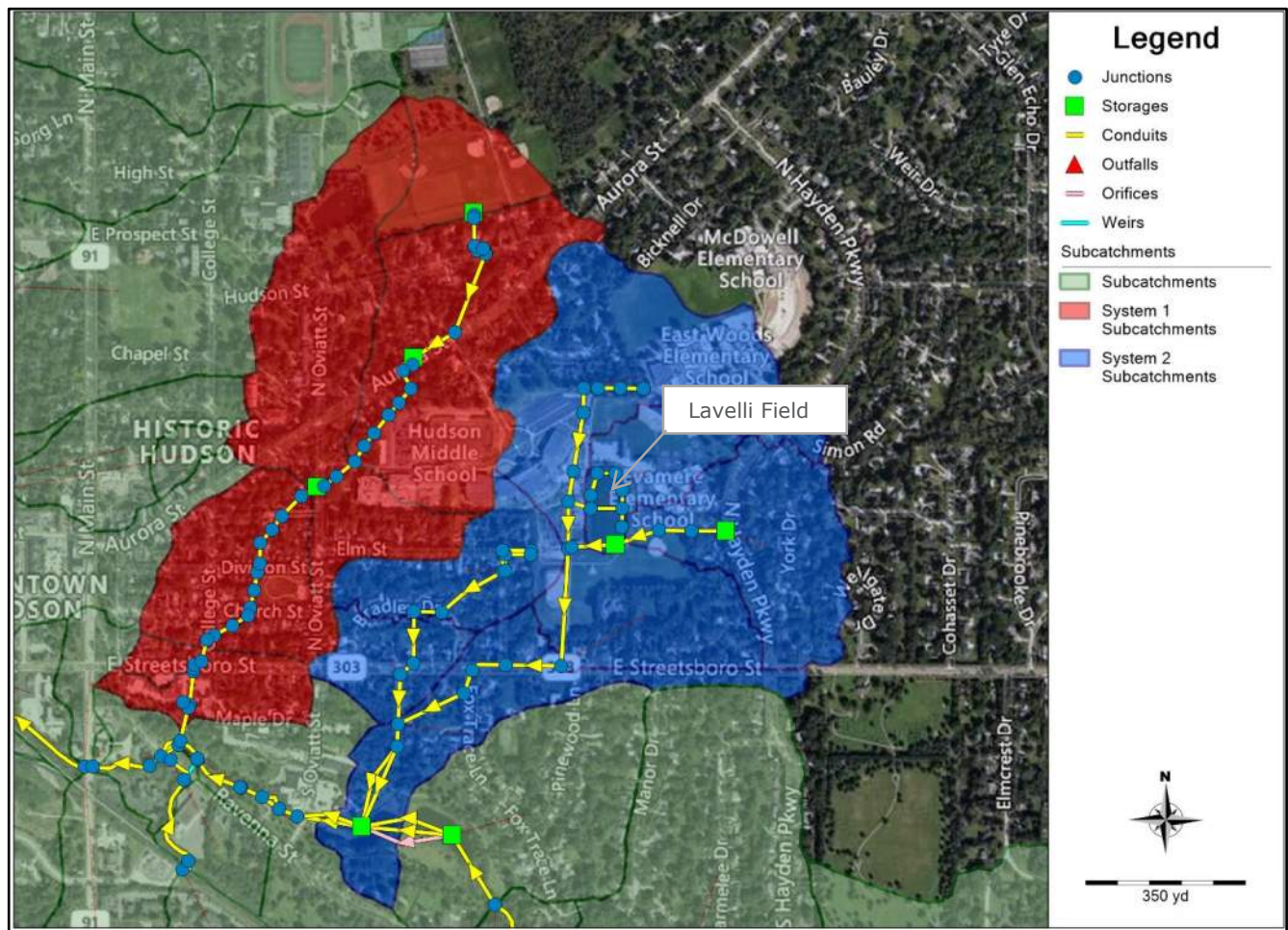
Purpose

The purpose of this technical memorandum (TM) is to summarize GPD Group's efforts employed to evaluate the hydraulic performance for several of the primary trunk storm sewers in the Brandywine Creek watershed, beginning near the Hudson Middle and Evamere Elementary schools and continuing downstream towards the Barlow Community Center and Ravenna Street. The analysis will include alternatives to improve conveyance and storage within the watershed with the goal of providing flood reduction.

Background

Two existing storm sewer systems, both of which traverse the Hudson School property, were overwhelmed during the storm event on August 8th, 2024, leading to the flooding of several nearby properties. The first system begins at the detention basin on the Western Reserve Academy property which discharges into a series of small diameter storm sewers (less than 24-inch) before eventually flowing into a 3-foot by 3-foot concrete box storm sewer, located on the western portion of the Middle School property, that increases in size as it flows downstream. This system continues to the southwest before discharging into the Brandywine Creek Tributary near Ravenna St. The second system consists of a 48-inch storm sewer that exits from the southernmost part of Evamere Elementary School property and flows southward to the Barlow Community Center ponds. The areas will be discussed as System 1 and System 2 in this memorandum, as shown in **Figure 1**. The analysis generally focuses on the primary storm sewers that are 36-inches in diameter or larger and did not include all catch basins within the study area. A few segments of storm sewers smaller than 36-inch were included near Lavelli Field and north of Aurora St.

Several alternatives are presented that focused on improvements targeting the 10-year and 100-year design storms, with hydraulic profiles for those storm events provided in the attachments to this TM. The 25-year was also analyzed for the alternatives focused on the 10-year event with a brief discussion on the 25-year results. Hydraulic profiles for the 25-year are not included in the attachments to this TM.



Existing Condition

GPD Group performed a hydraulic and hydrologic analysis on the project area using PCSWMM (Version 7.6.3610). PCSWMM utilizes the EPA's Storm Water Management Model (SWMM) as the computational engine.

GPD refined the elements within the PCSWMM model for the Brandywine Creek watershed, developed by the Northeast Ohio Regional Sewer District (NEORS) as part of the Cuyahoga River South Stormwater Master Plan (SWMP). Updates to the hydraulic network within PCSWMM were made based on survey data collected by the City of Hudson, survey information from the Hudson Middle School project by GPD Group (GPD), and available record plans. The subcatchments were redelineated based on the addition of sewers to the model and topography in the area. The redelineated subcatchments were checked to ensure they produced similar runoff (peak and volume) as the original SWMP subcatchments, however, these subcatchment updates should be validated in a future study.

The focus of the analysis for System 1 began with the 3-foot by 3-foot concrete box storm sewer located on the western side of the school property. It gradually increases in size as it extends southwest, eventually discharging into the Brandywine Creek Tributary near Ravenna St. The subcatchment area for System 1 covers approximately 142.4-acres. Hydraulic analysis indicates that the system experiences surcharging during the 10-year design storm, from E. Streetsboro St. to Western Reserve Academy, with minor flooding in a few locations north of Aurora St. During the 25-year storm there is flooding occurring between E. Streetsboro St. and N. Oviatt St. and north of Aurora St. Modeling results indicate that System 1 is heavily surcharged or flooded from E. Streetsboro St. to N. Oviatt St. during the 100-year storm event.

Hydraulic profiles of the area are provided in **Attachment A**.

The focus for System 2 began with storm sewers on Eastwoods and Evamere Elementary School Property that flow to a 48-inch storm sewer that exits from the southernmost part of the school property on E. Streetsboro St. and flows west before heading south near Fox Trace Lane where it transitions to a 6-foot by 5-foot elliptical sewer before reaching the ponds at the Barlow Community Center. Sewers primarily 24-inches in diameter and larger were added to the model for System 2, totaling approximately 7,500-feet. Storage nodes were incorporated to account for the sewers not included in the model, less than 24-inch, at the upstream end of the modeled sewer system. Two subcatchments were redelineated to improve the accuracy of the model, ensuring that the runoff volume for the divided subcatchments generally matched the original configuration. System 2 includes a total subcatchment area of 164.3-acres.

Hydraulic results indicate that the 36-inch sewer near Lavelli Field is surcharged, and the 24-inch sewer flowing onto the school property from N. Hayden Parkway is flooding during the 10-year design storm. This 24-inch sewer captures flow from approximately 28.5 acres. Additionally, the 48-inch sewer that begins near the southwest corner of Lavelli Field is surcharged from E. Streetsboro St. to Fox Trace Lane. The 25-year storm surcharges much of the system with sporadic flooding throughout the entire area. Hydraulic profiles of the area are provided in **Attachment A**.

Alternatives

Six alternatives were developed to improve the sewer system.

- Alternative 1 focuses on storm sewer improvements for the 10-year design storm.
- Alternative 2 addresses storm sewer improvements for the 100-year design storm.
- Alternative 3 combines storage basin and sewer improvements for the 10-year storm.
- Alternative 4 focused on System 1, evaluating an underground detention for the 10-year storm.
- Alternative 5 combined both System 1 and 2 detention basins, the System 1 underground detention, and storm sewer improvements to manage the 100-year storm.
- Alternative 6 combined the underground storage on System 1, the detention basin on System 2 with storm sewer improvements for the 100-year storm.

Hydraulic profiles for the alternatives are provided in **Attachment A**.

Assumptions & Clarifications

The following assumptions were made for the analysis:

- The hydrology from the SWMP model was not modified.
- The sewer replacements discussed for each alternative that follows were modeled as only a change in pipe/culvert size; inverts were not adjusted. Should any alternative be pursued into design, a detailed evaluation of the inverts, pipe slope, cover, etc. would be necessary.
- The modeling assumes that all flow can enter the storm sewer system efficiently. The inlets within the study area likely do not have the capacity to efficiently capture all storms up to the 100-year. If an alternative is pursued to implementation, a study of the inlet capacity in the project area should be completed.

Alternative 1

Alternative 1 was developed to evaluate the necessary sewer system improvements to convey the 10-year design storm without surcharging the storm sewers (see **Figure 2**). For System 1, the alternative involves the following:

- Replace 114-feet of 16-inch sewer with 24-inch sewer north of Hudson St.
- Replace 909-feet of 18-inch sewer with a 30-inch sewer between Aurora St. and Hudson St.

- Replace 242-feet of 48-inch sewer under parcel 3204075, located at the corner of S. College St. and E. Streetsboro St., with an 8-ft by 4-ft box culvert to align with the downstream box culvert sewer. The 48-inch (12.6-ft² opening) segment acts as a "choke point" in the system, restricting flow between the upstream 4-ft x 4-ft (16-ft² opening) pipe and the downstream 8-ft x 4-ft (32-ft opening) pipe. This "choke point" is necessary to be replaced for all alternatives evaluated.

For System 2, this alternative involves the following improvements:

- Replace 160-feet of the 36-inch sewer north and west of Lavelli Field with 48-inch sewer.
- Replace 2,309-feet of 48-inch sewer from Lavelli Field to Fox Trace Lane with 60-inch sewer.
- Replace 1,049-feet of 24-inch sewer from N. Hayden Pkwy. onto the school property with 36-inch sewer.
- Replace 628-feet of 36-inch sewer that starts on Bradley Dr. to E. Streetsboro St. with 48-inch sewer.

Alternative 1 successfully achieved its objective of eliminating surcharging within the sewers during the 10-year storm event. The proposed improvements also can carry the 25-year in both System 1 and 2 without flooding at all locations except the manhole on the south side of Church Street for System 1. Hydraulic results are in **Attachment A**.

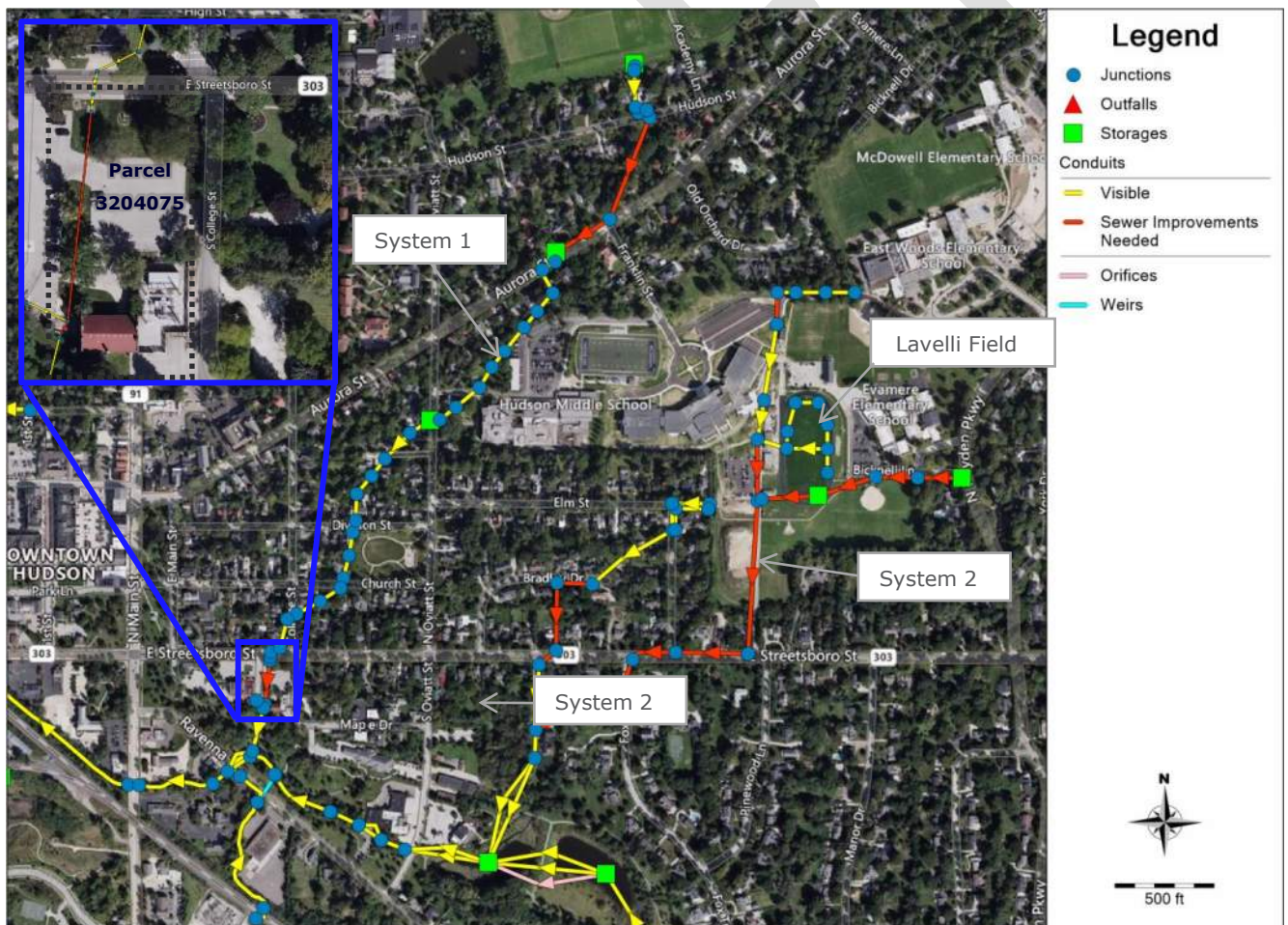


Figure 2: Alternative 1-Sewer Improvements for 10-yr Design Storm

Alternative 2

Alternative 2 was developed to evaluate the sewer improvements required to contain the 100-year design storm without causing surface flooding. For System 1, the alternative involves replacing the stretch of various-sized culverts from N. Oviatt St. to Ravenna St. The following improvements are needed:

- Replace 114-feet of 16-inch sewer with 24-inch sewer north of Hudson St.
- Replace 909-feet of 18-inch sewer with a 30-inch sewer between Aurora St. and Hudson St.
- Replace 459-feet of 4-ft x 3-ft box culvert storm sewer from N. Oviatt St. to south of Ellsworth St. with a 5-ft x 4-ft culvert. This would need to be investigated in more detail as cover could be an issue at some locations.
- Replace 719-feet of box culvert storm sewer, ranging from 4-ft x 3-ft to 5-ft x 3-ft, from south of Ellsworth St. to south of Church St. with a 6-ft x 4-ft box culvert.
- Replace 893-feet of box culvert and circular storm sewer, ranging from 5-ft x 3-ft, 4-ft x 4-ft, 4-ft circular, and 8-ft x 4-ft, with a 10-ft x 4-ft box culvert.

For System 2, the storm sewers from the school property to Edward Drive would need to be replaced. The improvements include the following:

- Replace 546-feet of 36-inch and 42-inch storm sewer with 54-inch sewer, beginning near the elementary school to Lavelli Field.
- Replace 506-feet of 48-inch storm sewer with 60-inch adjacent to Lavelli Field.
- Replace 2,002-feet of 48-inch storm sewer with 66-inch from south of the Lavelli Field to Edward Dr.
- Replace 142-feet of 6-ft x 5-ft elliptical storm sewer with 11-ft x 5-ft box culvert on Edward Dr.
- Replace 1,049-feet of 24-inch storm sewer from N. Hayden Pkwy. onto the school property with a 42-inch sewer
- Replace 628-feet of 36-inch storm sewer from Bradley Dr. to E. Streetsboro St. with a 48-inch sewer, similar to the approach in Alternative 1.

Alternative 2 successfully achieved its goal of containing the 100-year design storm, with System 1 fully contained and free from surcharging, while System 2 exhibits surcharging. The sewer along E. Streetsboro St. to Edward Dr. and the sewer from N. Hayden Pkwy. also remain surcharged. The hydraulic profiles are available in **Attachment A**.

Alternative 3

Alternative 3 was developed to evaluate the use of detention basins along with necessary sewer improvements to maintain the 10-yr within the sewer. System 1 improvements include the following:

- Replace 114-feet of 16-inch sewer with 24-inch sewer north of Hudson St.
- Replace 909-feet of 18-inch sewer with a 30-inch sewer between Aurora St. and Hudson St.
- Two detention basins located near Hudson Middle School. The most upstream basin, Basin 1, utilizes 2.87 ac-ft of the total available 6.73 ac-ft of storage, while the downstream basin, Basin 2, utilizes 3.58 ac-ft of the total available 8.31 ac-ft of storage for the 10-year storm.
- Replace 242-feet of 48-inch sewer, choke point, under parcel 3204075, located at the corner of S. College St. and E. Streetsboro St., with an 8-ft by 4-ft box culvert.

System 2 improvements include the following:

- A detention basin south of the Lavelli Field that utilizes 4.93 ac-ft of the total available 17.36 ac-ft of storage during the 10-yr design storm.
- Replace 488-feet of 48-inch storm sewer with a 60-inch sewer from the Lavelli Field to the basin.
- Replace the 24-inch sewer from N. Hayden Pkwy. onto the school property with 1,049-ft of 36-inch sewer, similar to Alternative 1.

Hydraulic results indicate that the basins provide minimal improvement in System 1 compared to Alternative 1, and the alternative still requires the replacement of the 48-inch sewer near the corner of College St. and E. Streetsboro St. to prevent surcharging. The ponds provide minimal benefit due to their location in the upper part of the watershed. The flow out of the ponds would need to be reduced to almost nothing to have an impact downstream and there isn't sufficient storage available. In System 2, incorporating the basin decreases the required sewer replacement downstream by approximately 1,815-feet and results in a lower hydraulic grade line (HGL) downstream compared to Alternative 1. The System 1 improvements can carry the 25-year storm by surcharging the system, but flooding does not occur. System 2 can also carry the 25-year in all locations except the section on the drive adjacent to Eastwoods Elementary, where flooding occurs. Hydraulic profiles and detention basin exhibits available in **Attachment A** and **Attachment B**, respectively.

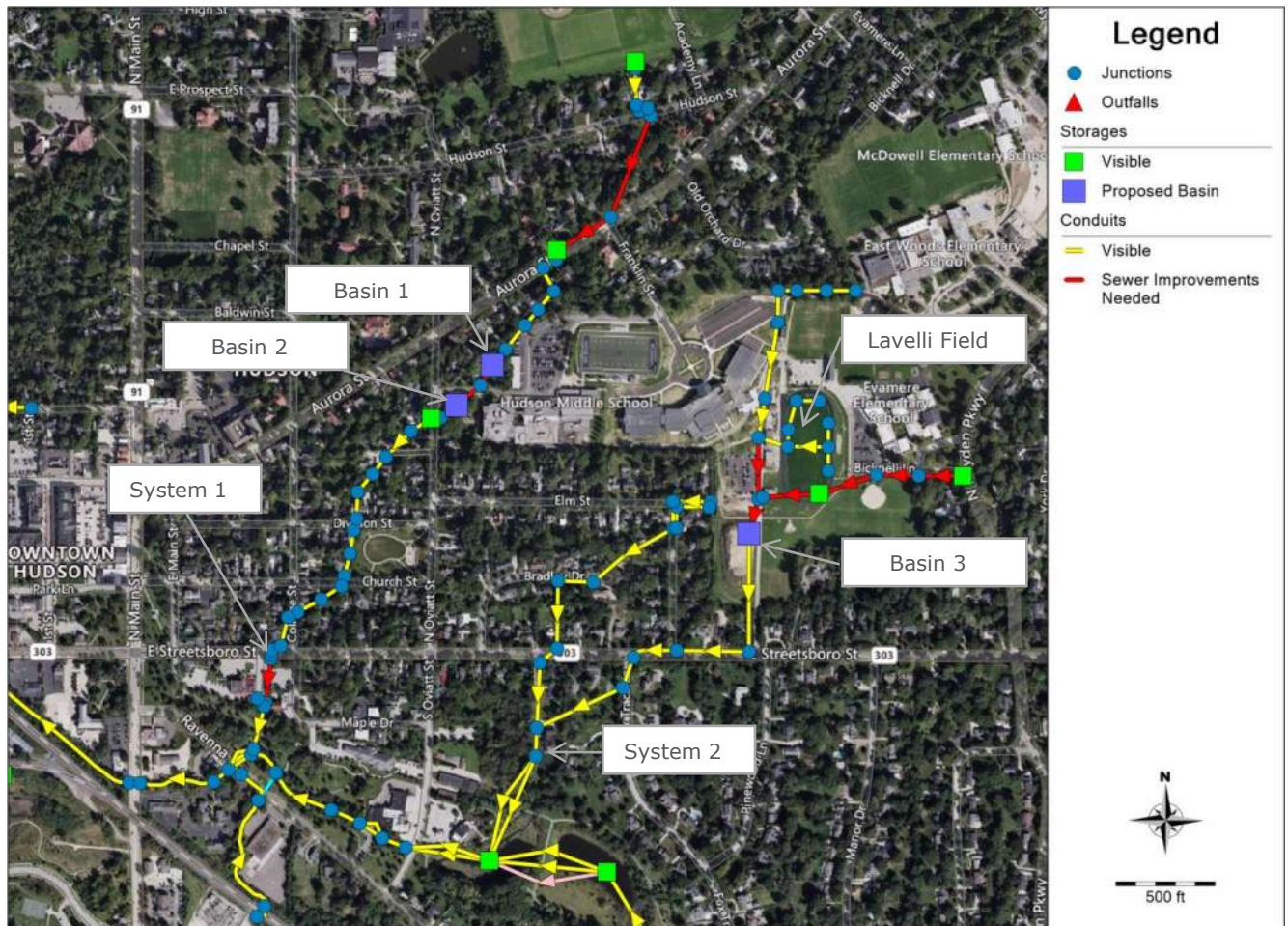


Figure 4: Alternative 3 - Basins and Sewer Improvements for 10-yr

Alternative 4

Alternative 4 examines the use of an underground detention for System 1 under 10-year storm conditions. The underground detention is located on parcel 3200188, between Division St and Church St. It can accommodate the 10-year design storm with minimal downstream surcharging. However, the upstream, small diameter, sewers between Aurora St and Hudson St showed surcharging above the rims and the system was unable to handle the 25-year design storm. The underground detention stage-storage curve was developed using the ADS StormTech sizing spreadsheet. The conceptual storage features the MC-3500 Chamber Model, consisting of 450 chambers that would require an area of approximately 24,000-square feet. The chamber provides 1.96 ac-ft of storage. The chamber system as modeled utilizes a storage volume of 0.49 ac-ft out of an available 1.96 ac-ft during the 10-yr design storm. Supporting calculations are included in **Attachment C**. The project site for the detention system is highlighted in **Figure 5** below.

For Alternative 4 to prevent surcharging during the 10-year design storm and accommodate the 25-year design storm without system flooding, the following improvements would be necessary:

- Replace 114-feet of 1.33-ft sewer with 2-ft sewer north of Hudson St.
- Replace 909-feet of 1.5-foot sewer with a 2.5-foot sewer between Aurora St. and Hudson St.
- Underground detention at parcel 3200188 between Division St. and Church St.
- Replace 242-feet of 48-inch sewer, choke point, under parcel 3204075, located at the corner of S.

College St. and E. Streetsboro St., with an 8-foot by 4-foot box culvert
Detailed hydraulic profiles are available in **Attachment A**.

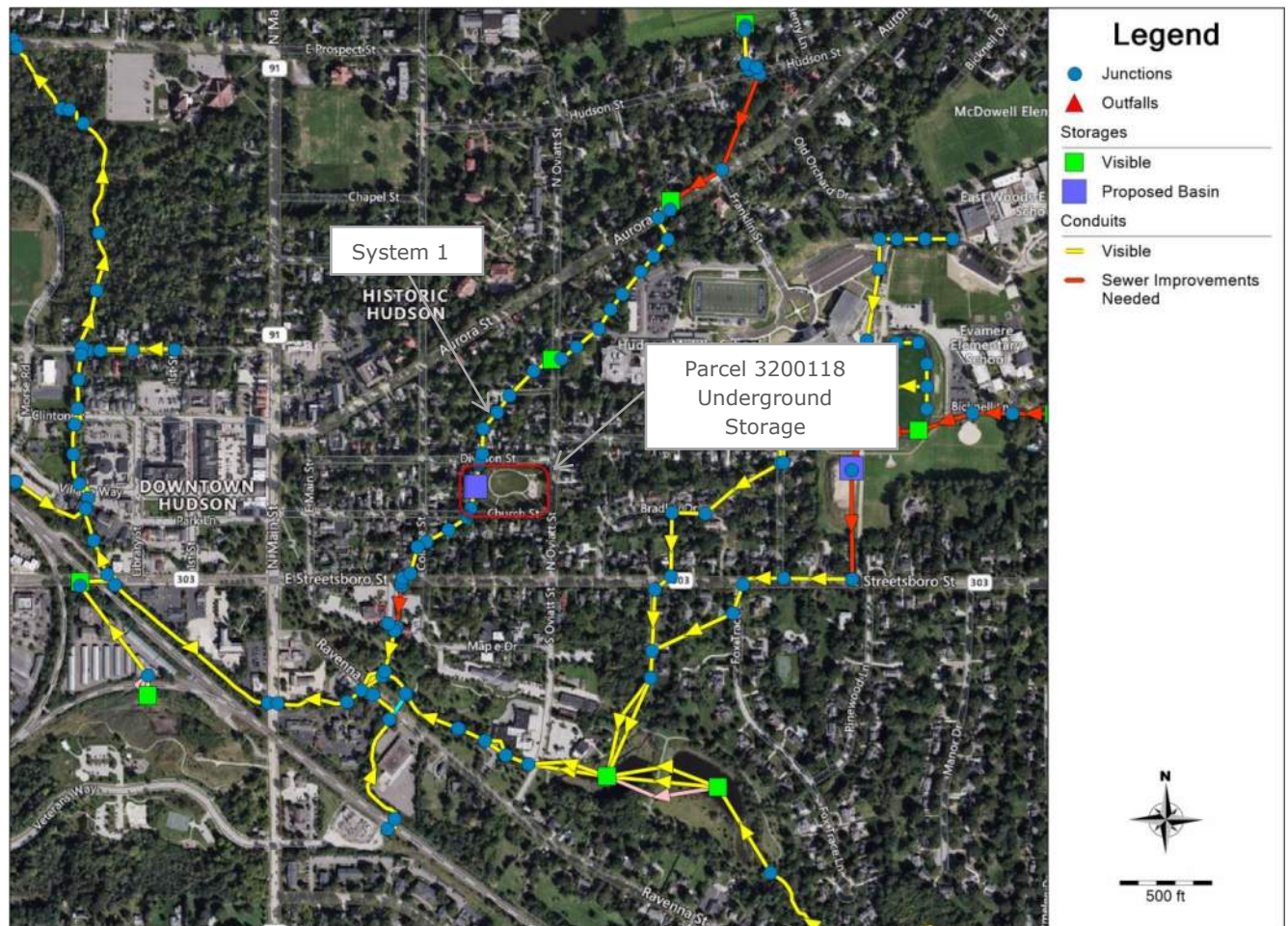


Figure 5: Alternative 4 - Underground Detention for System 1

Alternative 5

Alternative 5 assesses the use of both underground detention for System 1 and detention basins for System 1 and 2 along with storm sewer improvements to manage the 100-year storm. This alternative incorporates the following:

- Replace 114-feet of 16-inch sewer with 24-inch sewer north of Hudson St.
- Replace 909-feet of 18-inch sewer with a 30-inch sewer between Aurora St. and Hudson St.
- Two detention basins located near Hudson Middle School, similar to Alternative 3. The most upstream basin, Basin 1, utilizes 5.36 ac-ft of the total available 6.73 ac-ft of storage, while the downstream basin, Basin 2, utilizes 6.91 ac-ft of the total available 8.31 ac-ft of storage for the 100-year storm.
- The underground detention basin on parcel 3200118, between Division St. and Church St from Alternative 4. The basin utilizes 1.09 ac-ft of the total available 1.96 ac-ft of storage during the 100-yr storm.
- Replace 240-ft of 4-ft x 4-ft culvert with 8-ft x 4-ft north of E Streetsboro St.
- Replace 242-feet of 48-inch storm sewer, choke point, under parcel 3204075, located at the corner

of S. College St. and E. Streetsboro St., with an 8-foot by 4-foot box culvert

System 2 improvements contain the following:

- Replace 1234-feet of 42-inch and 48-inch sewer with 60-inch sewer north of the basin along Lavelli field.
- A detention basin south of the Lavelli Field that utilizes 10.56 ac-ft of the total available 17.36 ac-ft of storage during the 100-yr design storm.
- Replace the 24-inch sewer from N. Hayden Pkwy. onto the school property with 1,049-ft of 48-inch sewer.
- Replace 628-feet of 36-inch storm sewer from Bradley Dr. to E. Streetsboro St. with a 48-inch sewer, similar to the approach in Alternative 1.

Hydraulic profiles are available in **Attachment A**.

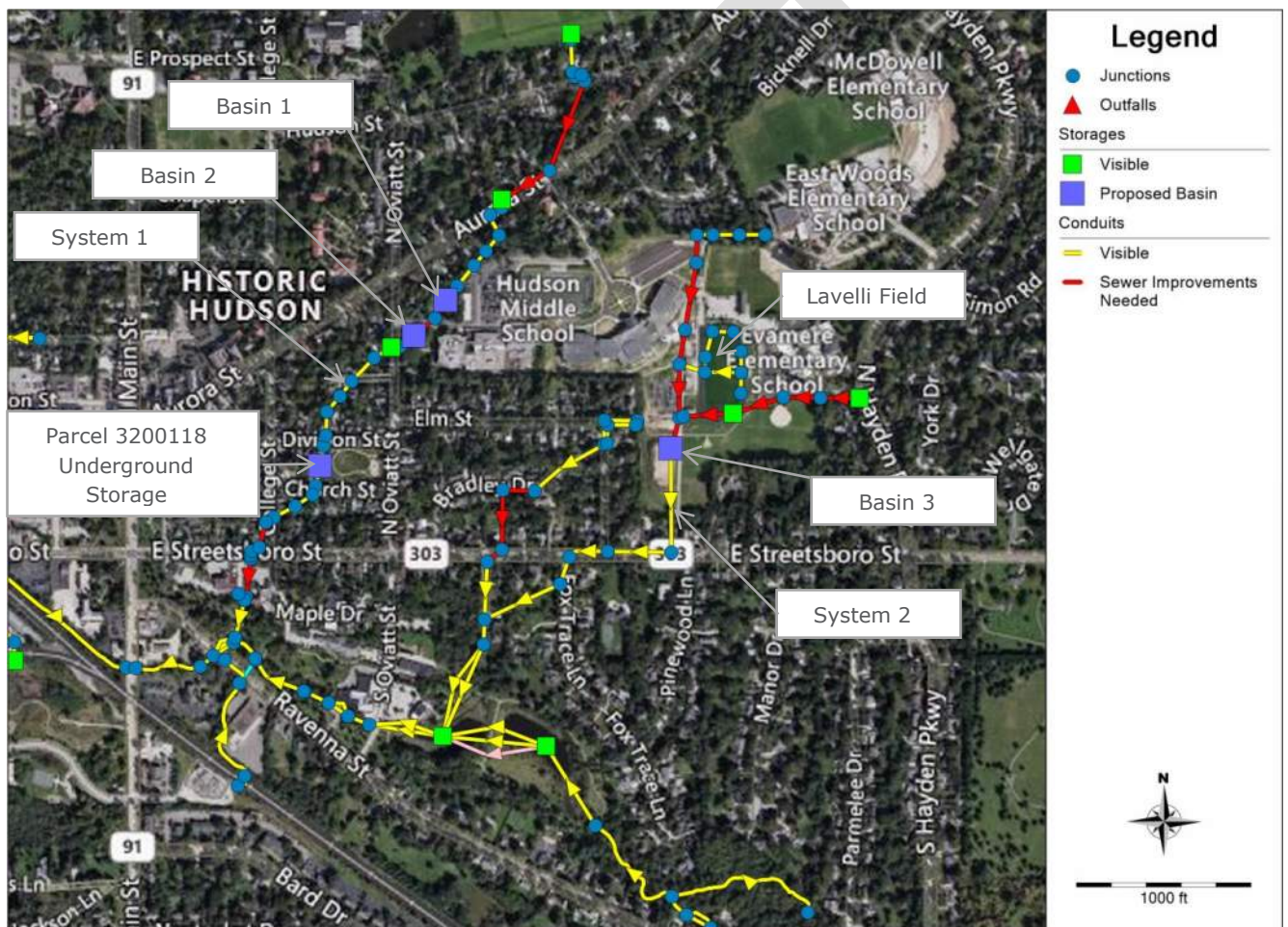


Figure 6: Alternative 5 - Detention to Manage the 100-yr Storm

Alternative 6

Alternative 6 assesses the use of the underground detention basin and the 48-inch sewer replacement to manage the 100-year storm for System 1. This alternative incorporates the following:

- Replace 114-feet of 16-inch sewer with 24-inch sewer north of Hudson St.
- Replace 909-feet of 18-inch sewer with a 30-inch sewer between Aurora St. and Hudson St.

- The underground detention basin on parcel 3200118, between Division St. and Church St. from Alternative 4. The basin utilizes 1.01 ac-ft of the total available 1.96 ac-ft of storage during the 100-yr storm.
- Replace 93-feet of 4-ft by 4-ft box culvert with 8-ft by 4-ft culvert along E Streetsboro St.
- Replace 242-feet of 48-inch storm sewer, choke point, under parcel 3204075, located at the corner of S. College St. and E. Streetsboro St., with an 8-foot by 4-foot box culvert

Hydraulic profiles are available in **Attachment A**.

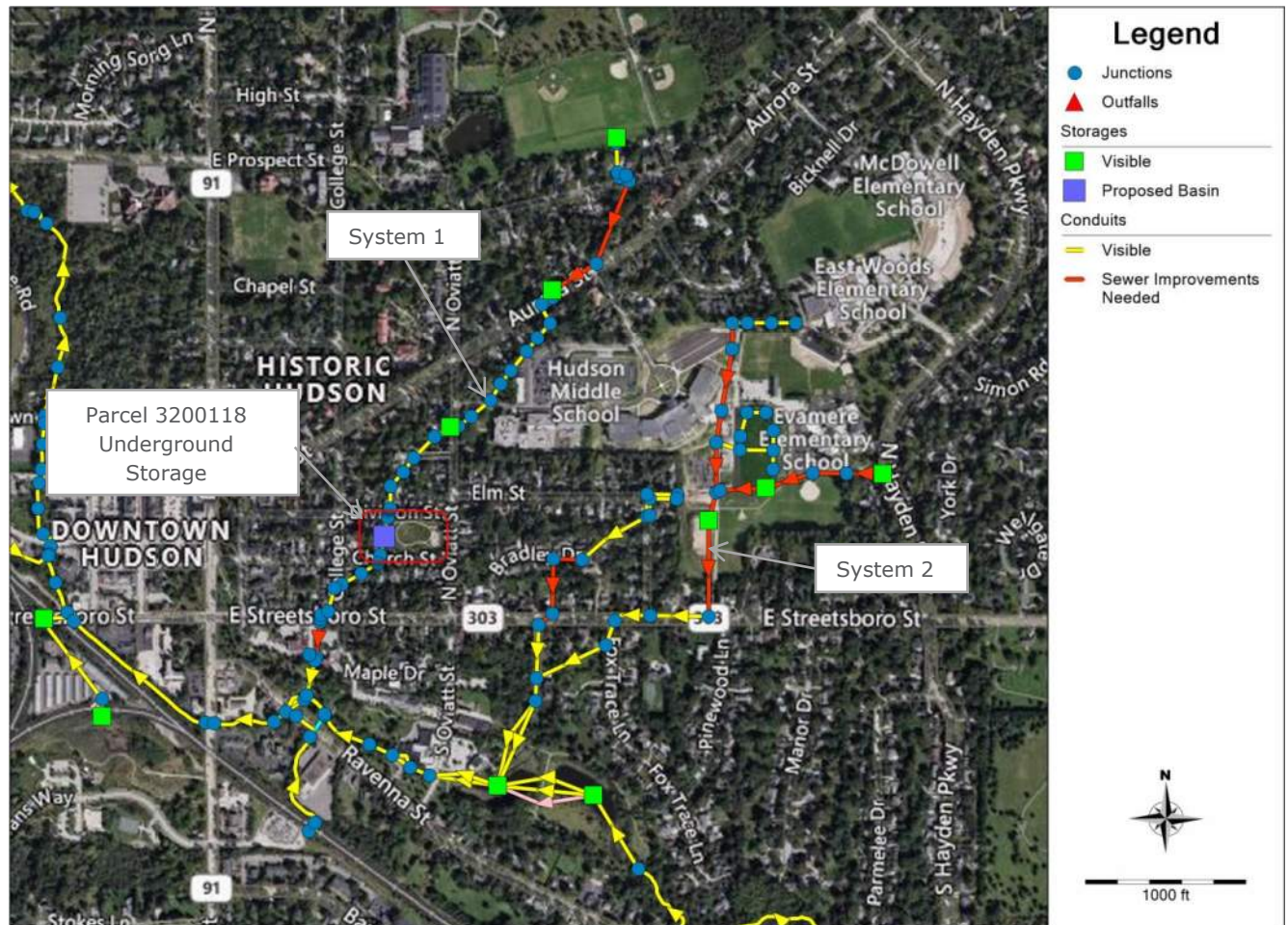


Figure 7: Alternative 6 - Detention to Manage the 100-yr Storm

Conclusion

The alternatives presented in this technical memorandum offer a range of solutions to address the hydraulic and hydrologic challenges facing the storm sewer system in the study area. GPD Group's analysis, conducted using PCSWMM, highlights the improvements necessary to manage both the 10-year and 100-year design storms. Alternatives 1, 3, and 4 were developed to contain the 10-year within the storm sewer without surcharging. Alternatives 2, 5, and 6 were developed to pass the 100-year without surface flooding or surcharging beyond the ground surface. Hydraulic profiles comparing the proposed conditions of each alternative to the existing conditions are provided in **Attachment A**. The key takeaways from this analysis are as follows:

- The sewers north of Aurora Street are undersized. The 16-inch sewers north of Hudson Street need to be replaced with 114-feet of 24-inch sewers, and the 18-inch sewer between Aurora Street and



Hudson Street needs to be replaced with 909-feet of 30-inch sewer.

- The 242-feet of 48-inch sewer under parcel 3204075, located at the corner of S. College St. and E. Streetsboro St. is a choke point between the connecting upstream 4-ft by 4-ft box culvert storm sewer and the downstream 4-ft by 8-ft box culvert storm sewer. Replacement of this sewer segment will allow the capacity in the downstream box culvert to be fully utilized and reduce the HGL upstream for all events analyzed.
- The proposed detention basins (Basins 1 and 2) on the school property for System 1 do not provide a similar benefit to the proposed underground detention system on System 1, however, additional stormwater storage in any urban drainage system can provide flood mitigation benefits. It is recommended that the benefit-cost ratio of the introduction of additional stormwater management be further evaluated.
- The proposed detention basin (Basin 3) on System 2 would reduce the amount of sewer improvements needed downstream to reduce flooding.

Improvements at key locations appear to have a significant impact on system performance, however, several steps should still be taken before any of the alternatives are advanced to the design stage.

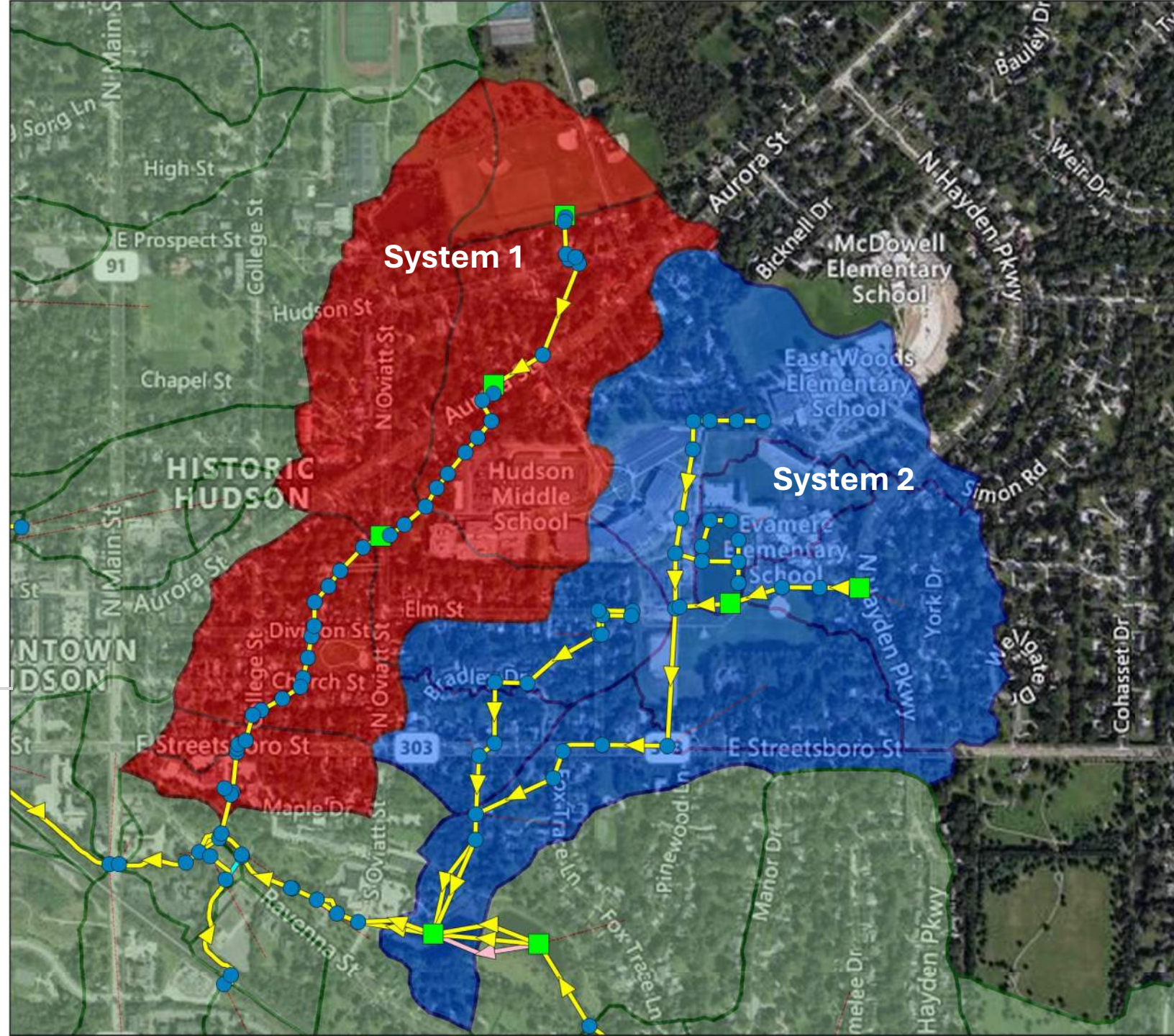
- Verification of the improvements could be achieved by implementing a flow monitoring program and then calibrating the models to confirm they are producing realistic flow rates and volumes.
- Inlet capacities within the system should be verified and/or improved to ensure that all runoff can enter the storm sewer system and is not contributing to surface flooding.
- Schematic level plans and opinions of probable cost should be developed to evaluate the benefit-cost ratio for any project further pursued.

Attachment A

Existing and Proposed Hydraulic Profiles

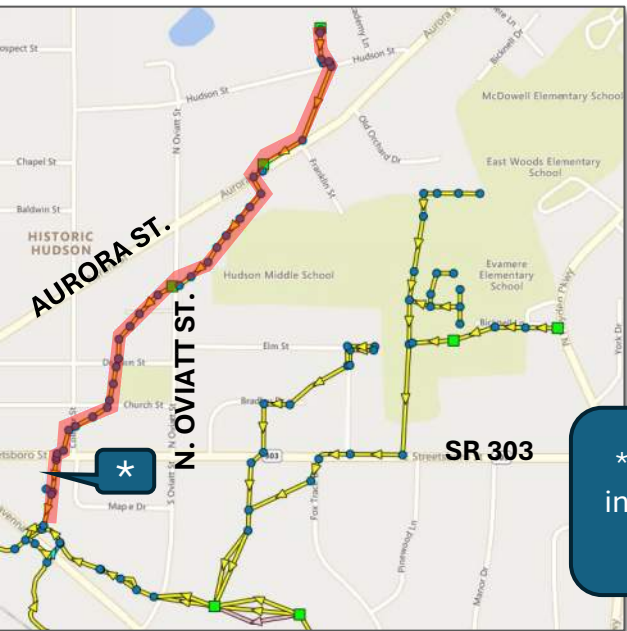
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Existing Conditions

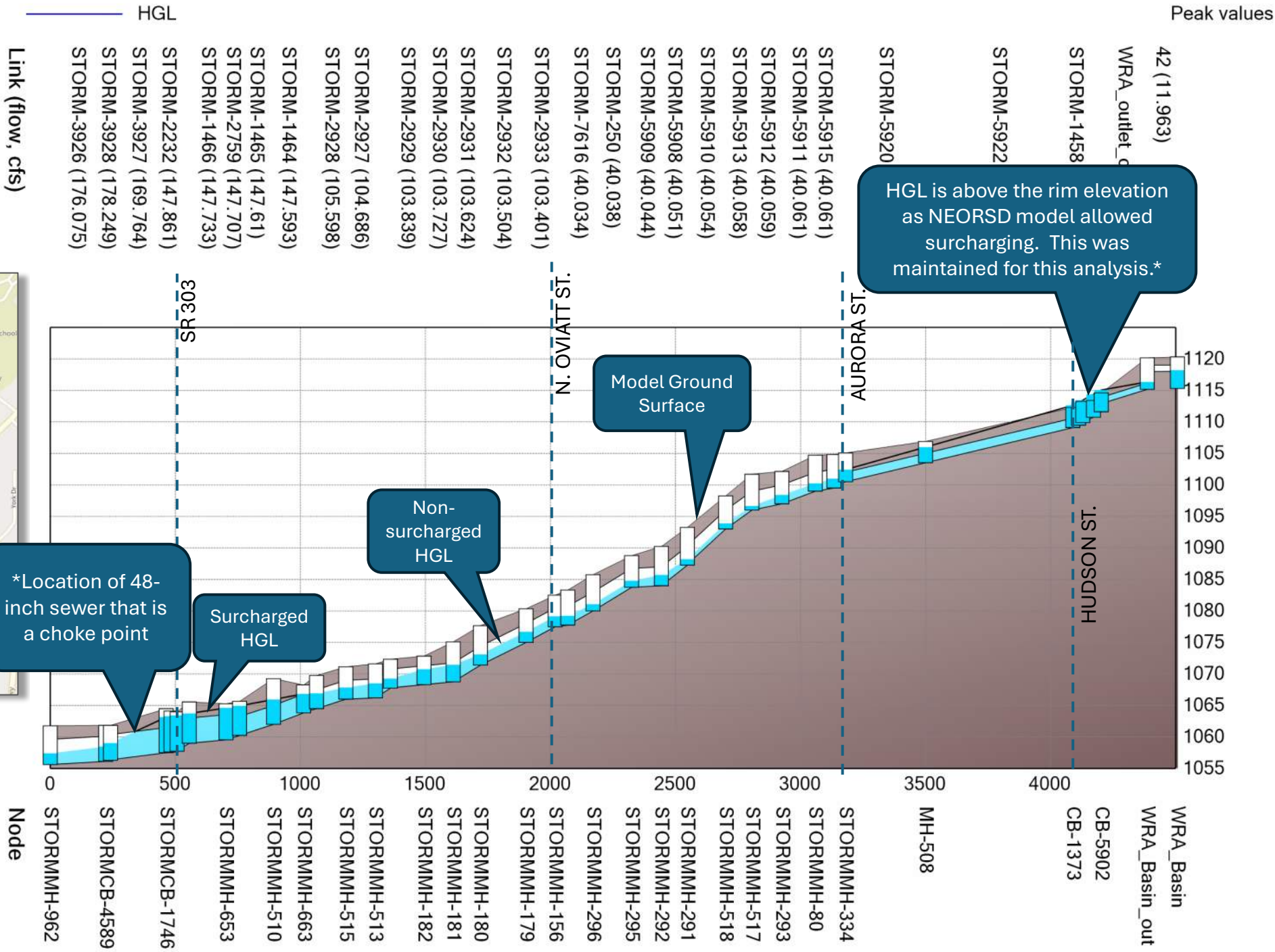


Existing 10-yr System 1

Profile Location



*The surcharging in the NEORS model was likely used to prevent a loss of volume from the system for analysis of the larger stream systems downstream from the sewer locations.



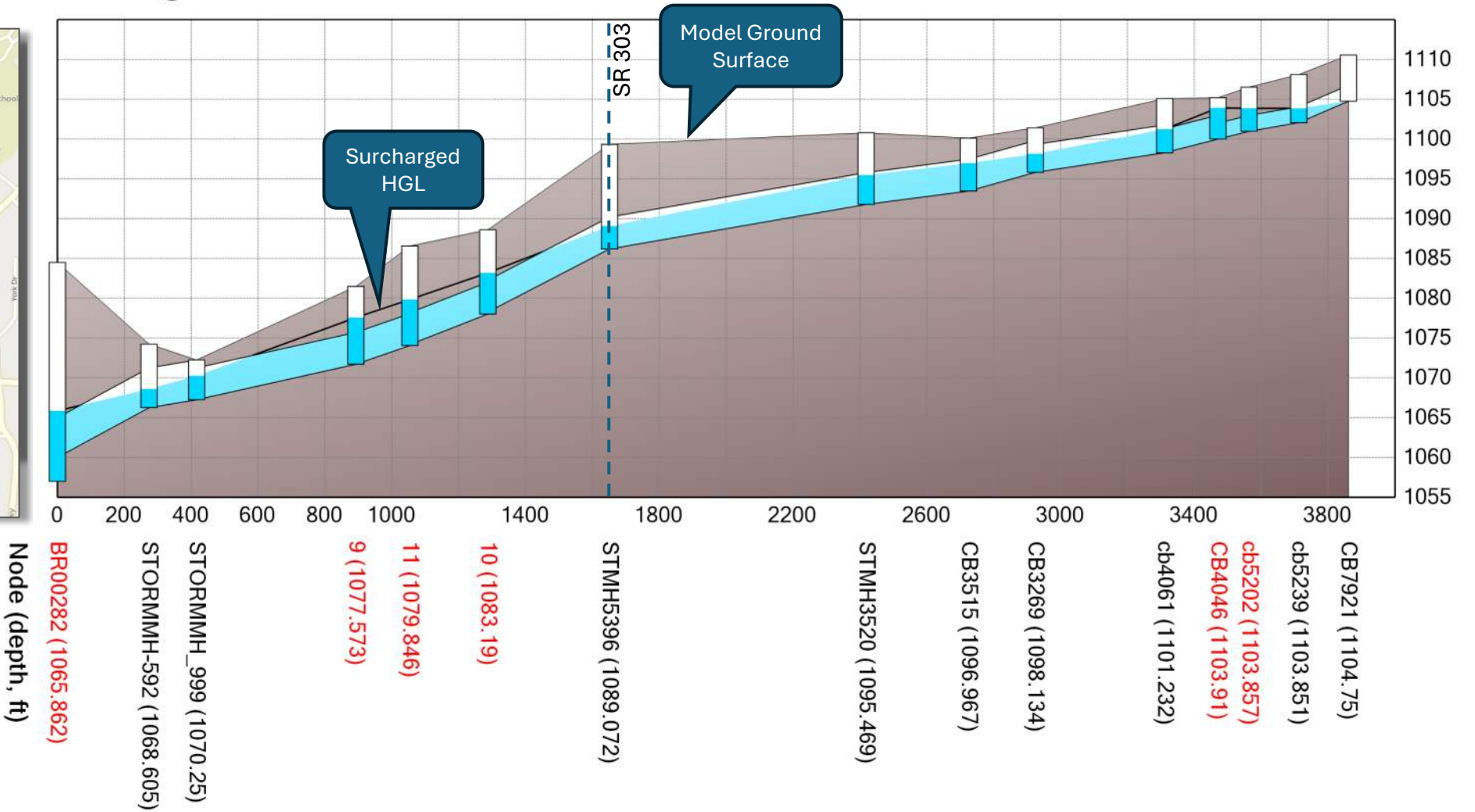
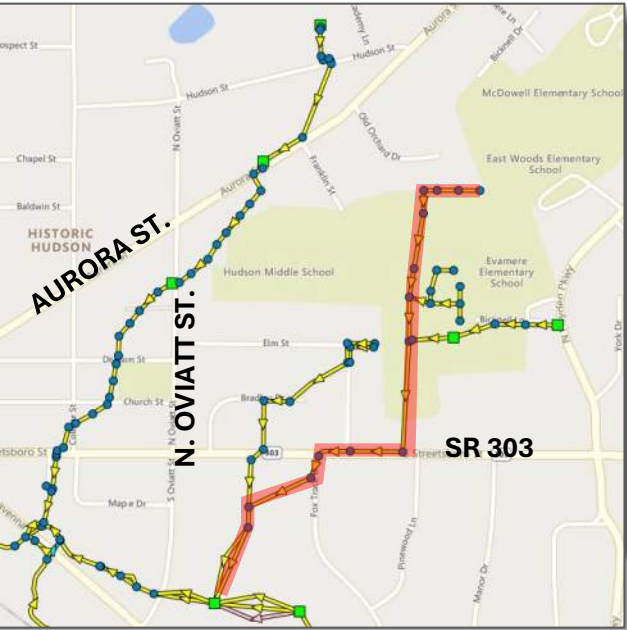
Existing 10-yr System 2

School property to Fox

Trace Lane

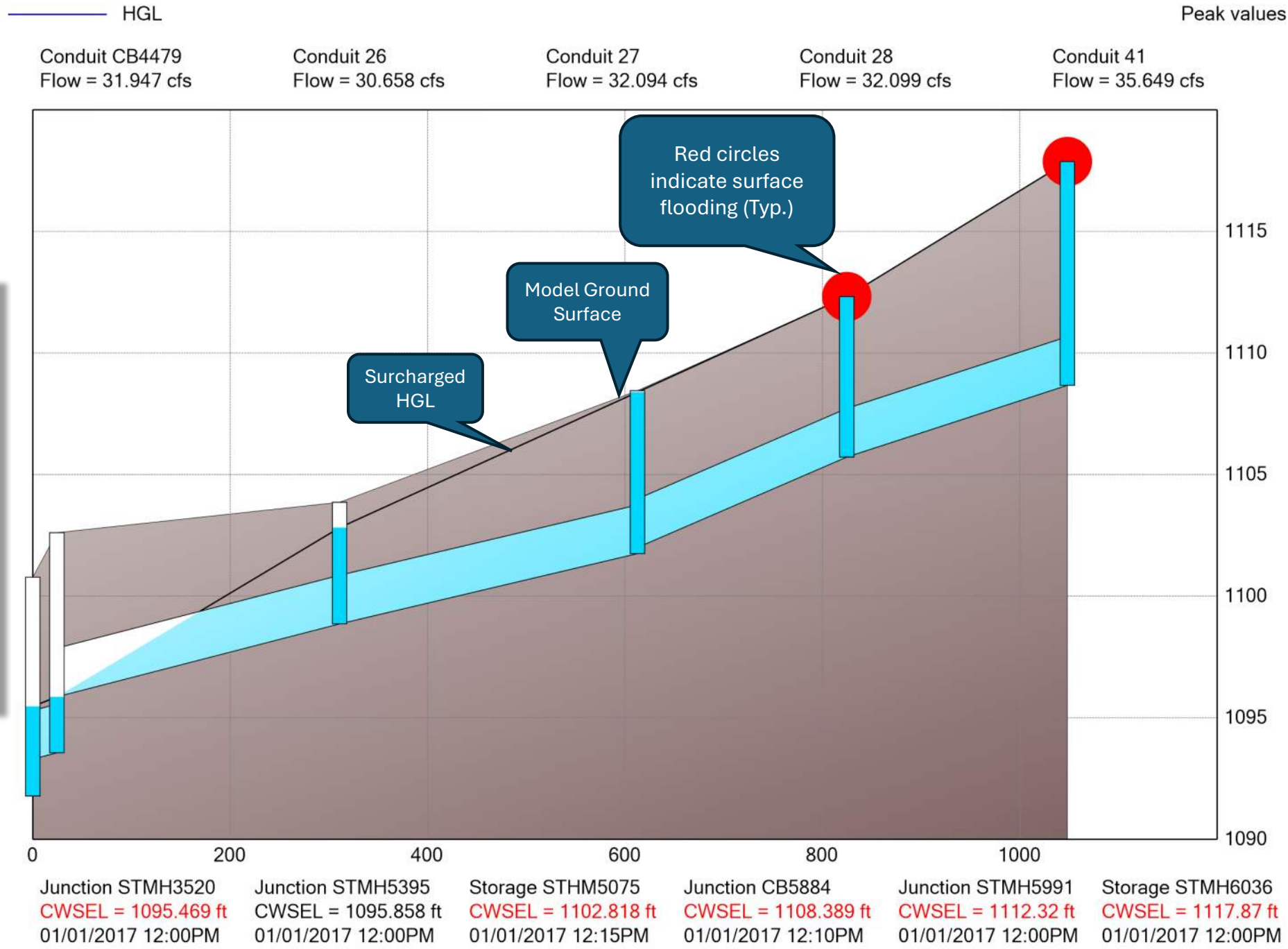
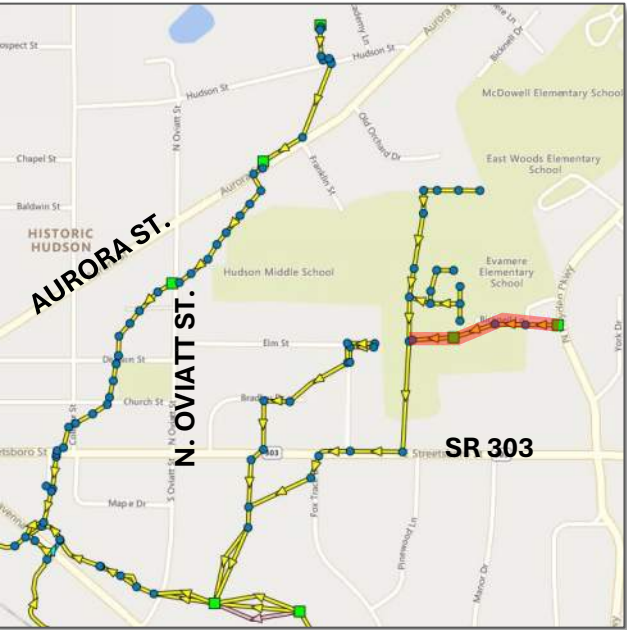
Link (flow, cfs)	HGL	Peak values
STORM-458 (284.731)	16 (170.656)	44 (0)
STORM-2734 (286.398)	15_2 (170.676)	36 (0.818)
	15_1 (170.688)	37 (2.082)
	14 (170.848)	31 (87.709)
	13 (133.828)	30 (87.038)
		29 (86.847)
		12 (108.701)

Profile Location



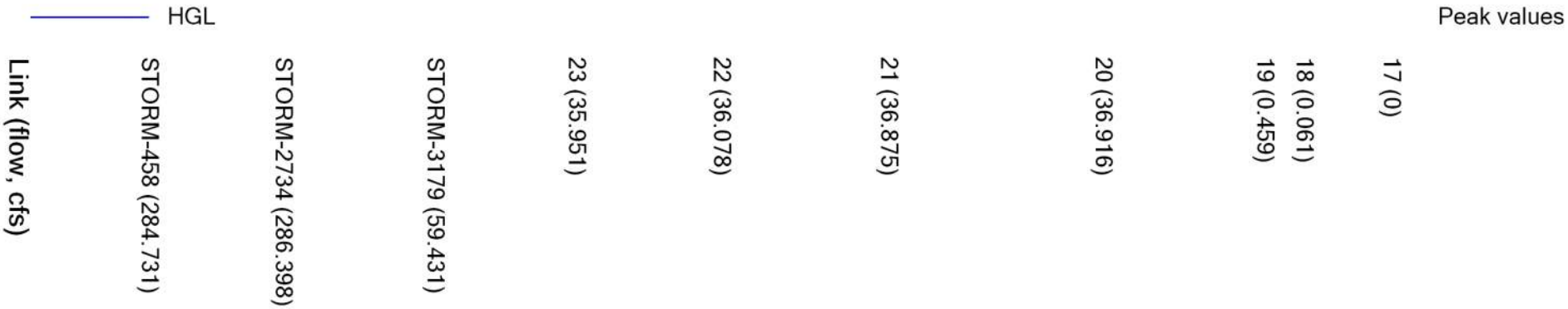
Existing 10-yr System 2
N Hayden Pkwy into school
property

Profile Location

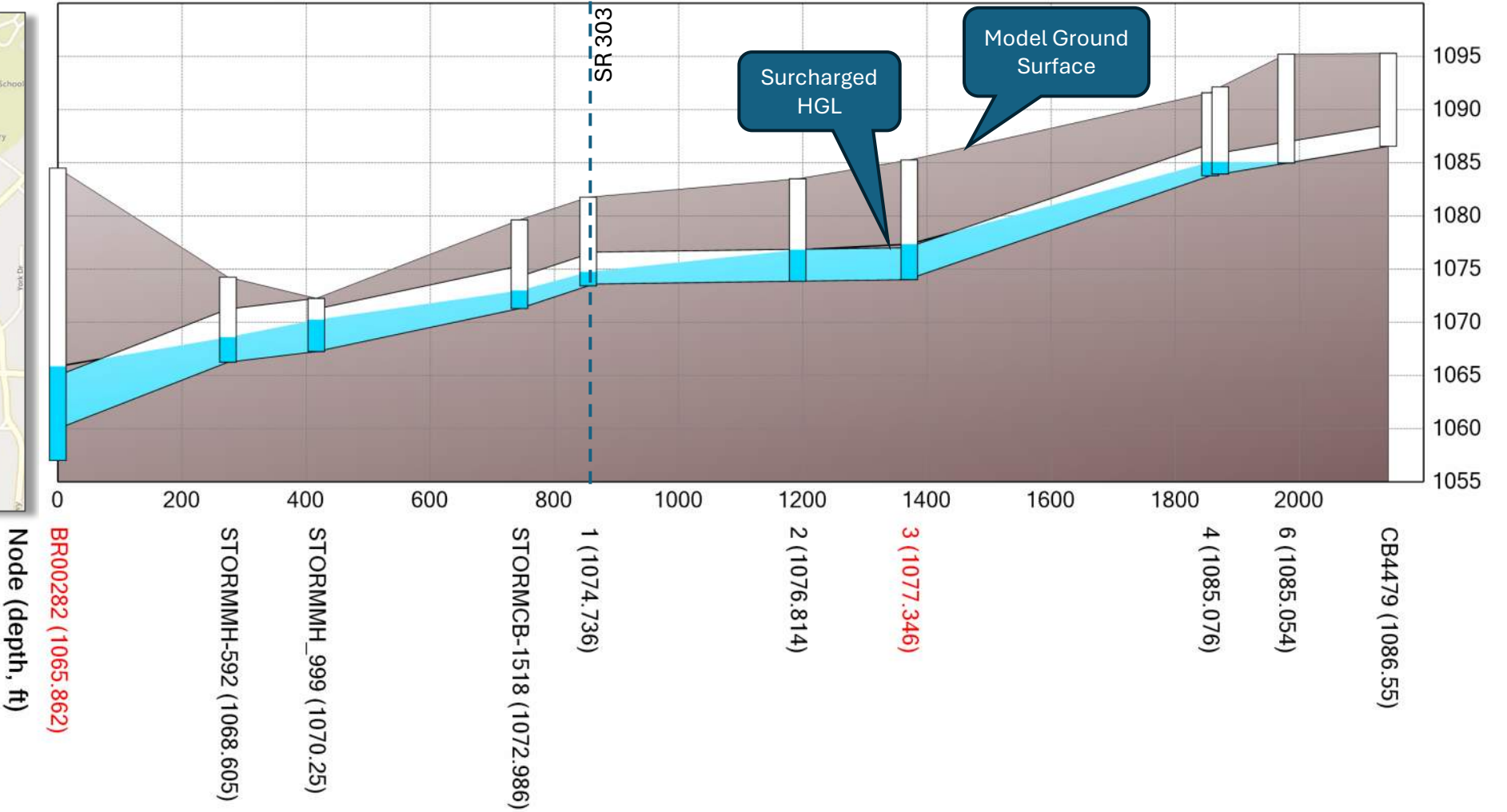
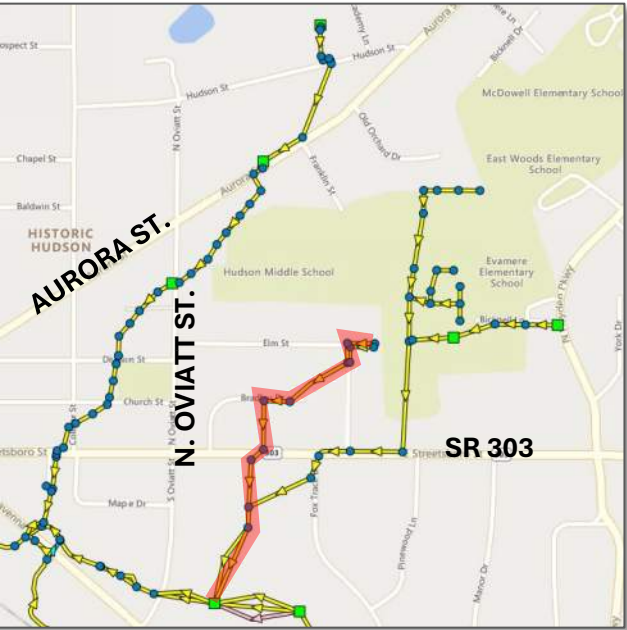


Existing 10-yr System 2

Elm St to Edward Dr



Profile Location



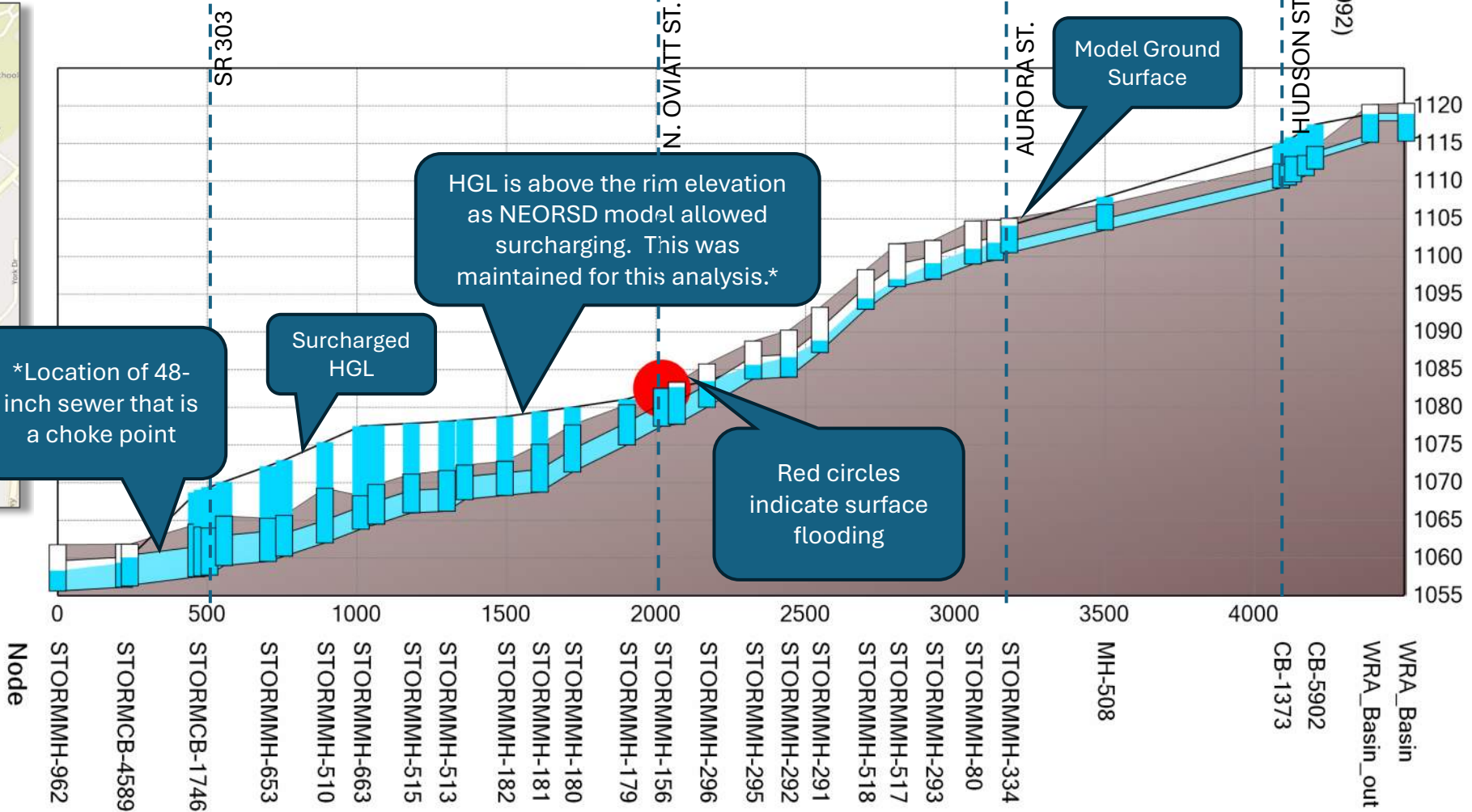
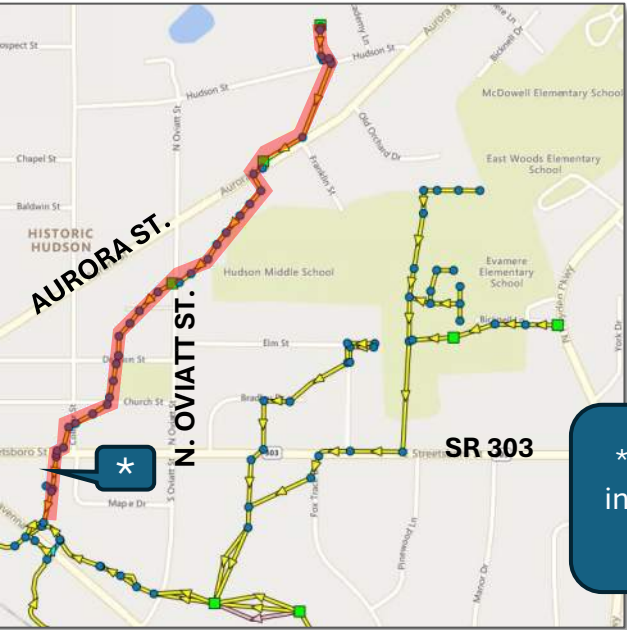
Existing 100-yr System 1

Peak values

42 (37.865)
WRA_outlet_channel (16.092)
STORM-1458 (11.693)
STORM-5922 (11.694)
STORM-5920 (11.693)
STORM-5915 (75.795)
STORM-5911 (75.798)
STORM-5912 (75.799)
STORM-5913 (75.797)
STORM-5910 (75.792)
STORM-5908 (75.789)
STORM-5909 (75.8)
STORM-250 (75.845)
STORM-7616 (75.862)
STORM-2933 (155.423)
STORM-2932 (155.438)
STORM-2931 (155.43)
STORM-2930 (155.416)
STORM-2929 (155.404)
STORM-2927 (155.406)
STORM-2928 (155.417)
STORM-1464 (219.037)
STORM-1465 (219.033)
STORM-2759 (219.028)
STORM-1466 (219.03)
STORM-2232 (219.045)
STORM-3927 (276.847)
STORM-3928 (294.456)
STORM-3926 (293.26)

Link (flow, cfs)

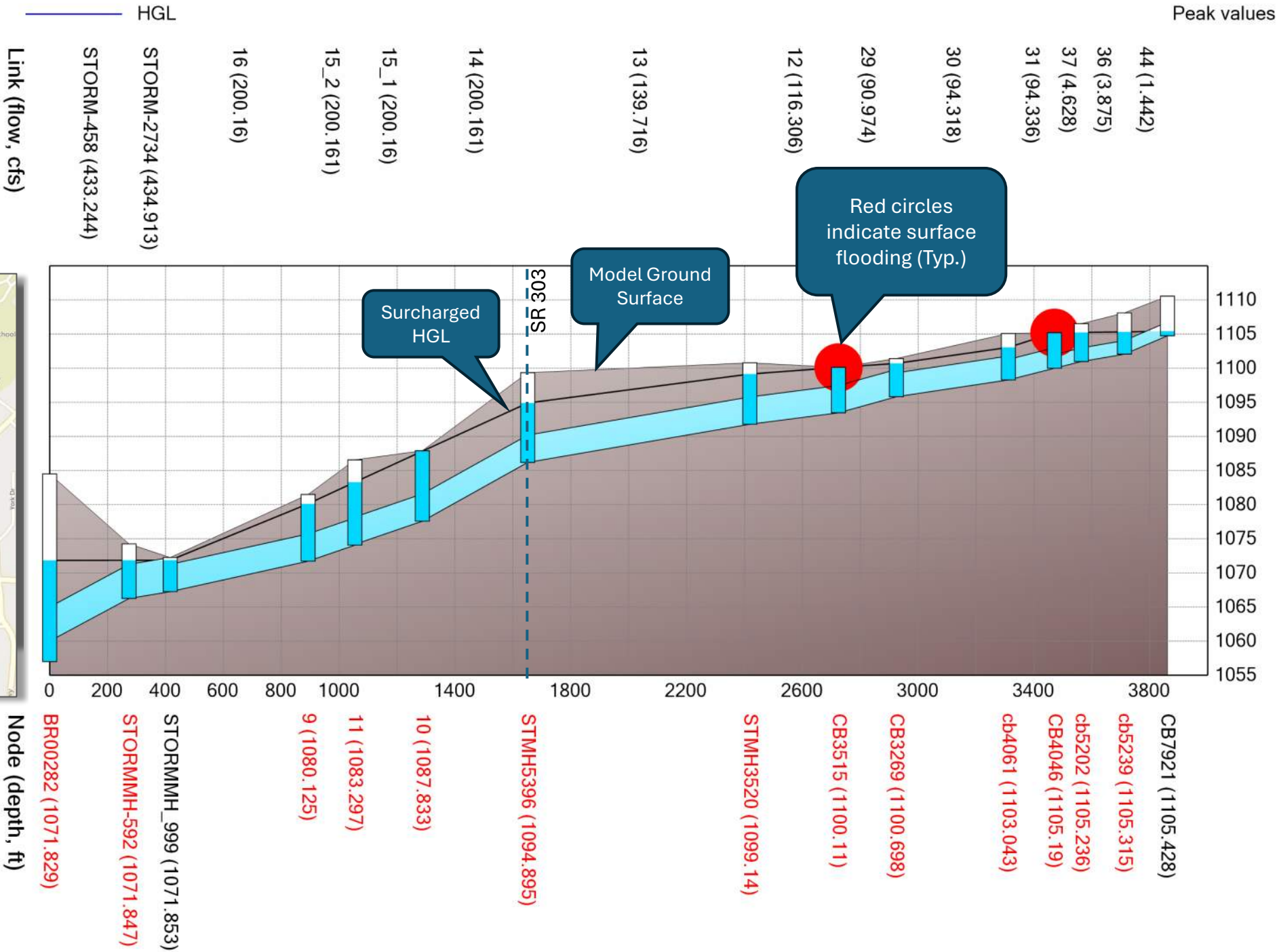
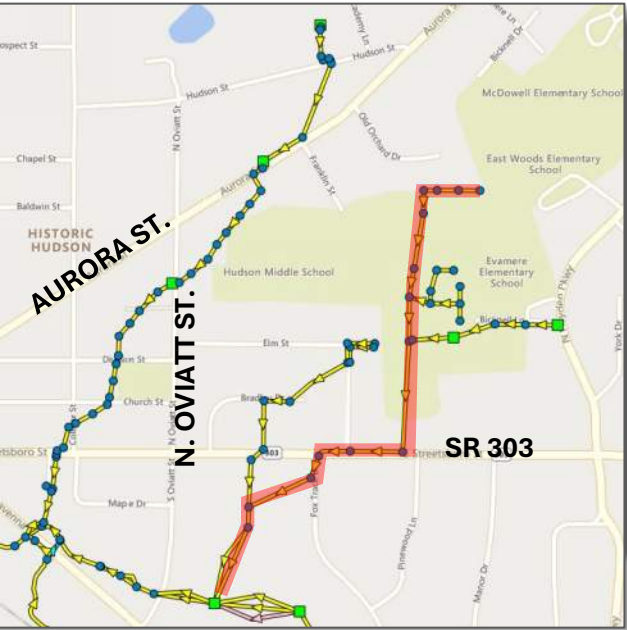
Profile Location



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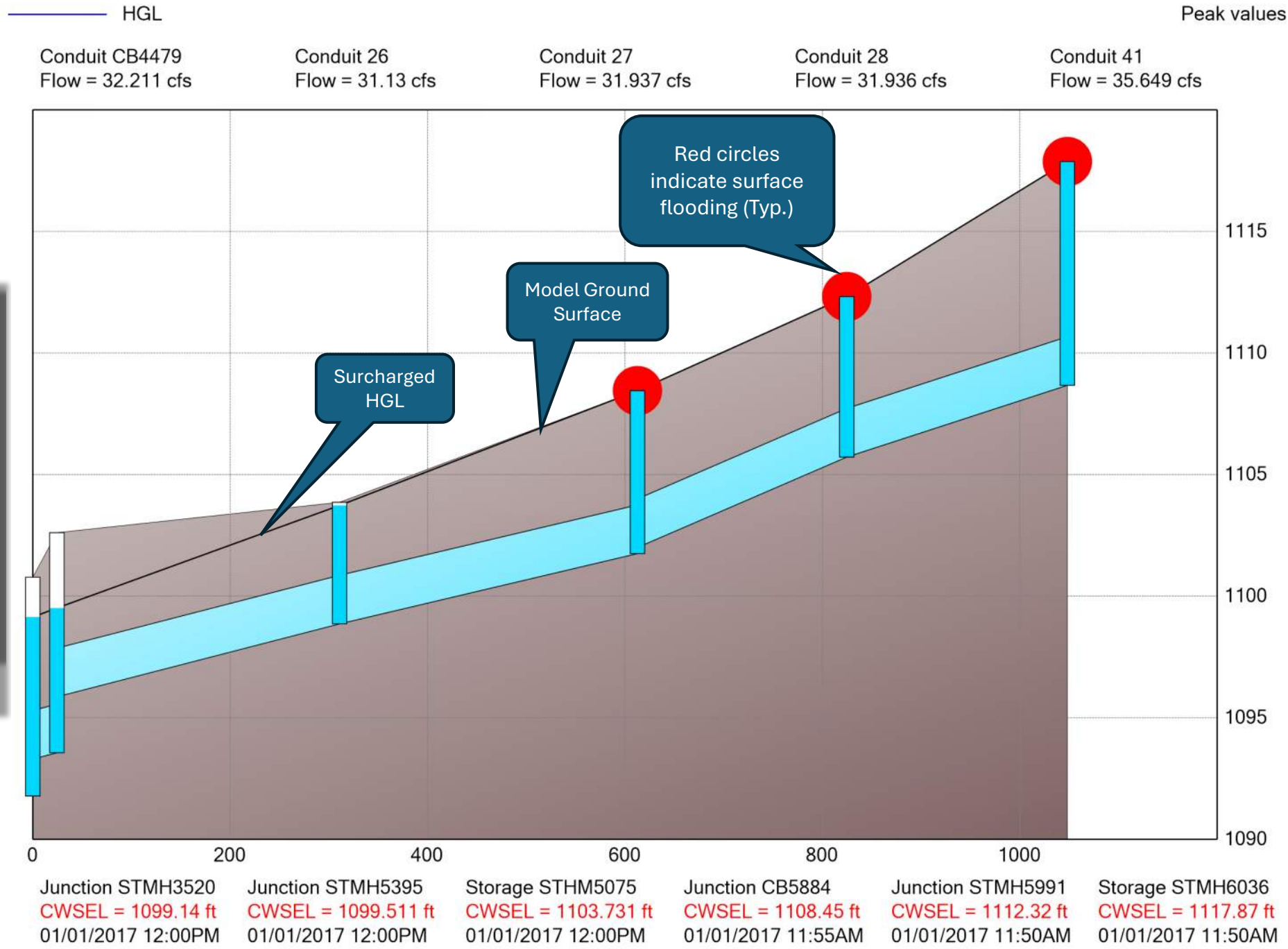
Existing 100-yr System 2
School property to Fox
Trace Lane

Profile Location



Existing 100-yr System 2
N Hayden Pkwy into school
property

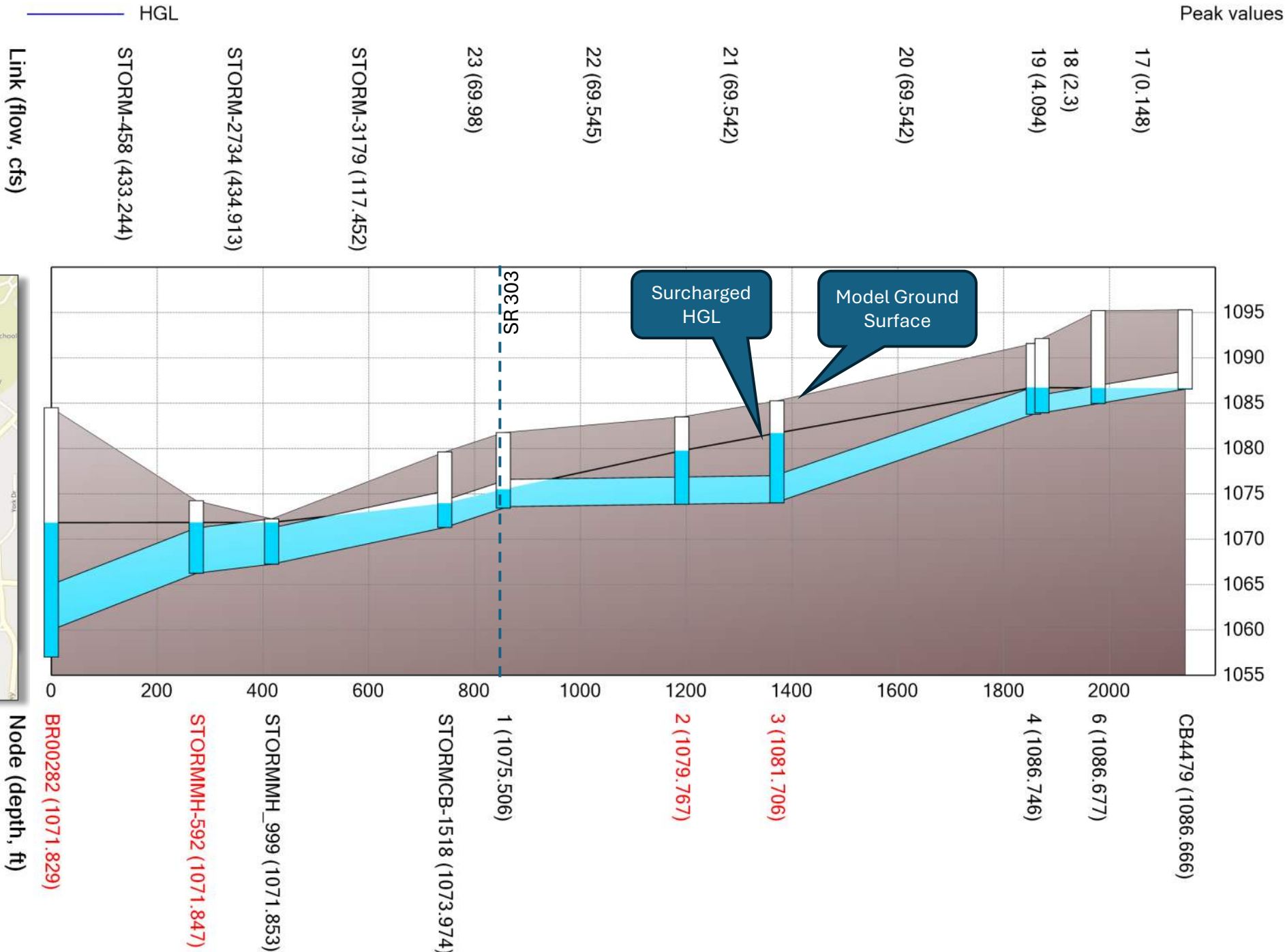
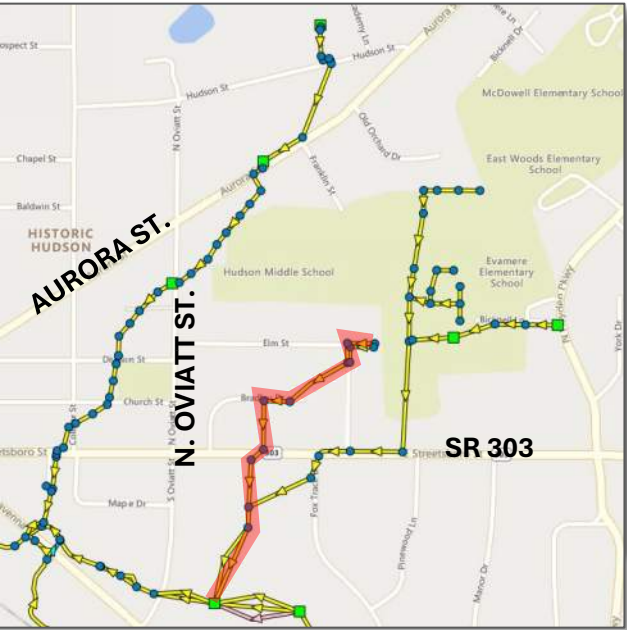
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Existing 100-yr System 2

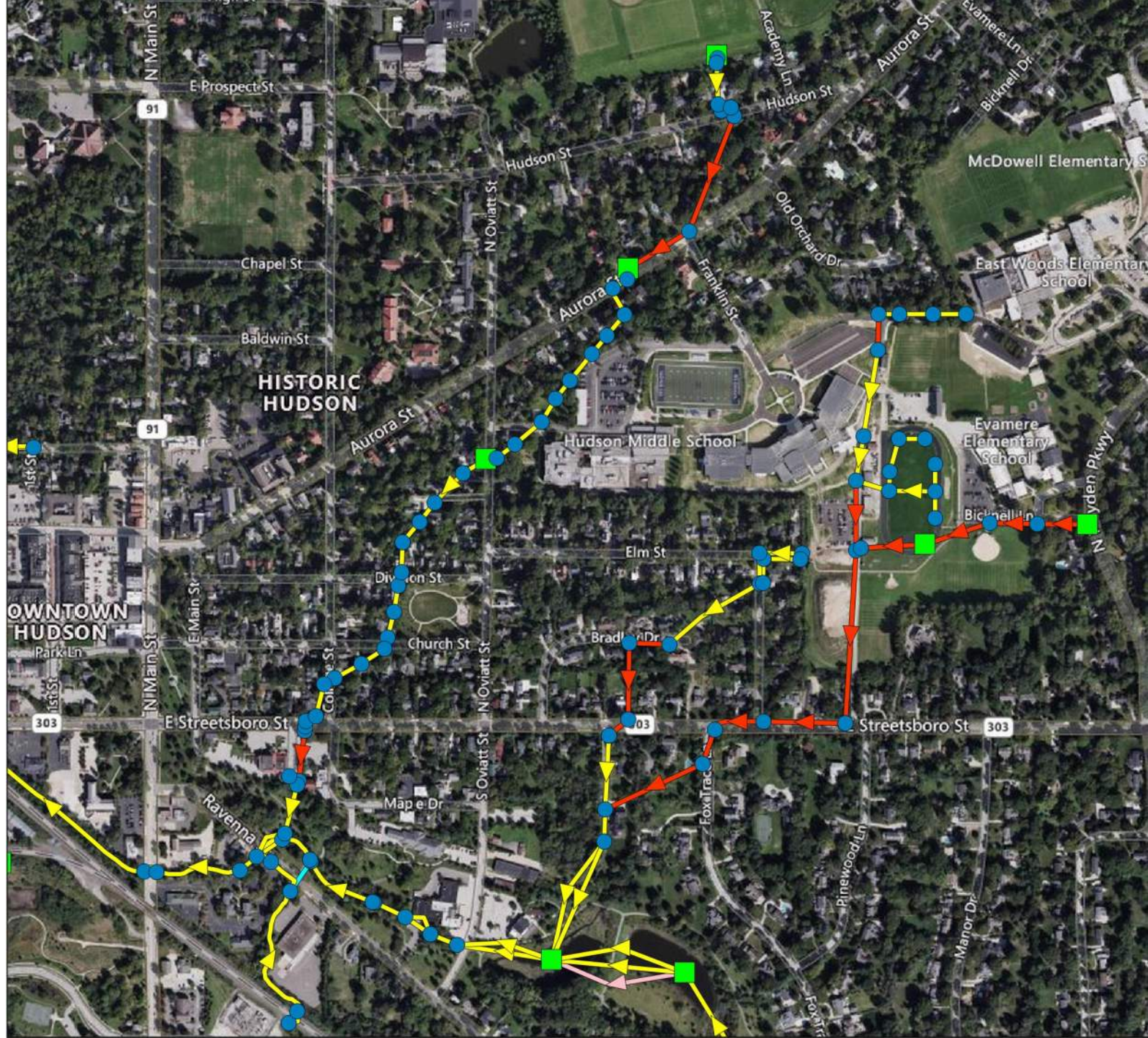
Elm St to Edward Dr

Profile Location



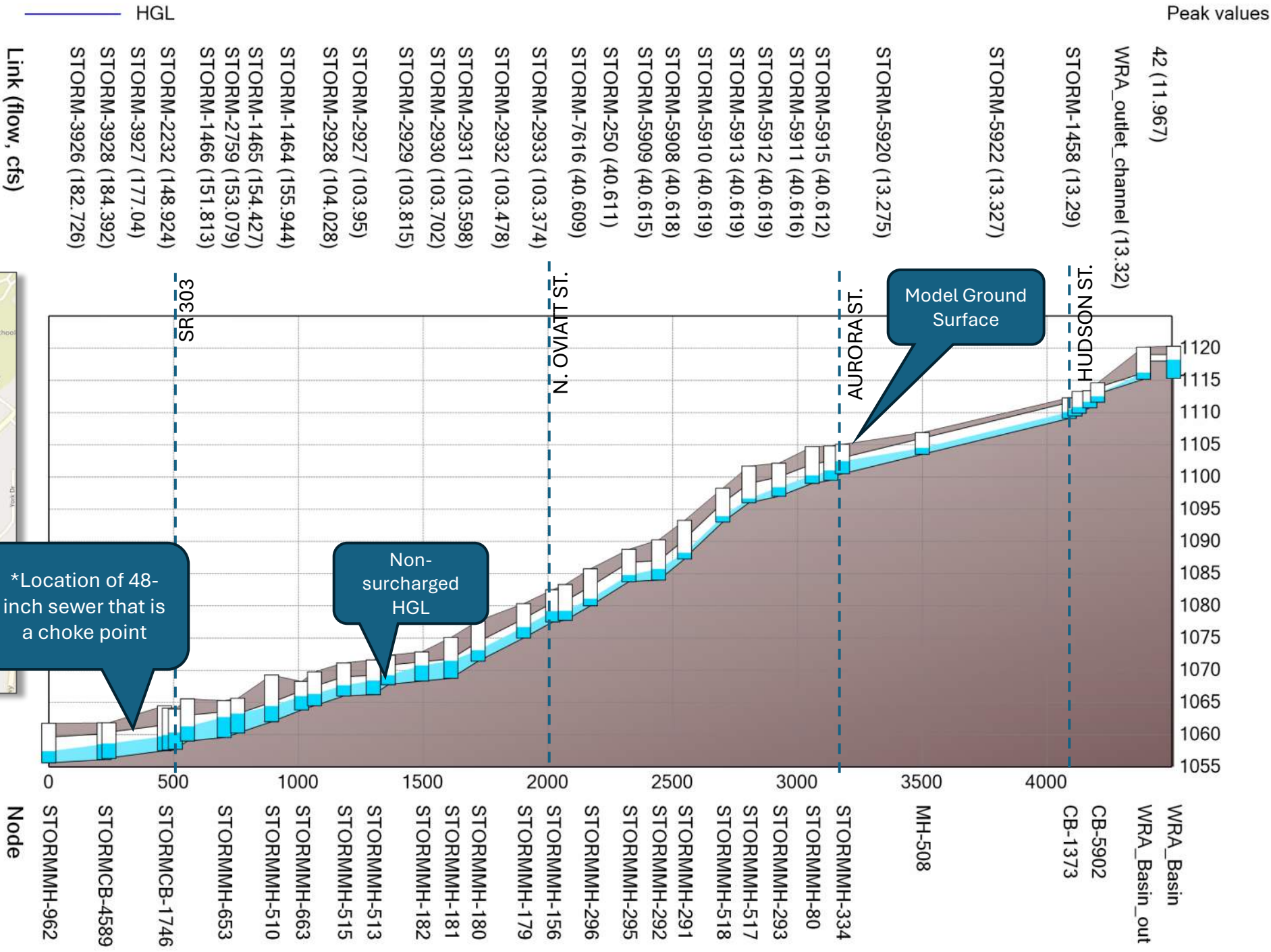
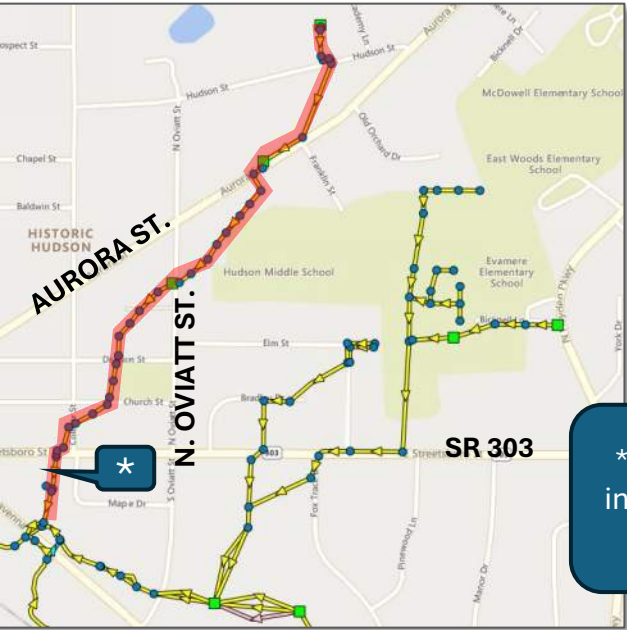
Alternative 1

- 10-year maintained within the storm sewer
- Improvements shown in red



Alternative 1
10-yr System 1

Profile Location

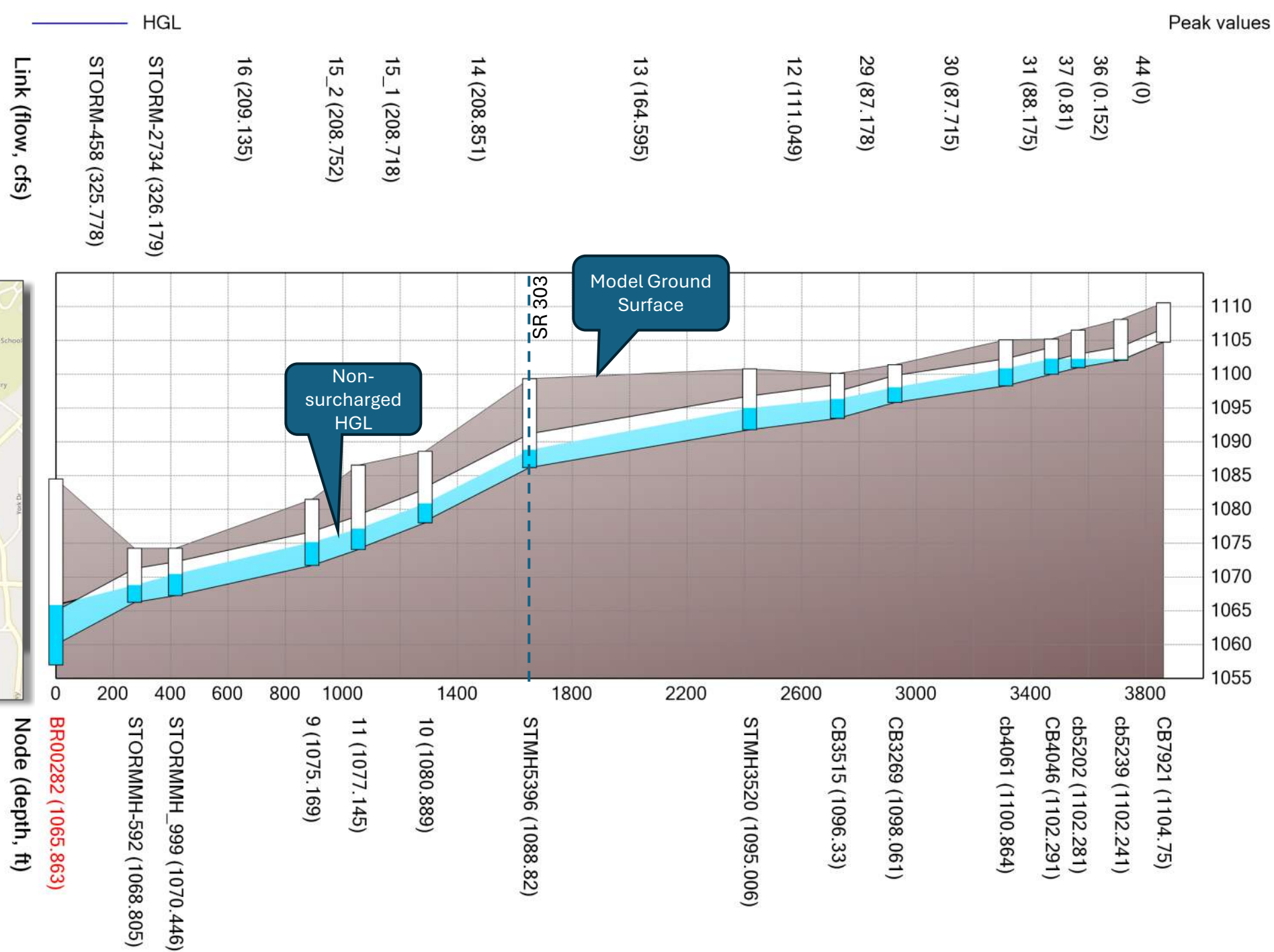
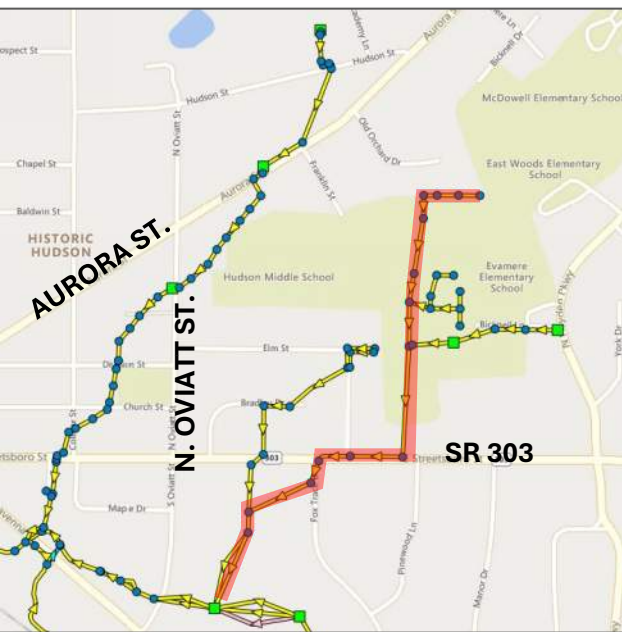


Alternative 1

10-yr System 2

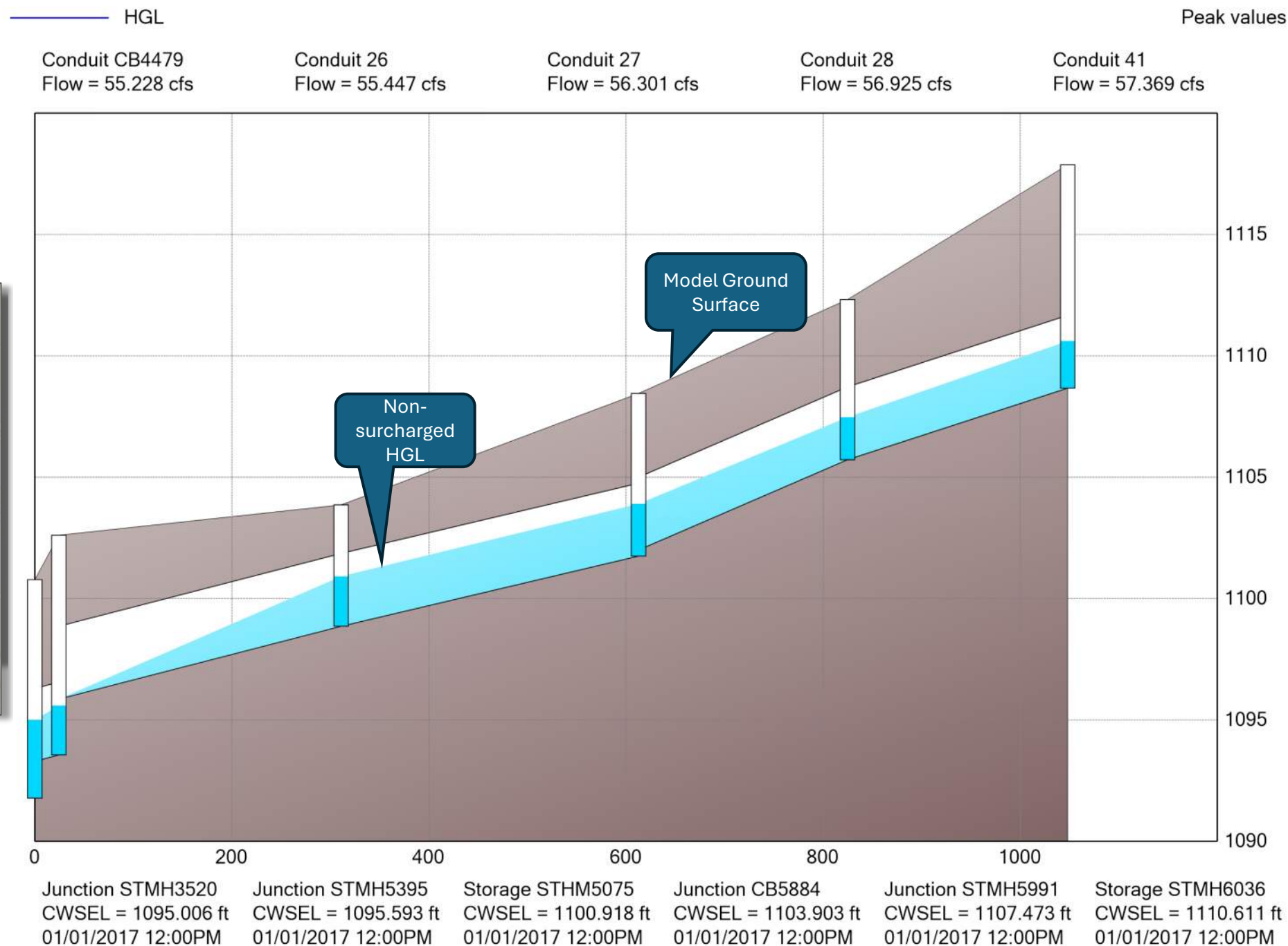
School Property to Fox Trace Lane

Profile Location



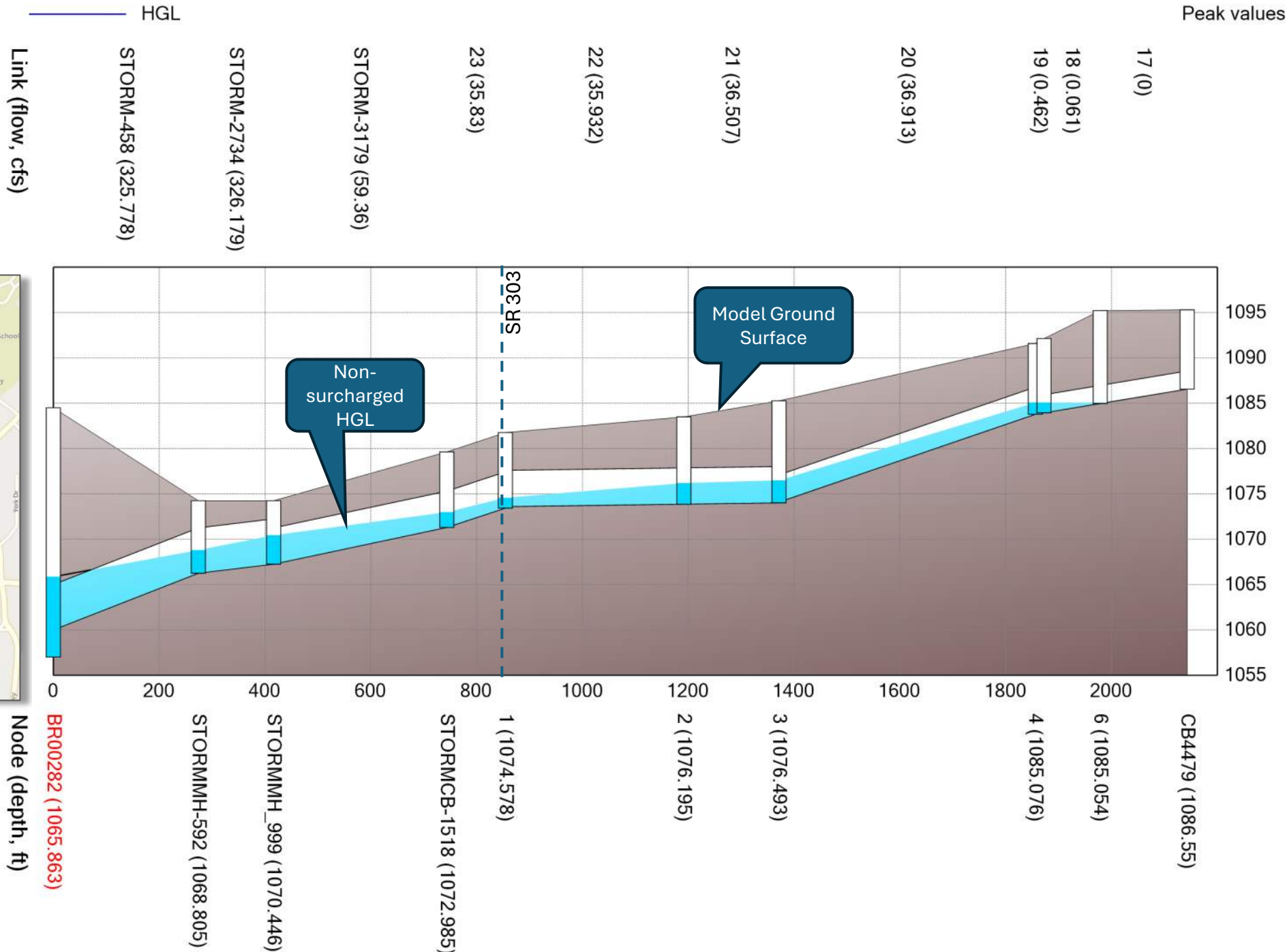
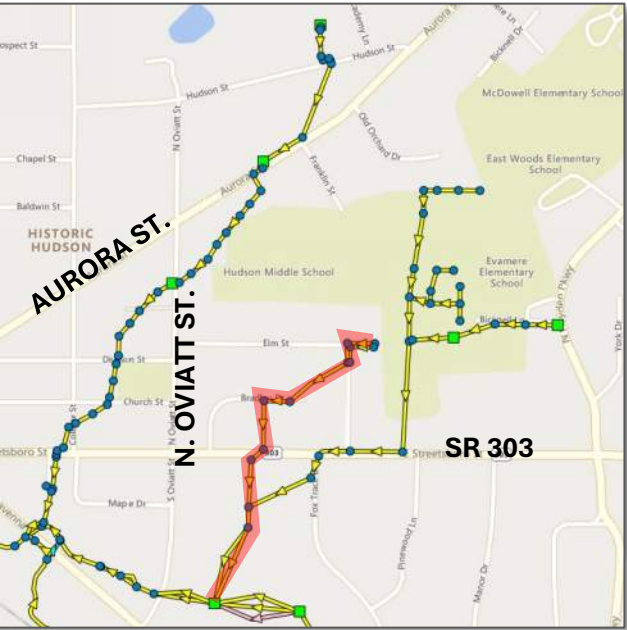
N Hayden Pkwy into school property

A map of the Hudson, New York area, showing the route of SR 303. The route is marked with a yellow line and blue dots, starting from the bottom left and ending at the top right. Key streets shown include Hudson St, Aurora St, N Oviatt St, and SR 303. Landmarks include Hudson Middle School, East Woods Elementary School, and McDowell Elementary School. The map also shows the Hudson River and surrounding residential areas.



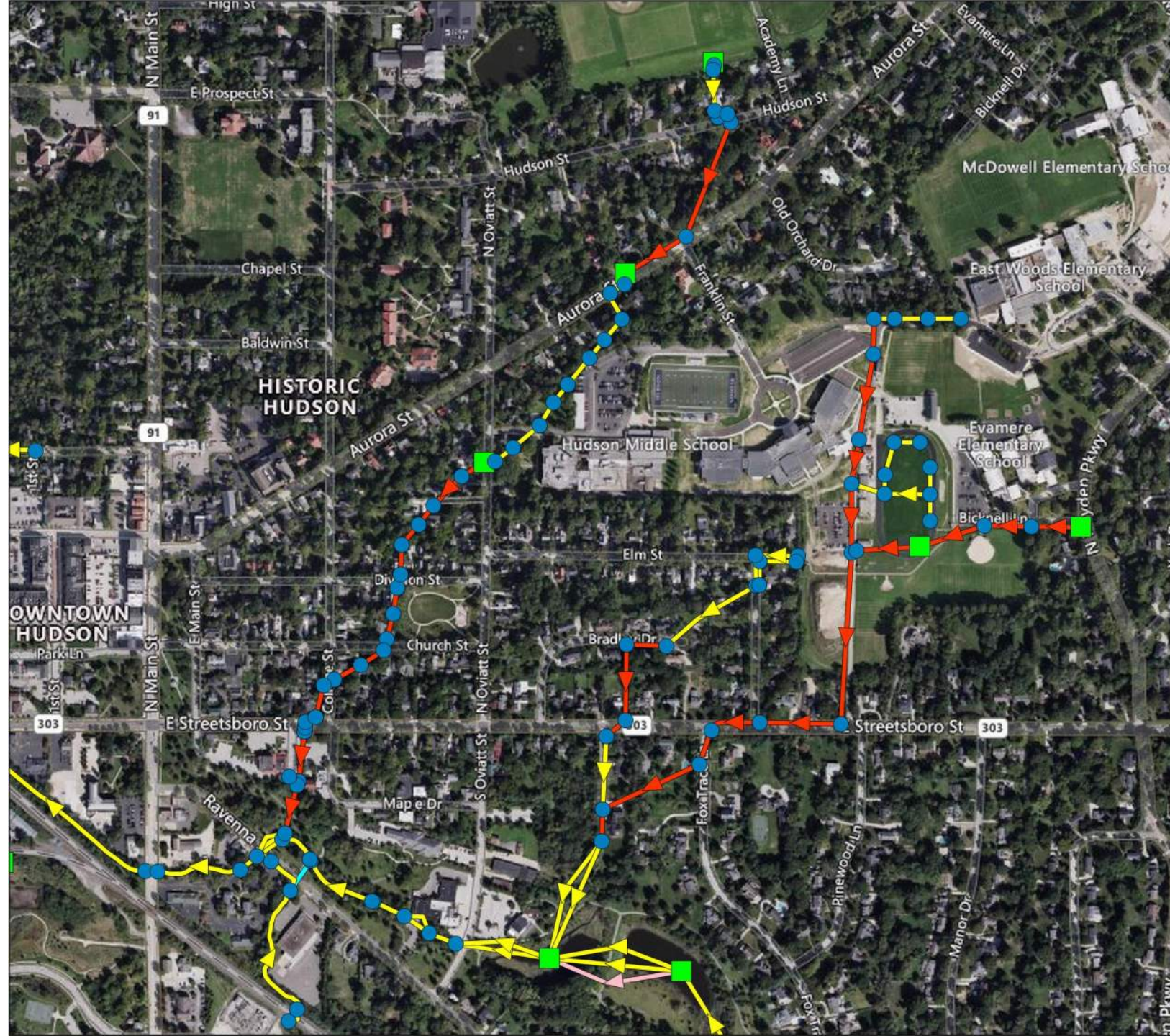
Alternative 1
10-yr System 2
Elm St to Edward Dr

Profile Location



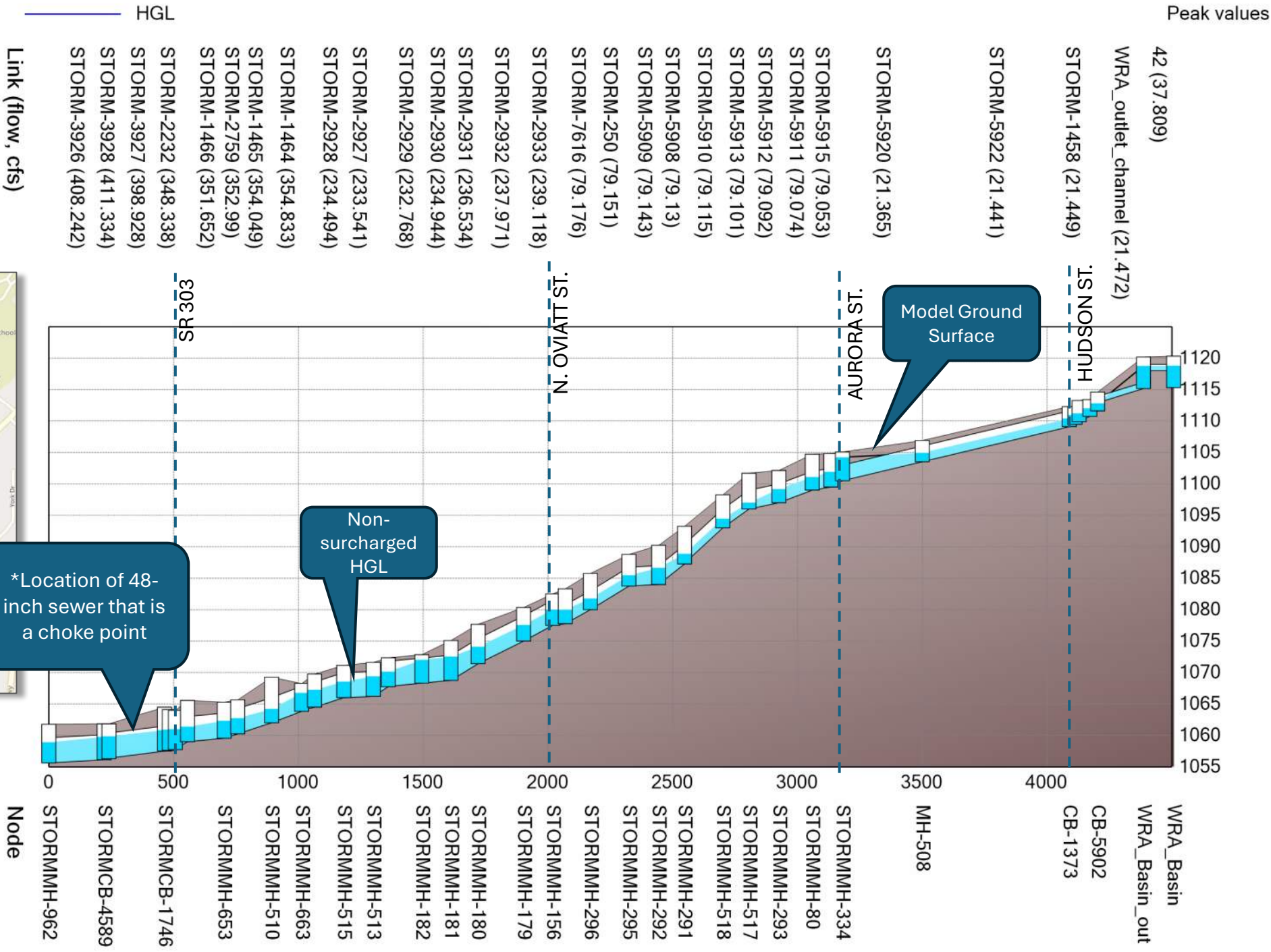
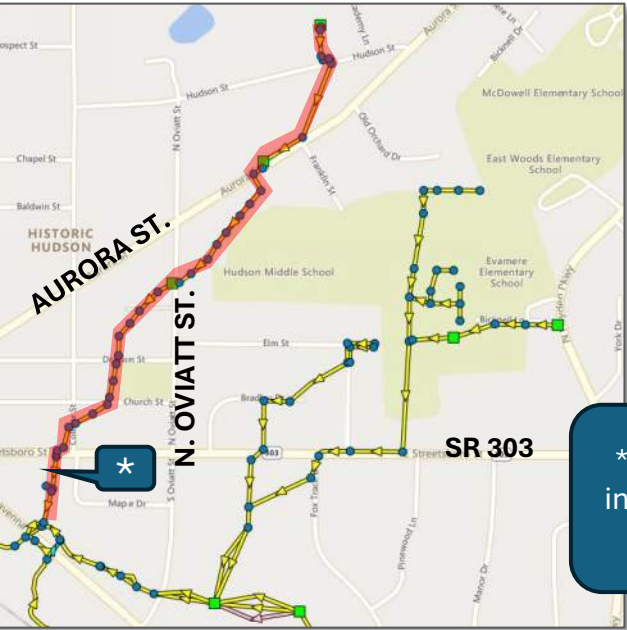
Alternative 2

- 100-year kept from flooding to surface
- Improvements shown in red



Alternative 2
100-yr System 1

Profile Location

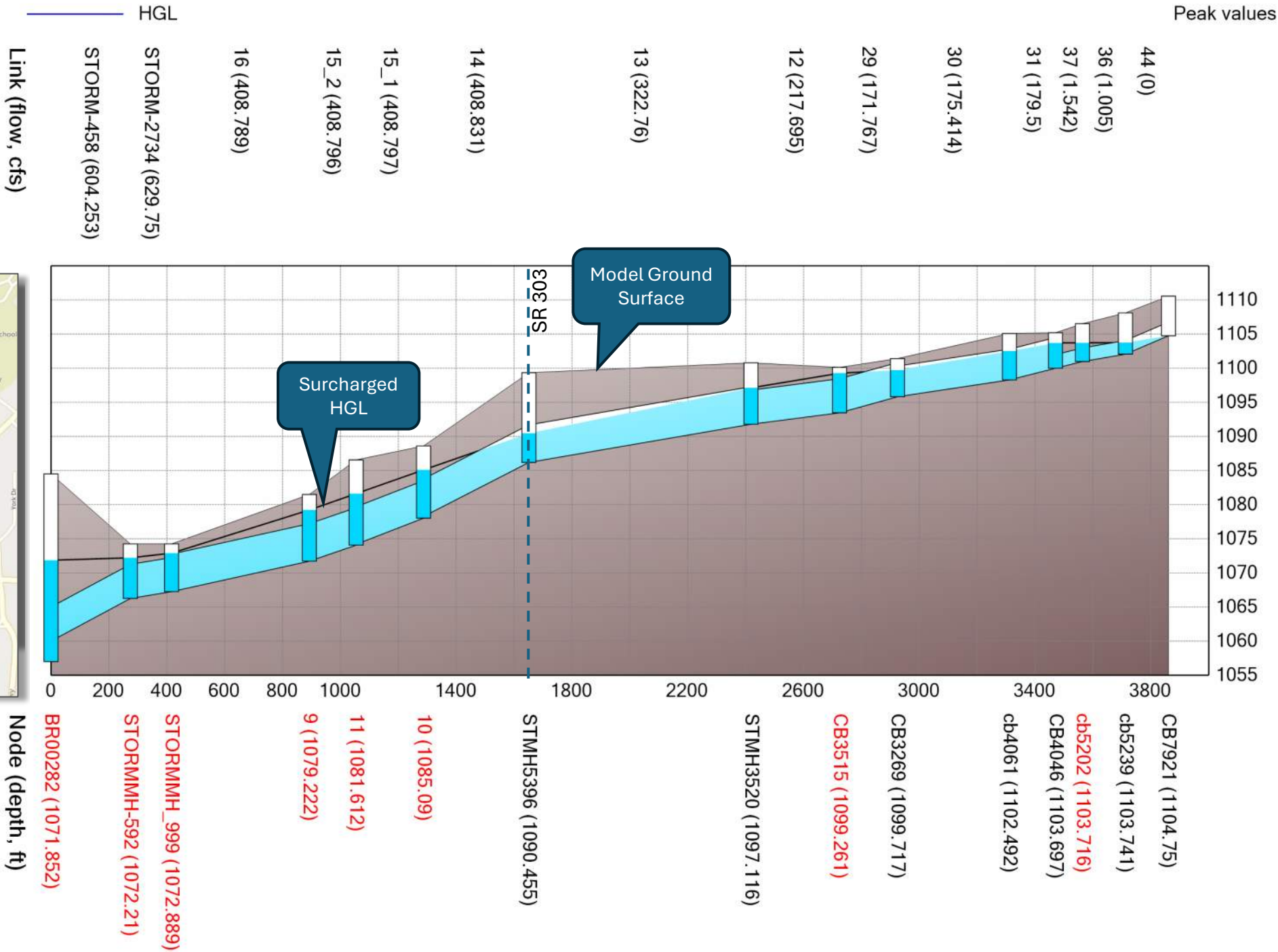
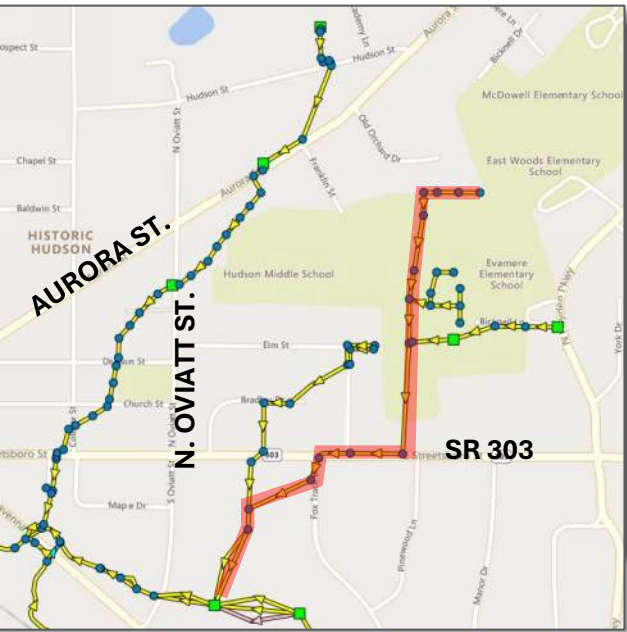


Alternative 2

100-yr System 2

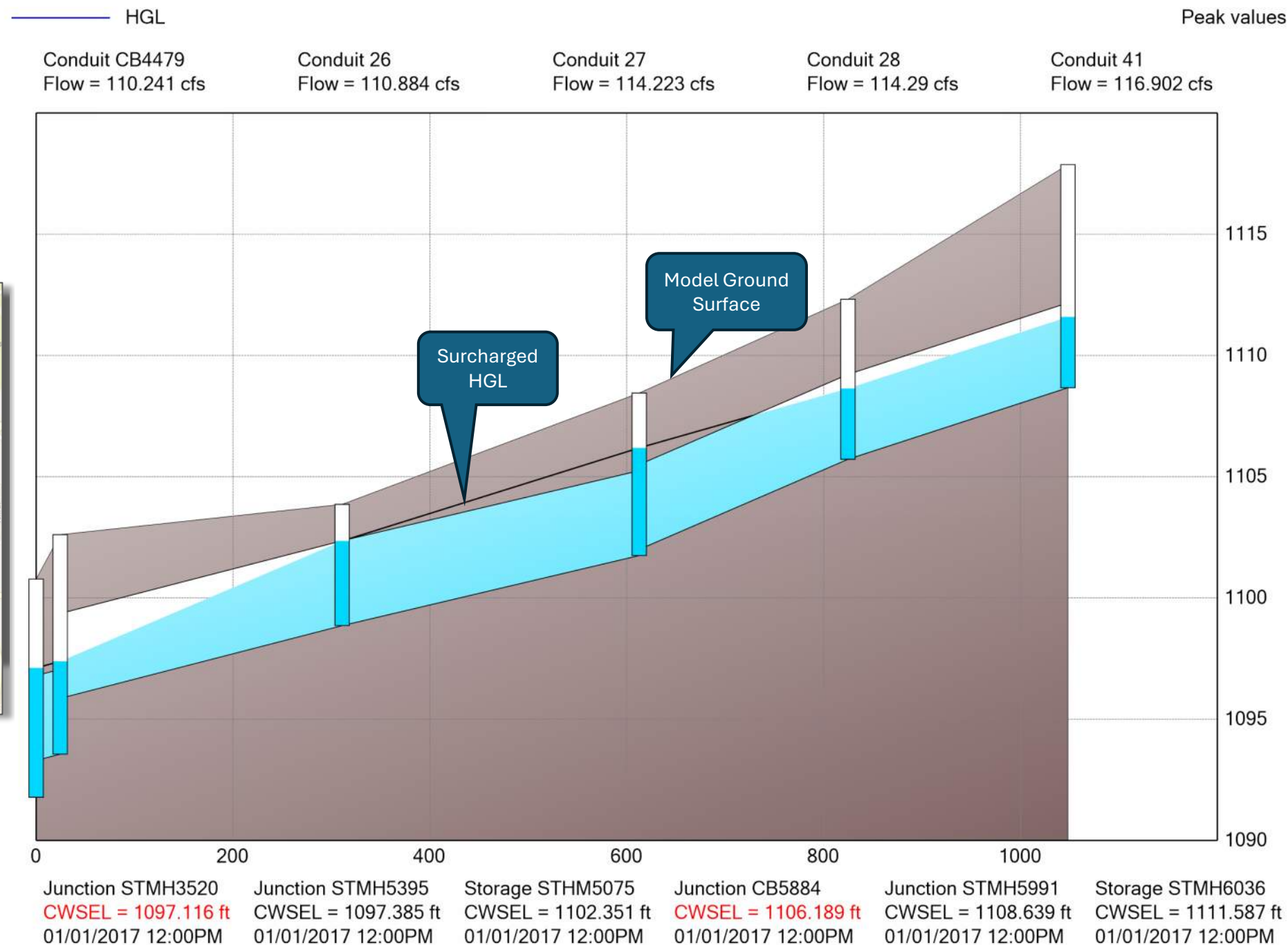
School property to Fox
Trace Lane

Profile Location



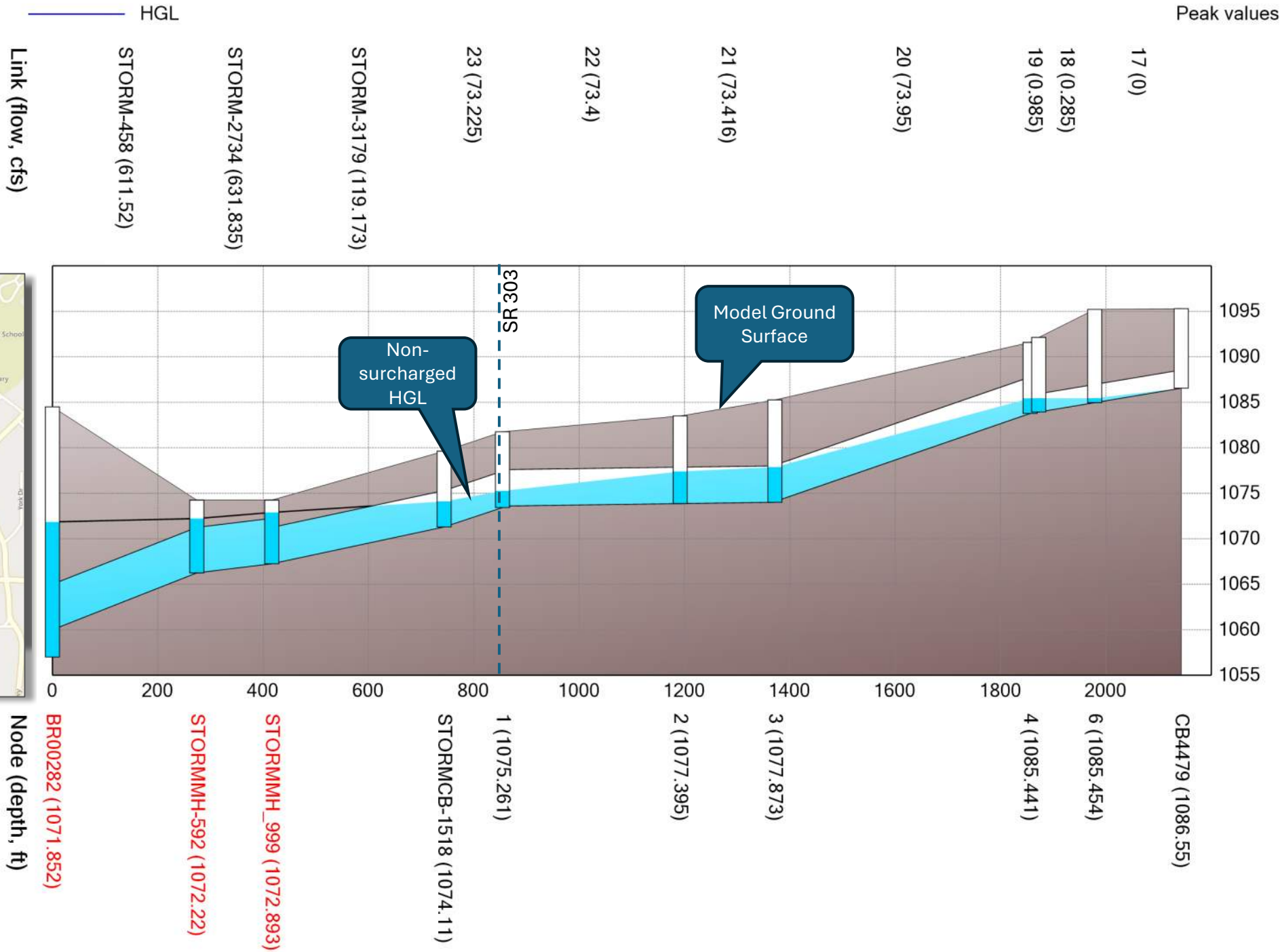
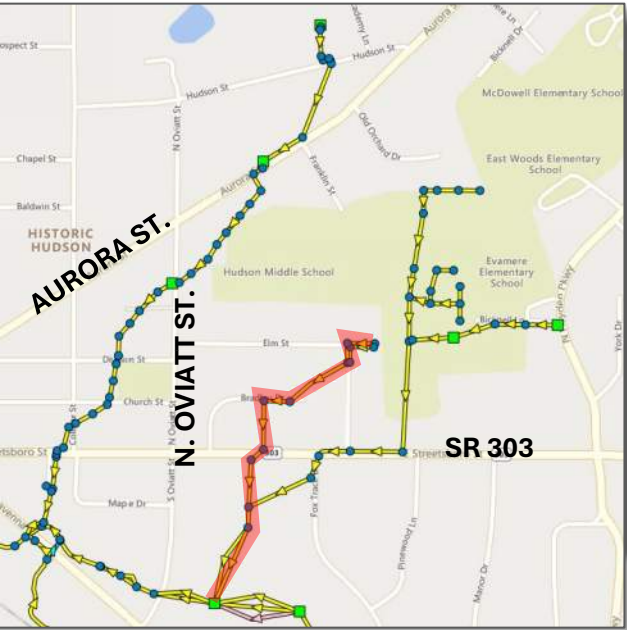
N Hayden Pkwy into school property

The map displays the SR 303 route in Hudson, New York. The route is highlighted with a yellow line and blue dots, indicating the path of the bus. The route starts at the bottom left, near the intersection of Hudson St and N. Oviatt St, and proceeds generally north and east. Key locations along the route include Hudson Middle School, East Woods Elementary School, and Evamere Elementary School. The map also shows major roads like Aurora St and N. Oviatt St. The route ends at the top right, near the intersection of Hudson St and N. Oviatt St.



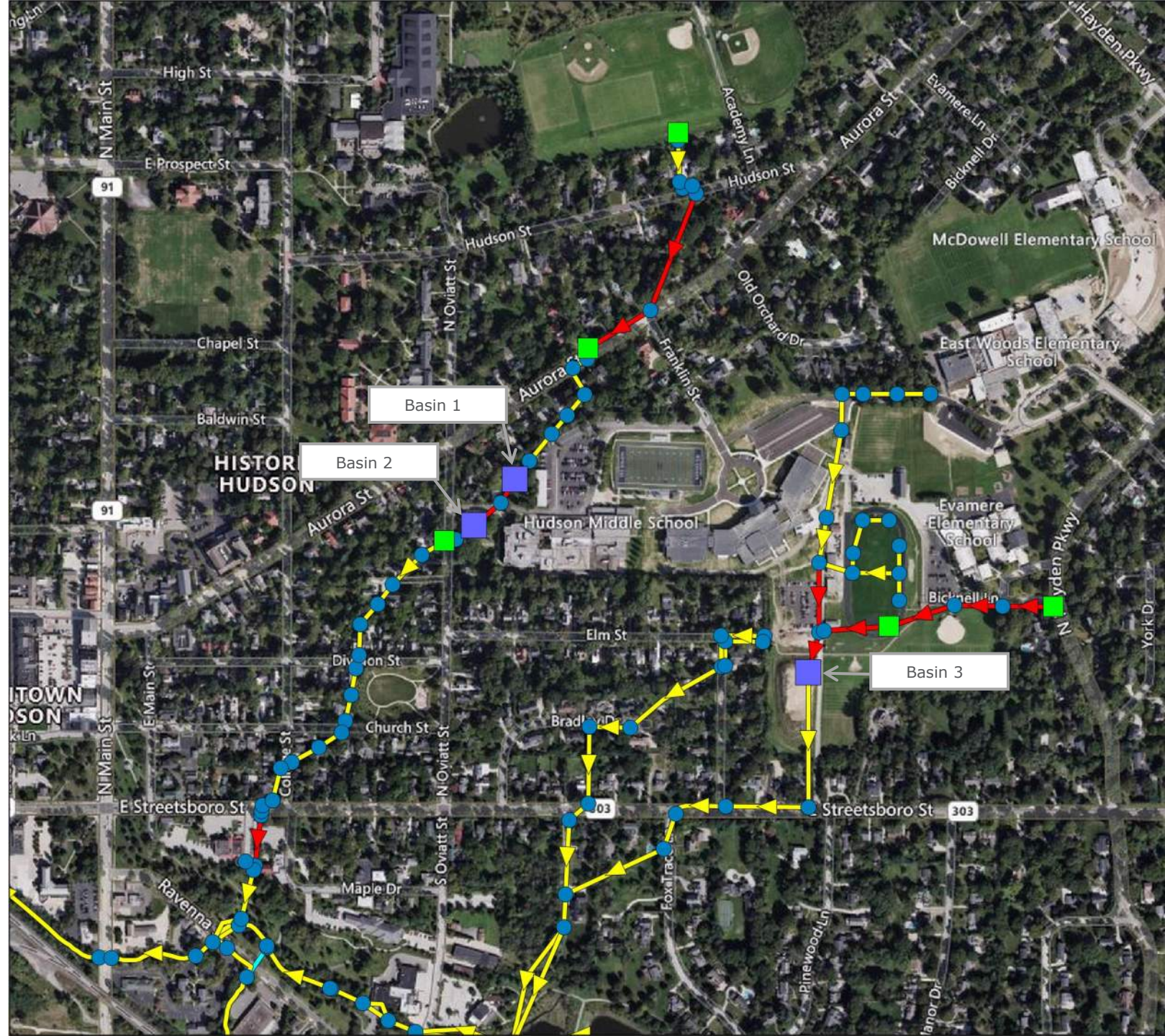
Alternative 2
100-yr System 2
Elm St to Edward Dr

Profile Location



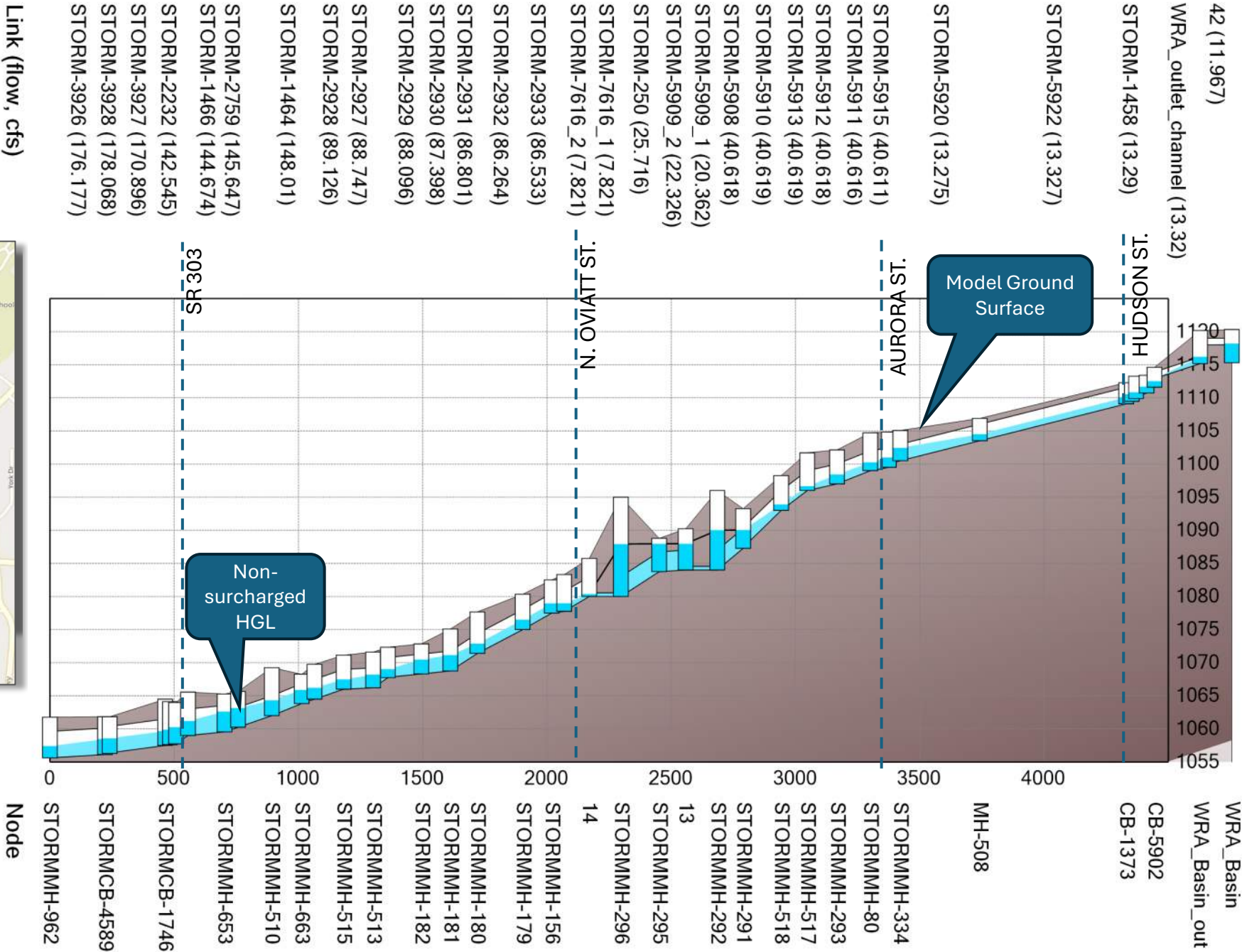
Alternative 3

- 10-year improvements via storm sewer and detention basins
- Improvements shown in red

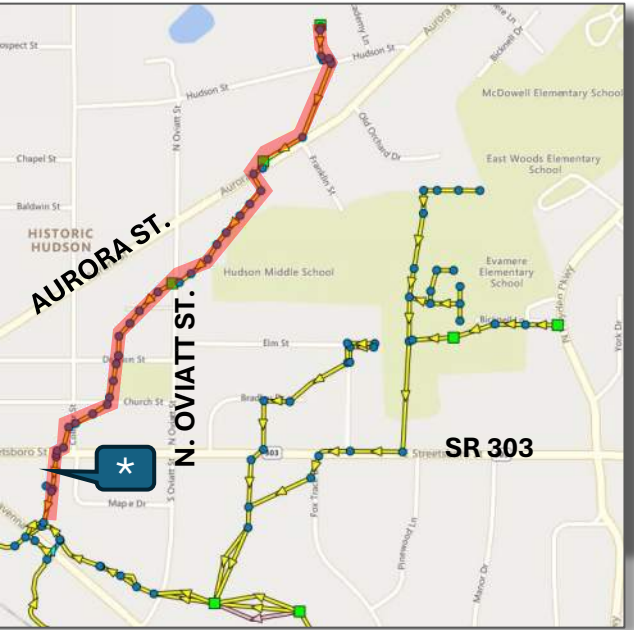


Alternative 3
10-yr System 1

Peak values

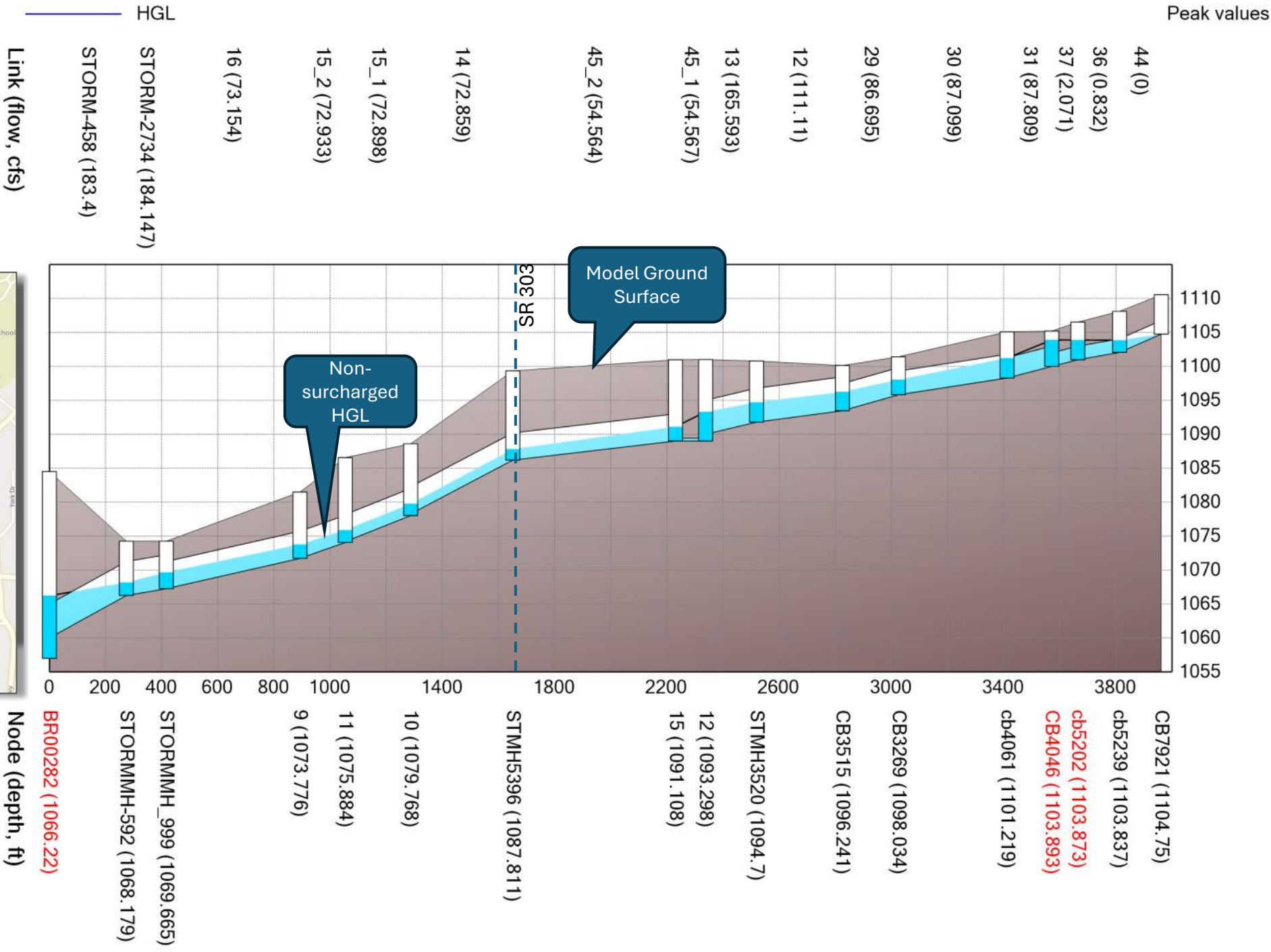
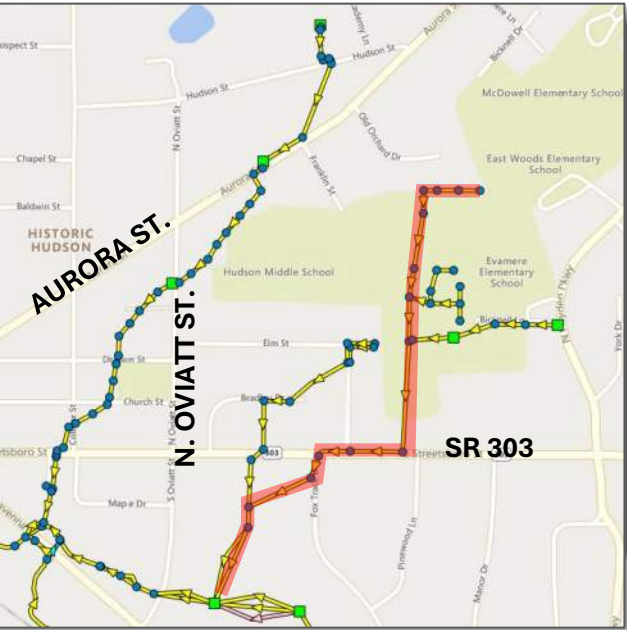


Profile Location



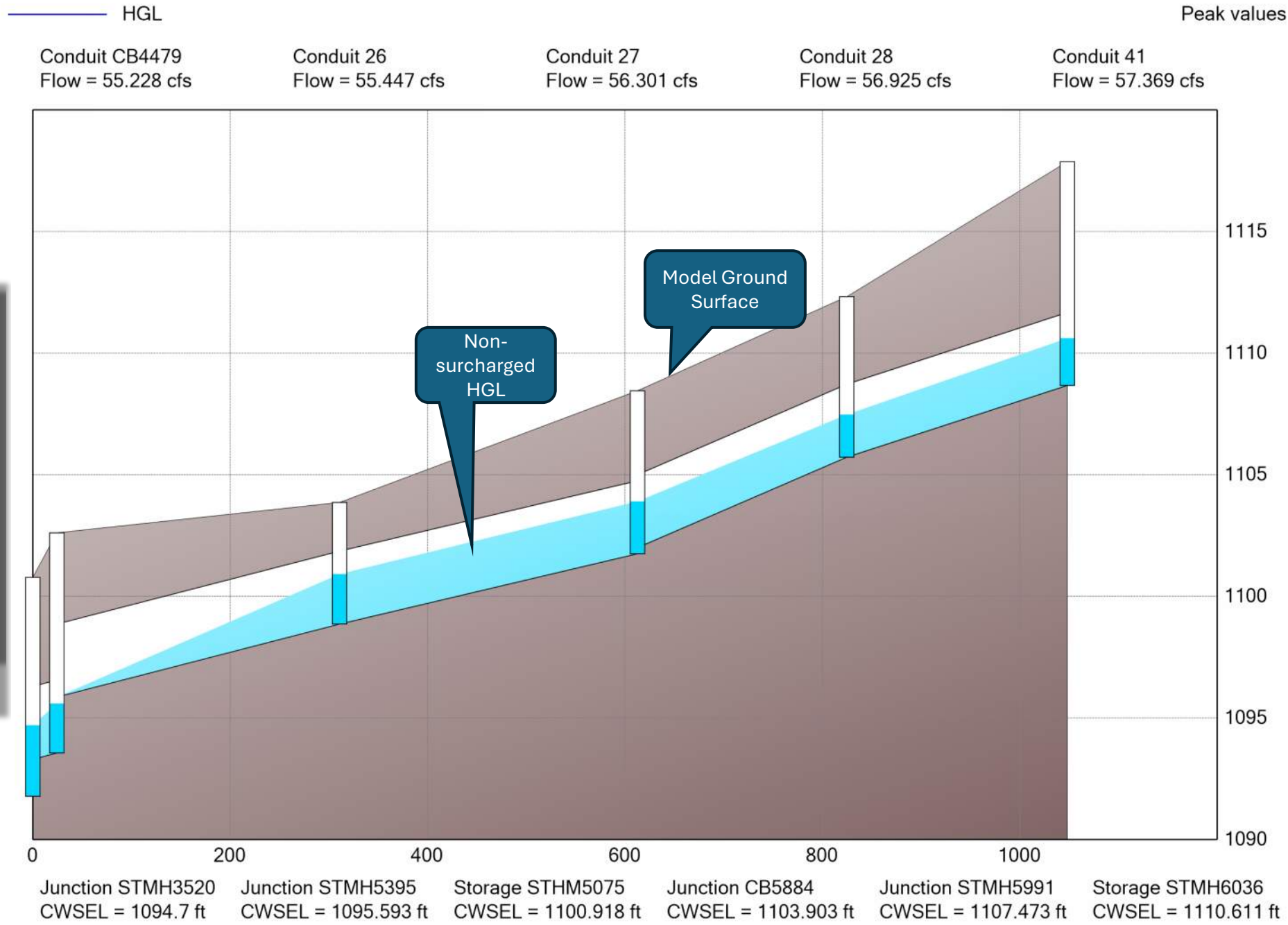
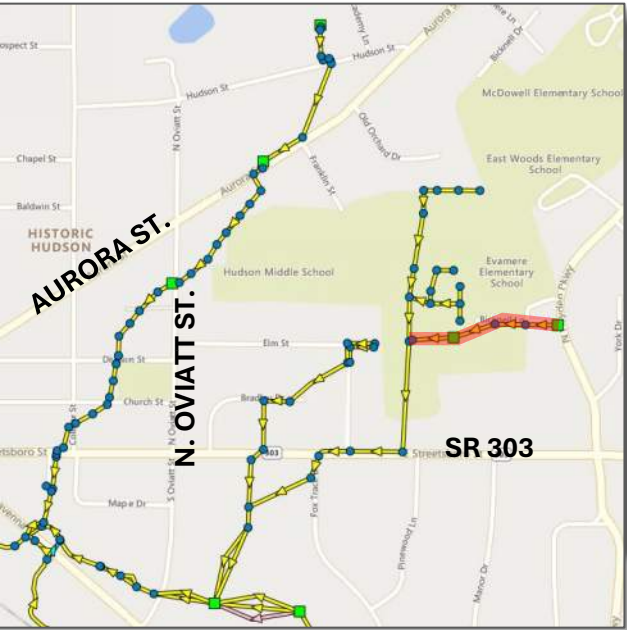
Alternative 3
10-yr System 2
School property to Fox
Trace Lane

Profile Location



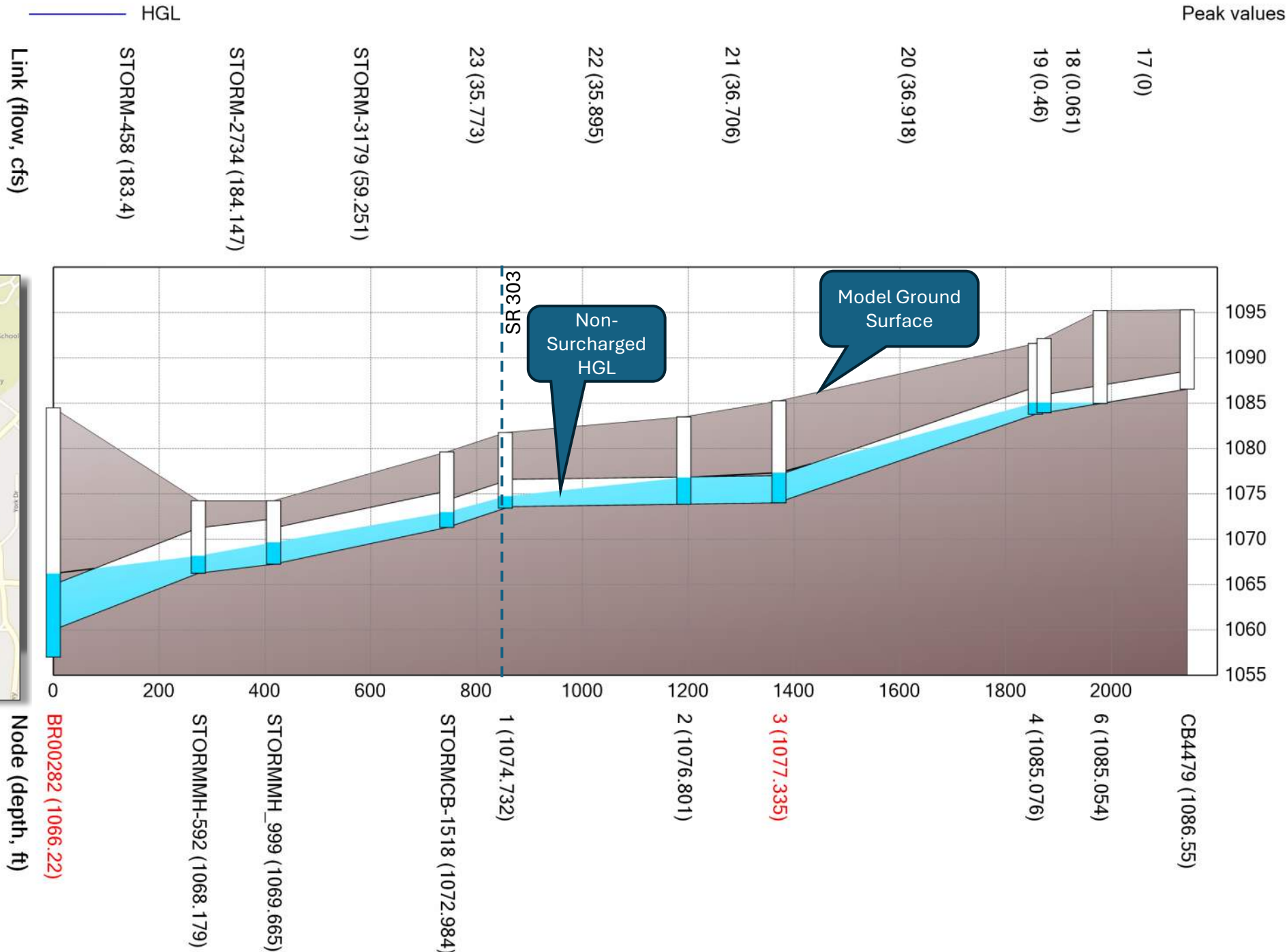
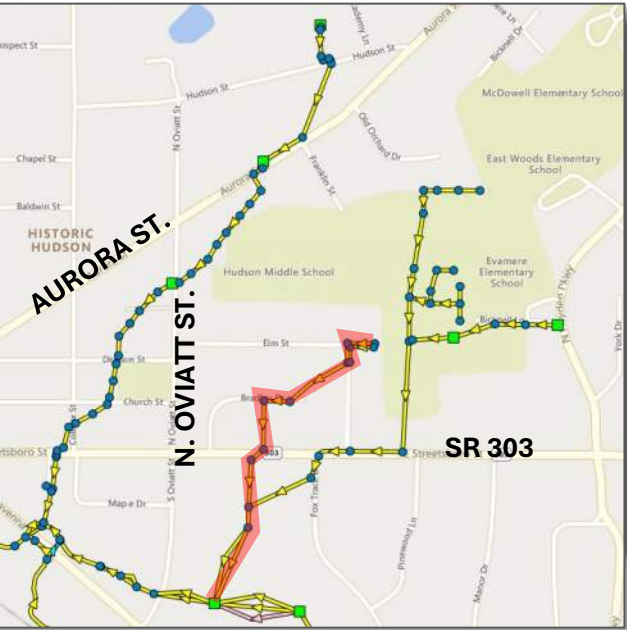
Alternative 3
10-yr System 2
N Hayden Pkwy into school
property

Profile Location



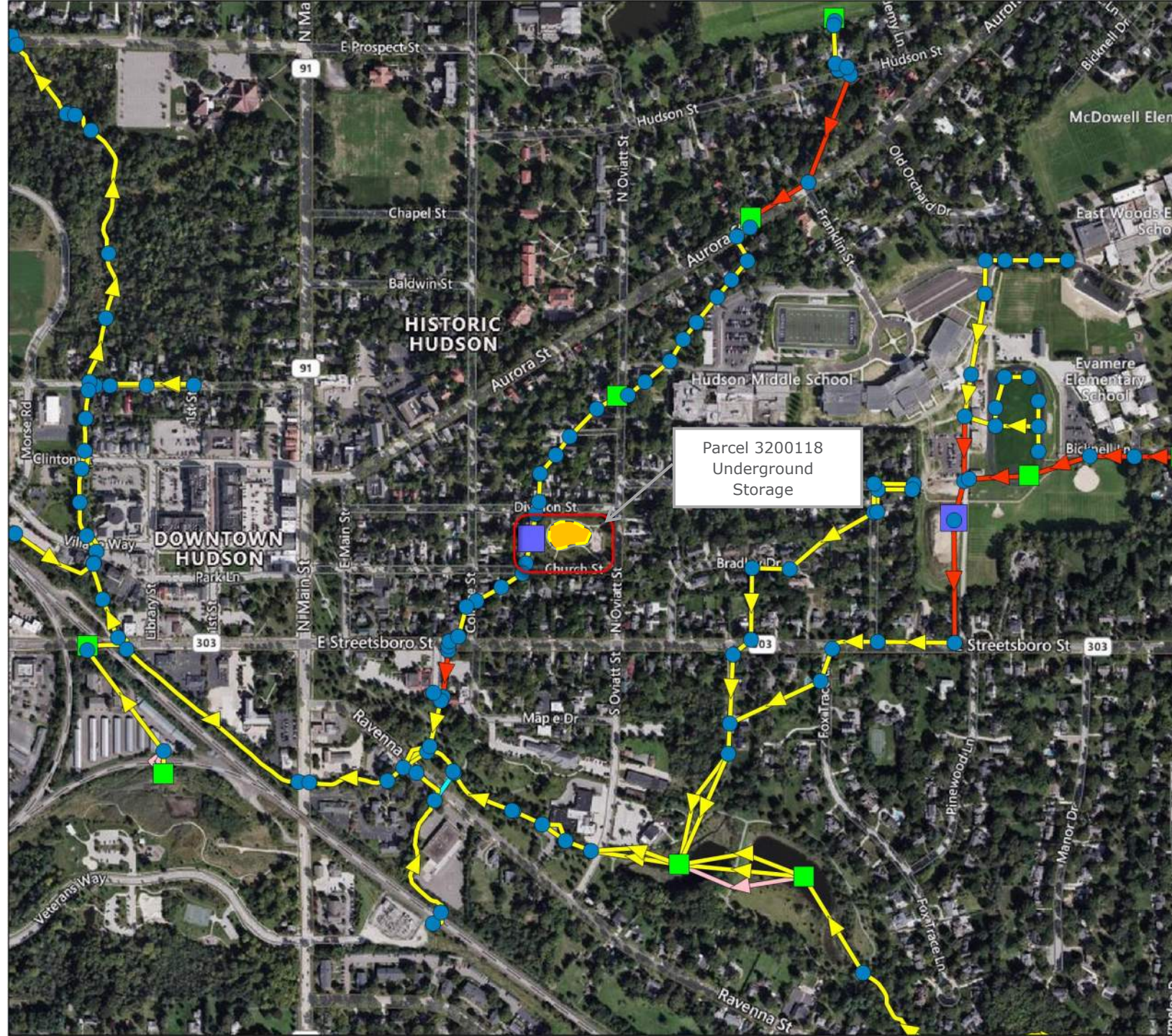
Alternative 3
10-yr System 2
Elm St to Edward Dr

Profile Location



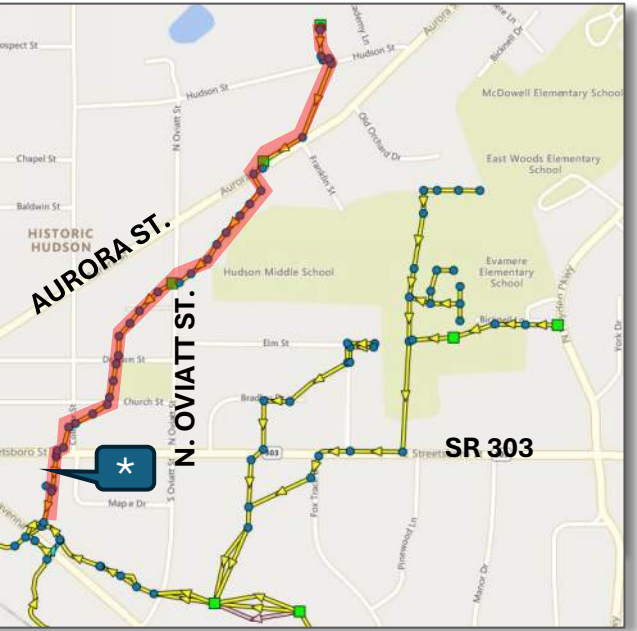
Alternative 4

-10-year basin improvement System 1



Alternative 4
10-yr System 1

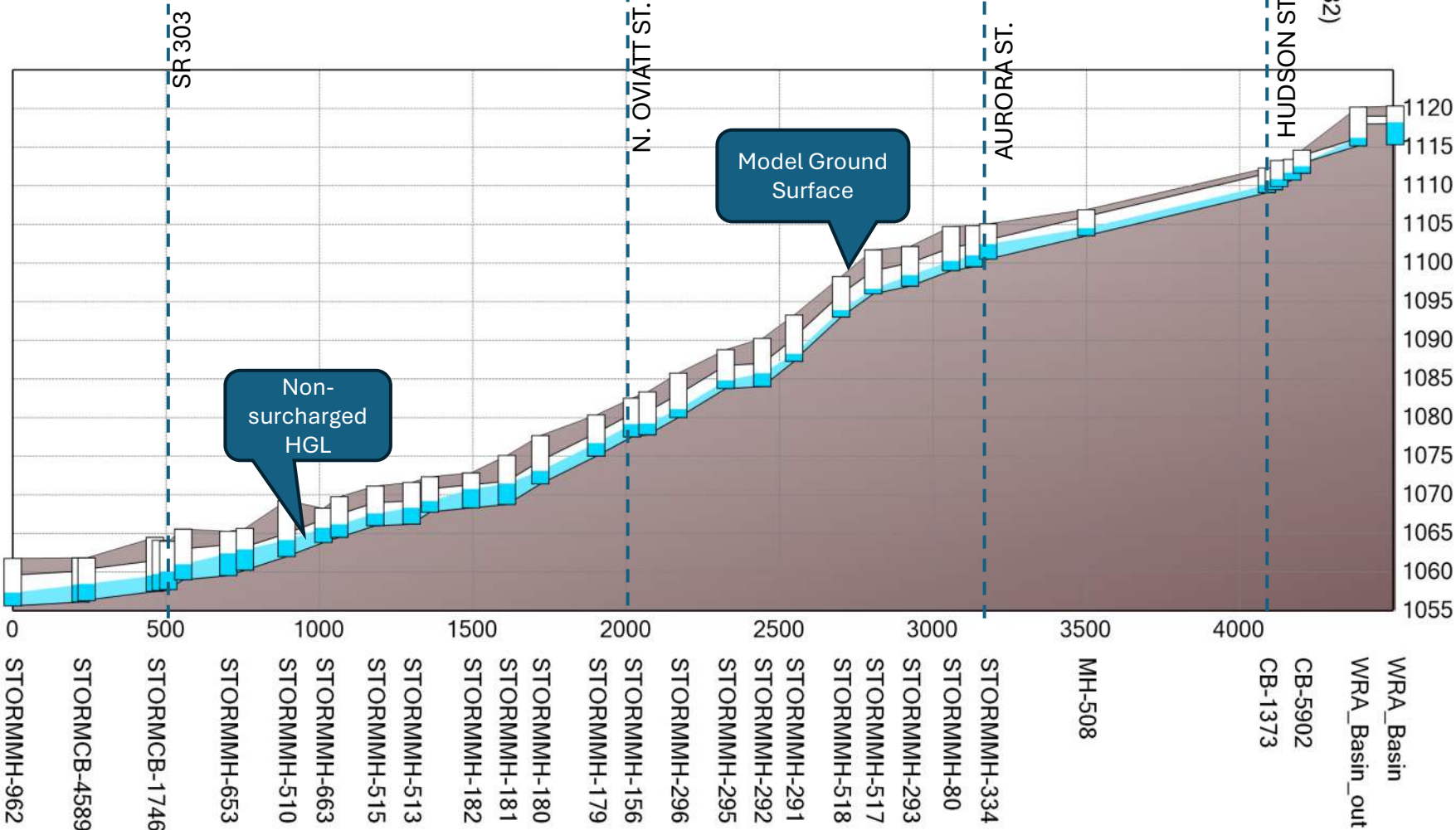
Profile Location



Link (flow, cfs)

42 (11.967)
WRA_outlet_channel (13.32)
STORM-1458 (13.29)
STORM-5922 (13.327)
STORM-5920 (13.276)
STORM-5915 (40.612)
STORM-5911 (40.616)
STORM-5912 (40.618)
STORM-5913 (40.619)
STORM-5910 (40.619)
STORM-5908 (40.618)
STORM-5909 (40.615)
STORM-250 (40.611)
STORM-7616 (40.609)
STORM-2933 (103.373)
STORM-2932 (103.477)
STORM-2931 (103.597)
STORM-2930 (103.701)
STORM-2929 (103.814)
STORM-2927 (103.586)
STORM-2928 (99.445)
STORM-1464 (133.689)
STORM-1465 (132.505)
STORM-2759 (131.255)
STORM-1466 (130.111)
STORM-2232 (128.439)
STORM-3927 (157)
STORM-3928 (165.189)
STORM-3926 (164.294)

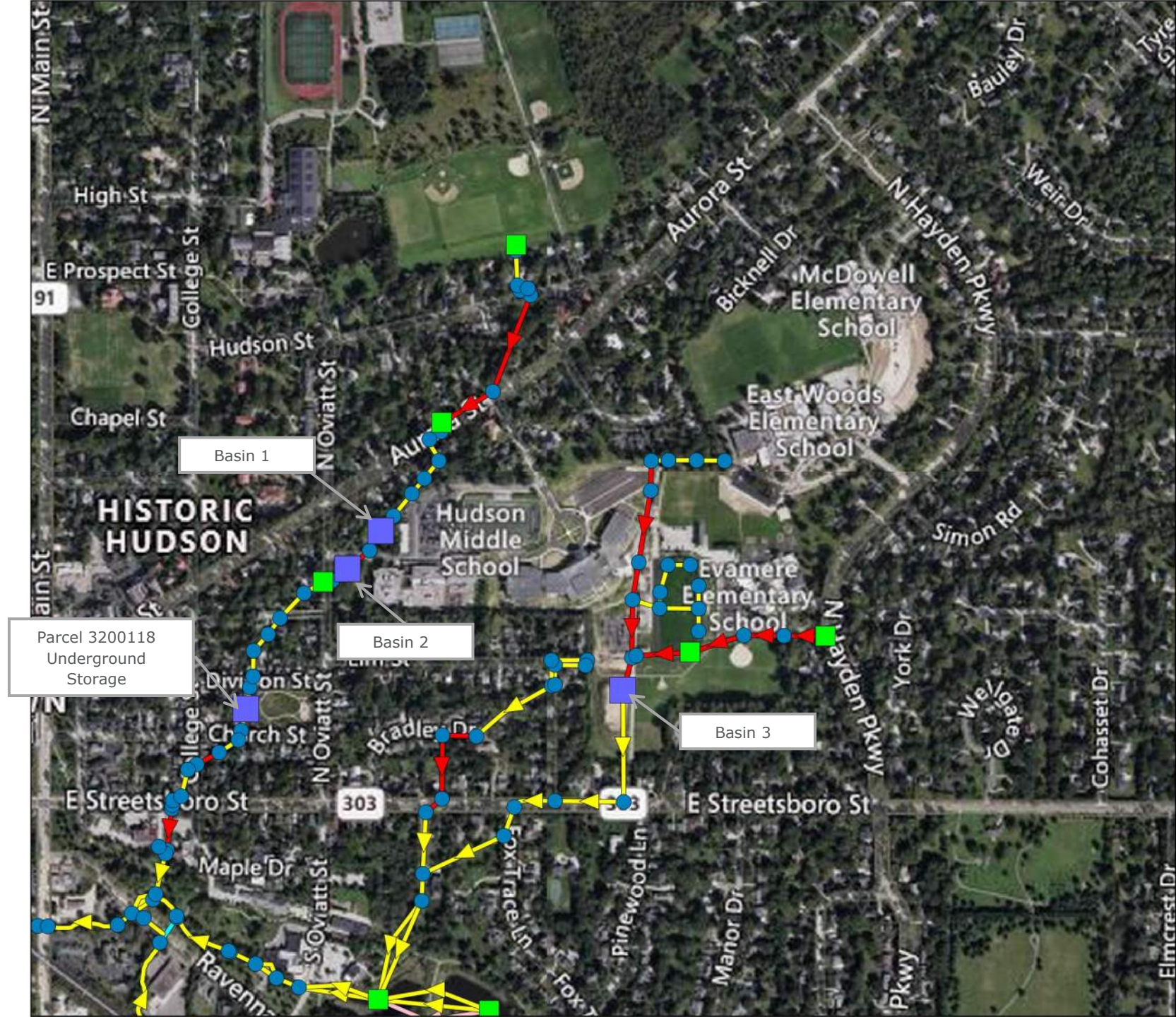
Node



Peak values

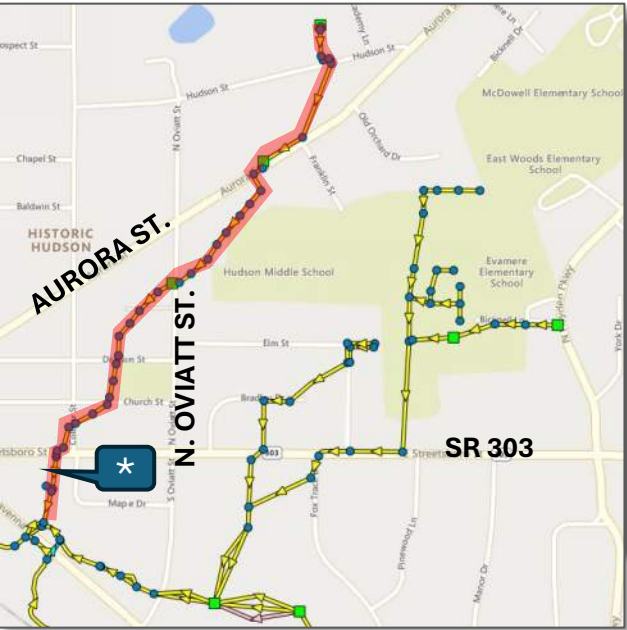
Alternative 5

- 100-year basin and sewer improvements for System 1 & 2
- Improvements shown in red



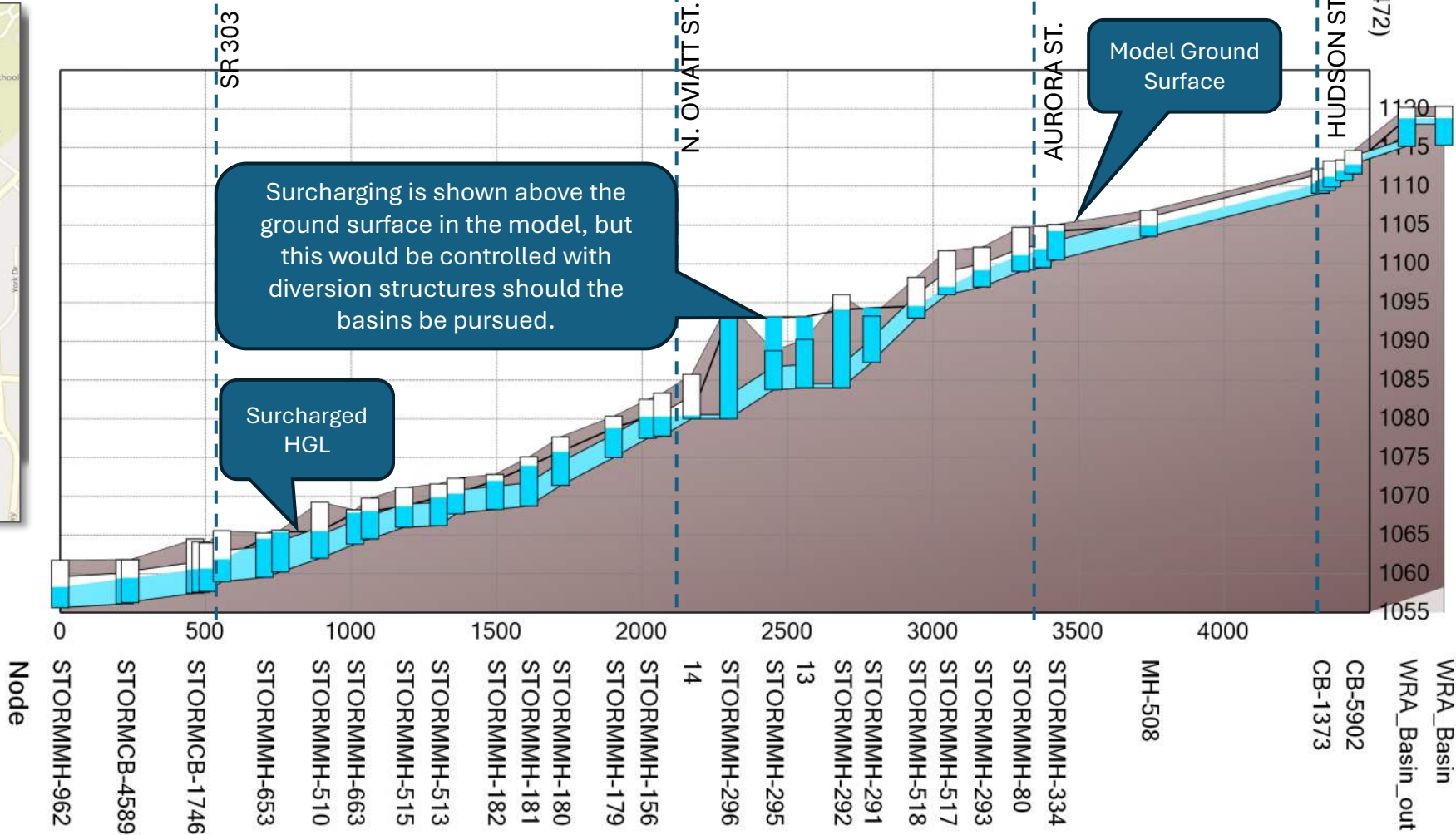
Alternative 5
100-yr System 1

Profile Location



Link (flow, cfs)

42 (37.808)
WRA_outlet_channel (21.472)
STORM-1458 (21.449)
STORM-5922 (21.441)
STORM-5920 (21.365)
STORM-5915 (79.052)
STORM-5911 (79.073)
STORM-5912 (79.091)
STORM-5913 (79.1)
STORM-5910 (79.114)
STORM-5908 (78.536)
STORM-5909_1 (48.817)
STORM-5909_2 (48.144)
STORM-250 (47.143)
STORM-7616_1 (10.126)
STORM-7616_2 (10.126)
STORM-2933 (160.086)
STORM-2932 (160.087)
STORM-2931 (160.071)
STORM-2930 (160.085)
STORM-2929 (160.094)
STORM-2927 (160.139)
STORM-2928 (168.492)
STORM-1464 (229.988)
STORM-2759 (227.805)
STORM-1466 (227.801)
STORM-2232 (226.967)
STORM-3927 (278.845)
STORM-3928 (292.24)
STORM-3926 (290.315)

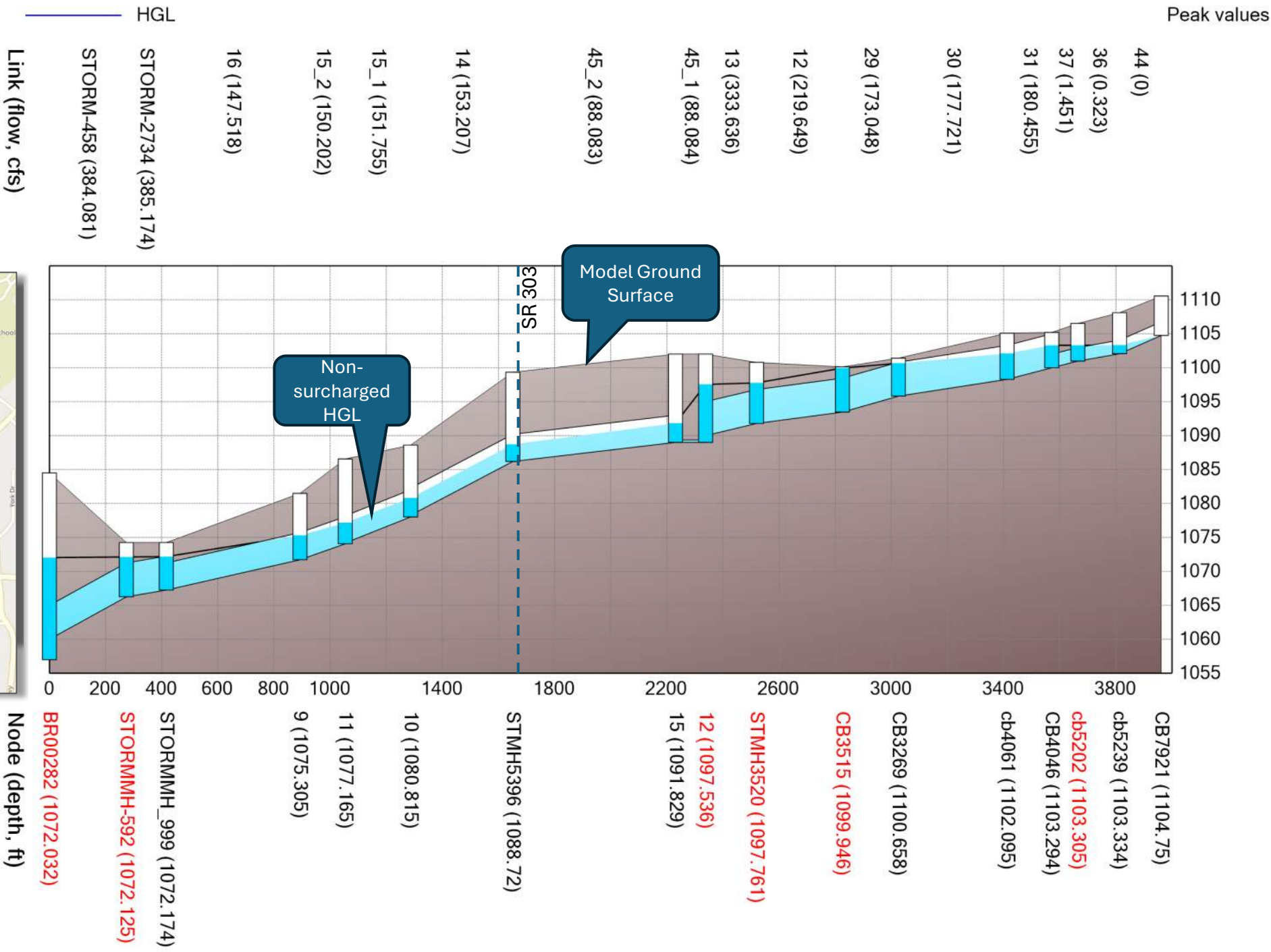
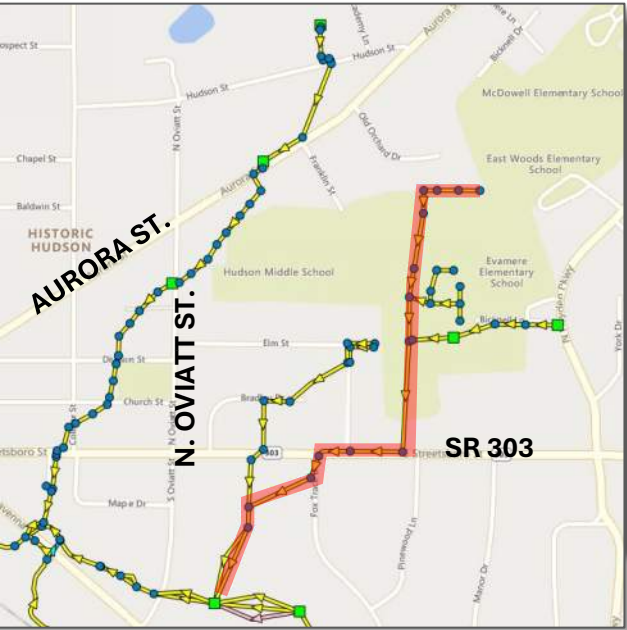


Alternative 5

100-yr System 2

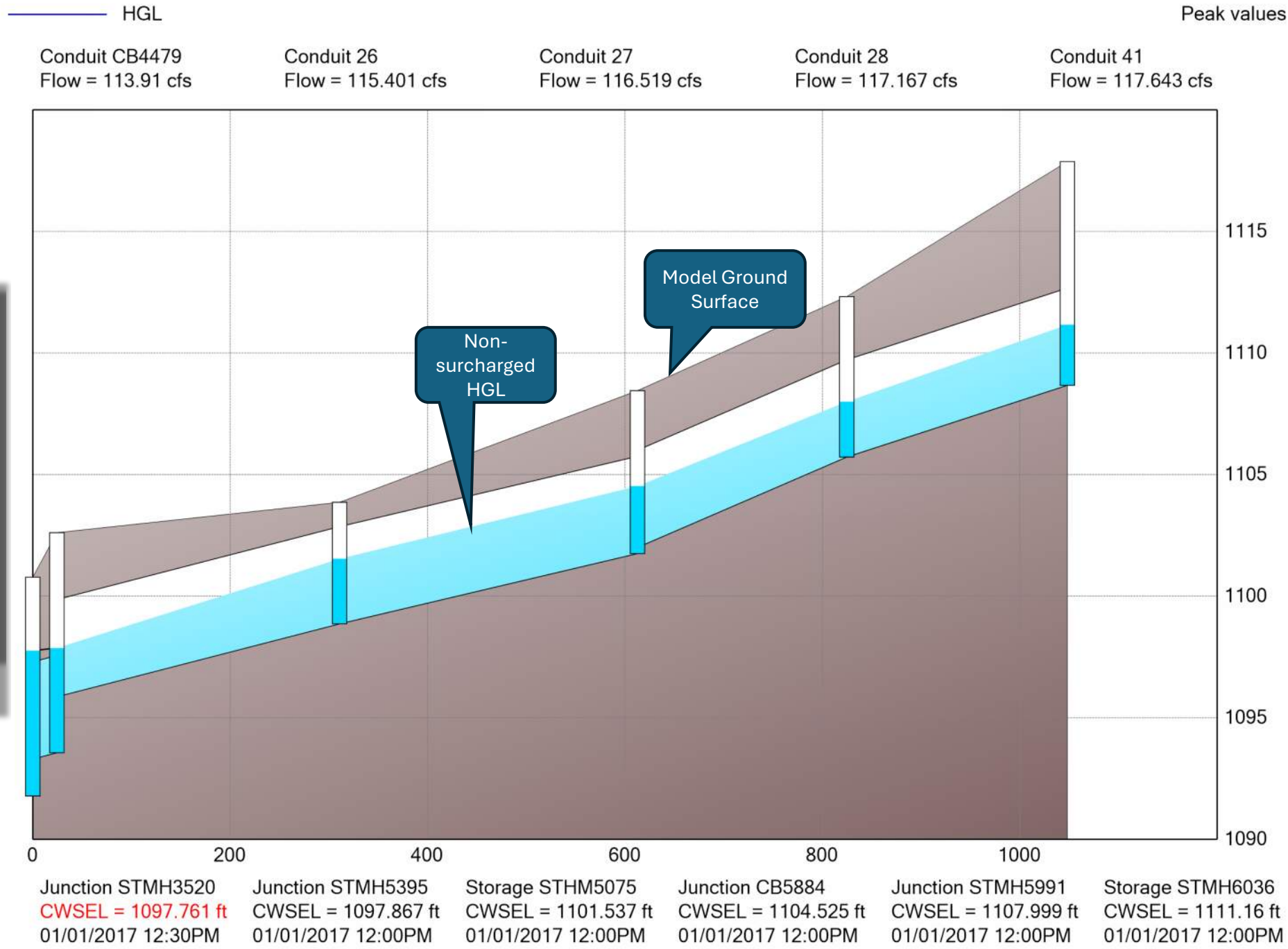
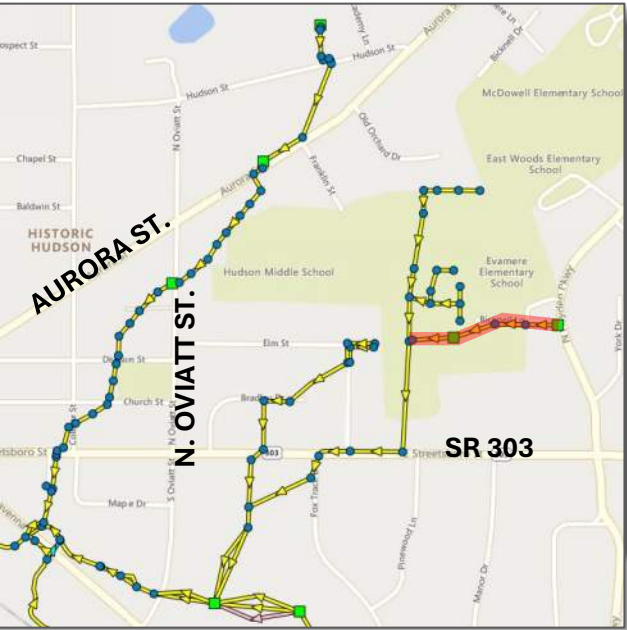
School property to Fox
Trace Lane

Profile Location



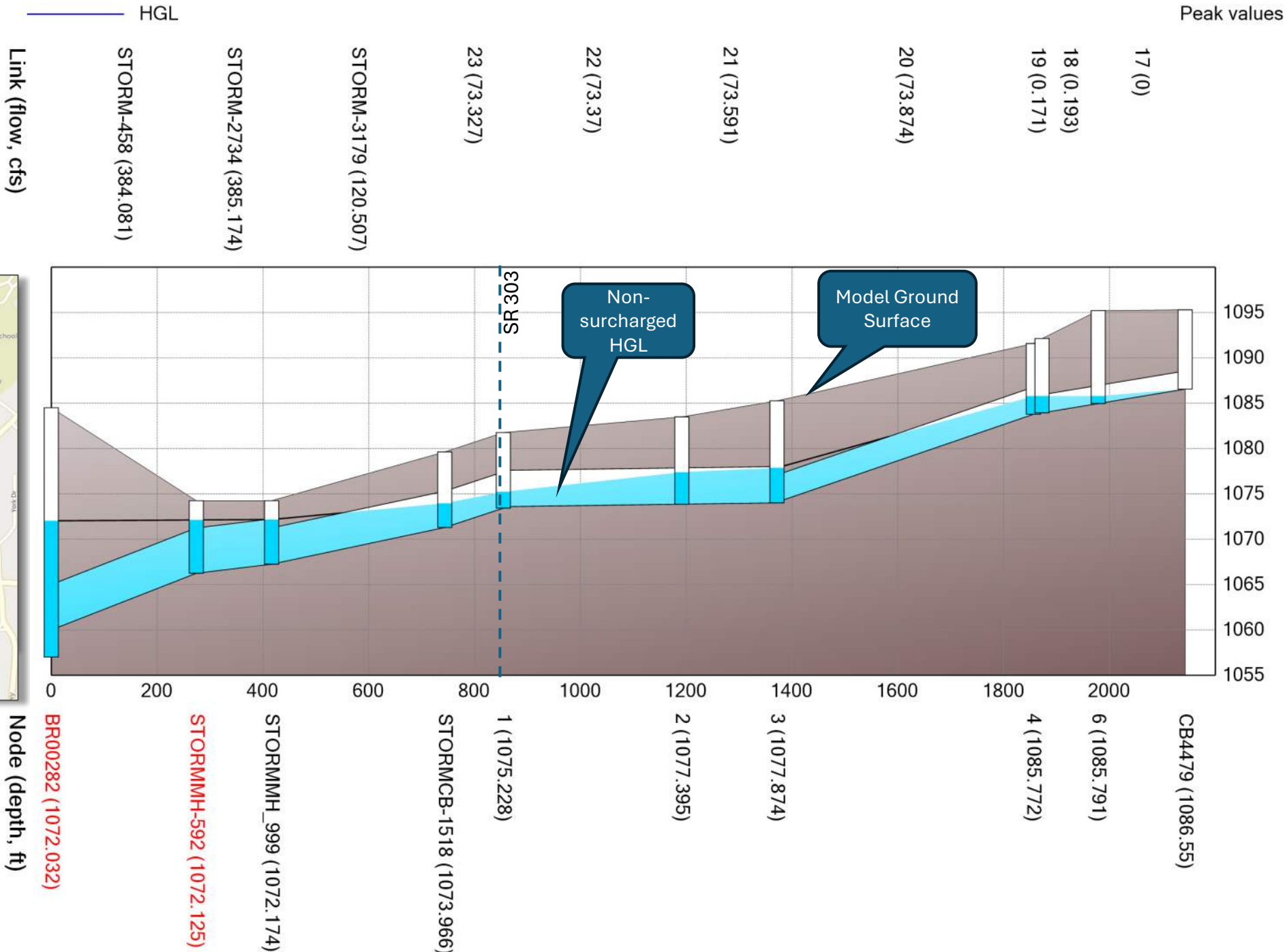
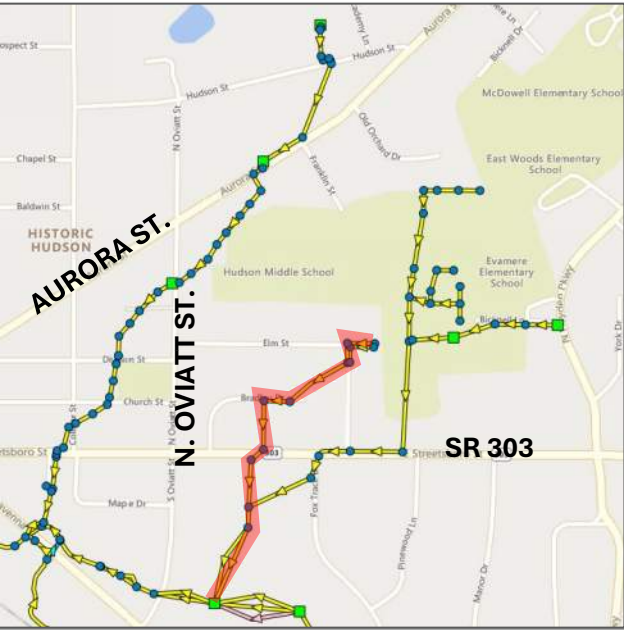
Alternative 5
100-yr System 2
N Hayden Pkwy into school
property

Profile Location



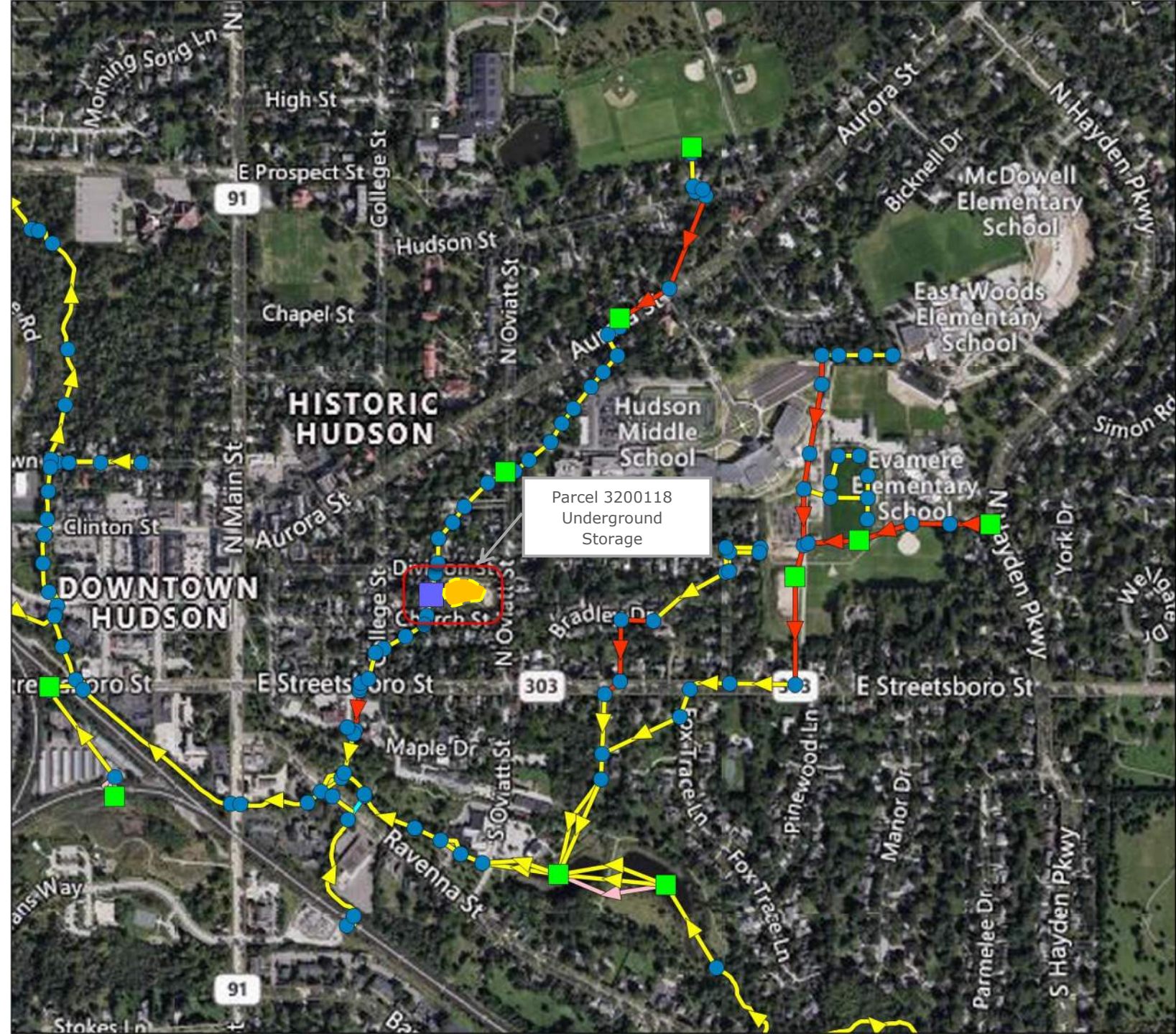
Alternative 5
100-yr System 2
Elm St to Edward Dr

Profile Location



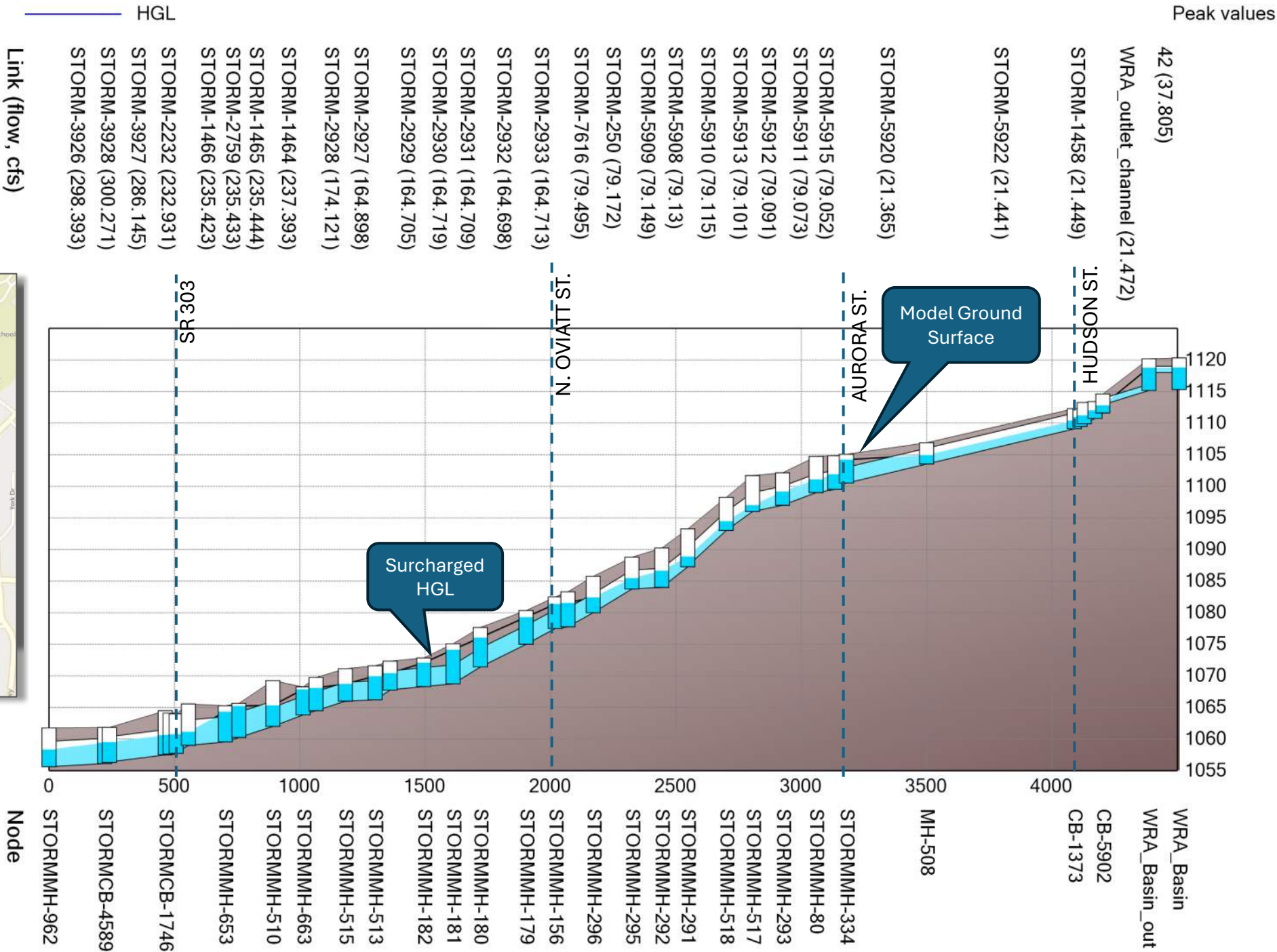
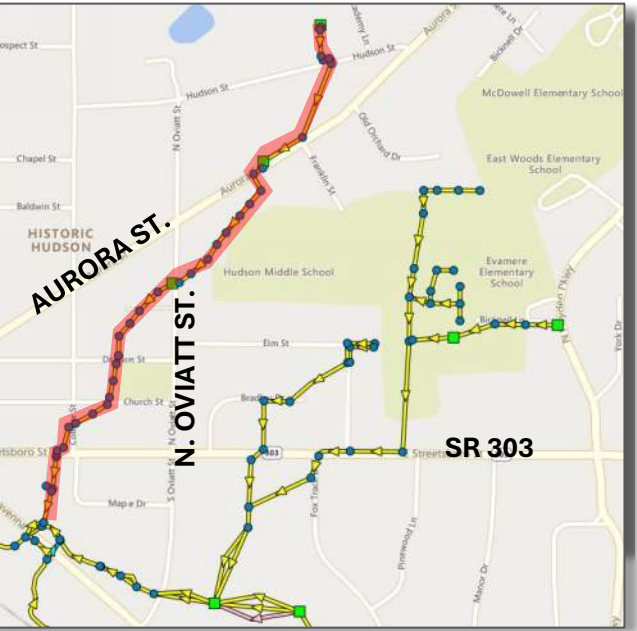
Alternative 6

- 100-year basin and sewer improvements for System 1
- Improvements shown in red



Alternative 6
100-yr System 1

Profile Location

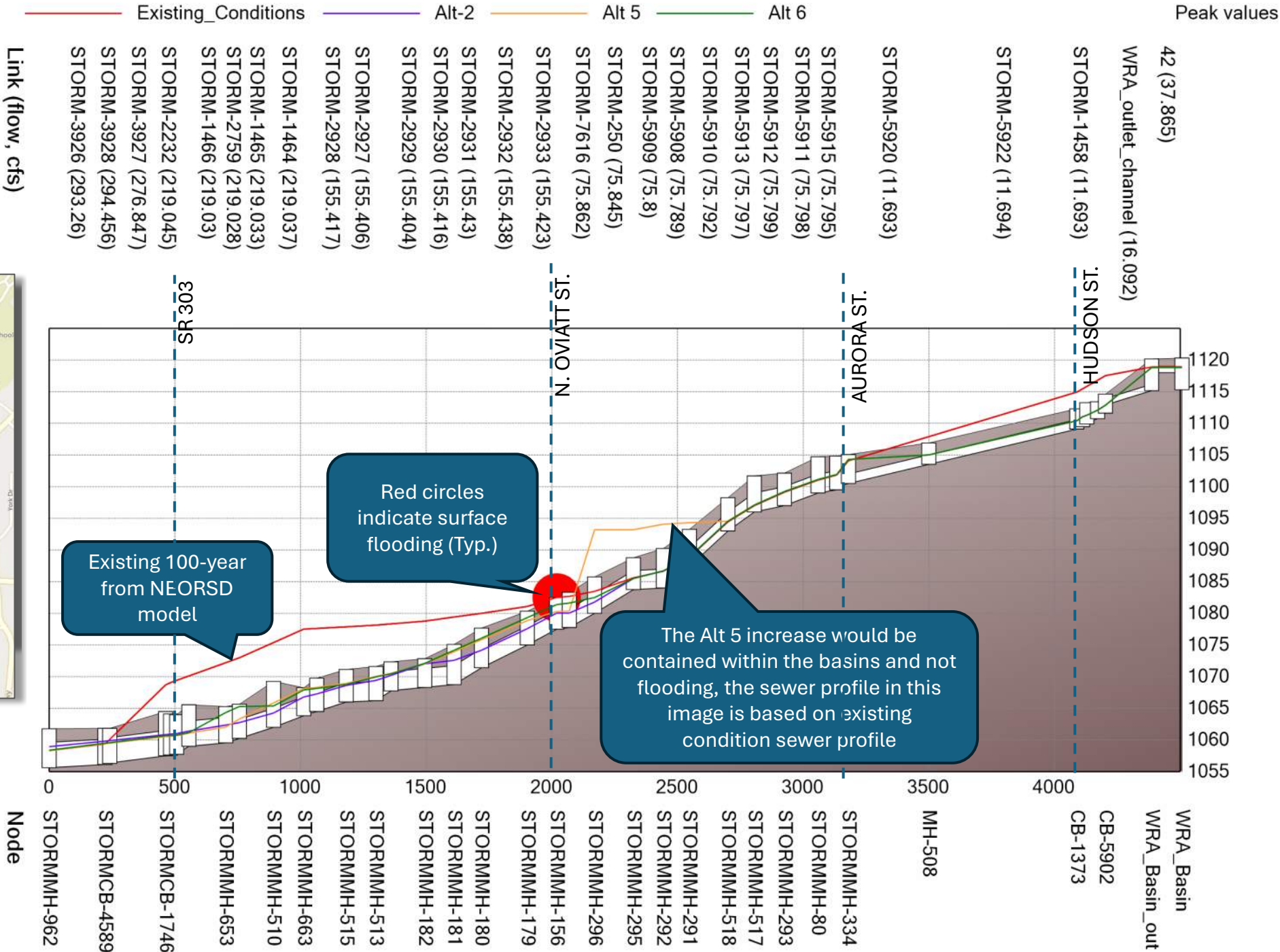
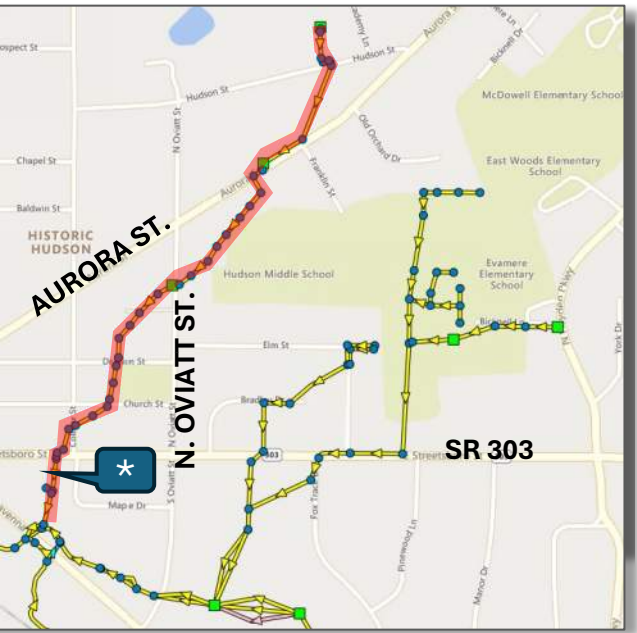


Alternatives vs Existing Conditions

100-yr design storm

100-yr System 1

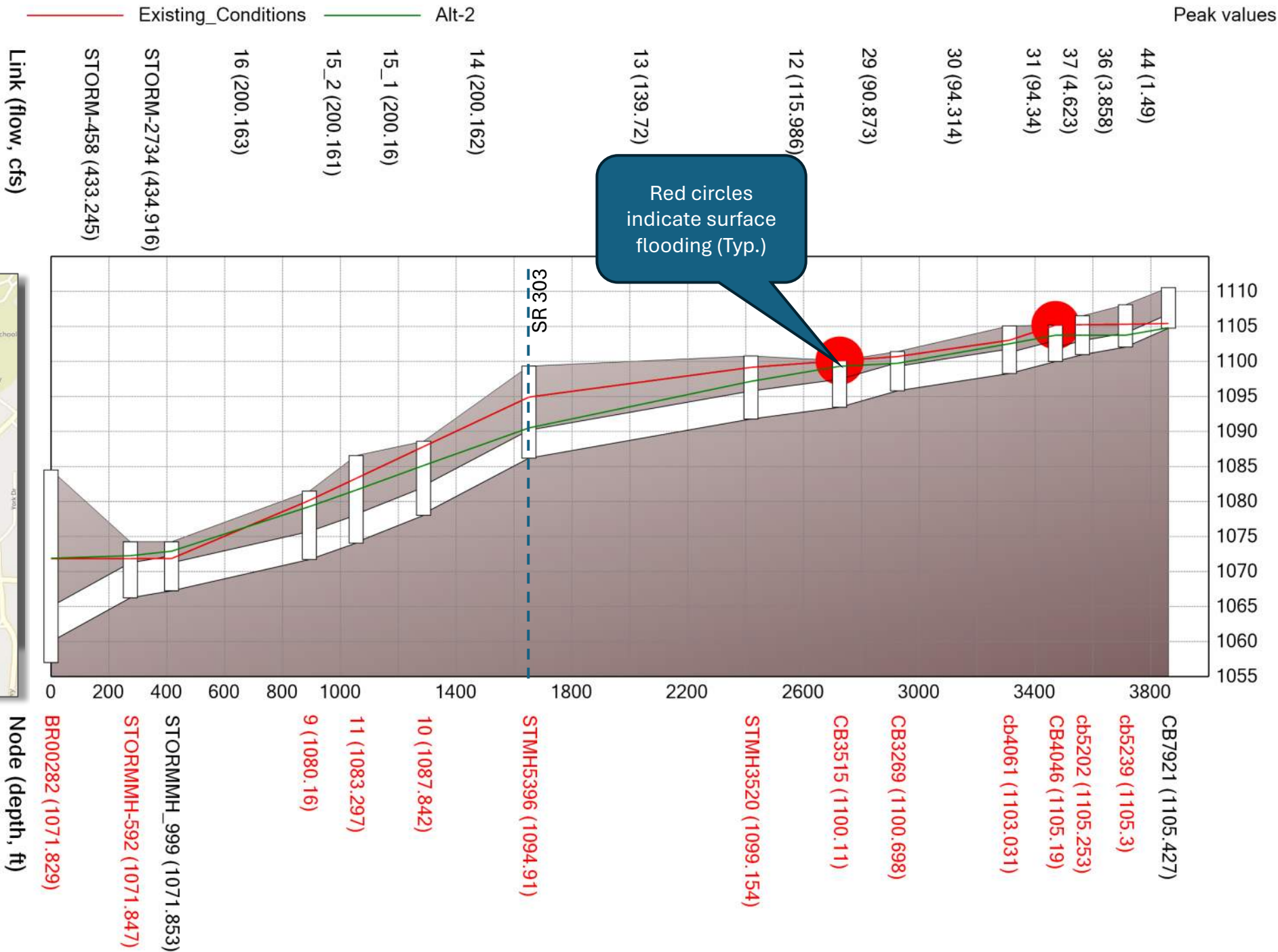
Profile Location



100-yr System 2

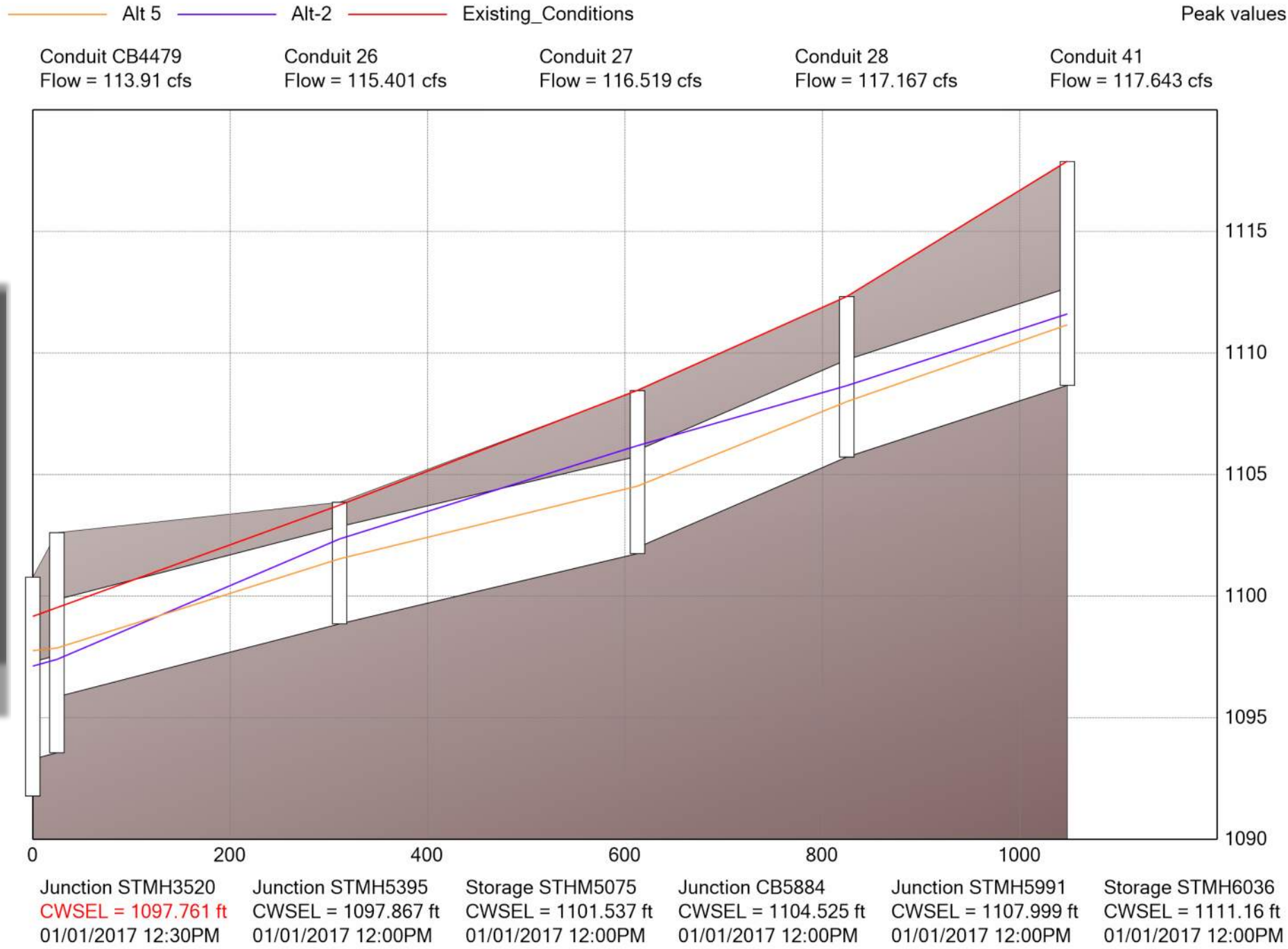
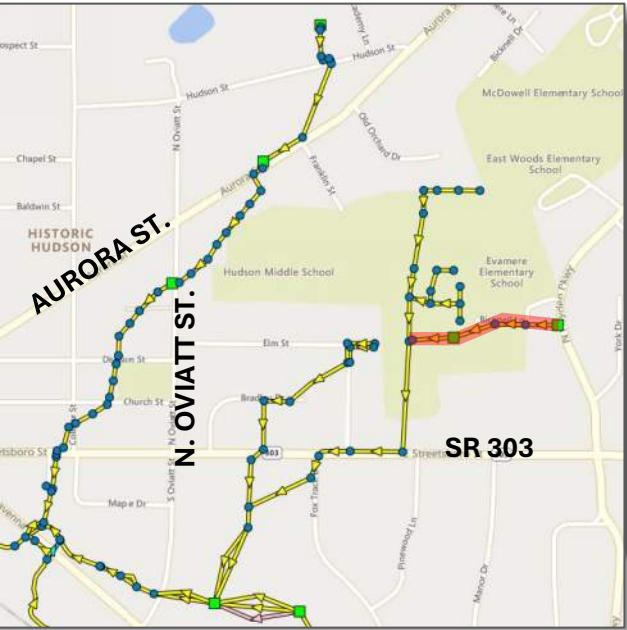
School property to Fox Trace Lane

Profile Location



100-yr System 2
N Hayden Pkwy onto school
property

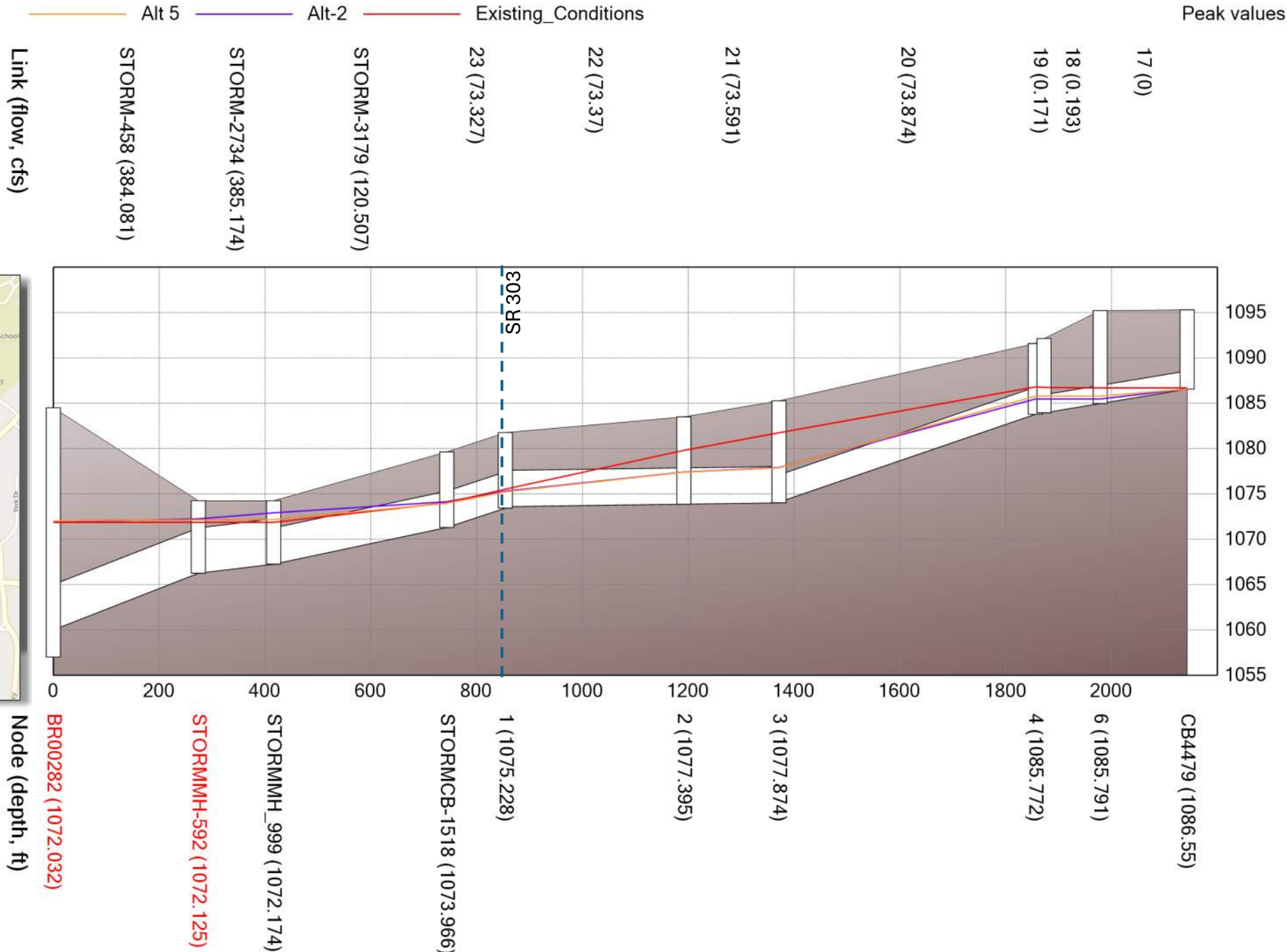
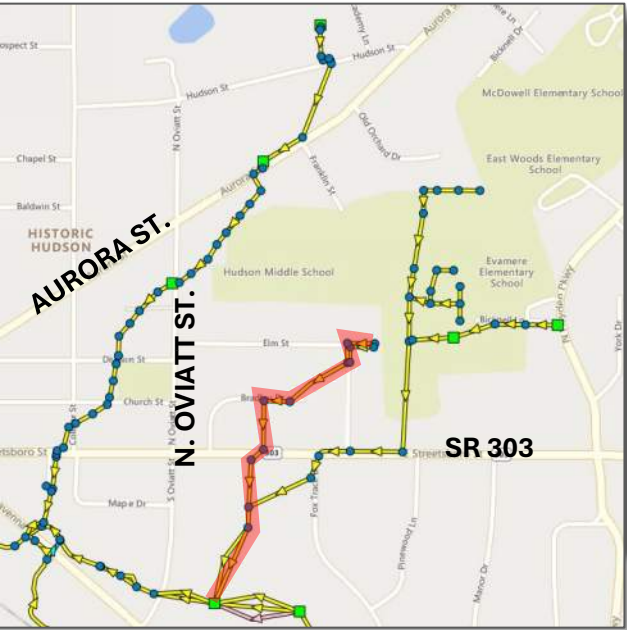
Profile Location



100-yr System 2

Elm St to Edward Dr

Profile Location

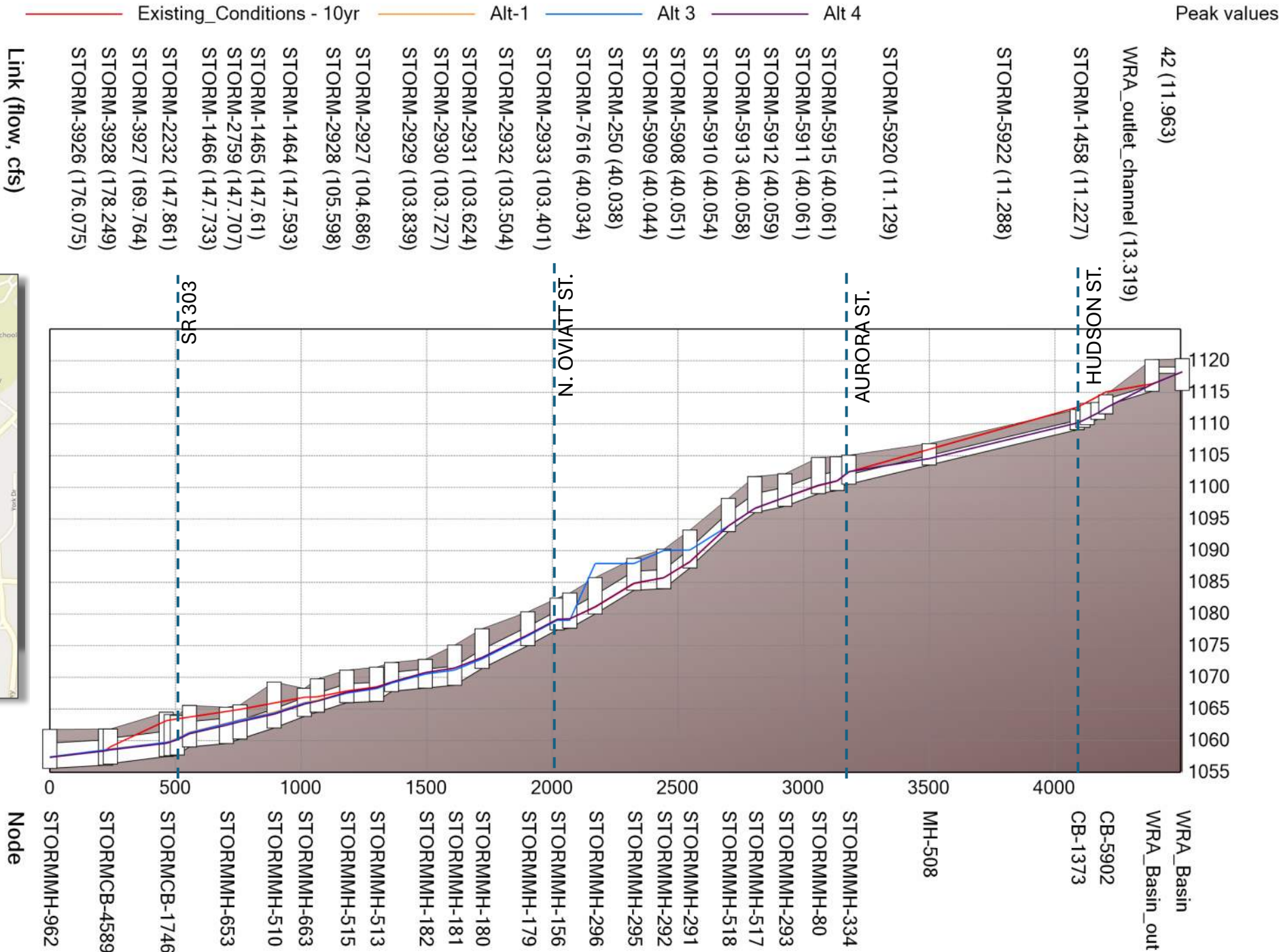
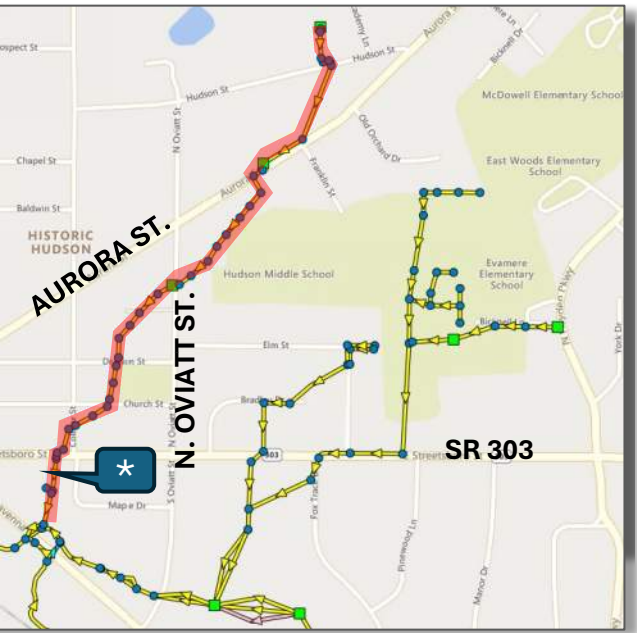


Alternatives vs Existing Conditions

10-yr design storm

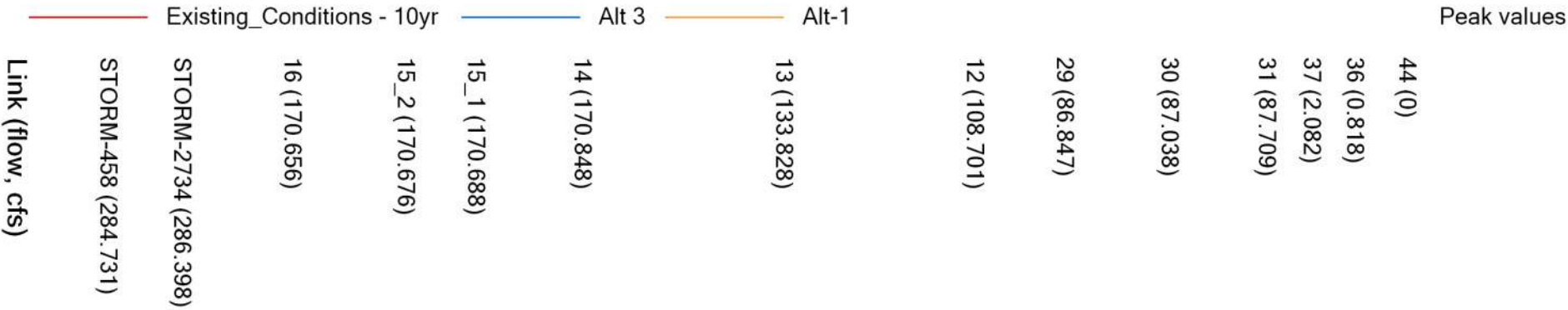
10-yr System 1

Profile Location

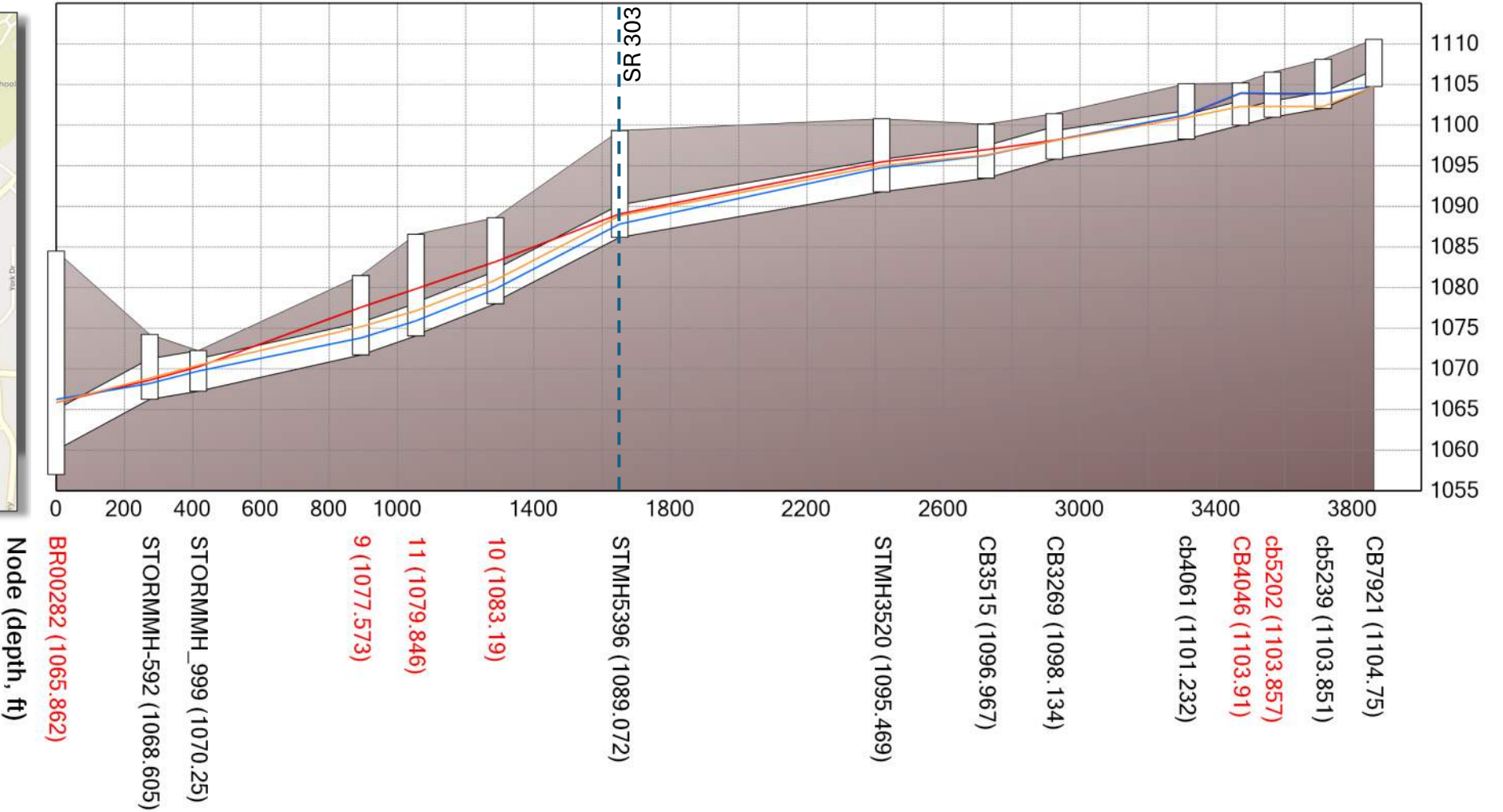
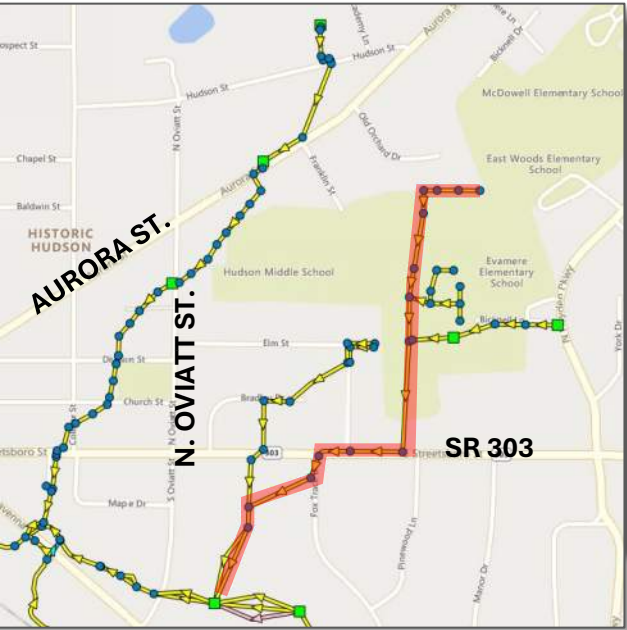


10-yr System 2

School property to Fox Trace Lane

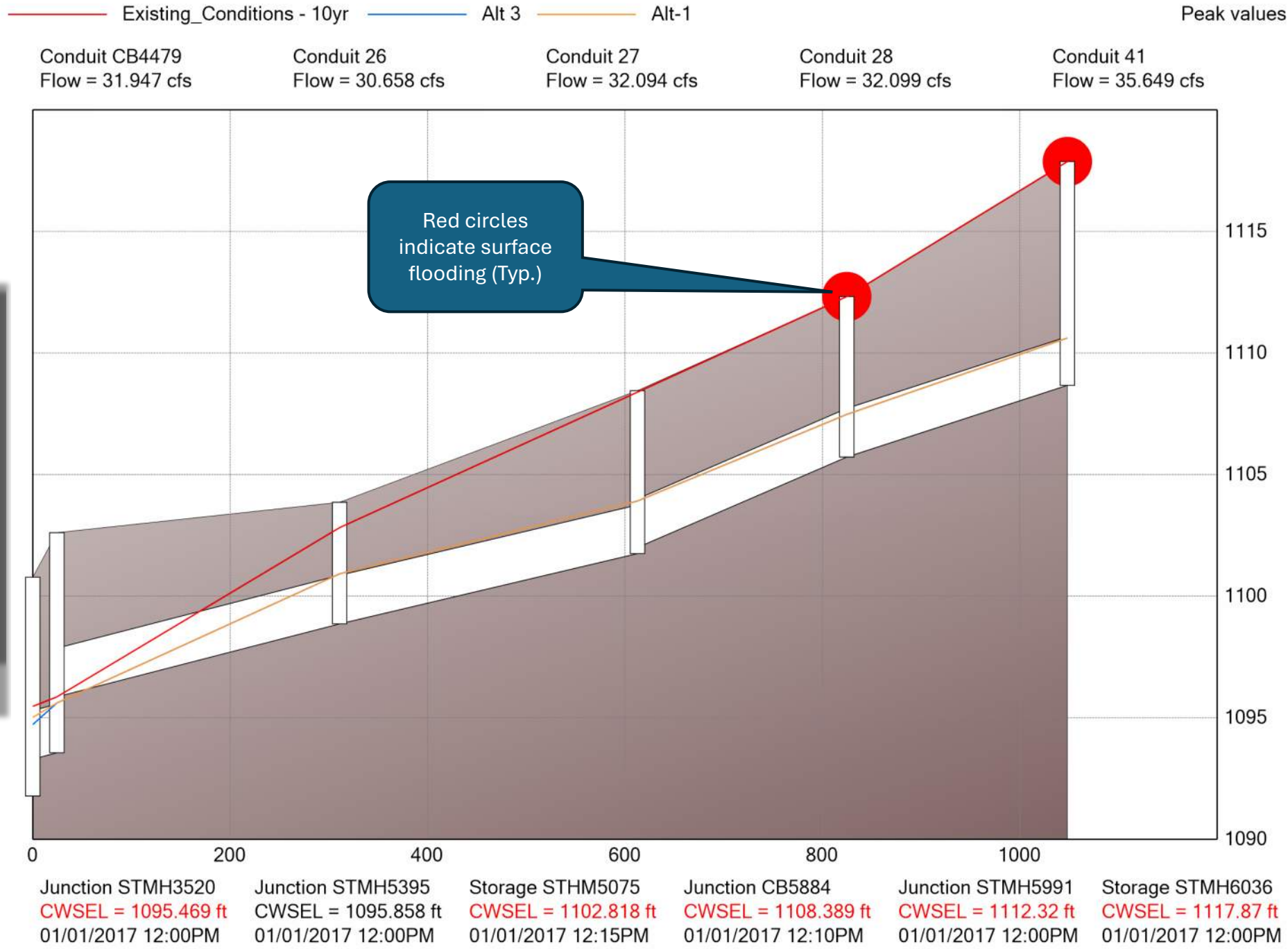
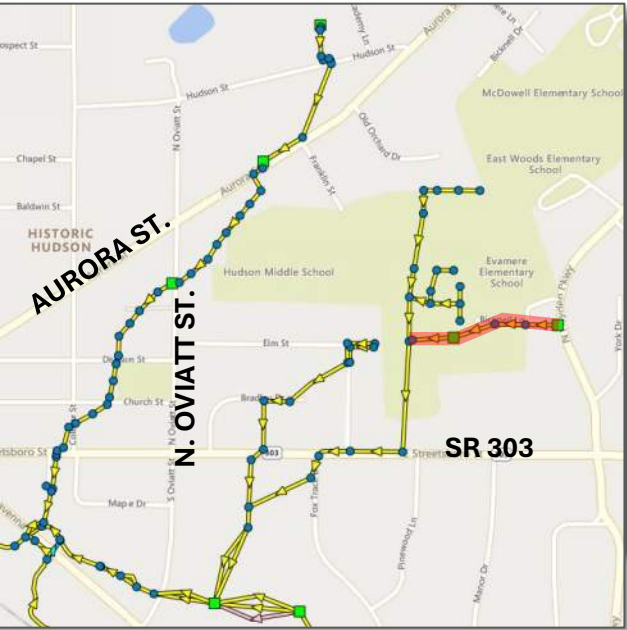


Profile Location



10-yr System 2
N Hayden Pkwy onto school
property

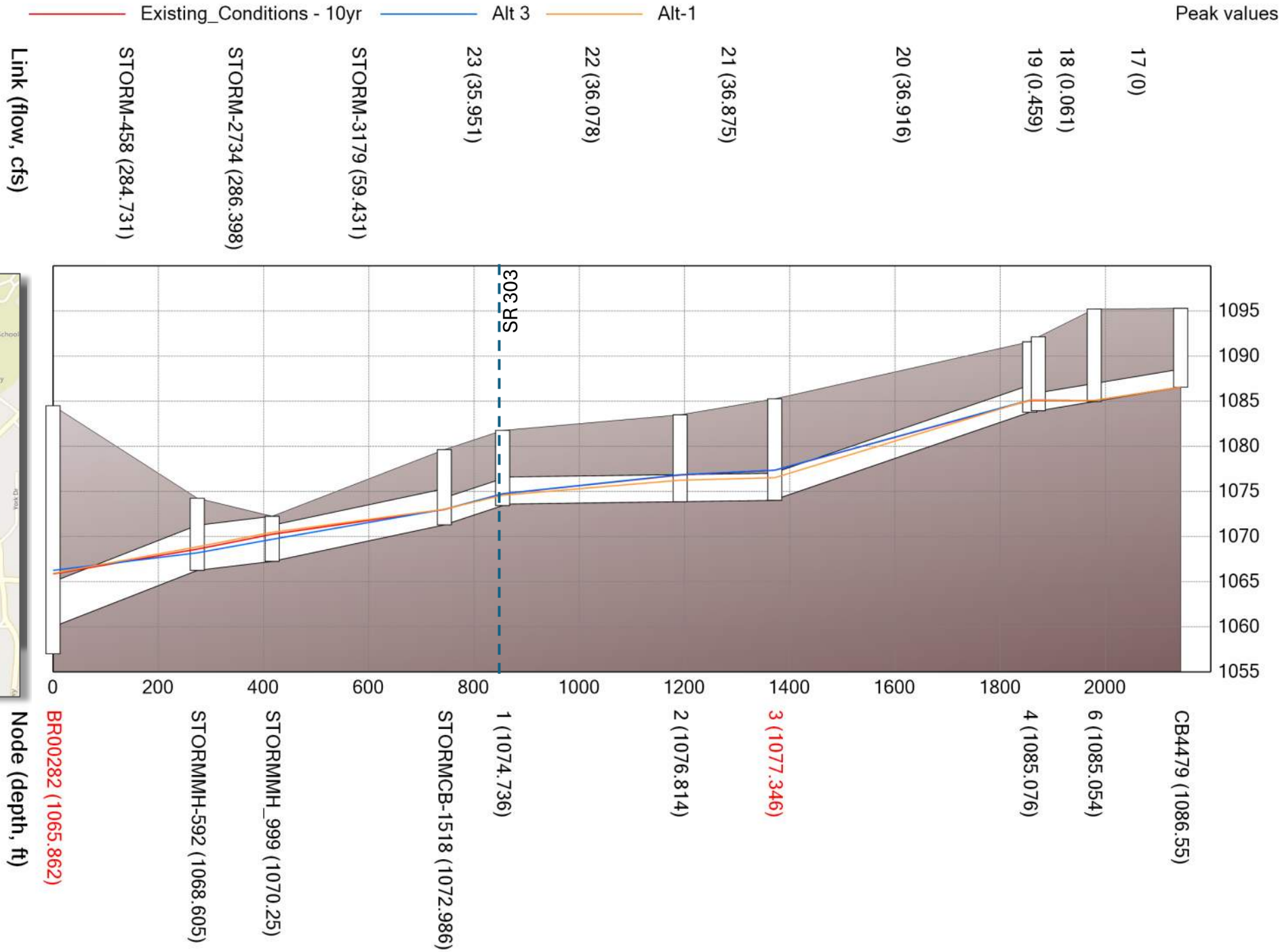
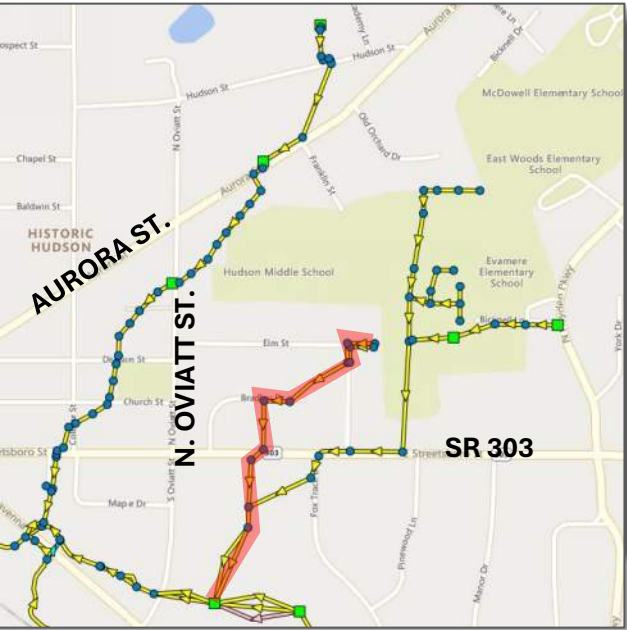
Profile Location



10-yr System 2

Elm St to Edward Dr

Profile Location



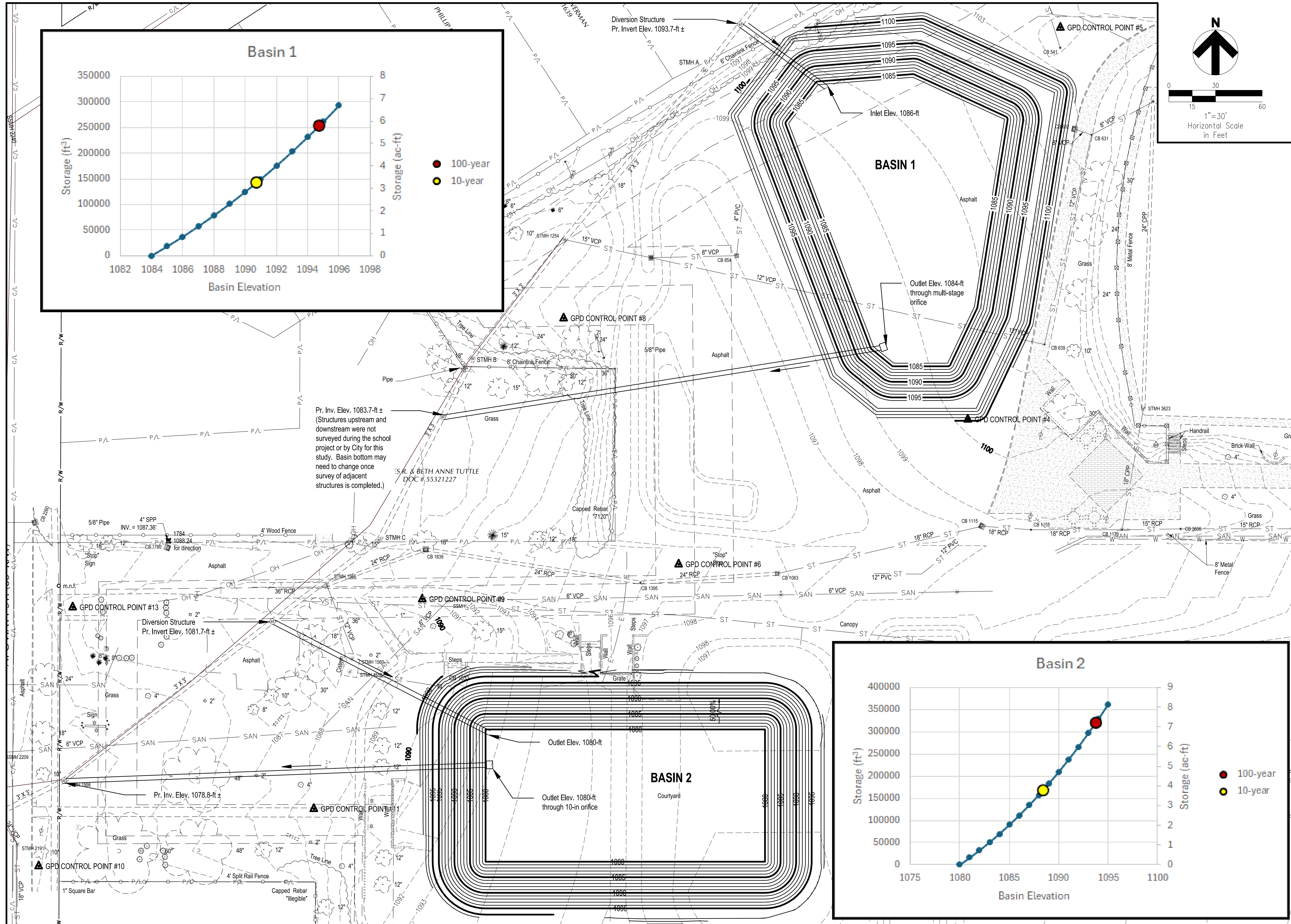
Attachment B

Proposed Basin Exhibits

DRAFT

PRELIMINARY DRAFT NOT FOR CONSTRUCTION, BID, RELIANCE, RECORDING PURPOSES OR IMPLEMENTATION

O:\2024\2024041 HPF56-HUDSON BRANDY WINE MODELING\CA\EXHIBITS\BASIN EXHIBITS\DWG - NORTHERN BASINS - PLOTTED XXXXXX BY RUFEHER, JESSE



REV.	DATE	DESCRIPTION

Darrow Road Park Basin Study
Hudson, Ohio

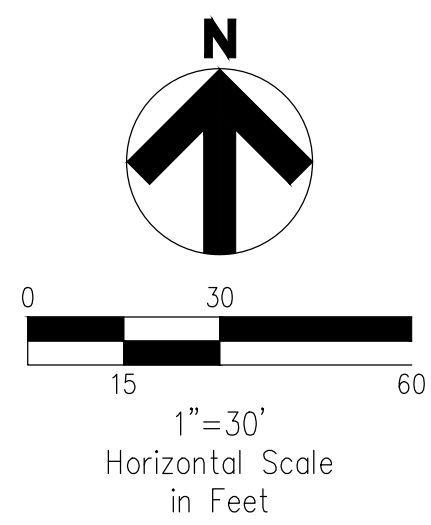
NORTHERN BASIN

ISSUED FOR:	
PERMIT	-
BID	-
CONSTRUCTION	-
RECORD	-
PROJECT MANAGER	DESIGNER

JOB NO.
2024041.50

SHEET:
SHEET NO: **1 OF 2**

PRELIMINARY DRAFT NOT FOR CONSTRUCTION, BID, RELIANCE, RECORDING PURPOSES OR IMPLEMENTATION

[illegible]

Darrow Road Park Basin Study
Hudson, Ohio

SOUTH BASIN

ISSUED FOR:	
PERMIT	-
BID	-
CONSTRUCTION	-
RECORD	-

PROJECT MANAGER	DESIGNER

JOB NO.
2024041.50

SHEET:

SHEET NO: 2 OF 2

Attachment C

Underground Detention Basin Calculations

DRAFT

Project: Brandywine



☒ Include Perimeter Stone in Calculations

☒ Click for Stage Area Data

☐ Click to Invert Stage Area Data

[Click Here for Metric](#)

Chamber Model - MC-3500
Units - Imperial
Number of Chambers - 450
Number of End Caps - 35
Voids in the stone (porosity) - 40 %
Base of Stone Elevation - 1065.00 ft
Amount of Stone Above Chambers - 12 in
Amount of Stone Below Chambers - 12 in

Area of system - 24000 sf Min. Area - 22875 sf min. area

StormTech MC-3500 Cumulative Storage Volumes

Height of System (inches)	Incremental Single Chamber (cubic feet)	Incremental Single End Cap (cubic feet)	Incremental Chambers (cubic feet)	Incremental End Cap (cubic feet)	Incremental Stone (cubic feet)	Incremental Ch, EC and Stone (cubic feet)	Cumulative System (cubic feet)	Elevation (feet)
69	0.00	0.00	0.00	0.00	800.00	800.00	85199.81	1070.75
68	0.00	0.00	0.00	0.00	800.00	800.00	84399.81	1070.67
67	0.00	0.00	0.00	0.00	800.00	800.00	83599.81	1070.58
66	0.00	0.00	0.00	0.00	800.00	800.00	82799.81	1070.50
65	0.00	0.00	0.00	0.00	800.00	800.00	81999.81	1070.42
64	0.00	0.00	0.00	0.00	800.00	800.00	81199.81	1070.33
63	0.00	0.00	0.00	0.00	800.00	800.00	80399.81	1070.25
62	0.00	0.00	0.00	0.00	800.00	800.00	79599.81	1070.17
61	0.00	0.00	0.00	0.00	800.00	800.00	78799.81	1070.08
60	0.00	0.00	0.00	0.00	800.00	800.00	77999.81	1070.00
59	0.00	0.00	0.00	0.00	800.00	800.00	77199.81	1069.92
58	0.00	0.00	0.00	0.00	800.00	800.00	76399.81	1069.83
57	0.06	0.00	26.14	0.00	789.54	815.68	75599.81	1069.75
56	0.19	0.02	87.35	0.84	764.73	852.91	74784.13	1069.67
55	0.29	0.04	132.28	1.32	746.56	880.16	73931.22	1069.58
54	0.40	0.05	181.64	1.80	726.62	910.07	73051.06	1069.50
53	0.69	0.07	309.23	2.37	675.36	986.96	72141.00	1069.42
52	1.03	0.09	462.73	3.09	613.67	1079.49	71154.04	1069.33
51	1.25	0.11	562.29	3.75	573.58	1139.62	70074.55	1069.25
50	1.42	0.13	640.00	4.42	542.23	1186.66	68934.92	1069.17
49	1.57	0.14	707.91	5.05	514.81	1227.78	67748.27	1069.08
48	1.71	0.16	768.22	5.70	490.43	1264.35	66520.49	1069.00
47	1.83	0.18	822.82	6.36	468.33	1297.51	65256.14	1068.92
46	1.94	0.20	872.00	7.02	448.39	1327.41	63958.63	1068.83
45	2.04	0.22	918.37	7.64	429.60	1355.61	62631.22	1068.75
44	2.13	0.23	960.61	8.22	412.47	1381.30	61275.61	1068.67
43	2.22	0.25	1000.90	8.77	396.13	1405.80	59894.31	1068.58
42	2.31	0.27	1038.06	9.30	381.06	1428.41	58488.51	1068.50
41	2.38	0.28	1073.15	9.80	366.82	1449.77	57060.10	1068.42
40	2.46	0.29	1106.59	10.29	353.25	1470.13	55610.33	1068.33
39	2.53	0.31	1137.68	10.78	340.62	1489.07	54140.21	1068.25
38	2.59	0.32	1167.18	11.24	328.63	1507.06	52651.13	1068.17
37	2.66	0.33	1195.23	11.71	317.23	1524.16	51144.08	1068.08
36	2.72	0.35	1221.80	12.14	306.42	1540.37	49619.92	1068.00
35	2.77	0.36	1247.08	12.60	296.13	1555.81	48079.56	1067.92
34	2.82	0.37	1271.09	13.03	286.35	1570.47	46523.75	1067.83
33	2.88	0.38	1293.96	13.45	277.04	1584.44	44953.27	1067.75
32	2.92	0.40	1315.86	13.86	268.11	1597.83	43368.83	1067.67
31	2.97	0.41	1336.45	14.27	259.71	1610.43	41770.99	1067.58
30	3.01	0.42	1355.60	14.65	251.90	1622.15	40160.57	1067.50
29	3.05	0.43	1373.97	15.04	244.40	1633.40	38538.41	1067.42
28	3.09	0.44	1392.42	15.41	236.86	1644.70	36905.01	1067.33
27	3.13	0.45	1408.75	15.78	230.19	1654.72	35260.31	1067.25
26	3.17	0.46	1424.55	16.13	223.73	1664.41	33605.59	1067.17
25	3.20	0.47	1439.75	16.47	217.51	1673.74	31941.18	1067.08
24	3.23	0.48	1454.00	16.80	211.68	1682.48	30267.45	1067.00
23	3.26	0.49	1467.63	17.12	206.10	1690.85	28584.96	1066.92
22	3.29	0.50	1480.62	17.43	200.78	1698.83	26894.11	1066.83
21	3.32	0.51	1493.08	17.72	195.68	1706.48	25195.28	1066.75
20	3.34	0.51	1504.86	18.01	190.85	1713.72	23488.80	1066.67
19	3.37	0.52	1515.88	18.28	186.34	1720.49	21775.08	1066.58
18	3.39	0.53	1526.63	18.54	181.94	1727.10	20054.59	1066.50
17	3.41	0.54	1536.54	18.78	177.87	1733.19	18327.49	1066.42
16	3.44	0.54	1546.66	19.01	173.73	1739.40	16594.30	1066.33
15	3.46	0.55	1555.97	19.23	169.92	1745.12	14854.90	1066.25
14	3.48	0.56	1565.41	19.43	166.06	1750.91	13109.78	1066.17
13	3.51	0.59	1577.29	20.82	160.75	1758.87	11358.87	1066.08
12	0.00	0.00	0.00	0.00	800.00	800.00	9600.00	1066.00
11	0.00	0.00	0.00	0.00	800.00	800.00	8800.00	1065.92
10	0.00	0.00	0.00	0.00	800.00	800.00	8000.00	1065.83
9	0.00	0.00	0.00	0.00	800.00	800.00	7200.00	1065.75
8	0.00	0.00	0.00	0.00	800.00	800.00	6400.00	1065.67
7	0.00	0.00	0.00	0.00	800.00	800.00	5600.00	1065.58
6	0.00	0.00	0.00	0.00	800.00	800.00	4800.00	1065.50
5	0.00	0.00	0.00	0.00	800.00	800.00	4000.00	1065.42
4	0.00	0.00	0.00	0.00	800.00	800.00	3200.00	1065.33
3	0.00	0.00	0.00	0.00	800.00	800.00	2400.00	1065.25
2	0.00	0.00	0.00	0.00	800.00	800.00	1600.00	1065.17
1	0.00	0.00	0.00	0.00	800.00	800.00	800.00	1065.08

Stage Area Data

Depth (feet)	Elevation (feet)	Area (ft²)	Area (acres)
0.00	1065.00	9600.00	0.2204
0.08	1065.08	9600.00	0.2204
0.17	1065.17	9600.00	0.2204
0.25	1065.25	9600.00	0.2204
0.33	1065.33	9600.00	0.2204
0.42	1065.42	9600.00	0.2204
0.50	1065.50	9600.00	0.2204
0.58	1065.58	9600.00	0.2204
0.67	1065.67	9600.00	0.2204
0.75	1065.75	9600.00	0.2204
0.83	1065.83	9600.00	0.2204
0.92	1065.92	9600.00	0.2204
1.00	1066.00	9600.00	0.2204
1.08	1066.08	21106.42	0.4845
1.17	1066.17	21010.88	0.4823
1.25	1066.25	20941.44	0.4807
1.33	1066.33	20872.82	0.4792
1.42	1066.42	20798.32	0.4775
1.50	1066.50	20725.16	0.4758
1.58	1066.58	20645.92	0.4740
1.67	1066.67	20564.61	0.4721
1.75	1066.75	20477.82	0.4701
1.83	1066.83	20385.93	0.4680
1.92	1066.92	20290.24	0.4658
2.00	1067.00	20189.80	0.4635
2.08	1067.08	20084.83	0.4611
2.17	1067.17	19972.88	0.4585
2.25	1067.25	19856.61	0.4558
2.33	1067.33	19736.43	0.4531
2.42	1067.42	19600.83	0.4500
2.50	1067.50	19465.85	0.4469
2.58	1067.58	19325.15	0.4436
2.67	1067.67	19174.01	0.4402
2.75	1067.75	19013.33	0.4365
2.83	1067.83	18845.69	0.4326
2.92	1067.92	18669.69	0.4286
3.00	1068.00	18484.38	0.4243
3.08	1068.08	18289.91	0.4199
3.17	1068.17	18084.67	0.4152
3.25	1068.25	17868.86	0.4102
3.33	1068.33	17641.54	0.4050
3.42	1068.42	17397.21	0.3994
3.50	1068.50	17140.93	0.3935
3.58	1068.58	16869.61	0.3873
3.67	1068.67	16575.60	0.3805
3.75	1068.75	16267.27	0.3734
3.83	1068.83	15928.90	0.3657
3.92	1068.92	15570.12	0.3574
4.00	1069.00	15172.21	0.3483
4.08	1069.08	14733.35	0.3382
4.17	1069.17	14239.86	0.3269
4.25	1069.25	13675.47	0.3139
4.33	1069.33	12953.91	0.2974
4.42	1069.42	11843.49	0.2719
4.50	1069.50	10920.80	0.2507
4.58	1069.58	10561.90	0.2425
4.67	1069.67	10234.91	0.2350
4.75	1069.75	9788.20	0.2247
4.83	1069.83	9600.00	0.2204
4.92	1069.92	9600.00	0.2204
5.00	1070.00	9600.00	0.2204
5.08	1070.08	9600.00	0.2204
5.17	1070.17	9600.00	0.2204
5.25	1070.25	9600.00	0.2204
5.33	1070.33	9600.00	0.2204
5.42	1070.42	9600.00	0.2204
5.50	1070.50	9600.00	0.2204
5.58	1070.58	9600.00	0.2204
5.67	1070.67	9600.00	0.2204
5.75	1070.75	9600.00	0.2204

Attachment D

Comment Responses

DRAFT

The following are responses to comments in the memo that were not directly discussed in the memo.

City Comment: Was any backwater effect from the main channel near Ravenna St considered for the 100-yr event? In other words, would the "upgraded" storm systems be able to discharge if the creek was full?

GPD response: The model used for the analysis incorporated the entire Brandywine Creek watershed as developed by NEORSD. As the entire system was modeled, the backwater impacts were accounted for in the analysis. Please note that Ravenna St. will be overtopped for the 100-year which ultimately controls the amount of backwater to the upstream system.

City Comment: Was the size of pipe required to eliminate surcharge for the 100-yr event in system 2 identified? (This was in reference to Alternative 2.)

GPD response: The slopes of the sewers were not changed between the existing and proposed condition. The surcharging for the 100-year north of E. Streetsboro St. was minimal and it is likely that more consistent slopes would allow the system to function without surcharging. South of E. Streetsboro St. System 2 discharges through a 6-ft by 5-ft horizontal elliptical pipe into the Barlow Community center ponds. The horizontal elliptical pipe has an outlet invert elevation of 1060-ft. During the 100-year storm, the max HGL at the Barlow ponds reaches 1071.83-ft, resulting in a backwater effect that reaches to E. Streetsboro St. Due to the backwater from the ponds, the 6-ft by 5-ft horizontal ellipse was not considered for replacement in the evaluated alternatives.

City Comment: Would a 6-ft x 4-ft culvert work at the choke point instead of the 8-ft x 4-ft culvert modeled?

GPD Response: Alternative 1 – A 6-ft x 4-ft box culvert would work, however, 8-ft x 4-ft was chosen to align with downstream culvert.

City Comment: In reference to the Existing 100-yr System 1 figure in Attachment A - why did the NEORSD allow system surcharging before flooding occurred?

GPD Response: We believe that NEORSD allowed system surcharging to keep flow from leaving the system. In PCSWMM, when node flooding occurs, that flow is "lost" from the system. NEORSD wanted to evaluate the overall watershed and stream hydraulics in the master plan and so they allowed the surcharging to ensure that all the flow made it to the larger streams they were studying in more detail. In subsequent master plan models, NEORSD has

started utilizing overland flow conduits and/or two-dimensional elements to allow flow to surcharge out of the sewer, but not surcharge and artificially increase the HGL.

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