WEST HARTFORD
CONNECTICUT

Town of West Hartford, Connecticut

Drainage System Evaluations in the Trout Brook Watershed

Phase 1

Area 1: FEAT Study Area

Area 2: Milton and Fern Study Area

Area 3: East Branch and Trout Brook Confluence Study Area

June 8, 2020

CDM Smith

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Section 1 - Introduction

CDM Smith performed an assessment of the existing storm drainage system to mitigate street flooding, identify the existing drainage system deficiencies, provide alternatives to improve the drainage system, and provide cost estimates for each alternative for the Town of West Hartford (Town). The Town identified six sub-watersheds tributary to Trout Brook (**Figure 1-1**) that will be evaluated with respect to flooding and drainage system capacity in a two phased project. This study includes the watersheds within Phase 1: Areas 1, 2 and 3.

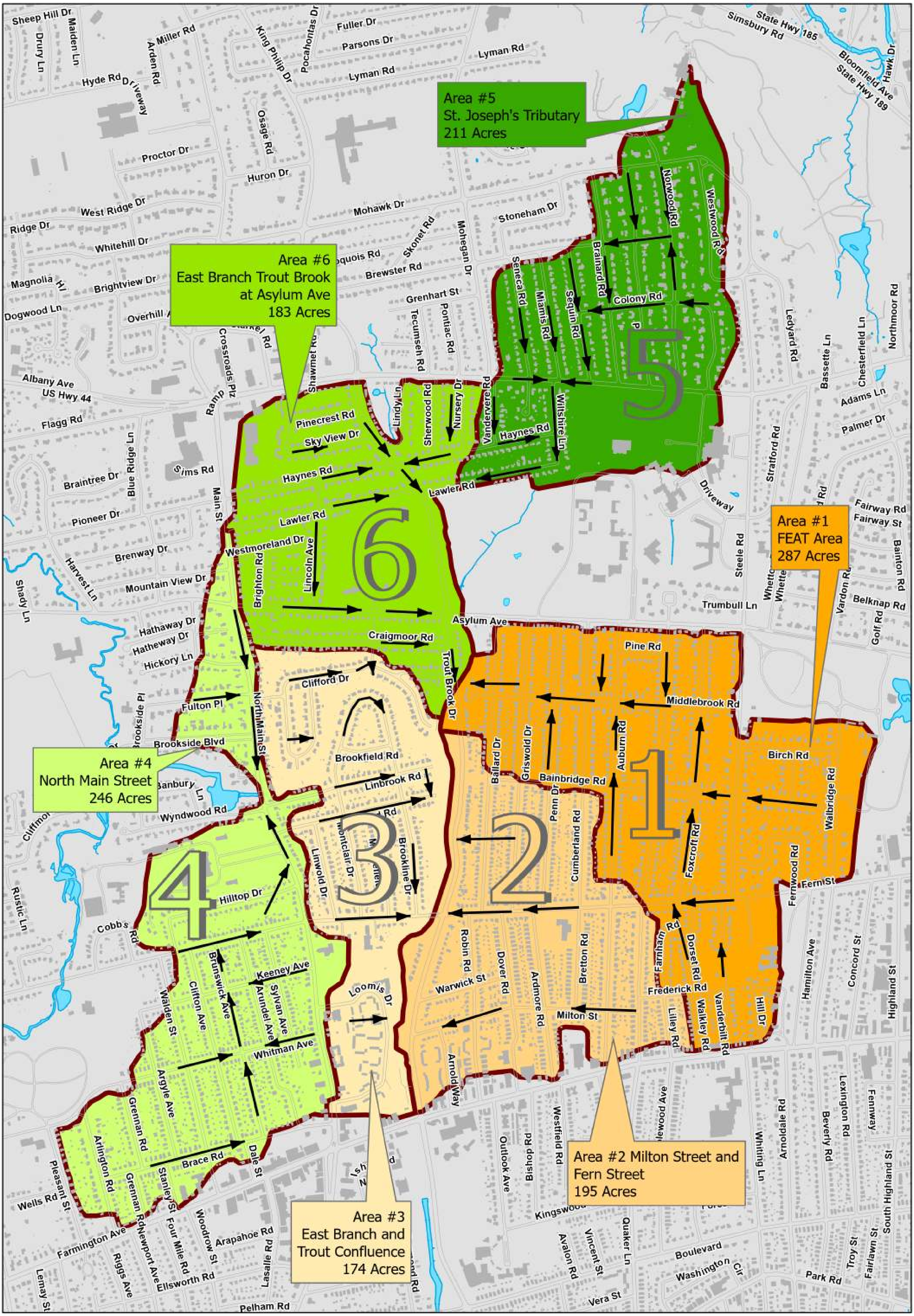
1.1 Phase 1 Project Area

The original focus of the analysis was the flood prone areas located between Frederick Road (south), Elizabeth Park (east), Asylum Ave (north), and Trout Brook Drive (west). This area is referred to as the "FEAT area." The project was expanded to include the area directly south of the FEAT area (Fern and Milton Street) and the area west of Trout Brook that is bound by Clifford Drive (north), Linwold Drive (west), and Loomis Drive (south). **Figure 1-2** is an illustration of the project area that was divided into three study areas, "*Area 1 – FEAT Study Area*", "*Area 2 – Milton and Fern Study Area*", and "*Area 3 – East Branch and Trout Brook Confluence Study Area*".

During heavy rain storms, streets in the Town of West Hartford experience flooding that impacts the residents, businesses, and visitors, including periodically requiring the town to close sections of roads. The Town Engineering Division receives notifications from residents, public works staff, and fire department staff on flooding locations and the severity of the impact. The Town engineers performed field visits during rain storms and summarized the reports for CDM Smith to utilize in the drainage system evaluation. A summary of the reporting flooding during April 15, 2018, September 13, 2018, and August 7, 2019 are shown on **Figure 1-2**. This information was used to validate the calibrated model performance of the drainage system.

On June 6, 2019, the Town and CDM Smith held a public meeting to provide information on this drainage system evaluation to keep the stakeholders informed on the project. The presentation emphasized that the solutions to address drainage problems will have three key participants: the Town, the Metropolitan District Commission (MDC), and property owners. The Town owns the public storm drainage system and is responsible for maintaining the drainage system to limit the extent and duration of street flooding caused by storm events. The MDC owns the sanitary sewer system and is responsible for maintenance of the sewer system and abating sanitary sewer overflows (SSOs). Individual property owners are responsible for private sewer service laterals and stormwater management on their property.

This report provides recommendations for improvements to the storm drainage system in the study area to decrease the intensity and frequency of street flooding. The recommendations are prioritized and suitable for inclusion in the Town's capital improvement program planning.


Area #1
FEAT Area
287 Acres

Area #2 Milton Street and Fern Street
195 Acres

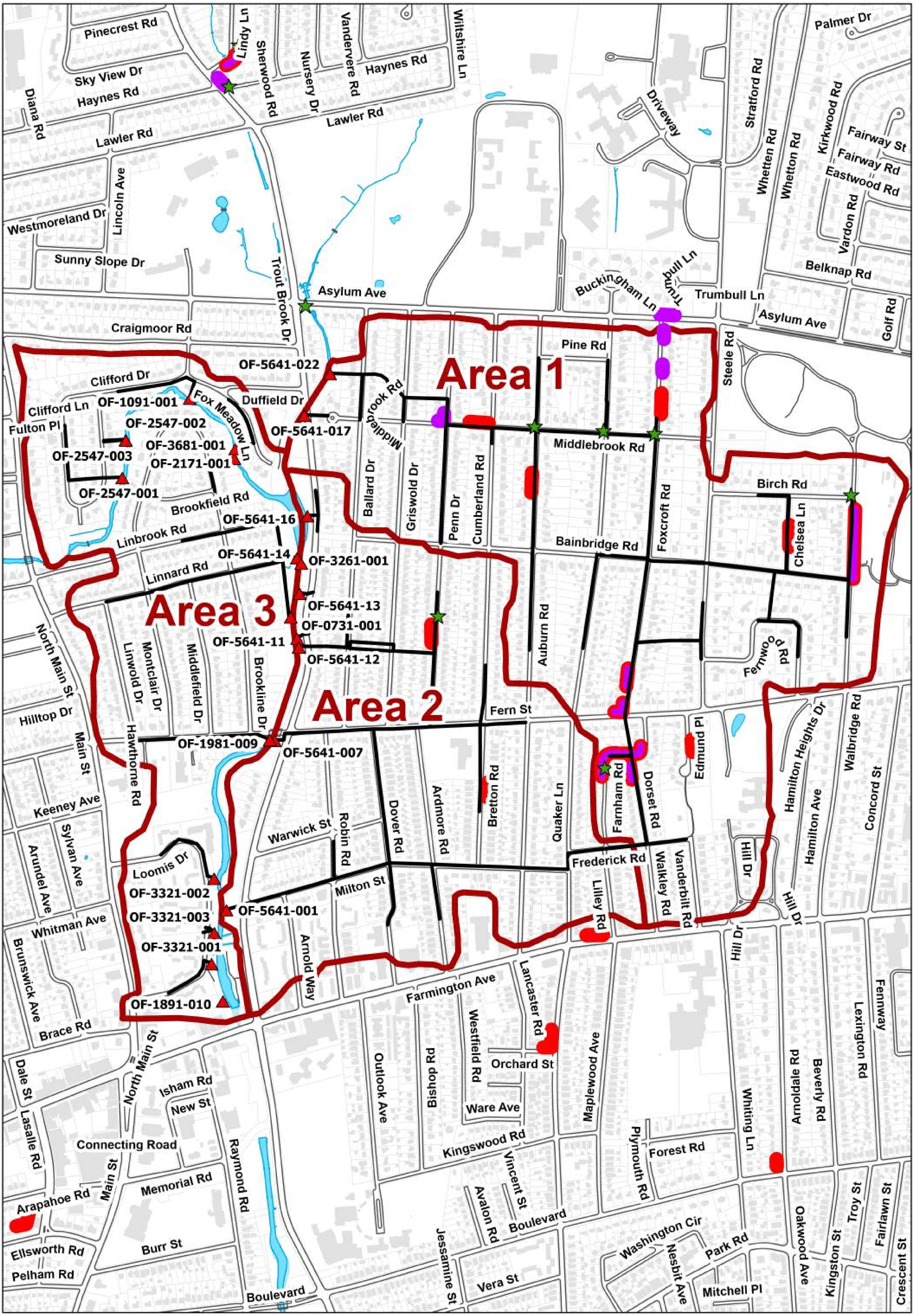
Area #3
East Branch and Trout Confluence
174 Acres

Area #4
North Main Street
246 Acres

Area #5
St. Joseph's Tributary
211 Acres

Area #6
East Branch Trout Brook at Asylum Ave
183 Acres

Figure 1-1
Study Areas Overview
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020



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Legend

▲ Outfalls

▬ Modeled Existing Storm Pipe

☐ Study Areas

Flooding

🟪 April 17, 2018

🟥 September 12, 2018

🟥 Both Dates

★ August 7, 2019

Scale

1 inch = 700 feet

0 350 700 Feet

N

Figure 1-2
Project Overview
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

1.2 MDC Sanitary Sewer System

During a storm event, the flow in the town-wide sanitary sewer system in West Hartford can increase from an average dry weather flow of 2.3 million gallons per day (mgd) to a peak flow of 65 mgd (based on the MDC's permanent flow meter data). For the sewershed in the Phase 1 study area, the average dry weather flow is about 0.24 mgd and can peak to as high as 14 mgd during heavy rain events. This increased flow is comprised of stormwater and groundwater and the MDC is working to remove this extraneous flow from the sanitary sewer system to abate SSOs. SSO abatement is required by a Consent Decree with the United States Environmental Protection Agency (US EPA) and has benefits for human health and the environment.

Stormwater and groundwater currently conveyed through the sanitary sewer system is primarily from private property connections (such as foundation drains, sump pumps, roof leaders, and yard drains) and will need to be transferred to an existing or new Town storm drainage system, the street, or watercourse. MDC sewer ordinance (S2l) specifies that sanitary sewers shall be used only for conveyance and disposal of sanitary sewage; flow from stormwater, surface water, and subsoil drainage are not allowed into the MDC sanitary sewer system.

1.3 Purpose and Scope

The purpose of this study is to assess the exiting storm drainage system and develop solutions to lessen street flooding. The first task in the project was to collect, review, and analyze existing data, which was performed through discussions with the Town, evaluation of existing data, and a desktop analysis. CDM Smith contracted with a surveyor to obtain supplemental elevation information on manhole rims and pipe inverts and a metering firm to install flow meters in the storm drainage system to collect data during wet weather for model calibration.

The data collected in the first task was used to develop a model of the existing storm drainage system. The model was developed to represent existing conditions and alternative scenarios for reducing street flooding. Alternatives to improve the existing storm drainage system were developed for each of the three project areas. The drainage solutions were designed to minimize street flooding during a 10-year storm. The 10-year storm is the industry standard design storm for storm drainage systems. Within West Hartford the 10-year design storm is a storm resulting in 5.1 inches of rainfall in a 24-hour period. This storm has a 1/10 or 10% chance of occurring in any given year and would potentially occur once every 10 years.

CDM Smith also performed a conceptual evaluation of groundwater within the study area as well as an assessment of collector drains to assist with the collection of potential private inflow connections within the study area. These two components of the study address potential basement flooding as a result of high groundwater and inflow connections.

1.4 System Description

The project study area is approximately 675 acres in a densely populated section of West Hartford, which is primarily residential properties with commercial buildings on the arterial roads. The drainage study area evaluates 5 percent of the total land area in Town, and a summary of the project areas existing drainage system is presented in **Table 1-1**. Area 1 has a diversion with Area 2 via a 15-inch pipe on Frederick Road. Milton system and Fern Street systems area connected via an 18-inch pipe on Dover Road.

Table 1-1: Existing Drainage System Statistics

Area Name	Area (acres)	Number of Properties	Pipe Length (ft)	Pipe Size Range (in.)	Outfalls (#)
1 - FEAT	270	791	31,380	10 to 48	2
2 - Milton and Fern	230	554	23,686	7 to 24	7
3 - East Branch and Trout Brook Confluence	175	402	15,328	7 to 24	12
Total	**675**	**1,747**	**70,394**	**7 to 48**	**21**

The existing GIS data used for this report is the version that was available in the Spring/Summer of 2019.

Section 2 – Model Development and Calibration

2.1 Approach

This section summarizes development and calibration of a hydrologic and hydraulic model of the drainage system in the study area. The model was developed using the US EPA Stormwater Management Model (SWMM). The drainage system model was calibrated based on temporary flow metering data from five meters deployed in fall 2019 in Area 1 and validated against reported street flooding during historical events in 2011, 2018, and 2019. The calibrated model represents the drainage system's response to storm events and was used to assess the flooding during historical storm events and during a 10-year, 24-hour NRCS Type III design storm. This model was also used to develop recommended alternatives to address flooding during this design storm.

2.2 Model Development

The West Hartford drainage system model of Areas 1, 2 and 3 consists of 21 outfalls, 181 structures and 185 pipes. The drain model dynamically simulates rainfall-runoff, groundwater infiltration, evaporation, snow accumulation and melting, and groundwater inflow into drains from pipe defects and sump pumps. Contributing areas to each outfall were subdivided into individual sub-catchments based on topography and the Town's drainage network. Drain pipe configuration was derived from the Town's Geographic Information System (GIS) and supplemented with survey.

Several data sources were used in the model development:

- The Town's GIS containing pipe, manhole, and outfall data including pipe diameter, material, and invert and rim elevations for manholes, catch basins, and outfalls;
- Road reconstruction drawings and the Town's field journals to populate invert and rim elevations not included in GIS;
- Survey conducted in 160 structures to extend lateral drainage network connections not included in the Town's GIS or existing survey;
- Impervious surface raster data from the National Land Cover Database at a 1/3 arc-second (approximately 33 feet) resolution; and
- Daily temperature at Hartford Brainard Airport obtained from the National Oceanic and Atmospheric Administration's National Centers for Environmental Information.

Once the model was developed, the modeling team developed a metering program to obtain data to assist with calibration of the drainage system model. Calibration of the model also utilized historical storm events and local knowledge to confirm that responses from the model replicate actual storm events and flooding limits.

2.2.1 2019 Flow Metering Program

During fall 2019 CDM Smith deployed five area-velocity flow meters in Area 1, which represents the watershed area between Frederick Road, Elizabeth Park, Asylum Ave, and Trout Brook (FEAT area). The meter program was implemented because initial model runs did not show good agreement with observed flooding during historical events in Area 1, which was noted as a high- priority area within the Town for existing flooding. Once calibrated, the hydrologic parameters identified during calibration were transferred to the unmetered areas in Area 2 and Area 3.

Meter locations were selected (**Figure 2-1**) to characterize flow entering the main trunk line via lateral connections, flow within the main trunk line, and to characterize flow leaving Area 1 through the diversion in the southern position of the study area. The meters measured velocity, flow, and depth at 5-minute increments for 7 weeks from October 12 to November 26, 2019.

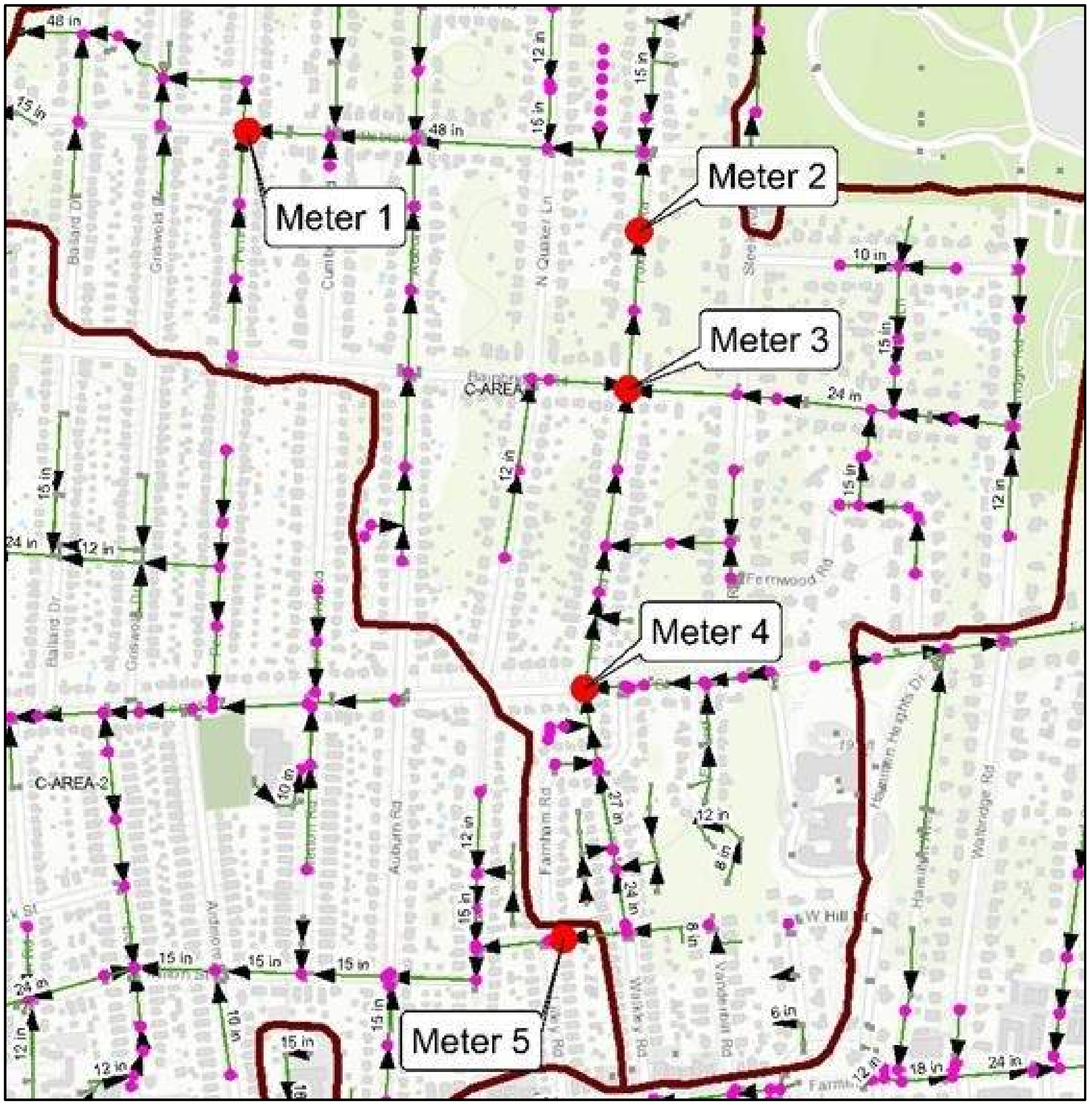

Figure 2-1: Flow Meter Locations for the 2019 Temporary Metering Program

The flow metering locations are summarized in **Table 2-1**. The average, maximum, and minimum velocity, depth, and flow at each meter is summarized in **Table 2-2**.

Table 2-1: Flow Meter Locations

Meter Name	Manhole ID	Pipe ID	Pipe Diameter (inches)	Location
Meter 1	MH3571-004	DL-4261-009	48	82 Middlebrook Road
Meter 2	MH-2176-011	DL-4261-080	36	77 Foxcroft Street
Meter 3	MH-2176-009	DL-3838-016	24	67 Bainbridge Street
Meter 4	MH-1981-042	DL-1981-050	30	289 Fern Street
Meter 5	MH-2191-002	DL-1891-168	15	16 Fredrick Street

Table 2-2: Observed Flow Meter Statistics

Meter Name	Depth (ft)			Flow (cfs)			Velocity (ft/sec)		
	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Meter 1	0.19	0.26	3.68	0.01	0.45	56.8	0.06	0.71	4.69
Meter 2	0.00	0.11	1.64	0.00	0.18	33.6	0.10	0.74	9.32
Meter 3	0.05	0.14	1.59	0.01	0.13	10.77	0.16	0.61	5.67
Meter 4	0.02	0.06	1.70	0.00	0.03	4.30	0.00	0.13	3.48
Meter 5	0.00	0.01	1.07	0.00	0.01	1.64	0.00	0.16	4.99

As part of the metering program, one rain gauge was installed at the fire station located on the intersection of Brace Road and Arundel Avenue. The rain gauge recorded rainfall data in 5-minute increments. Four principal calibration storms exceeding 0.5 inches occurred during the flow metering program. A typical model calibration is performed on one or two such storms; the range of storms captured during the metering program allowed for a robust model calibration. Storm statistics for these four principal storms are summarized in **Table 2-3**.

2-3: Flow Metering Program Storm Statistics

Storm Start Date	Total Rainfall (inches)	5-minute Peak Intensity (in/hr)	Maximum Average Recurrence Interval (ARI)
October 16 2019	1.88	1.20	6-month, 6-hour
October 27 2019	1.56	0.72	7-month, 6-hour
October 31 2019	0.72	0.48	<1-month (all durations)
November 26 2019	1.75	0.60	3-month, 24-hour

2.2.2 Groundwater Contributions

High groundwater within the West Hartford study area can have a significant impact on flooding. Groundwater can enter the storm drainage and sanitary sewer systems through defects in the pipes or through foundation drain connections from building basements. Currently many foundation drains are connected to the sanitary sewer system. However, the MDC is working with the Town to disconnect foundation drains from the sanitary sewer and redirect them to the Town's new or existing drainage system. To represent the potential impact of foundation drains and groundwater on drainage system capacity, the model representation of groundwater infiltration was transferred from the calibrated MDC sanitary sewer model for West Hartford to the drainage system model developed for this project. This drainage system model dynamically simulates groundwater elevation in each sub-catchment based on soil parameters and was calibrated to the observed groundwater response in the sewer system based on metering data, therefore incorporating existing groundwater within the MDC sewer system into the drainage system model for this project. The groundwater portion of the MDC model includes foundation drain discharges.

The modeled peak groundwater inflow (10-year recurrence interval) is presented in **Table 2-4**, along with the percentage of the peak discharge for the design storm. This result indicates that at the 10-year recurrence interval the groundwater contribution is much less than the peak discharge from the 10-year design storm. The groundwater was found to be a small part of the flow during the design storm.

Table 2-4: Peak 10-year Groundwater Flow and Percentage as Part of the Design Storm

Location	Peak 10-year Groundwater Flow (cfs)	Percentage of NRCS Type III Design Storm Peak Flow
FEAT	2.2	1.4%
Linnard Road	0.5	1.7%
Fern Street, East	2.0	1.5%
Fern Street, West	0.4	1.9%
Milton Street	0.9	1.6%

As shown in **Table 2-4,** the groundwater contributions are a very small percentage of the stormwater runoff contributions. All alternatives were run using the dynamic groundwater model to evaluate the cumulative impact of foundation drain discharges and groundwater infiltration on drain capacity.

2.2.3 Model Calibration and Validation

The drain model hydrology and hydraulics were calibrated based on observed flow, depth, and velocity at each of the five meters in Area 1. Hydrologic parameters in the unmetered Areas 2 and 3 were inferred based on calibrated hydrologic parameters in Area 1.

Model Calibration

Model calibration focused on matching simulated and observed flows, velocities, and depths. The model calibration to four storms at the five metering locations were primarily achieved by adjusting the following parameters:

- Sub-catchment impervious to pervious routing coefficient. The routing factor partitions a sub-catchment's impervious area into components connected and not directly connected to the drainage system. A lower routing factor indicates a higher portion of directly connected impervious area.

- Sub-catchment width (hydrograph shape). The width factor inversely correlates with the overland flow length; decreasing widths increases storm hydrograph duration, yielding lower peak flows. This parameter is similar to the time of concentration applied in a SCS method calculation.

- Soil saturated hydraulic conductivity and conduit roughness coefficient (Manning's N)

The range of calibration variables in the model is summarized in Appendix A. **Figure 2-2** shows an example of calibration plots at Meter 1 during the November 26, 2019 event. Calibration hydrographs and scatterplots for all meters are presented in Appendix A. In the calibration plots, the blue lines represent model simulated depth, velocity, and flow and the red lines represent meter observed values.

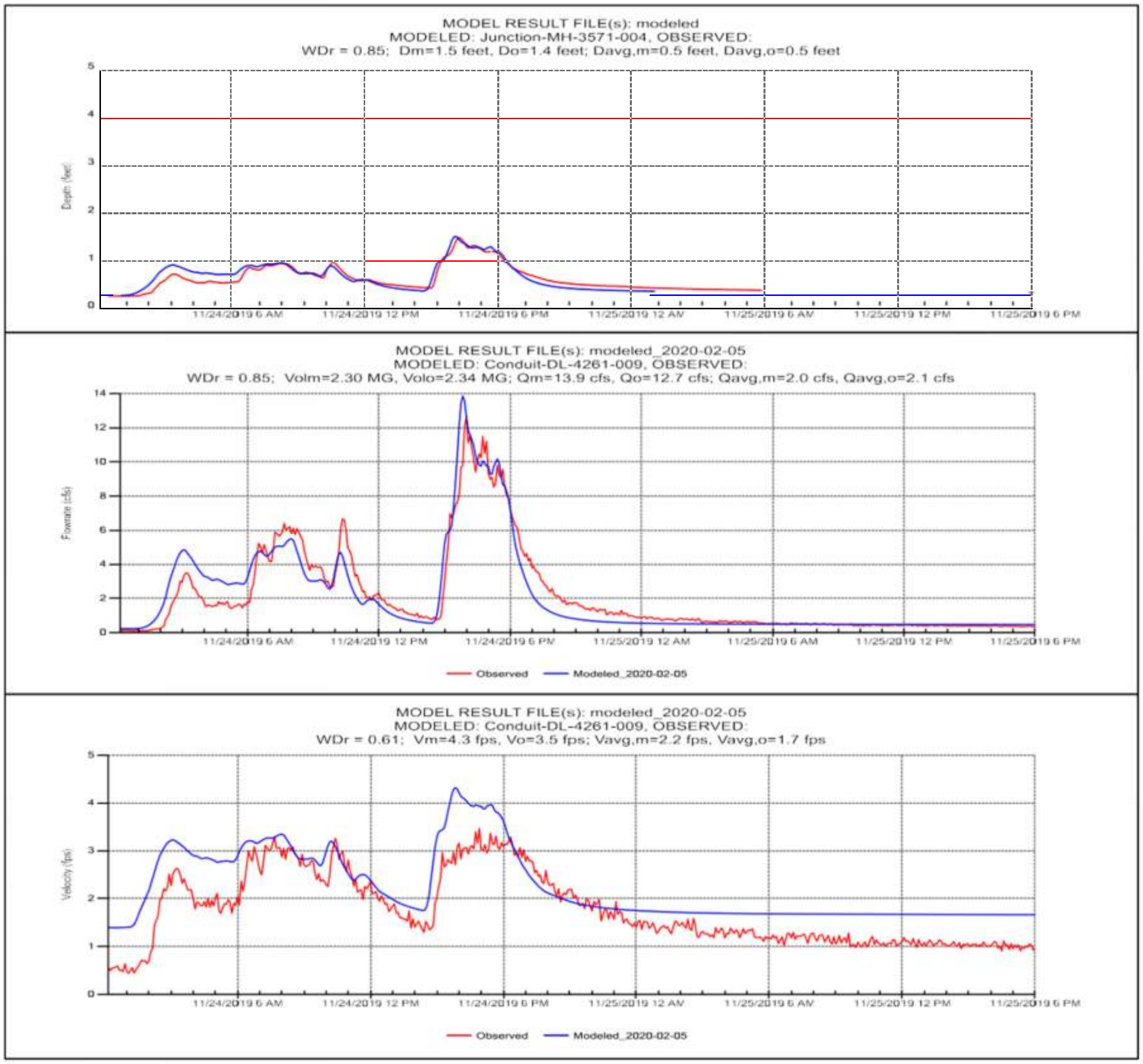

Figure 2-2: Calibration Plots at Meter 1 during the November 24, 2019 Storm

Calibration Assessment

The overall strength of calibration was evaluated using guidance from the Chartered Institution of Water and Environmental Management (CIWEM)[1]. Model results were evaluated using the metrics in **Table 2-5**.

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[1] Chartered Institution of Water and Environmental Management (2017). Code of Practice for the Hydraulic Modelling of Urban Drainage Systems 2017. Version 01.

Table 2-5: CIWEM Model Calibration Metrics

Parameter	Criteria
Hydrograph peaks and troughs	Timing should match observed values throughout the duration of the event
Peak flow rate	+25 percent to -15 percent of observed values
Peak depth	+/- 10 percent of observed values
Volume	+20 percent to -10 percent of observed volume

Model calibration was evaluated against the CIWEM criteria using scatterplots comparing observed and modeled flow, volume, depth, and velocity for each calibration event and meter location. In these plots a perfect calibration would fall along the black line. Each red point represents a paired observed-modeled comparison; values falling above the black line indicate that the model is overpredicting relative to observed data. The blue lines above and below the black line indicate the CIWEM calibration metrics; a model calibration meeting these metrics is indicated by the red points falling between these lines. An example scatterplot for volume, peak discharge, peak depth, and peak velocity at Meter 1 is shown in **Figure 2-3**. Scatterplots for the remaining four meters are shown in **Appendix A**.

In general, the hydrographs and scatterplots indicate that model performance is good relative to the model calibration metrics. The simulated flow peaks, volume, and depth demonstrated good calibration to the observed data at all five meters during the October 27, 31, and November 26 storm events. The exception to this trend is for the October 16 event, where the modeled peak flow is lower than the observed peak flow at all four meters. During this event there was short duration, high-intensity periods of rainfall. This is the event that falls outside of the blue CIWEM guidelines on the scatterplots. Model adjustments necessary to match observed conditions would cause the preceding flow, depth, and velocity during this event as well as conditions during the other three events to be overestimated relative to observed data. Therefore, the model calibration was set to find the best fit to all observed data.

2.3 Historical Storm Events and Validation

The calibrated model was validated using historical flooding reports from the Town of West Hartford occurring September 5, 2011, April 17, 2018, September 12, 2018, and August 7, 2019. The rainfall statistics of these events are summarized in **Table 2-6**. The study area maps of reported flooding locations during the historical storm events were used to validate modeled results.

Table 2-6: Rainfall Statistics from the Four Historical Storms Used for Model Validation

Storm	Total Rainfall (inches)	5-minute Peak Intensity (in/hr)	Maximum Average Recurrence Interval (ARI)
September 5, 2011 (Tropical Storm Lee)	5.65	1.8	10-year, 2, 3, 6, and 12-hour
April 17, 2018	3.42	1.84	2-year, 6-hour
September 12, 2018	3.92	2.48	9-year, 3-hour
August 7, 2019	2.64	2.02	21-year, 1-hour

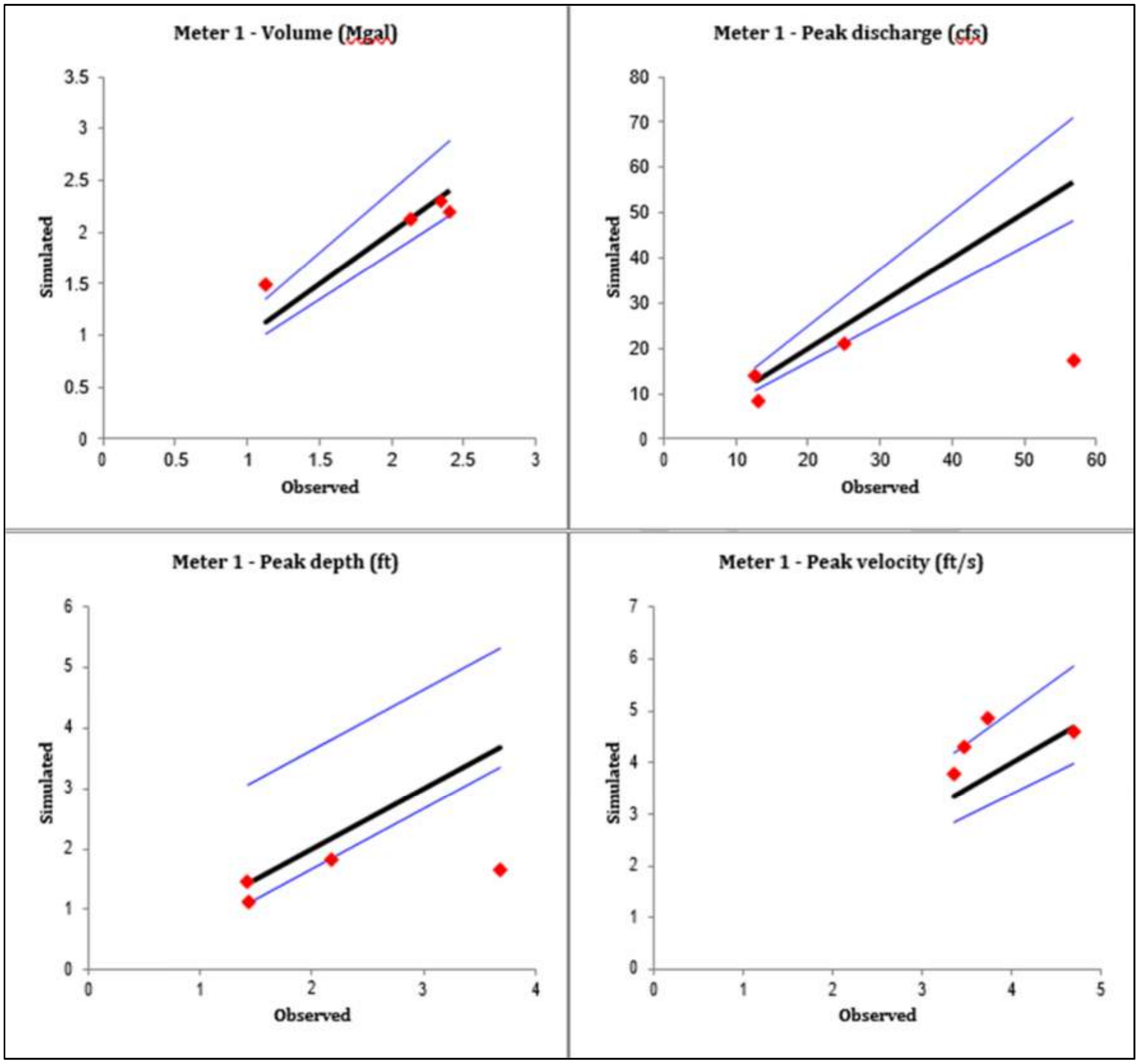
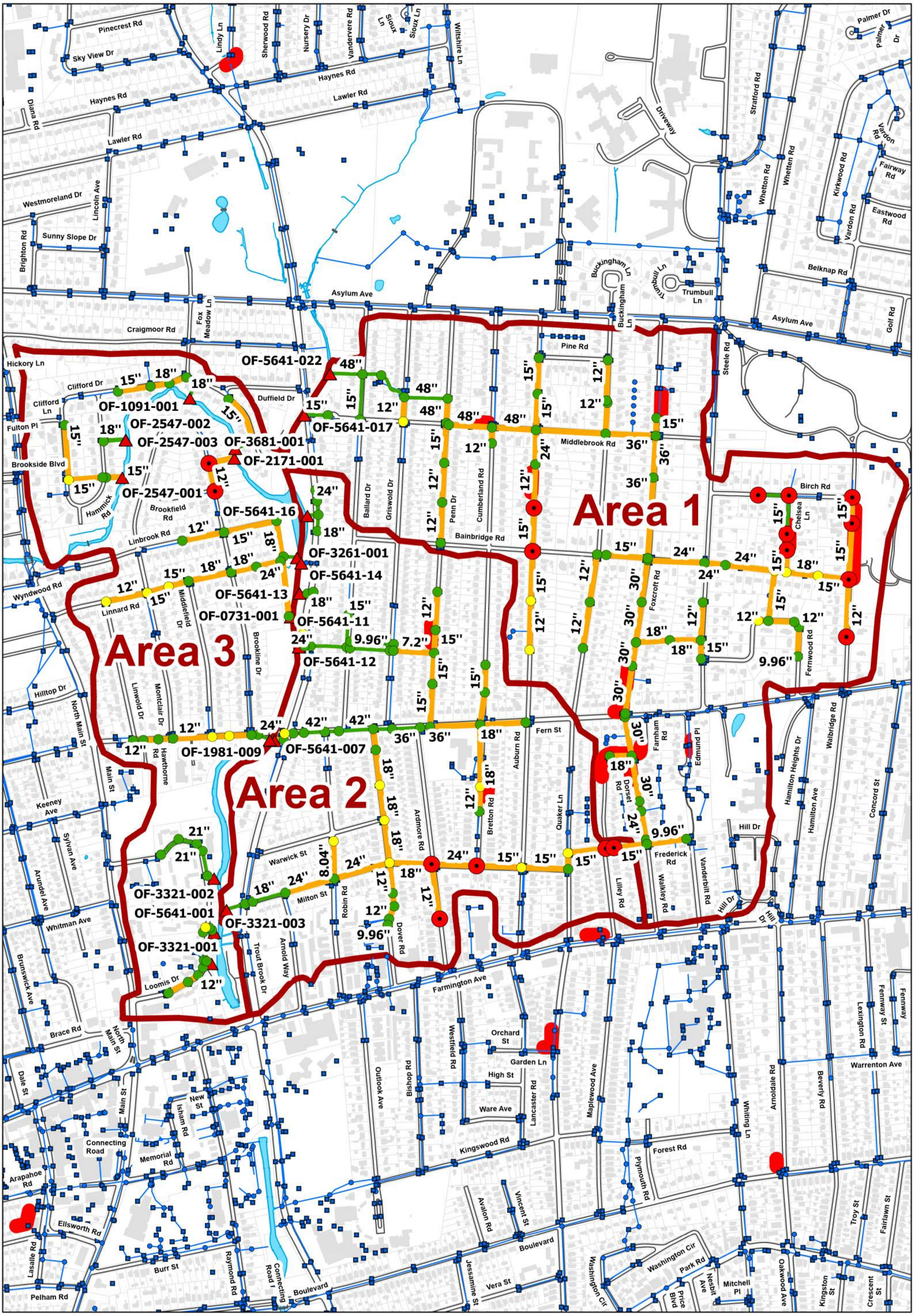


Figure 2-3: Representative Scatterplot for Meter 1 during the 2019 Metering Period

The model predicts flooding in many of the reported flooding locations during these four events. For example, Figure 2-4 shows that the model and the map show flooding on Walbridge Road, Birch Road, and Auburn Road at Middlebrook Road during the September 12, 2018. The Town also provided written complaints from residents about flooding on Montclair Drive and Linbrook Road (not shown on the map). Flooding reports do not differentiate between flooding caused by drain capacity limitations or by other flooding sources in the area. Therefore, areas where the model does not match observed flooding could be related to local flooding caused by high groundwater, maintenance problems, poor drainage, SSOs from the MDC sanitary sewer system, or other flooding causes not related to the drain network. The model's predicted flooding extent matches many of the reported flooding areas contained in the Town's records, suggesting that the model adequately represents existing conditions and flood risk in each area.



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Legend
- 🔴 Modeled Flooding
- 🟡 Modeled Surcharged Manhole - HGL within 1 foot of Grade
- 🟢 Modeled Flow Remains in System
- ▲ Outfalls
- 🟧 Modeled Over Capacity Storm Pipe
- 🟩 Modeled Under Capacity Storm Pipe
- ━ GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas
- 🟥 September 12, 2018 Flooding

Scale

1 inch = 700 feet

0 350 700 Feet

N

Figure 2-4
Model Validation
Tropical Storm Lee and September 12, 2018
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

Section 3 – Collection System Pipe Capacity Assessment

The drainage system capacity assessment was performed for 21 individual systems tributary to Trout Brook, as shown in **Figure 1-2**. The study area is divided into three sub-watershed areas. Area 1 is located between Frederick Road (South), Elizabeth Park (East), Asylum Avenue (North), and Trout Brook Drive (West), and is referred to as the FEAT area. Area 2 includes the drainage systems with Milton Street and Fern Street is referred to as the Milton and Fern area. Area 3 consists of the watershed along the west bank of Trout Brook near the confluence with the East Branch of Trout Brook.

Existing conditions were assessed using the model for each of the 21 drainage systems. This assessment considered:

- Pipe capacity, where each pipe was considered above capacity if the modeled peak flow exceeded the normal flow capacity based on pipe roughness, slope, and size.
- Manhole flooding and areas with less than one foot of freeboard.

For systems where flooding occurred, the model was used to develop preliminary design alternatives with adequate capacity for the 10-year, 24-hour design storm.

3.1 Historical Flooding Extent

The Town has records of flooding during Hurricane Irene (August 27, 2011) and Tropical Storm Lee (September 5, 2011), as well as events on April 17, 2018, September 12, 2018, and August 7, 2019. Recorded flooding reports for these events in 2011 and 2018 from Town records are shown in **Figure 1-2**. In this figure, the blue and green stars indicate flooding issues during Hurricane Lee and Tropical Storm Irene, purple lines indicate flooding issues during April 17, 2018, red lines indicate flooding issues during September 12, 2018, and red stars indicate flooding issues during August 7, 2019. Rainfall statistics from each of these historical storms are presented in **Table 2-6**. These events were all characterized by intense periods of rainfall, especially for short durations. These short duration, high intensity rainfall events are particularly important for urban flooding due to the short time of concentration in most of the study area.

3.2 Existing System Pipe Capacity

Model simulations were performed to identify capacity issues within the 21 existing drainage systems in Areas 1, 2, and 3 during both historical events and during the 10-year, 24-hour NRCS Type III design storm. This section provides an overview of existing conditions for the design storm for each area. Color-coded maps of the existing conditions within the study area were created to illustrate capacity constraints and flooding locations. In the existing condition assessment figures, pipes with adequate capacity are plotted in black, and pipes above full flow capacity are plotted in orange. Additionally, profiles for each system were generated. On profile figures, manhole flooding is shown as red dots and the simulated hydraulic grade line is shown as a solid, blue line.

The recommended improvements and the prioritization of improvements is discussed in **Section 4**. Estimated costs for each alternative are presented in **Section 5**.

3.2.1 Summary of Existing Pipe Capacity by Outfall

The model was used to evaluate whether flooding is predicted for the 10-year design storm as well as for the four historical events considered in this study. **Table 3-1** presents a summary of each of the 21 outfall systems with an indication of whether the model predicts flooding under the different storm events. A check mark indicates that flooding is predicted in the model. Systems without any check marks did not have flooding during the model runs and the existing drainage system has adequate capacity, therefore not requiring replacement pipes.

Table 3-1: Drainage Systems with Modeled Flooding During the Design Storm and Historical Storms

Area	Outfall	Location	10-year 24-hour NRCS Type III Design Storm	Tropical Storm Lee	Historical 2018 Storms	August 2019
Area 1	OF-5641-022	FEAT – Trunk line	√	√	√	√
Area 1	OF-5641-017	Middlebrook Road				
Area 2	OF-5641-007	Fern Street East	√	√	√	√
Area 2	OF-5641-001	Milton Street	√	√	√	√
Area 2	OF-5641-16	Trout Brook Drive East of Linbrook Road				
Area 2	OF-5641-14	Trout Brook Drive East of Linnard Road				
Area 2	OF-5641-13	Trout Brook Drive Central				
Area 2	OF-5641-11	Trout Brook Drive South				
Area 2	OF-5641-12	Ballard Drive	√			
Area 3	OF-1091-001	Clifford Drive North	√			
Area 3	OF-0731-001	Linbrook Road	√			
Area 3	OF-3261-001	Linnard Road	√	√	√	√
Area 3	OF-1981-009	Fern Street West	√	√	√	√
Area 3	OF-3681-001	Montclair Drive	√	√	√	√
Area 3	OF-2171-001	Fox Meadow Lane				
Area 3	OF-3321-002	Loomis North	√			
Area 3	OF-3321-001	Loomis South	√			
Area 3	OF-2547-002	Hammick Road North				
Area 3	OF-2547-003	Hammick Road South				
Area 3	OF-3321-003	Loomis Central	√			
Area 3	OF-2547-001	Clifford Drive Cross-County	√	√	√	√

Preliminary designs were developed for those systems where modeled flooding occurred during either the design storm or historical storm events (13 systems in **Table 3-1** above). Recommendations were not developed for those systems that did not have modeled flooding during the design storm (8 systems in **Table 3-1** above) and therefore have been omitted from Section 3.3.

3.3 Design Approach

The drainage system's performance during the existing conditions was evaluated for the historical storm events and the Natural Resources Conservation Services (NRCS) rainfall distribution for the 10-year, 24-hour design storm. The design storm rainfall distribution was developed using the site-specific National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall-duration-frequency data, which has a total rainfall depth of 5.13 inches for the design storm. The objectives of the collection system pipe capacity assessment are:

- Evaluate the existing drainage system performance for a 10-year, 24-hour design storm and the historical storm events
- Use the historical storm events to prioritize the recommended improvements
- Identify and characterize hydraulic capacity constraints

The following summarizes the existing conditions analysis for the 13 systems that had modeled flooding during the design storm and/or historical storm events.

3.3.1 Area 1 - FEAT Area

The FEAT drainage trunk line (OF-5641-002) starts at the Frederick-Dorset Street intersection, runs north 3.4 miles to Middlebrook, turns west along Middlebrook Road until it turns in the north-west direction while crossing private properties on Griswold Drive and Ballard Drive, and empties into Trout Brook. The total contributing area to the FEAT system is 270 acres. The modeled FEAT system consists of 70 pipes ranging in pipe diameter from 12 to 48 inches. The system profiles and maps of the FEAT system were broken into three segments: Dorset Street, Bainbridge Street, and the Fern-Middlebrook intersection. The Dorset and Fern-Middlebrook segments combined represent the FEAT trunk line.

Bainbridge Road Segment of the FEAT System

The Bainbridge Street segment is located in the northeastern part of the study area and extends from Walbridge Road to where the system connects with the main trunk line on Foxcroft Road. As identified in **Figure 3-1**, the model predicts flooding in 16 manhole locations and 14 pipes with hydraulic constraints. The profile in **Figure 3-2** shows capacity constraints and flooding in the main trunk of the Bainbridge system.

Dorset Road Segment of the FEAT System

The Dorset Road segment of the FEAT system includes a part of the system from the southern diversion with Area 2 down to Fern Street. The diversion overflows to the FEAT trunk line when the water level in the manhole (MH ID MH-5841-001) on Frederick Road is 0.75 feet above its invert elevation.

The model predicts flooding in 8 manhole locations and pipe capacity constraints in 8 pipe segments upstream of Fern Street/Dorset Road diversion. The profile in **Figure 3-3** shows pipe capacity limitations in the main trunk of the Dorset Road segment and **Figure 3-4** identifies locations with hydraulic constraints.

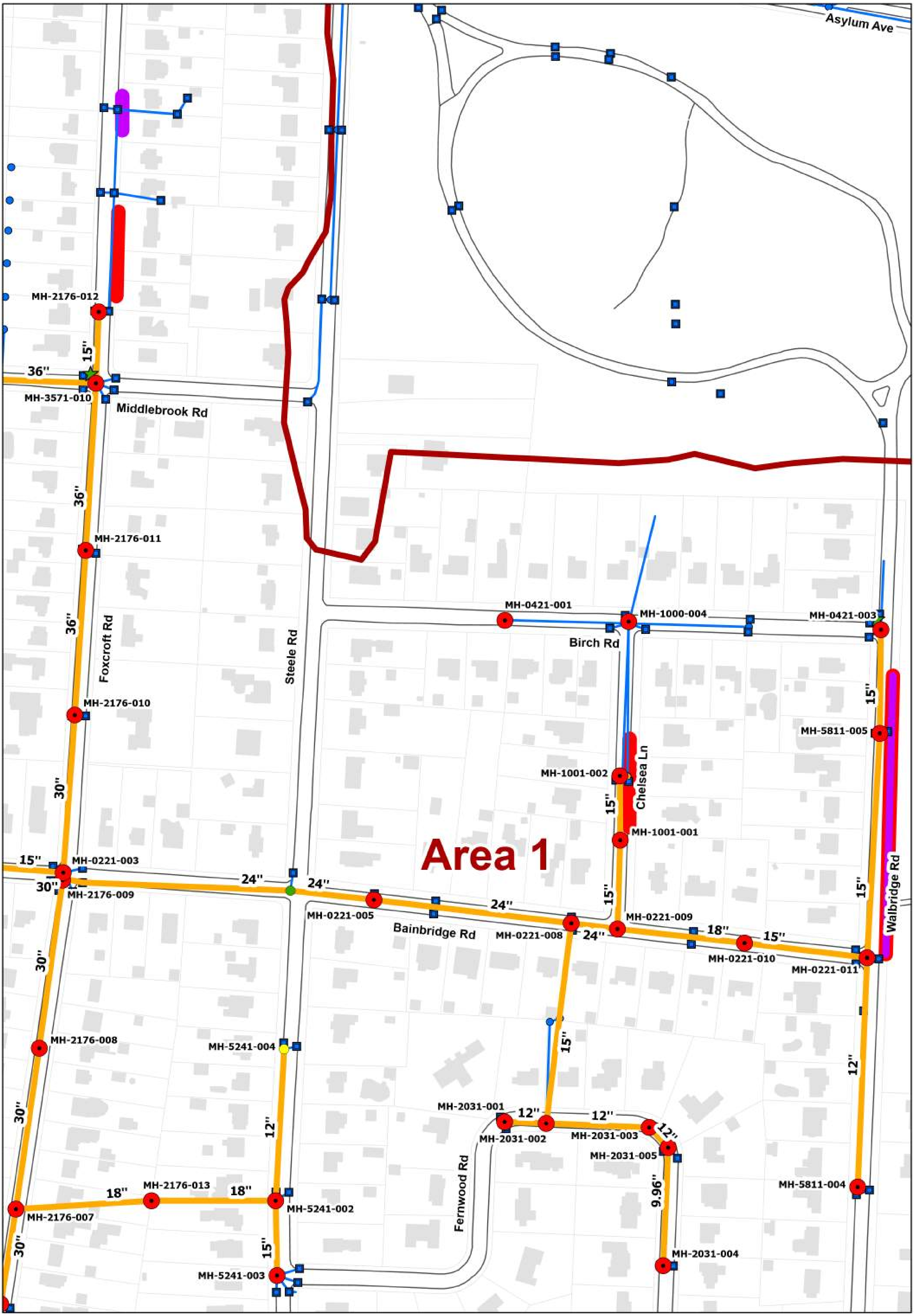

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Figure 3-1
Existing Flooding Assessment: Bainbridge Road
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

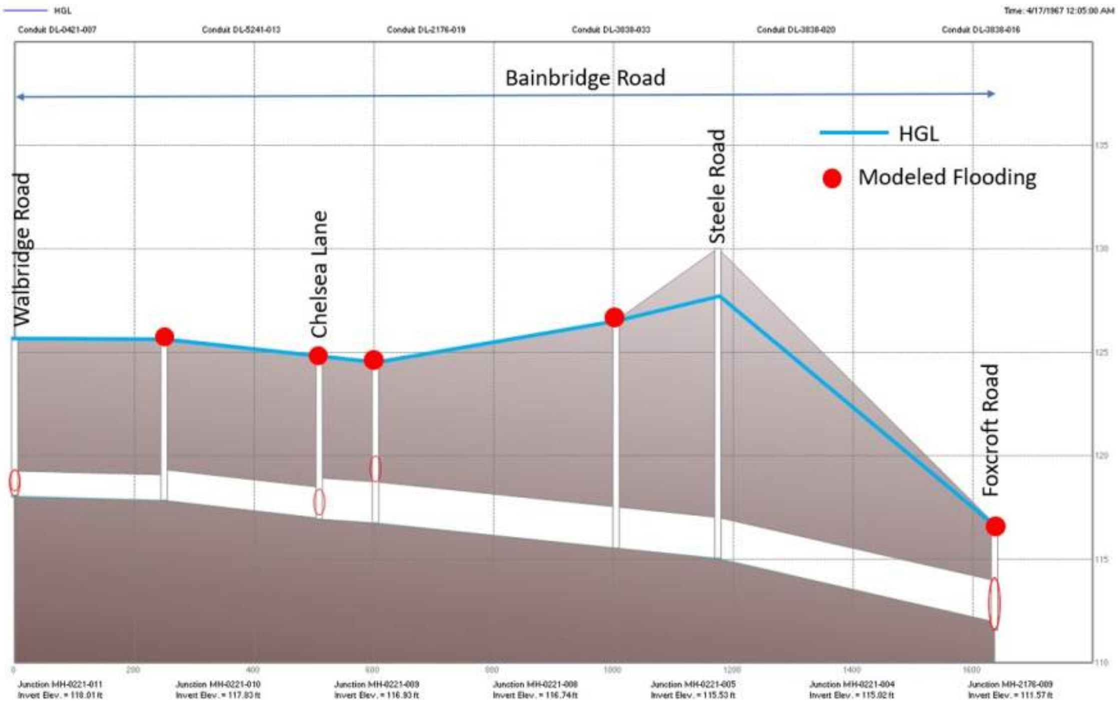


Figure 3-2: Existing Profile: Bainbridge Road for the Design Storm

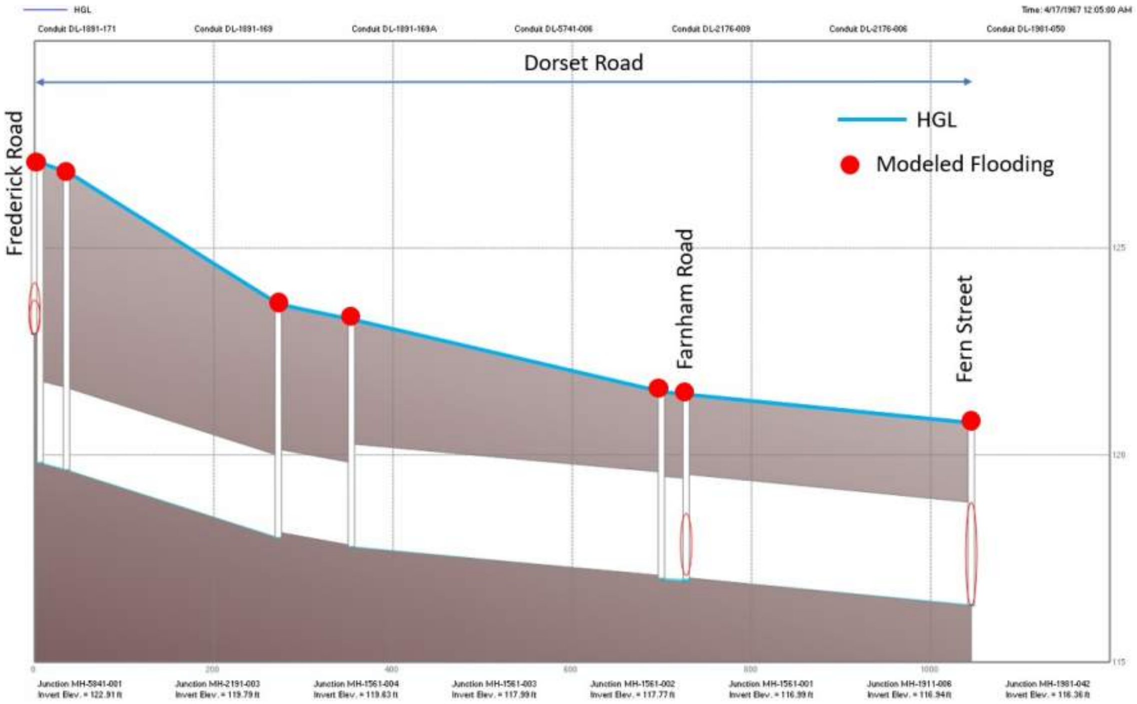
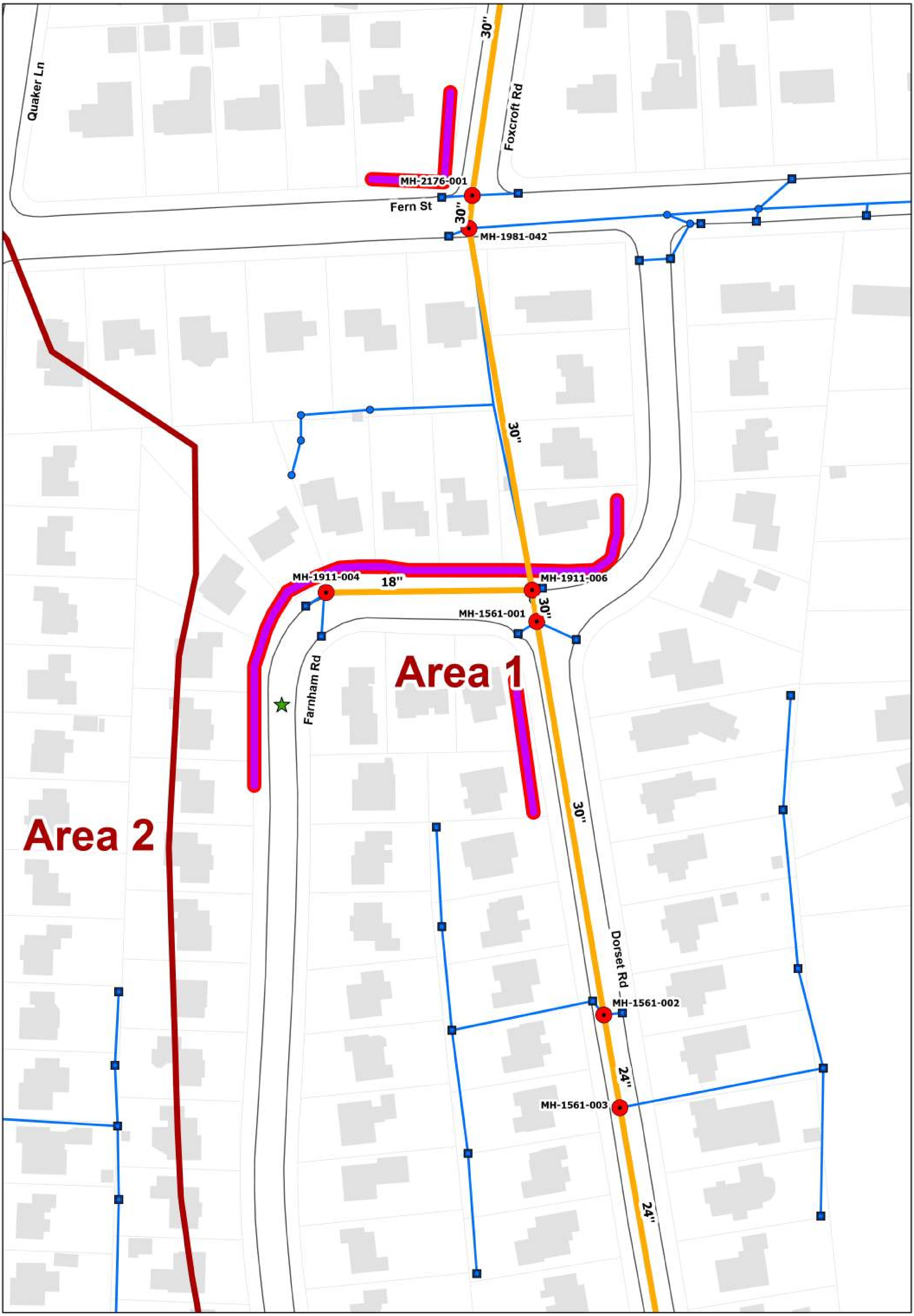


Figure 3-3: Existing Profile: Dorset Road for the Design Storm



CDM Smith

Legend

- ● Modeled Flooding
- 🟧 Modeled Over Capacity Storm Pipe
- 🟩 Modeled Below Capacity Storm Pipe
- GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding

- Both Dates
- ★ August 7, 2019

Scale

1 inch = 75 feet

0 37.5 75 Feet

N

Figure 3-4
Existing Flooding Assessment: Dorset Road
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

The Fern-Middlebrook Street Segment of the FEAT System

The Fern-Middlebrook Street segment the portion of the FEAT system downstream of Fern Street that discharges to Trout Brook. The profile in **Figure 3-5** identify the system's capacity constraints and flooding areas for the existing conditions using the 10-year design storm. **Figure 3-6** shows a plan view of the pipes and structures with insufficient capacity. The model predicts flooding at 27 manholes, with 29 pipes over capacity. In this system, the cross-country section near Trout Brook is the only pipe segment that has adequate capacity in the 10-year event; however, the model showed that the upstream capacity constraints and flooding are preventing the peak discharge from impacting this section of the trunk line. Through numerous model runs, it was shown that this downstream segment does not have sufficient capacity once the upper capacity constraints are addressed and additional flow can reach this downstream pipe segment.

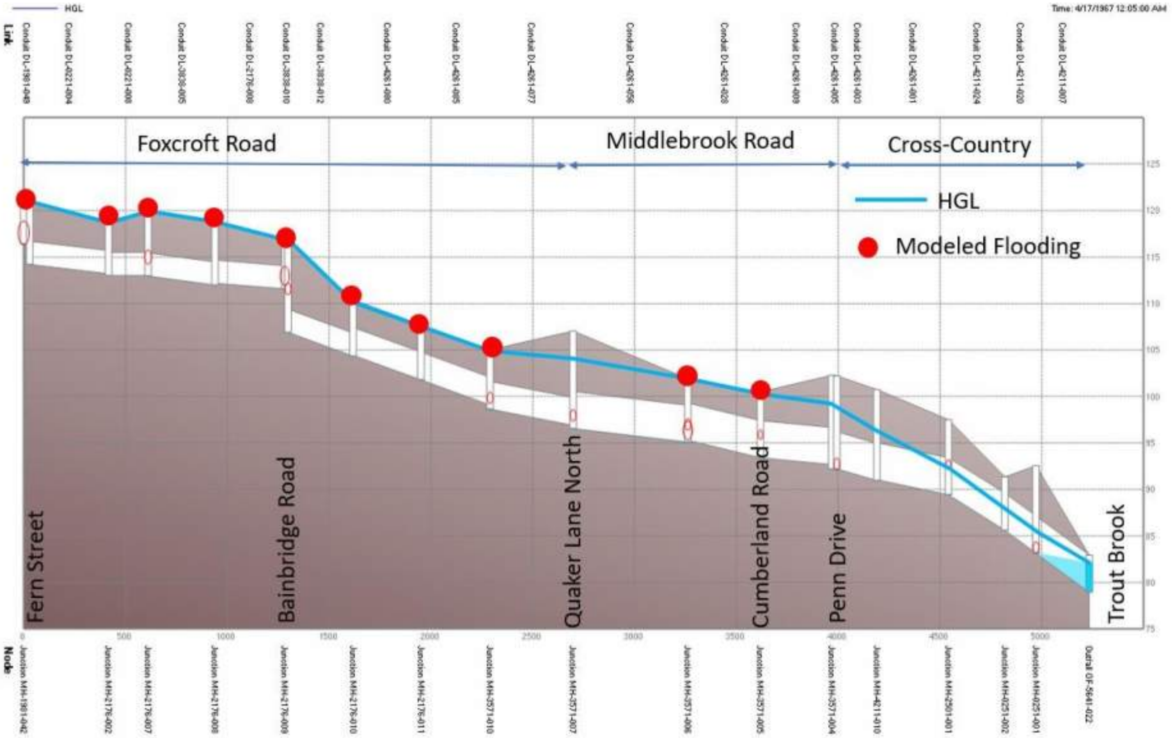
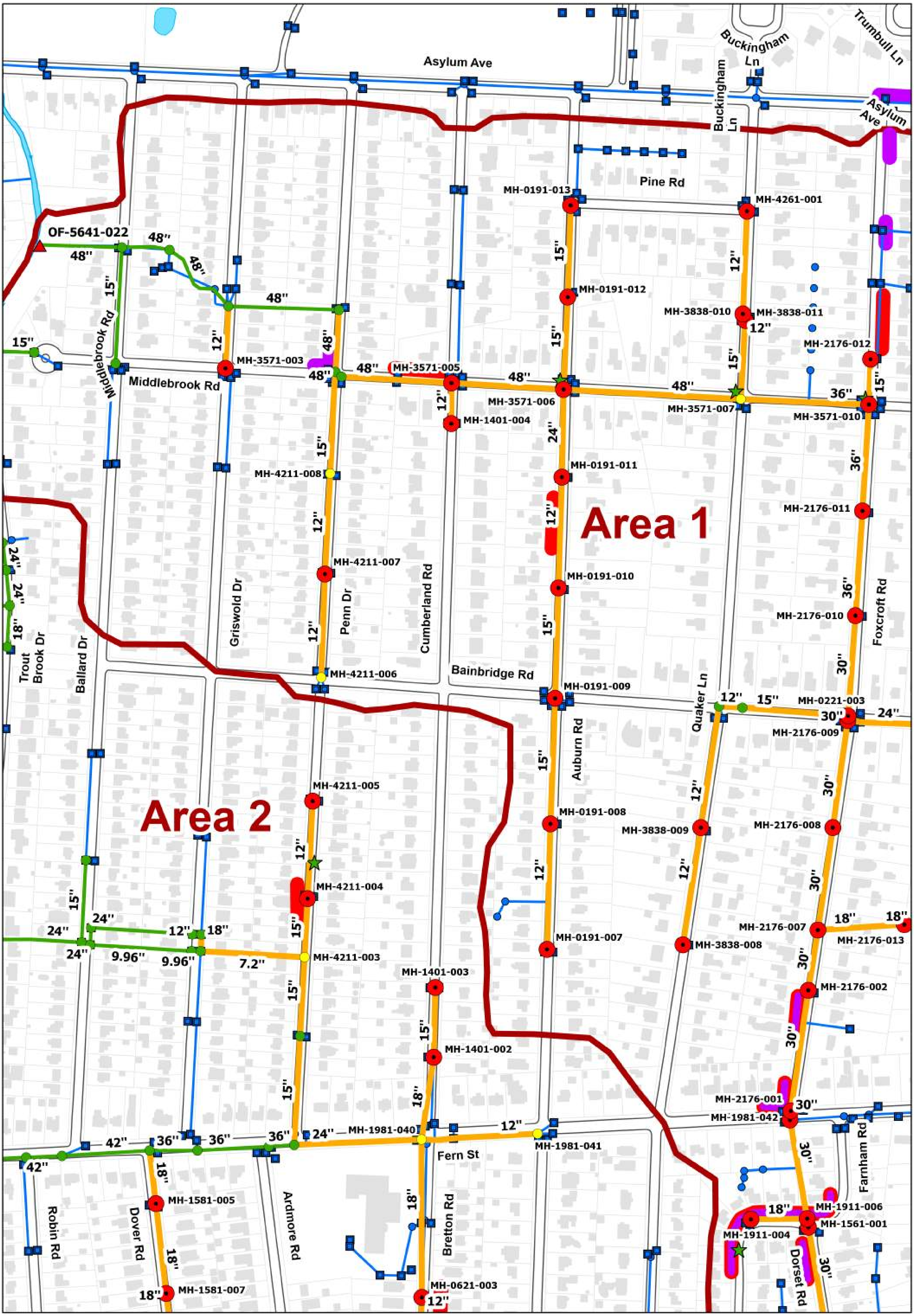


Figure 3-5 Existing Profile: Fern-Middlebrook for the Design Storm



Legend

- ● Modeled Surcharged Manhole - HGL within 1 foot of Grade
- ● Modeled Flow Remains in System
- ● Modeled Flooding
- ▲ Outfalls
- ▬ Modeled Over Capacity Storm Pipe
- ▬ Modeled Below Capacity Storm Pipe
- ▬ GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding
- ▬ April 17, 2018
- ▬ September 12, 2018
- ▬ Both Dates
- ★ August 7, 2019

Scale

1 inch = 275 feet

0 137.5 275 Feet

N

Figure 3-6
Existing Flooding Assessment: Fern - Middle
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

3.3.2 Area 2 – Milton Street and Fern Street Area

The area just south of the FEAT area is designated as Area 2 and includes eight systems in the Milton Street and Fern Street area. This area included 23,686 linear feet of pipe ranging in size from 7– to 24- inches. The watershed includes 230 acres with 554 properties. Only three of those systems had modeled flooding during the historical storms and/or the design storm. The following summarizes the existing conditions analysis for each of the three systems.

Milton Street System (OF-5641-001)

The Milton Street system is the second largest system in the study area. The total contributing area is 81 acres. This system consists of 20 pipes ranging in diameter from 10 to 24 inches. There is one diversion with the Fern Street system on Dover Road that serves as a relief pipe during storms.

The model predicts flooding at 18 manholes and hydraulic constraints in 18 pipes. A profile of the main trunk is shown in **Figure 3-7** and **Figure 3-8** shows a plan of the pipes and structures with insufficient capacity. There are two capacity-limited pipes in the main trunk: one between Arnold Way and Trout Brook and the second between Ardmore Road and Dover Road. Downstream pipes that discharge to Trout Brook Drive have adequate capacity; however, it is most likely that upstream capacity constraints and flooding are preventing the peak discharge from impacting the system. One pipe at the end of the system is slightly affected by tailwater conditions from Trout Brook. The invert elevation for the outfall pipe is 69 feet, and the predicted tailwater elevation during the design storm, as identified from the FEMA Flood Insurance Study maps, is 74 feet.

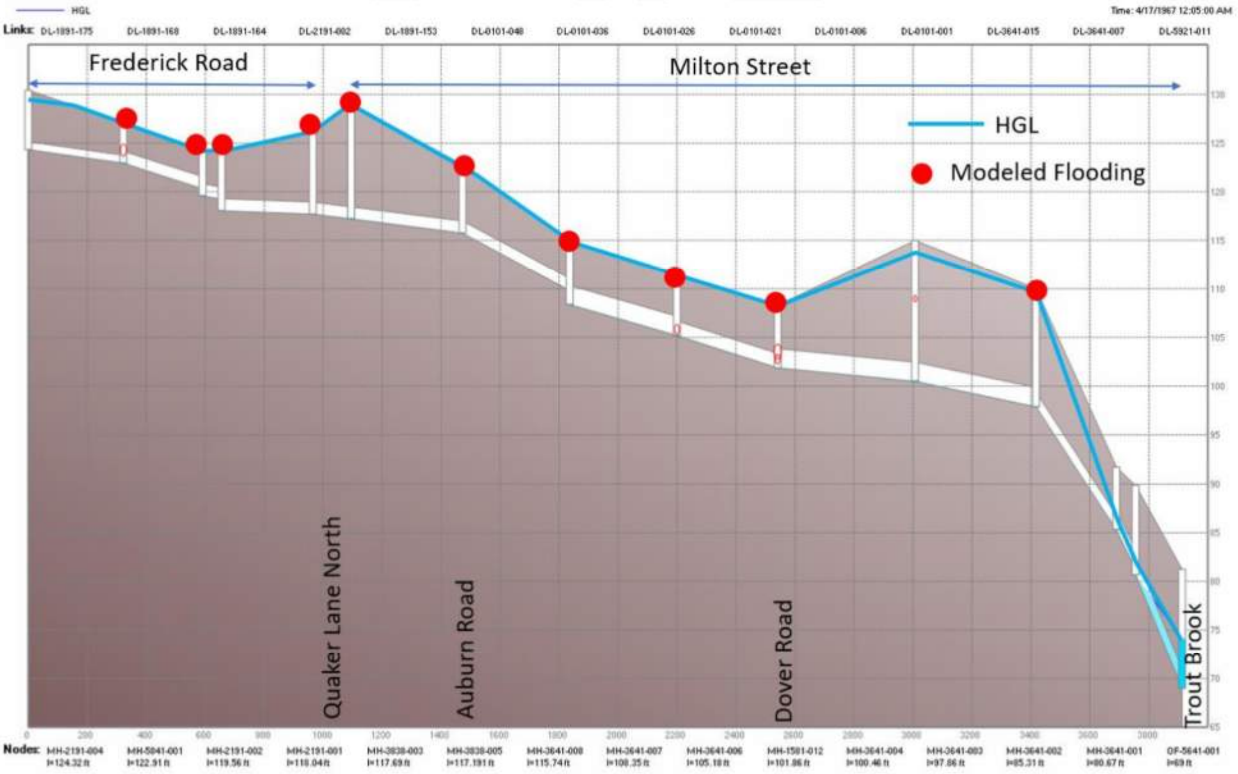


Figure 3-7: Existing Profile: Milton Street for the Design Storm

Legend

- 🟡 Modeled Surcharged Manhole - HGL within 1 foot of Grade
- 🟢 Modeled Flow Remains in System
- 🔴 Modeled Flooding
- ▲ Outfalls
- 🟧 Modeled Over Capacity Storm Pipe
- 🟩 Modeled Below Capacity Storm Pipe
- ━ GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding
- 🟥 September 12, 2018
- 🟪 Both Dates
- ★ August 7, 2019

Scale

1 inch = 350 feet

0 175 350 Feet

N

CDM Smith

Figure 3-8
Existing Flooding Assessment: Milton, Fern, Ballard
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

Fern Street East (OF-5641-007) and Ballard Drive (OF-5641-12) Systems

The Fern Street System is located east of Trout Brook, in the central part of the study area. The system consists of 24 pipe segments ranging in diameter from 12 to 42 inches. The total contributing area to the system is 68 acres. This system has 7 flooded manholes and 11 pipes with capacity constraints. The system has two diversions that provide connections to with other systems. The first diversion is with the Milton Street system via an 18-inch diameter pipe on Dover Road. The second diversion is a 7-inch diameter cross-country pipe connecting Penn Drive and Griswold Drive, therefore connecting to the Ballard Drive system. This system is located approximately 600 feet north of Fern Street. The system consists of 12 pipes ranging in pipe diameter from 7- to 24-inch (confirmed via survey).

Figure 3-8 presents the existing conditions assessment for these two systems. Profiles in **Figure 3-9** and **Figure 3-10** show the hydraulic grade line and flooded manholes in the main trunk of the Fern East and Ballard Drive systems during the design storm.

Two pipes at the end of the Fern system are slightly impacted by tailwater conditions from Trout Brook. The invert elevation for the outfall pipe is 73.4 feet, and the predicted tailwater elevation during the design storm, as identified from the FEMA Flood Insurance Study maps, is 78 feet.

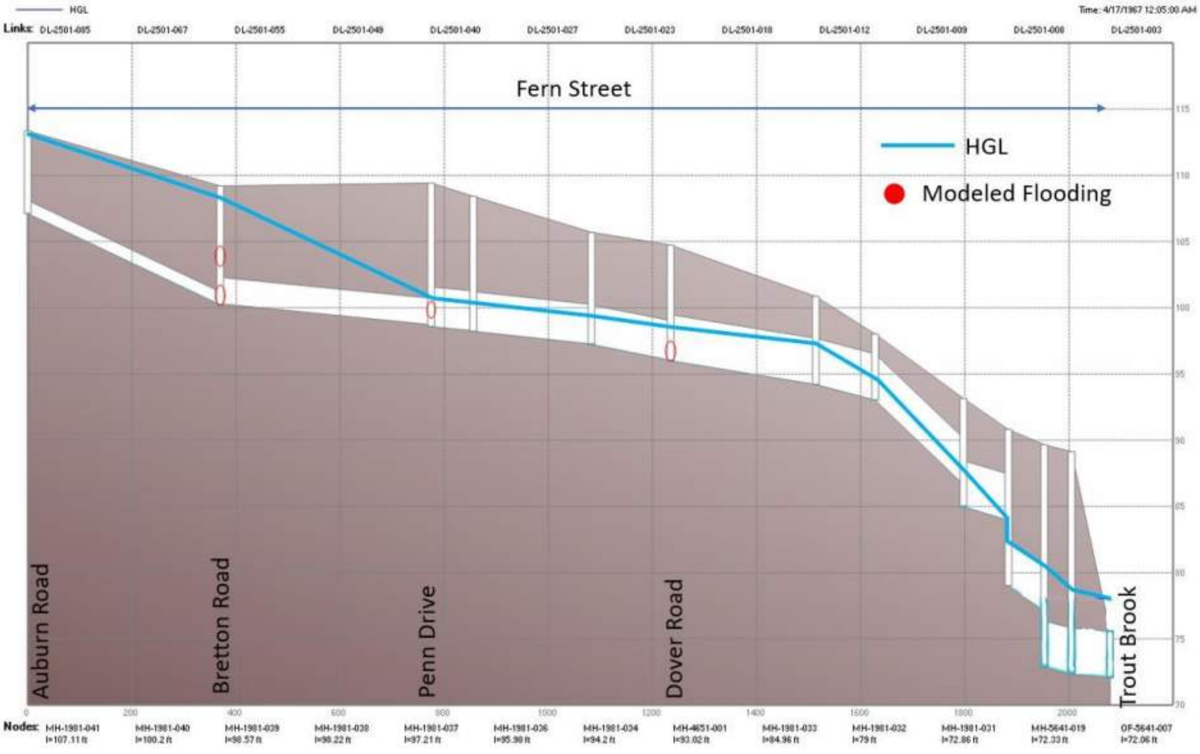


Figure 3-9: Existing Profile: Fern Street East for the Design Storm

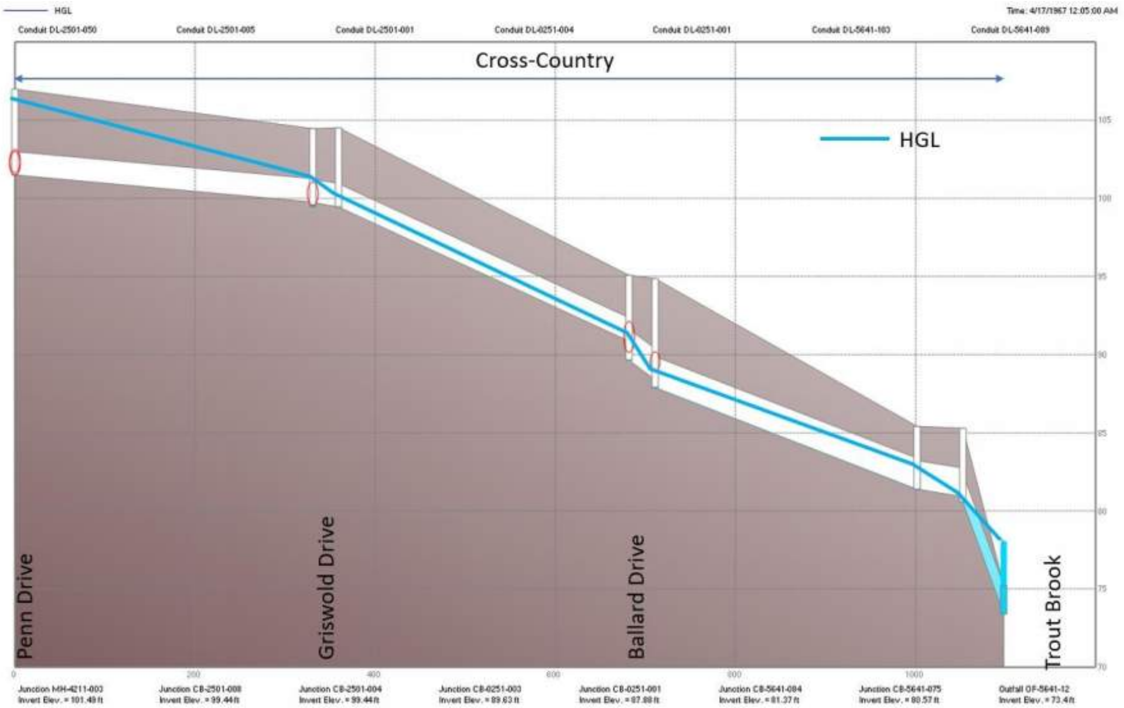


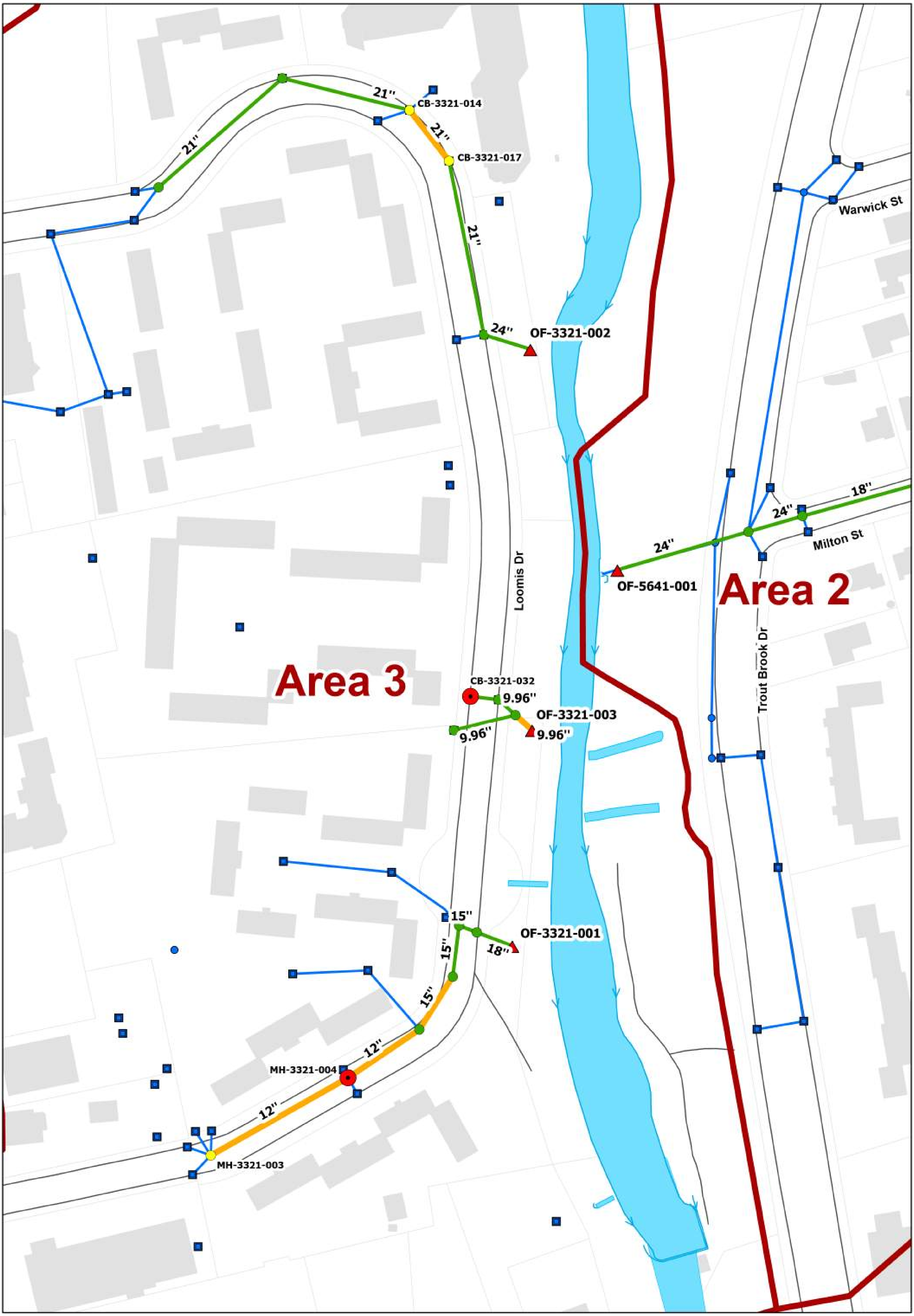
Figure 3-10: Existing Profile: Ballard Drive for the Design Storm

3.3.3 Area 3 – East Branch of Trout Confluence

Area 3 includes 175 acres draining to eleven outfalls that discharge to Trout Brook. The eleven drainage systems have 15,328 linear feet of pipe ranging in size from 7- to 24- inches. Nine out of the eleven drainage system modeled showed modeled flooding during the design storm and/or historical storm events. The following summarizes the existing conditions assessment of each drainage system.

Loomis Drive (Three outfalls)

The Loomis Drive system consists of three individual systems with outfalls draining to Trout Brook: Loomis Drive North (OF-3321-002), South (OF-3321-001), and Central (OF-3321-003). The total contributing area to the three systems is 28 acres. The three systems are comprised of 15 pipes ranging in diameter from 7- to 24-inch. The Town of West Hartford does not have a record of reported flooding in this area during Hurricane Irene and Tropical Storm Lee and during the historical storms in April and September 2018, or August 2019. The model predicts a short duration flooding in the Loomis Central system due to undersized pipes and an adverse slope in the upstream part of the system, as identified in **Figure 3-11** and the profiles in **Figures 3-12** through **3-14**. The model also predicts flooding and pipe capacity constraints in the Loomis Drive South system.



CDM Smith

Figure 3-11
Existing Flooding Assessment: Loomis
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

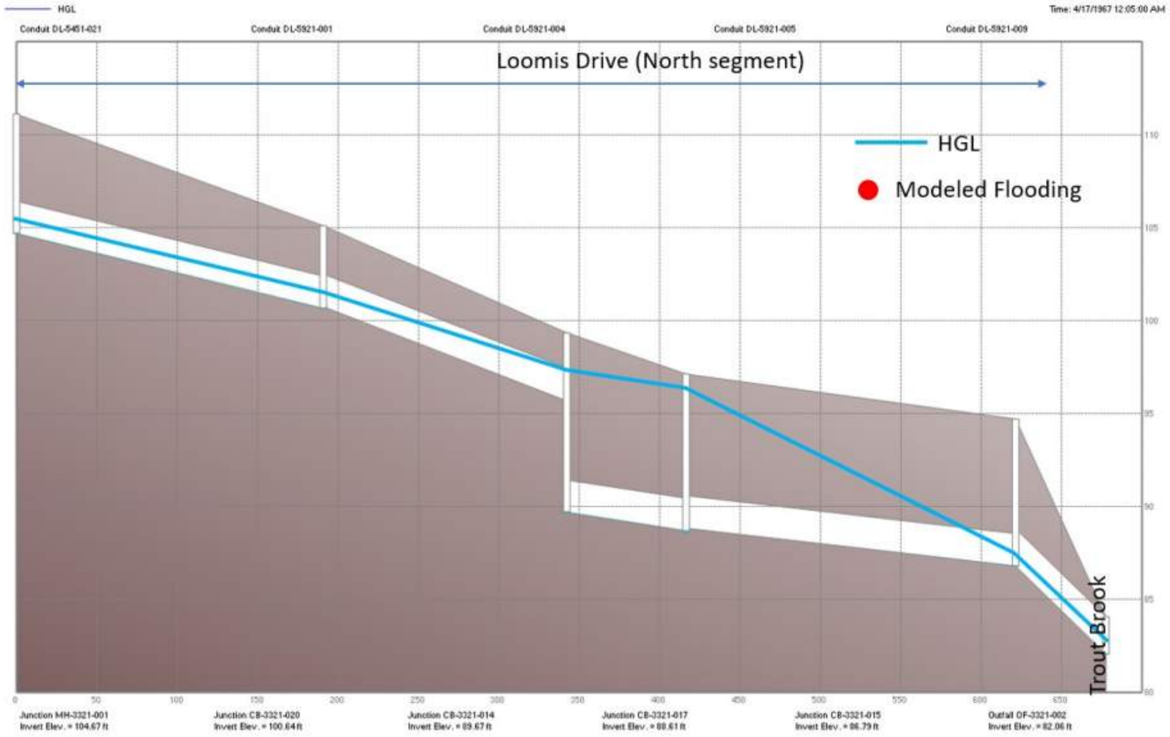


Figure 3-12: Existing Profile: Loomis Drive North for the Design Storm

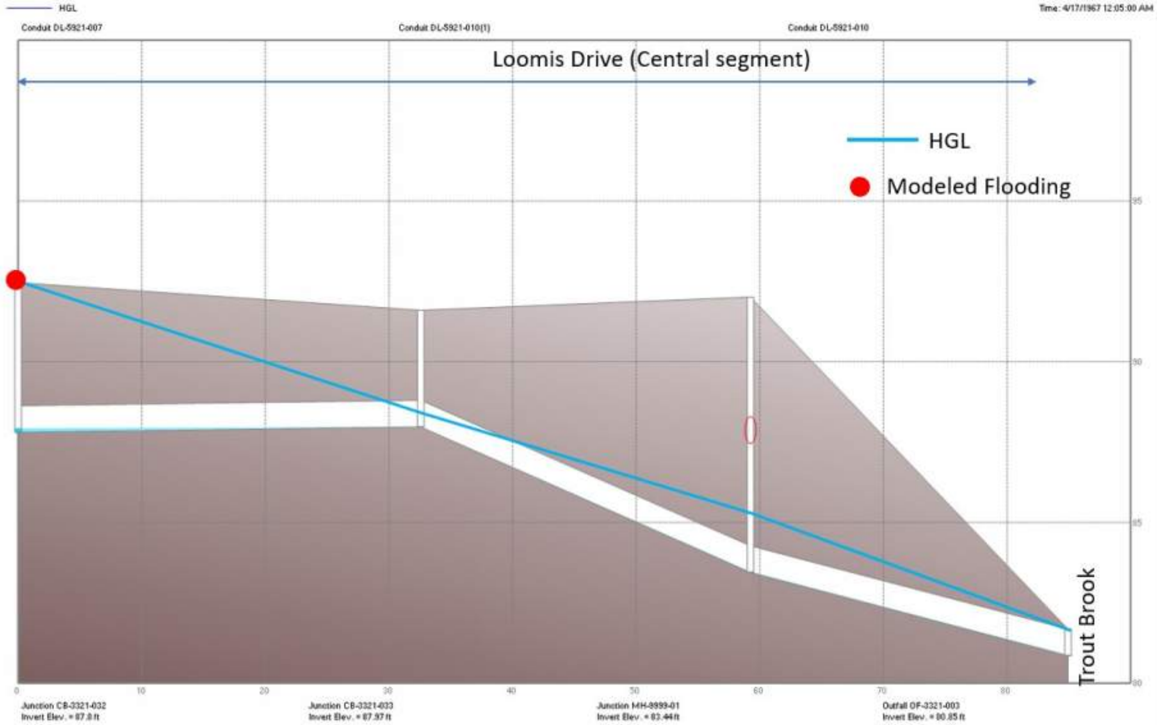


Figure 3-13: Existing Profile: Loomis Drive Central for the Design Storm

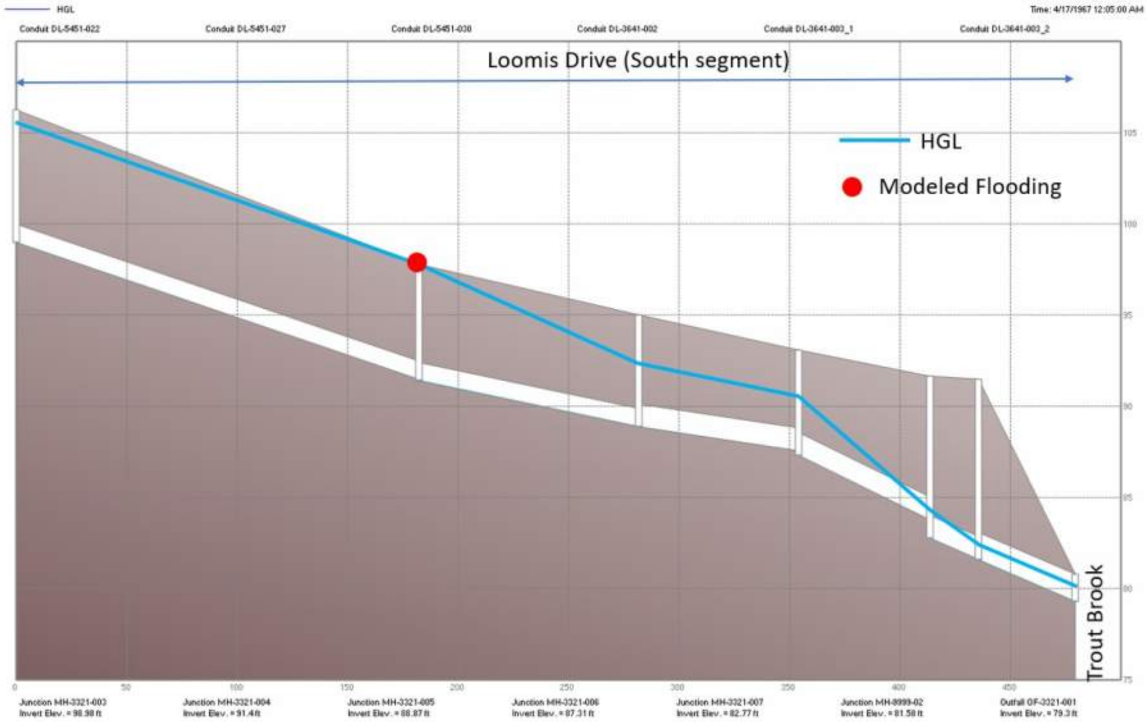


Figure 3-14: Existing Profile: Loomis Drive South for the Design Storm

Fern Street West (OF-1981-009)

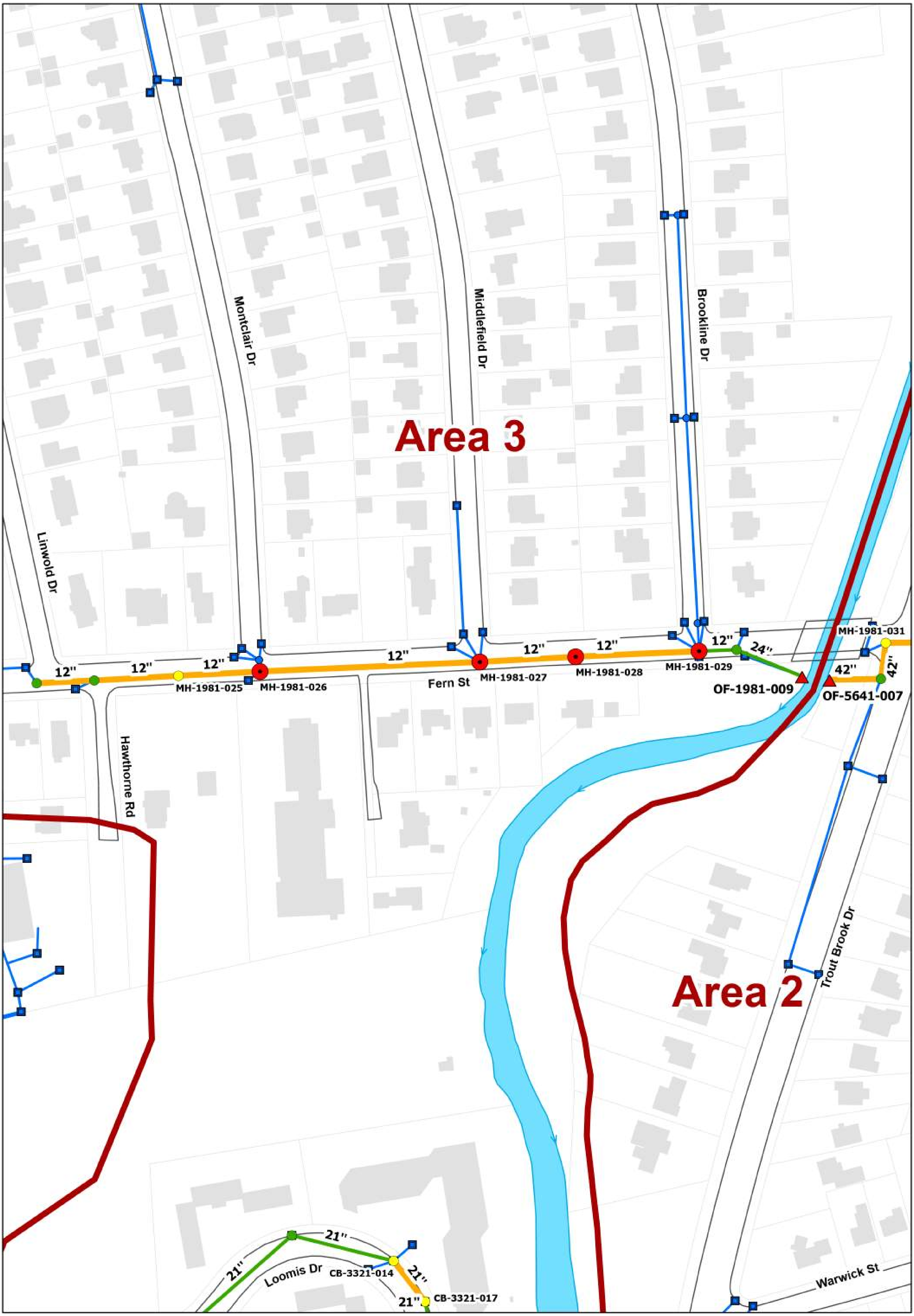
The Fern Street system is located West of Trout Book in Area 3. The system consists of 12- to 24- inch pipes, starting at the intersection of Linwold Drive and Fern Street, then running east for approximately 1,100 feet, and discharging to Trout Brook. The total contributing area is 16 acres.

The model predicts flooding in four locations during 10-year 24-hour NRCS Type III design storm due to pipe capacity limitations; however, during high intensity events the steep slope along Fern Street likely prevents stormwater from entering the collection system. The Town also does not have a record of reported flooding during the historical storm events (Hurricane Irene and Tropical Storm Lee, April and September 2018, and August 2019).

Locations of modeled overcapacity pipes and flooding locations are shown in **Figure 3-15**. The Fern Street West profile is shown in **Figure 3-16.** One pipe is impacted by tailwater conditions from Trout Brook. The invert elevation for the outfall pipe is 73.9 feet, and the predicted tailwater elevation during the design storm, as identified from the FEMA Flood Insurance Study is 81 feet.

Linnard Road System (OF-3261-001)

The Linnard Road system is located west of Trout Book in Area 3. The system starts at the intersection of Linwold Drive and Linnard Road, continues east for approximately 1,600 feet, and discharges to Trout Brook. The main trunk of the system consists of 8 pipes ranging from 12 to 24 inches. The total contributing area to the system is 57 acres. The Town does not have a record of reported flooding issues during the historical storm events; however, the model predicts flooding in five locations along the main trunk. The Linnard Road System is shown in profile in **Figure 3- 17** and **Figure 3-18** identify over capacity pipes and modeled flooding locations.



CDM Smith

Legend

- 🟡 Modeled Surcharged Manhole - HGL within 1 foot of Grade
- 🟢 Modeled Flow Remains in System
- 🔴 Modeled Flooding
- ▲ Outfalls
- 🟧 Modeled Over Capacity Storm Pipe
- 🟩 Modeled Below Capacity Storm Pipe
- ― GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Scale

1 inch = 125 feet

N

0 62.5 125 Feet

Figure 3-15
Existing Flooding Assessment: Fern Street West
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

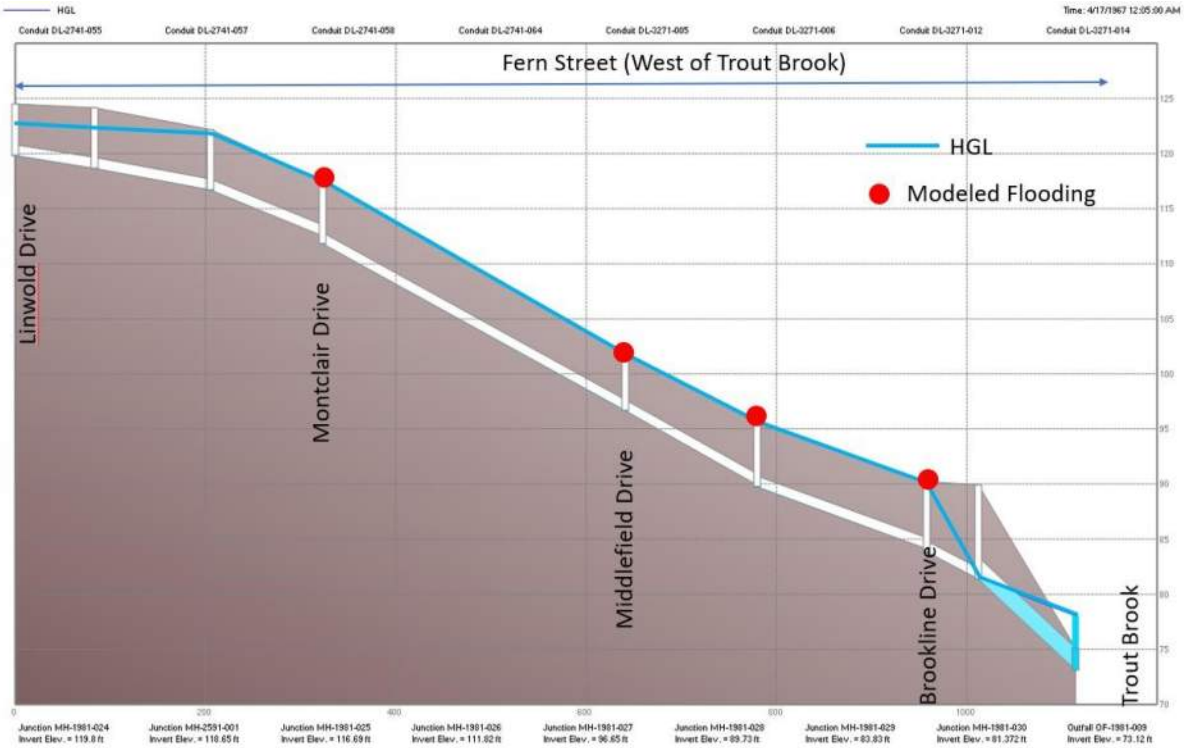


Figure 3-16: Existing Profile: Fern Street West for the Design Storm

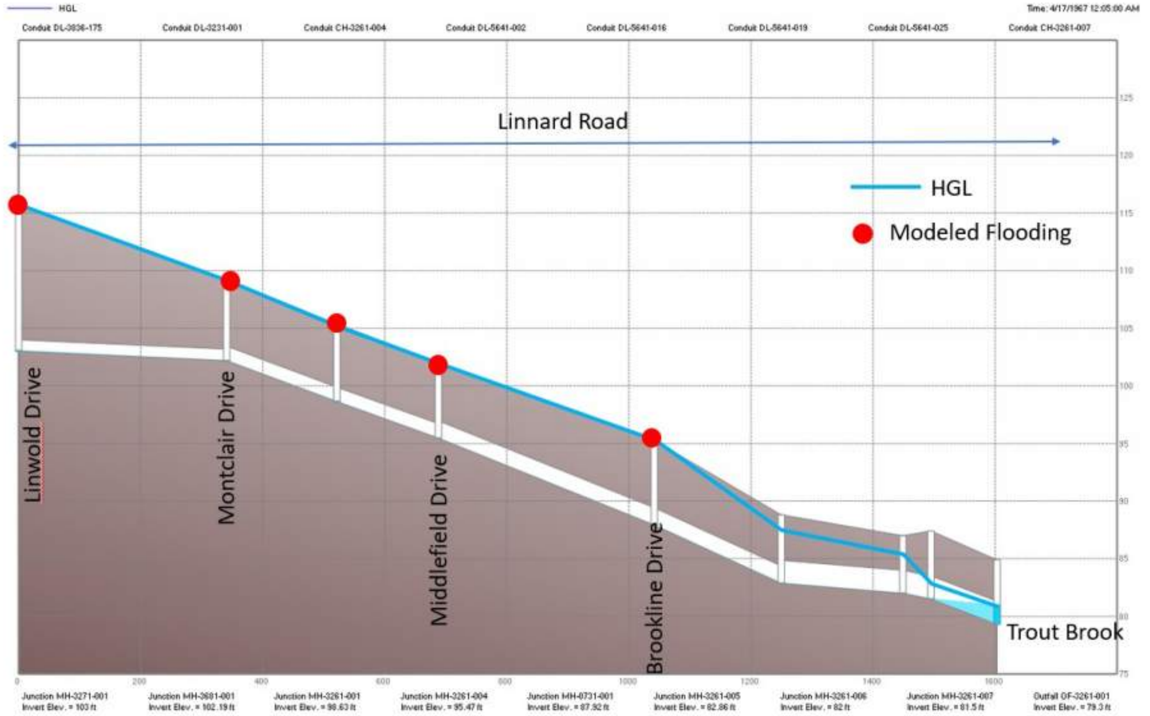
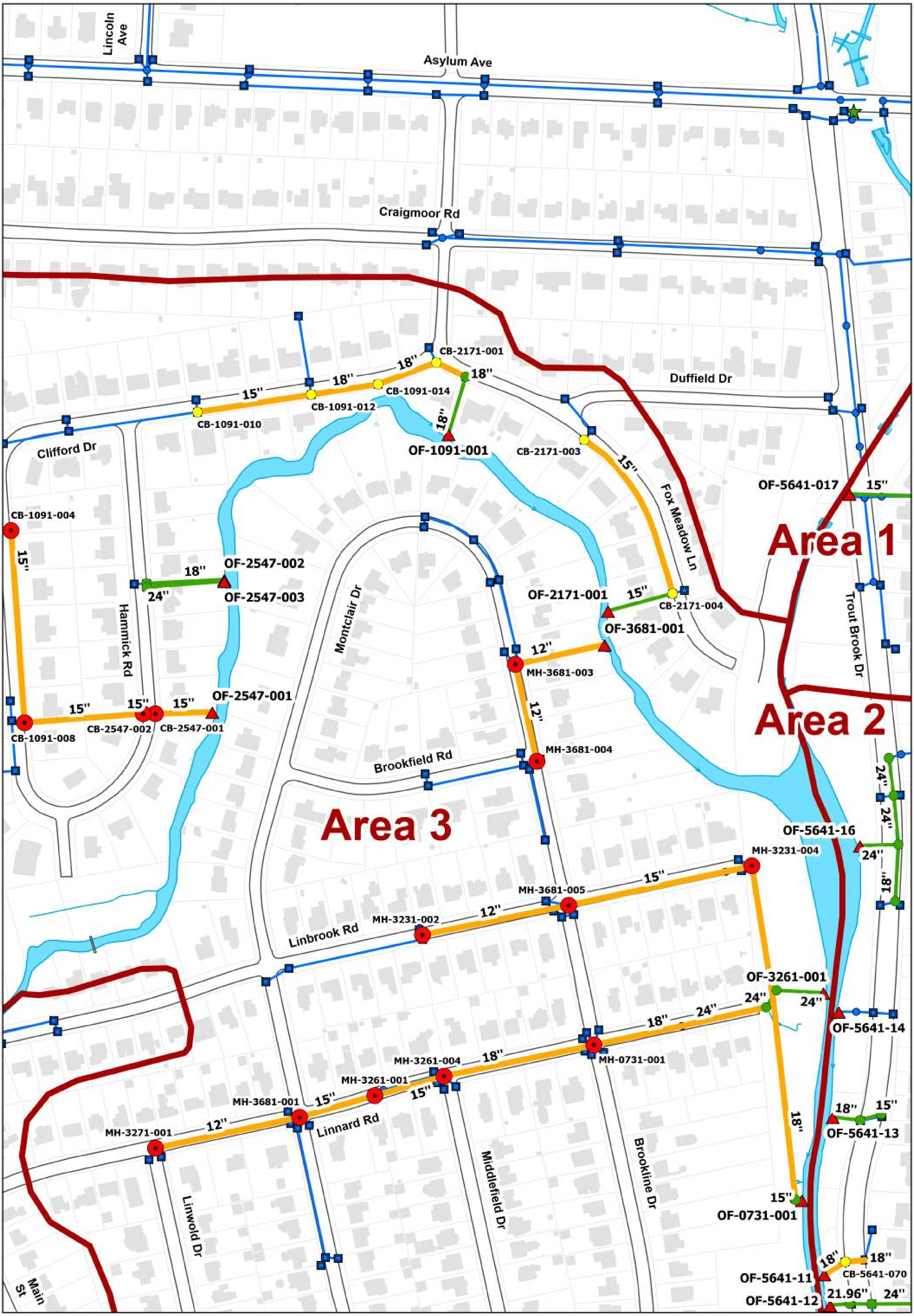


Figure 3-17: Existing Profile: Linnard Road for the Design Storm



CDM Smith

Legend

- 🟡 Modeled Surcharged Manhole - HGL within 1 foot of Grade
- 🟢 Modeled Flow Remains in System
- 🔴 Modeled Flooding
- ▲ Outfalls
- 🟧 Modeled Over Capacity Storm Pipe
- 🟩 Modeled Below Capacity Storm Pipe
- GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding

- ★ August 7, 2019

Scale

N

1 inch = 200 feet

0 100 200 Feet

Figure 3-18
Existing Flooding Assessment: Linnard, Montclair
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

Clifford Drive and Montclair Drive Area (six outfalls)

Linbrook Road, Montclair Drive, Clifford Drive, Hammick Road, Fox Meadow Lane systems are located in the northern part of Area 3 and may be affected by high groundwater elevations described in **Section 3.3**. The town has a record of flooding complaints during the historical events in 2011, 2018, and 2019.

The Linbrook Road system (OF-0731-001) stretches from west to east on Linbrook Road and discharges to Trout Brook via a 778 feet long pipe going south in a perpendicular direction to the main trunk. The main trunk line consists of four pipe segments ranging from 12 to 18 inches. The total contributing watershed area is 27 acres. The model predicts stormwater drain capacity issues in four pipes and street flooding in three locations, as identified in **Figure 3-18** and the profile in **Figure 3-19**.

The Montclair Drive (OF-3681-001), Clifford Drive Cross-County (OF-2547-001), Hammick Road (OF-2547-003), Clifford Drive North (OF-1091-001) and Fox Meadow Lane (OF-2171-001) stormwater systems are located along the West Branch of Trout Brook and all five systems discharge to Trout Brook. Each system consists of one and more pipe segments. The total contributing watershed area to these systems is 59 acres with pipe diameters ranging between 12 and 24 inches. The model predicts flooding due to stormwater system capacity constraints in three of these systems: Clifford Drive North, Clifford Drive Cross-country and Montclair Drive. **Figure 3-18** identifies flooding locations and undersized pipes. Profiles of these systems are presented in **Figure 3-20, Figure 3-21** and **Figure 3-22**.

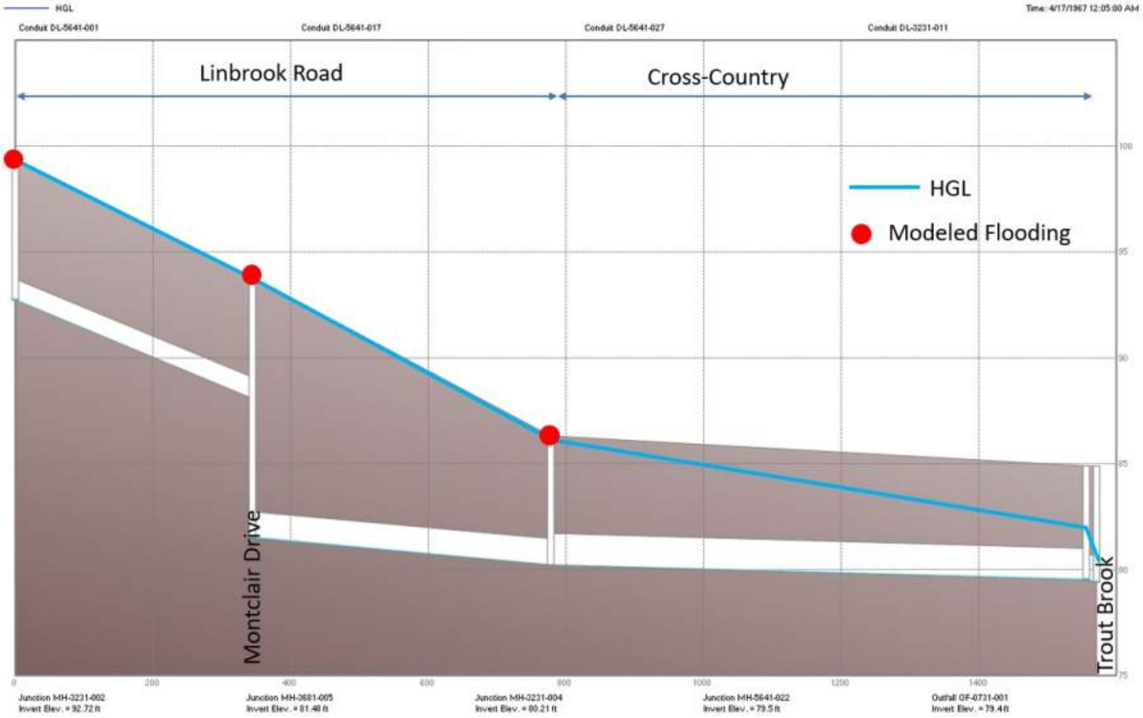


Figure 3-19: Existing Profile: Linbrook Road for the Design Storm

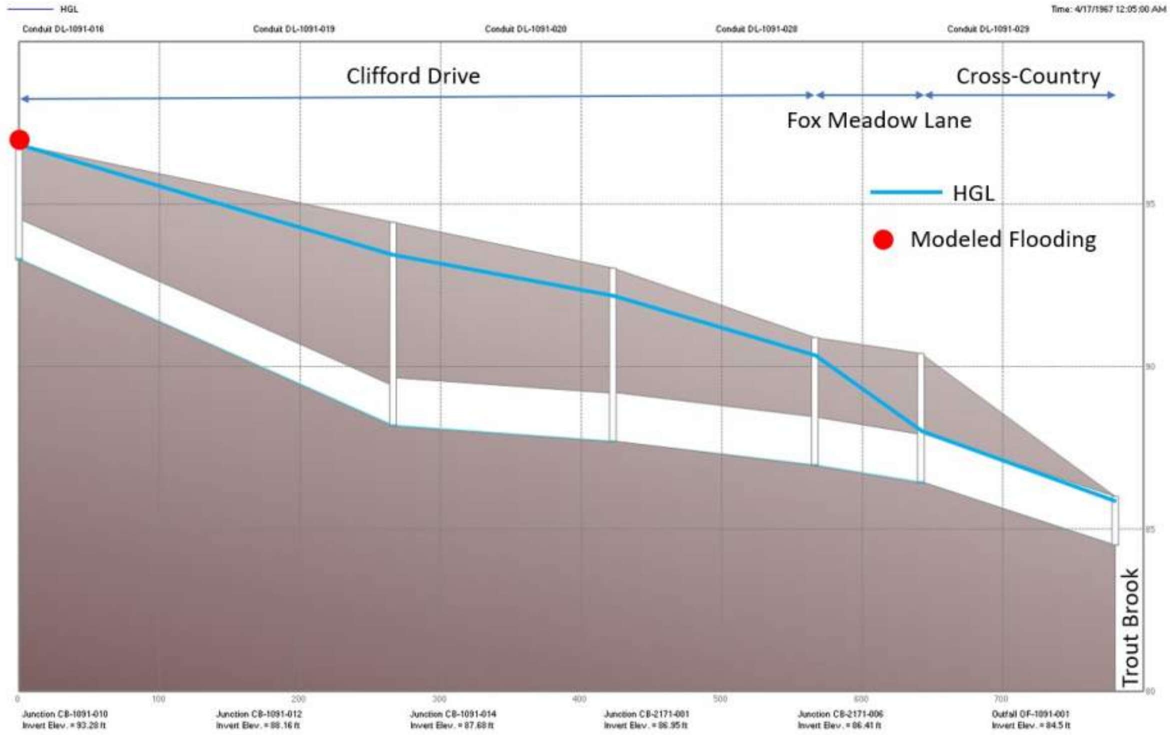


Figure 3-20: Existing Profile: Clifford Drive North for the Design Storm

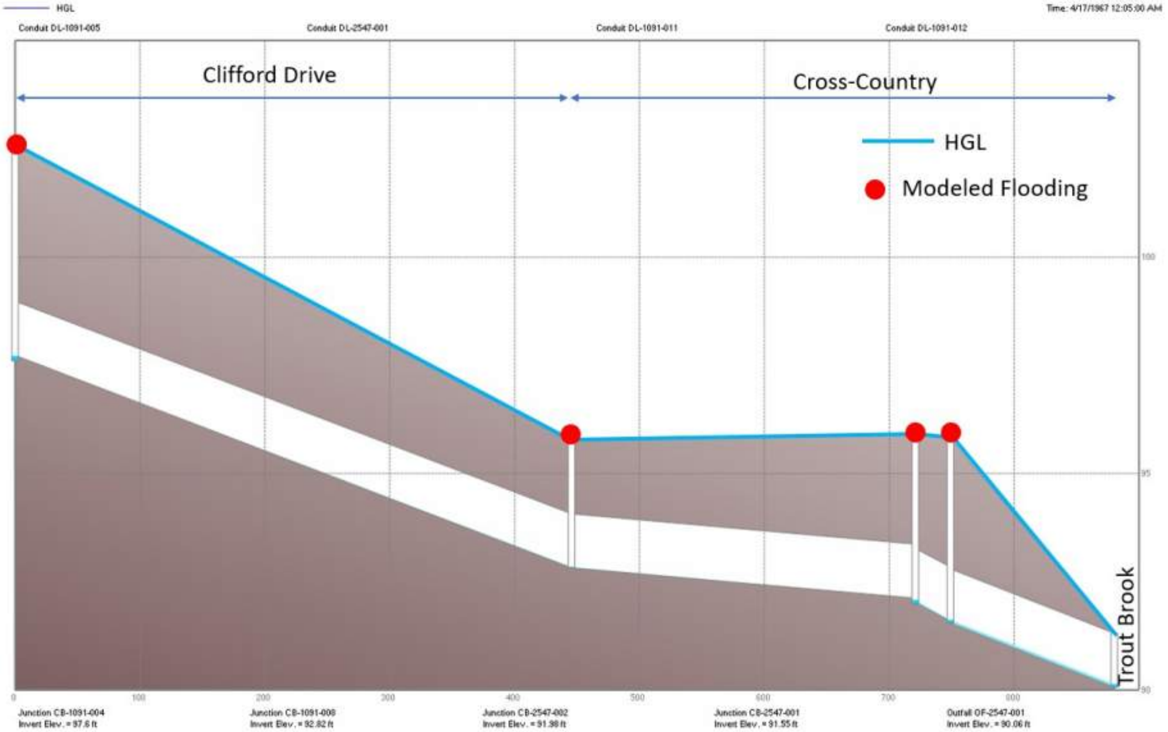


Figure 3-21: Existing Profile: Clifford Drive Cross Country for the Design Storm

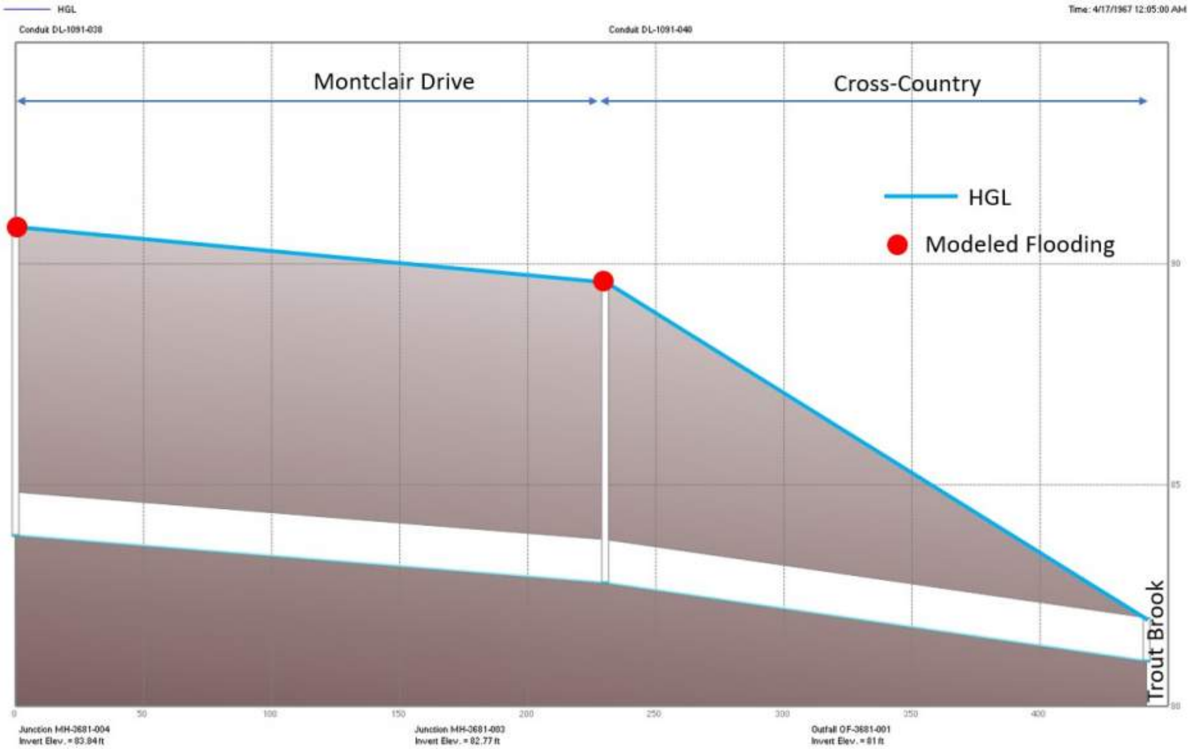


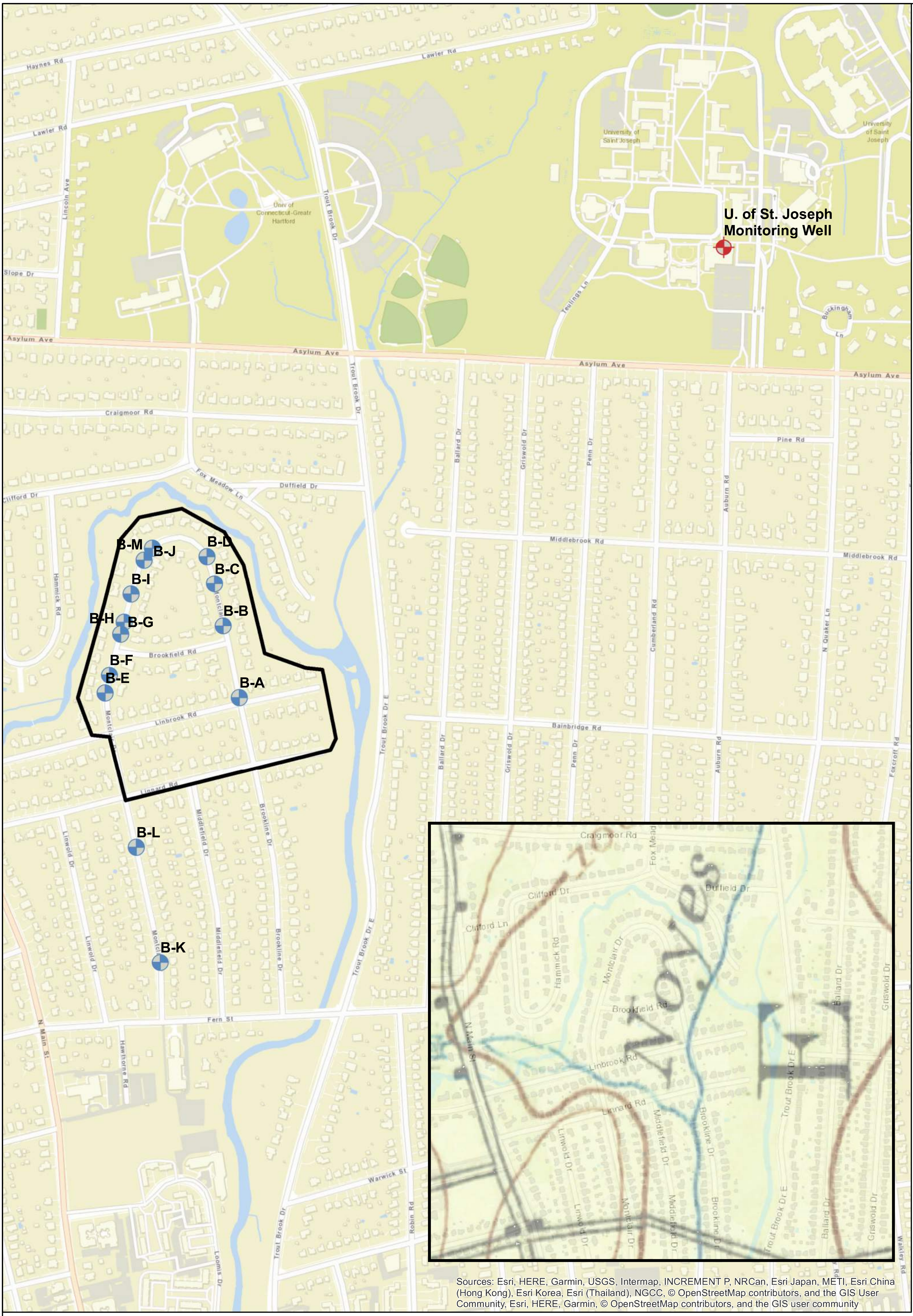
Figure 3-22: Existing Profile: Montclair Drive for the Design Storm

3.4 Groundwater Lowering Potential and Preliminary Screening

A preliminary review of historic maps, topography, groundwater elevation data, and soil borings was completed to provide some context for recent instances of apparent groundwater seepage into basements and yards in the neighborhood situated to the west of Trout Brook including Montclair Drive, Linbrook Road, and Linnard Road. The objective of this review was to determine if high groundwater levels are expected in this neighborhood and to better understand potential next steps to take to lessen the impacts of high groundwater in the future. This section describes the individual analyses completed. Recommendations for future consideration are discussed in **Section 4**.

3.4.1 Review of Historical Maps

The neighborhood bound on the east, west, and north by Trout Brook and the south by Linnard Road is referred to herein as the Groundwater Screening Site. Trout Brook flows west to east, meandering to the north along the curve of Montclair Drive before joining with a northerly tributary and flowing south before joining up with the Park River (South Branch). Historic maps available from the USGS/ERSI's Living Atlas (https://livingatlas.arcgis.com) show this to be case since at least 1928. However, the USGS's Living Atlas contains two maps prior to that date, one in 1906 and one in 1892 that show the Noyes River (present) oriented differently from Trout Brook (not present), with streams flowing across present-day Montclair Drive, Linbrook Road, and Linnard Road as shown in the inset in **Figure 3-23**.



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community, Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

CDM Smith

Legend

⊕ Monitoring Well

◍ Soil Borings from 2011

▭ Groundwater Screening Site

Scale

N

0 400 800 Feet

Figure 3-23
Groundwater Screening Site and Vicinity
Drainage System Evaluations, Trout Brk Watershed
Town of West Hartford, Connecticut
March 2020

The Noyes River, which does not appear on modern maps was described as follows in a 1916 USGS Water Supply paper (Gregory and Ellis, 1916):

> "The drainage finds its way into the Connecticut River through Park River. Neither of these streams passes through West Hartford, but Park River is formed by the junction of Noyes River, which lies wholly within the town, and Hog River and South Fork, which lies across the northeast and southeast corners, respectively. Trout Brook receives all the drainage from the west half of the town and enters Noyes River about 1 mile north of West Hartford Center. The drainage of the east half is divided among Noyes River, South Fork, and Hog River. Noyes River joins South Fork in the southeast corner of the town."

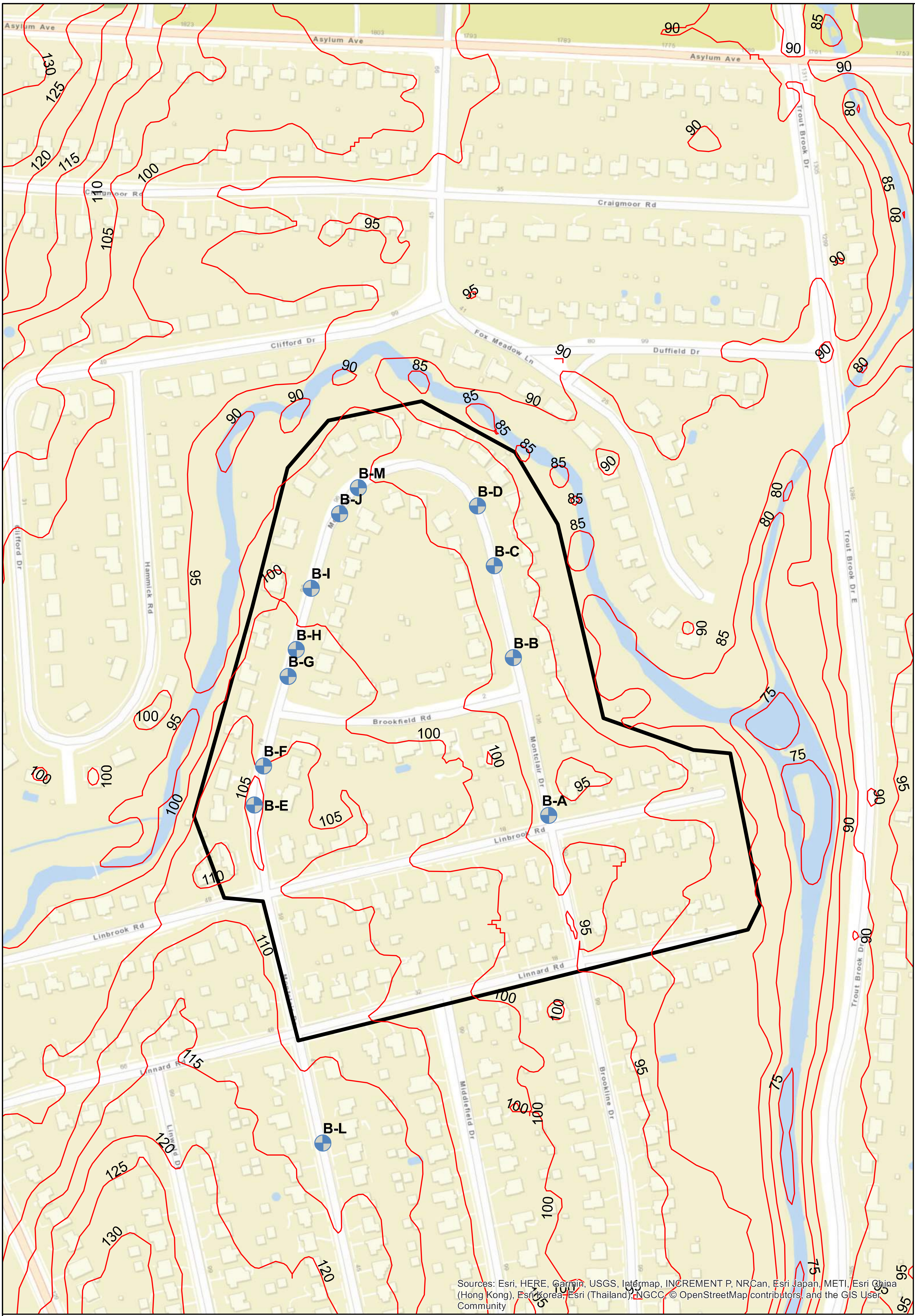
Based on this information, it can be inferred that the Groundwater Screening Site was once within the fluvial portion of the river system, from which it could be inferred that groundwater seepage within this area is not unexpected.

3.4.2 Review of Present-Day Topography

Ground surface topography data used for the project were reviewed in the context of potential groundwater seepage. Five-foot topographic contours are shown in **Figure 3-24** for the Groundwater Screening Site and surrounding area. Generally speaking, the Groundwater Screening Site is situated in a regional topographic low. Ground surface elevations within this area range from a high of 110 feet near the intersection of Montclair Drive and Linbrook Road to a low of 85 feet near Trout Brook. The ground surface elevations at the easternmost ends of Linbrook Road and Linnard Road are between 85 and 90 feet. Along the homes located between the northern portion of Montclair Drive and Trout Brook ground surface elevations are on the order of 90 to 95 feet.

3.4.3 Review of Groundwater Elevation Data

Groundwater elevation data near the Groundwater Screening Site were obtained from the USGS National Water Information System (NWIS) Mapper (https://maps.waterdata.usgs.gov/mapper/index.html). One well, located on the campus of the University of Saint Joseph situated to the northeast of the Groundwater Screening Site (**Figure 3-23**) was identified and its data were reviewed. The well has groundwater elevation data values that range from approximately 102 feet to 105 feet, corresponding to a range of depth to groundwater of approximately 3 to 6 feet below ground surface (bgs) between 2003 and 2018. The data, as published by USGS are shown on **Figure 3-25**. In the absence of more wells and associated data, it is assumed that the local groundwater table follows the topography contours and discharges to Trout Brook.



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

CDM Smith

Legend

- ⊕ Monitoring Well
- ⊕ Soil Borings from 2011
- — Ground Surface Elevation Contours (Feet)
- ▭ Groundwater Screening Site

Scale

N

0 175 350 Feet

Figure 3-24
Ground Surface Elevation Contours
Within Groundwater Screening Site
Drainage System Evaluations, Trout Brk Watershed
Town of West Hartford, Connecticut
March 2020

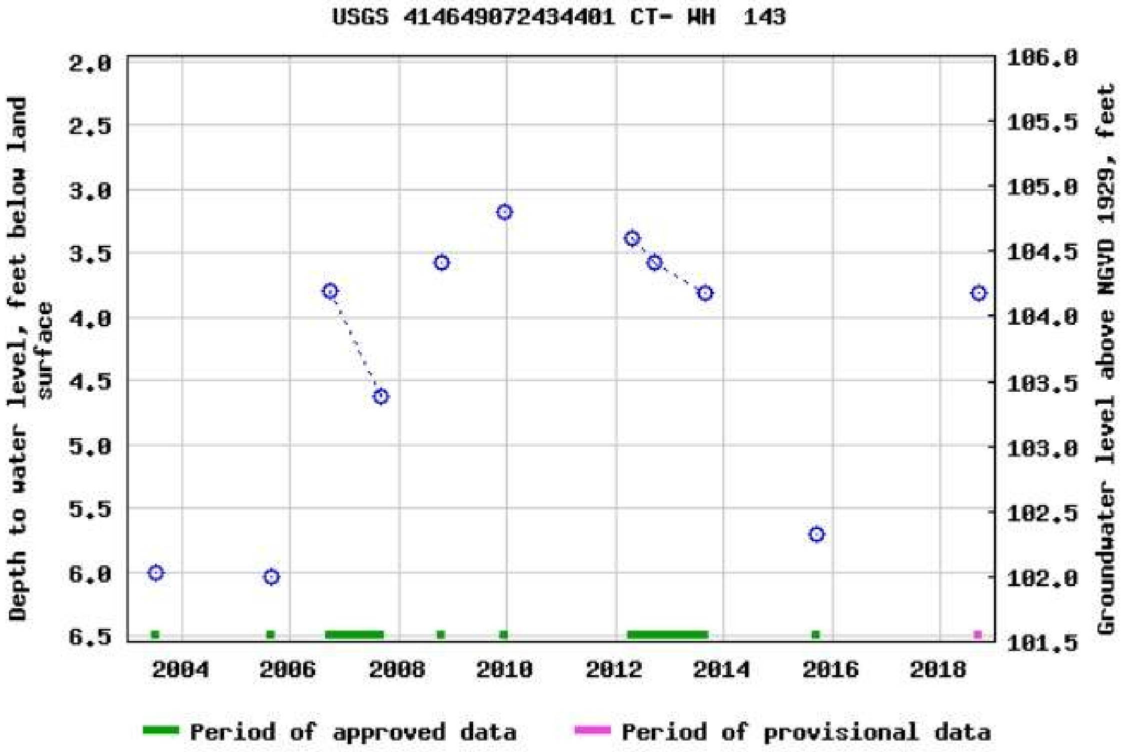


Figure 3-25: Groundwater Elevation Data from Monitoring Well at University of Saint Joseph

3.4.4 Review of Soil Boring Logs

Soil boring data provided by the MDC included thirteen soil borings that were drilled along Montclair Drive within the MDC Groundwater Screening Site in 2011 (**Figures 3-23** and **3-24**). The boring logs have been attached as **Appendix B** to this report. Each boring showed a similar profile, with shallow fill materials overlying till on top of rock. Thicknesses of each soil unit varies from boring to boring.

Fill materials are typically heterogeneous as they are put in place during development and often transported from outside the immediate area. Permeability of fill can vary wildly. In a few borings, materials described similarly to, and at similar depths of, fill in other borings were classified as fines. For this discussion, the fines are assumed to be fill material as well. The depths of fill materials range from approximately 1 to 16.5 feet bgs. Borings taken along the eastern portion of Montclair Drive had the most fill, with the maximum depth of 16.5 feet observed at boring B-A located at the eastern intersection of Montclair Drive and Linbrook Road. This location is also where the Noyes River was shown to have been present pre-development. Less fill is present in the borings along the western portion of Montclair Drive.

Beneath the fill is a layer of till overlying bedrock. The thickness of the till layer varies from minimal on the eastern portion of Montclair Drive to up to 10 feet on the western portion of Montclair Drive. Rock is encountered at depths of 7 to 22 feet bgs.

It is unknown what the permeability of the fill or the till are within the Groundwater Screening Site. However, due to the presence of fines, clays, and silts among the noted sands and gravels, the soils are not expected to be highly transmissive and have been noted as "Other Glacial Meltwater Deposits with Lower Potential Yield" in a surficial aquifer potential map published by the University of Connecticut (http://cteco.uconn.edu/maps/state/ctsurficialaquiferpotential.pdf).

The presence of the water table was noted in each of the borings. At boring B-A located at the eastern intersection of Montclair Drive and Linbrook Road the water table is noted to be less than 1 foot bgs. Depths to water at the other borings ranged from less than 1 to approximately 10 feet bgs. Water level estimates taken from borings are less reliable than those taken from monitoring wells, so a general approximation for the area's depth to the water table should be inferred from these data.

3.5 Private Inflow and Collector Drainage System

The study area includes private inflow connections to the sanitary sewer system that have been confirmed through building inspections and dye testing performed by the MDC over the past decade. The most prevalent sources of private inflow in all three areas are foundation drains and sump pumps that connect to the sanitary sewer service inside the building. Most residential homes in West Hartford built prior to 1959 were built with an internal sump or access pit which was typically installed to accept flow from foundation drains. Many of the access pits in these homes still have active connections to the sanitary sewer service that can contribute during wet weather or dry weather when groundwater levels are high.

The drainage study area overlaps with four sewer subareas (WH29, WH30, WH31 and WH34) that have been identified as problem areas by the MDC and prioritized for sewer system improvements. The improvements include sewer main, manhole and lateral rehabilitation, and disconnecting private inflow sources from the sanitary sewer system as part of a comprehensive rehabilitation program to address the problems in the area.

CDM Smith completed a conceptual design of the WH29, WH30 and WH31 recommendations for the MDC in early 2019 that included an initial assessment and plan of collector drains, new mainline drain extensions and new drainage structure for private inflow removal. This information was reviewed for the drainage study to determine the number of private inflow removal buildings in the three study areas. **Table 3-2** summarizes the number of total buildings and private inflow removal buildings that have been identified and **Figure 3-26** shows the private inflow removal buildings in the three study areas.

Table 3-2: Private Inflow Removal Buildings in Study Area

Study Area	Total Buildings	Private Inflow Removal Buildings	% Private Inflow Removal Buildings
Area 1	791	325	41%
Area 2	554	222	40%
Area 3	402	114	28%
Totals	**1,747**	**661**	**38%**

The private inflow removal buildings are based on the completed inspection program in the study area that includes 1,747 total buildings. The success rate for the building inspection program was 70% which means that approximately 1,227 building inspections have been completed in the study area. Building inspections that were incomplete after the minimum number of attempts were considered ‘not home’. If entry was refused by the property owner, the refusal was documented, and no further inspection attempts were made. There were approximately 520 incomplete building inspection in the study area, with 447 that were considered ‘not home’ and 73 that were listed as ‘refusals’.

The completed building inspections identified 661 buildings for private inflow removal which means that nearly 54% of the buildings (661 of 1,227) have confirmed or suspected private inflow sources. Prorating the remaining 520 buildings with incomplete inspections at 54% would add another 280 private inflow removal buildings in Area 1 (100), Area 2 (112) and Area 3 (68).

The general approach to disconnect most private inflow sources is through installation of pre-fabricated sump pits, sump pumps and discharge piping inside the home with the pumped discharge connecting to a 6” PVC gravity drain service outside the home. The drain service on private property would ultimately connect to a 6” PVC collector drain in the public right-of-way. The collector drains will connect to the Town of West Hartford drainage system at the nearest manhole or catch basin. This is the same approach successfully constructed for private inflow removal developed under the Four Mile Road Area project constructed in 2012-2013 and Greenhurst Road Area project constructed in 2015-2017. The collector drain system recommendations for the three study areas are further evaluated in **Section 4** and the collector drainage system costs are summarized for each outfall in the study area in **Section 5**.

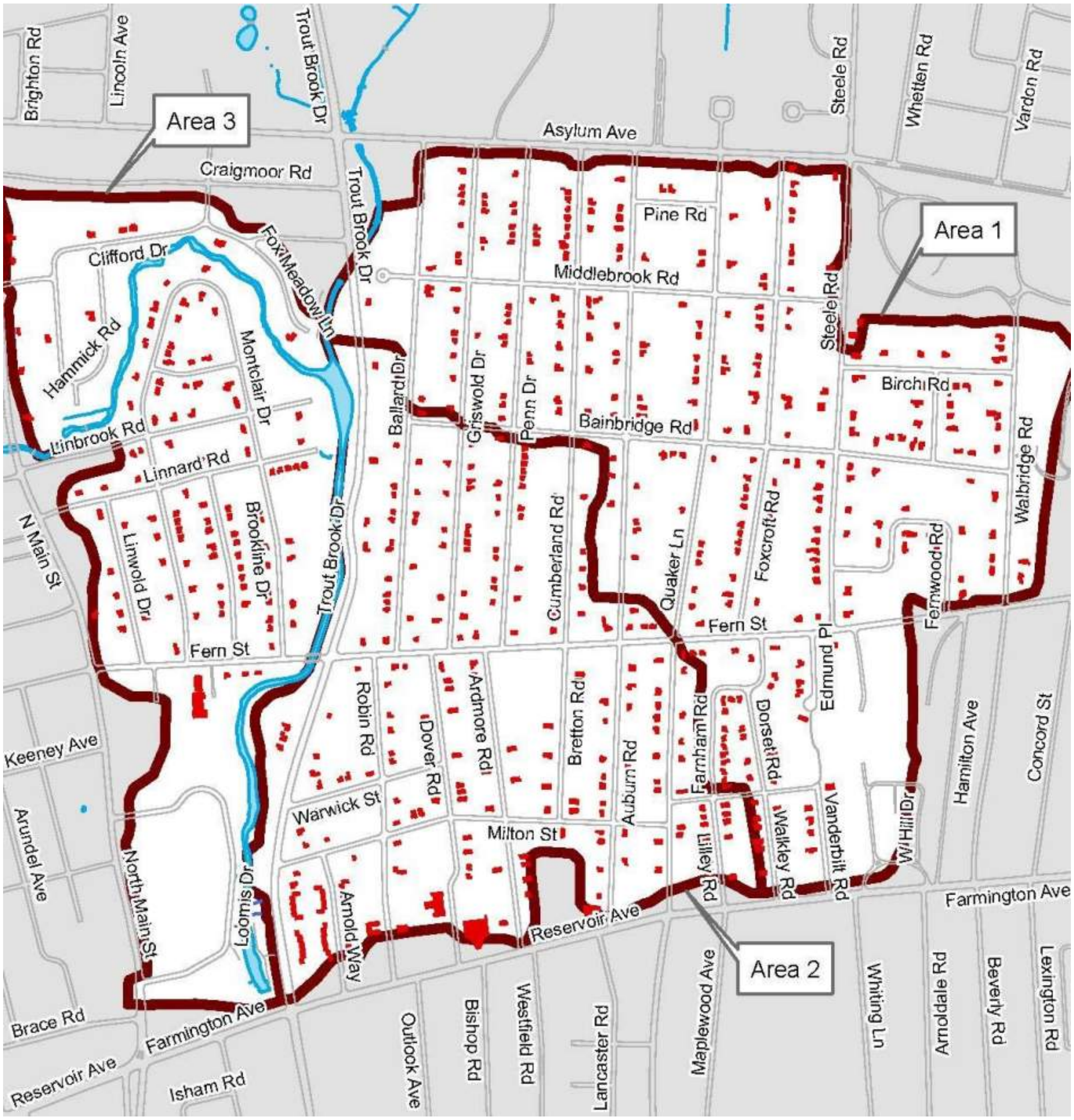


Figure 3-26: Private Inflow Removal Buildings in Study Area

Section 4 - Summary and Recommended Improvements

This section presents recommended drainage system improvements to mitigate flooding during the 10-year design storm. All alternatives consider redirecting foundation drains and sump pump discharges from the MDC sewer system to the Town's drainage system using the calibrated representation of infiltration/inflow in the MDC sewer model.

4.1 Prioritization of Drainage Improvements

The existing conditions evaluation described in Section 3 shows capacity constraints within most drainage systems in Areas 1, 2, and 3. While the NRCS Type III design storm was used to evaluate existing pipe capacity and to size the recommended preliminary drainage system design, this design storm is conservative and may overestimate the likelihood of flooding especially during smaller more frequent storm events. Therefore, recommended improvements were prioritized using the Town's records of flooding during Hurricane Irene and Tropical Storm Lee and during the storm events that occurred in April and September 2018 and August 2019. The following describes the tiers that were developed to prioritize improvements based on drainage system capacity deficiencies:

- *Tier 1 - High Priority*: These drainage areas include systems that had reported flooding complaints, flooded during Hurricane Irene and Tropical Storm Lee, flooded during the large storm events in April and September 2018, and August 2019; and predicted to flood in the design storm. The High priority drainage recommendations were subdivided into three sub-tiers. All three tiers are classified as high priority, but sub-tiers were created to assist with prioritization if funding is limited. The sub-tiers for Tier 1 are based on capacity differences and did not take into consideration constructability, phasing or logistics. Tier 1A has more existing capacity limitations than Tier 1B, and Tier 1B has more existing capacity limitations than Tier 1C. Once projects are identified to move forward to final design and construction, projects should be selected by the Town so that downstream projects are constructed before projects in upstream areas.
    - Tier 1A: areas with documented flooding during historical events, including the documented flooding event records from the Town.
    - Tier 1B: areas with reported flooding related to high groundwater elevations, so a more detailed groundwater study is recommended for this area.
    - Tier 1C: areas that have a record of reported flooding during the historical events in 2018 and 2019 with modeled flooding during Irene/Lee and during the 10-year design storm.
- *Tier 2 - Moderate Priority*: These areas include systems that the model predicted flooding during Hurricane Irene/Tropical Storm Lee, but no documented or modeled flooding occurred during the historical storm events in 2018 and 2019.

- *Tier 3 – Low Priority*: These areas include systems that the model predicts flooding during the NRCS design storm 10-year 24-hour design storm, but the Town does not have a record of reported flooding during Hurricane Irene/Tropical Storm Lee or during the historical storm events in 2018 and 2019. Recommended improvements in these areas are likely not necessary and should be addressed last or if flooding occurs frequently in the future.

The model domain included all 21 outfalls and the main trunk line and key minor drainage systems tributary to those outfalls, emphasizing areas of known and documented historical flooding concerns. Drains not explicitly represented in the model are located away from the main trunk lines and do not contain any areas of documented flooding during Hurricane Irene/Tropical Storm Lee or during the historical storms in 2018 and 2019. Therefore, this study assumes that these small drainage systems tributary to the major drainage systems have adequate capacity for the 10-year event, and consequently no improvements are recommended.

The flow Chart in **Figure 4-1** illustrates the three recommended tiers.

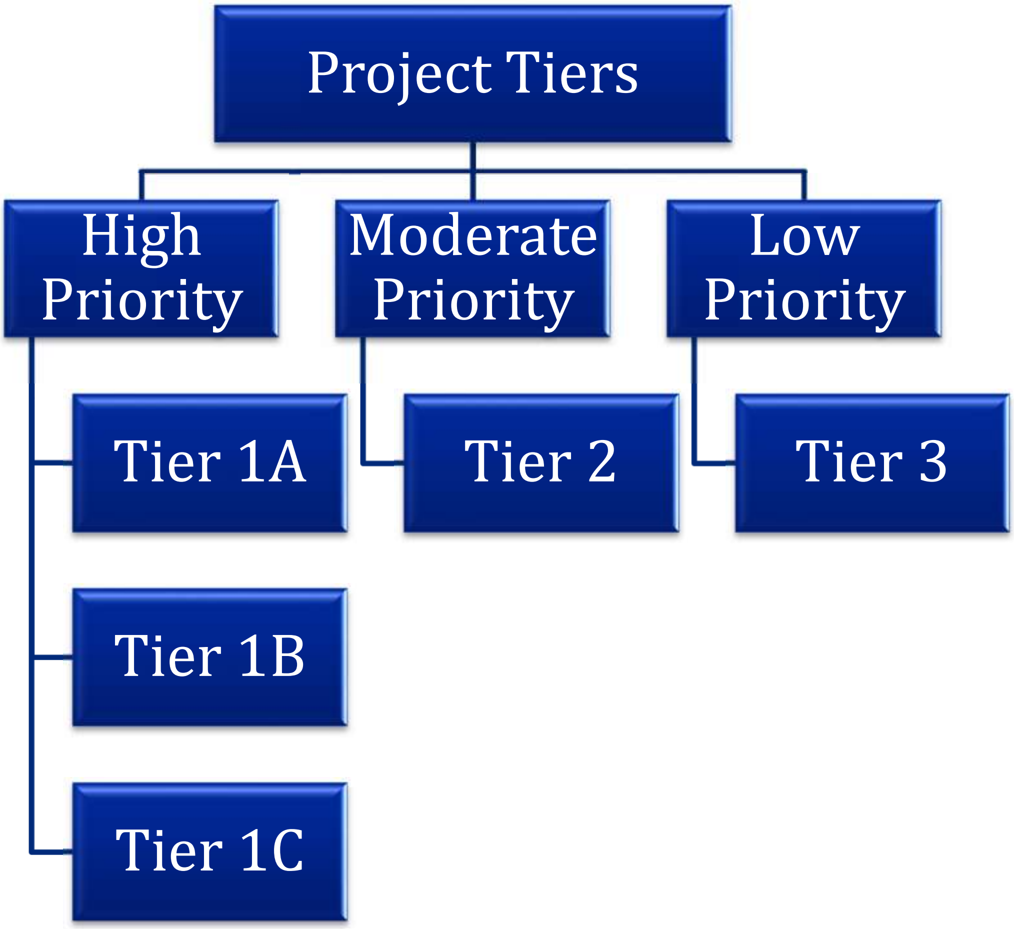


Figure 4-1: Recommended Prioritization of Drainage System Improvements Flow Chart

This section provides a brief discussion and prioritization of the recommended improvements for each outfall in the study area. The tier or tiers assigned to areas within each drainage system is presented in **Table 4-1.**

Table 4-1: Drainage Improvements - Prioritized Tiers

Area	Outfall	Location	Subarea in Outfall Drainage Area	Tier
Area1	**OF-5641-022**	FEAT Trunk Line	Bainbridge Road Area	
			Bainbridge Road and Walbridge Road	1A
			Birch Road and Chelsea Lane	1C
			Fernwood Road and Cross County	2
			Dorset Road	1A
			Fern Street - Middlebrook Road Area	1C
Area 2	**OF-5641-007**	Fern Street East	Penn Drive	1C
			Bretton Drive	1C
Area 2	**OF-5641-001**	Milton Street	Milton Street	2
Area 2	**OF-5641-12**	Ballard Drive	Ballard Drive	3
Area 3	**OF-3681-001**	Montclair Drive	Montclair Drive	1B
Area 3	**OF-0731-001**	Linbrook Road	Linbrook Road	3
Area 3	**OF-1981-009**	Fern Street West	Fern Street	2
Area 3	**OF-2547-001**	Clifford Road/Cross Country	Clifford Road/Cross-Country	2
Area 3	**OF-3261-001**	Linnard Road	Linnard Road	2
Area 3	**OF-1091-001**	Clifford Road	Clifford Road	3
Area 3	**OF-3321-002**	Loomis North	Loomis Drive North	3
Area 3	**OF-3321-003**	Loomis Central	Loomis Drive Central	3
Area 3	**OF-3321-001**	Loomis South	Loomis Drive South	3

4.2 Recommended Drainage Improvements

Recommended improvements were developed for the 13 drainage systems that showed flooding during the design storm and/or historical events. The following summarizes the analysis and recommendations for each outfall.

4.2.1 Area 1 – FEAT Trunk Line (OF-5641-002)

This system carries stormwater runoff from the entire 270-acre area and drains to Trout Brook through a 48-inch outfall. There are historical flooding problems in this area, documented during Hurricane Irene/Tropical Storm Lee, as well as during the storm events in April and September 2018 and in August 2019. Under existing conditions, the model predicts that the trunk line is undersized during the 10-year, 24-hour NRCS design storm.

Three different alternatives were developed for this area:

- *Alternative 1:* Replace existing under capacity pipes on the FEAT trunk line without adding relief pipes. (see discussion in the Fern-Middlebrook segment of the FEAT area).
- *Alternative 2:* Add a pipe extension from the end of the existing system on Middlebrook Road (before the system turns north) down Middlebrook Road to Trout Brook. This alternative was developed to provide hydraulic relief caused by head losses around a sequence of 90-degree bends in the cross-country section of the existing FEAT system.

- *Alternative 3:* In addition to a pipe extension on Middlebrook Road, add a 12-inch relief pipe on Fern Street to connect Area 1 and Area 2 (see discussion in Dorset Road segment).

These alternatives and recommendations will be discussed in each subdivision of the FEAT study area (Bainbridge Road, Dorset Road, and Fern-Middlebrook Street).

Bainbridge Road

Recommended replacement pipes to reduce flooding along the Bainbridge Road section of the FEAT trunk line are summarized in **Table 4-2** and identified in **Figure 4-2.**

Table 4-2: Hydraulic Improvements in Bainbridge Road Segment

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Bainbridge Road	MH-0221-004	MH-2176-009	24	48	462
Bainbridge Road	MH-0221-005	MH-0221-004	24	36	170
Bainbridge Road	MH-0221-008	MH-0221-005	24	36	402
Cross-Country	MH-2031-002	MH-0221-008	15	24	408
Fernwood Road	MH-2031-003	MH-2031-002	12	18	208
Fernwood Road	MH-2031-005	MH-2031-003	12	18	56
Bainbridge Road	MH-0221-009	MH-0221-008	24	36	94
Chelsea Lane	MH-1001-001	MH-0221-009	15	30	179
Chelsea Lane	MH-1001-002	MH-1001-001	15	24	130
Chelsea Lane	MH-1000-004	MH-1001-002	15	24	313
Birch Road	MH-0421-001	MH-1000-004	10	15	250
Bainbridge Road	MH-0221-010	MH-0221-009	18	36	259
Bainbridge Road	MH-0221-011	MH-0221-010	15	36	249
Walbridge Road South	MH-5811-004	MH-0221-011	12	18	464
Walbridge Road North	MH-5811-005	MH-0221-011	15	24	454
Walbridge Road North	MH-0421-003	MH-5811-005	15	24	210

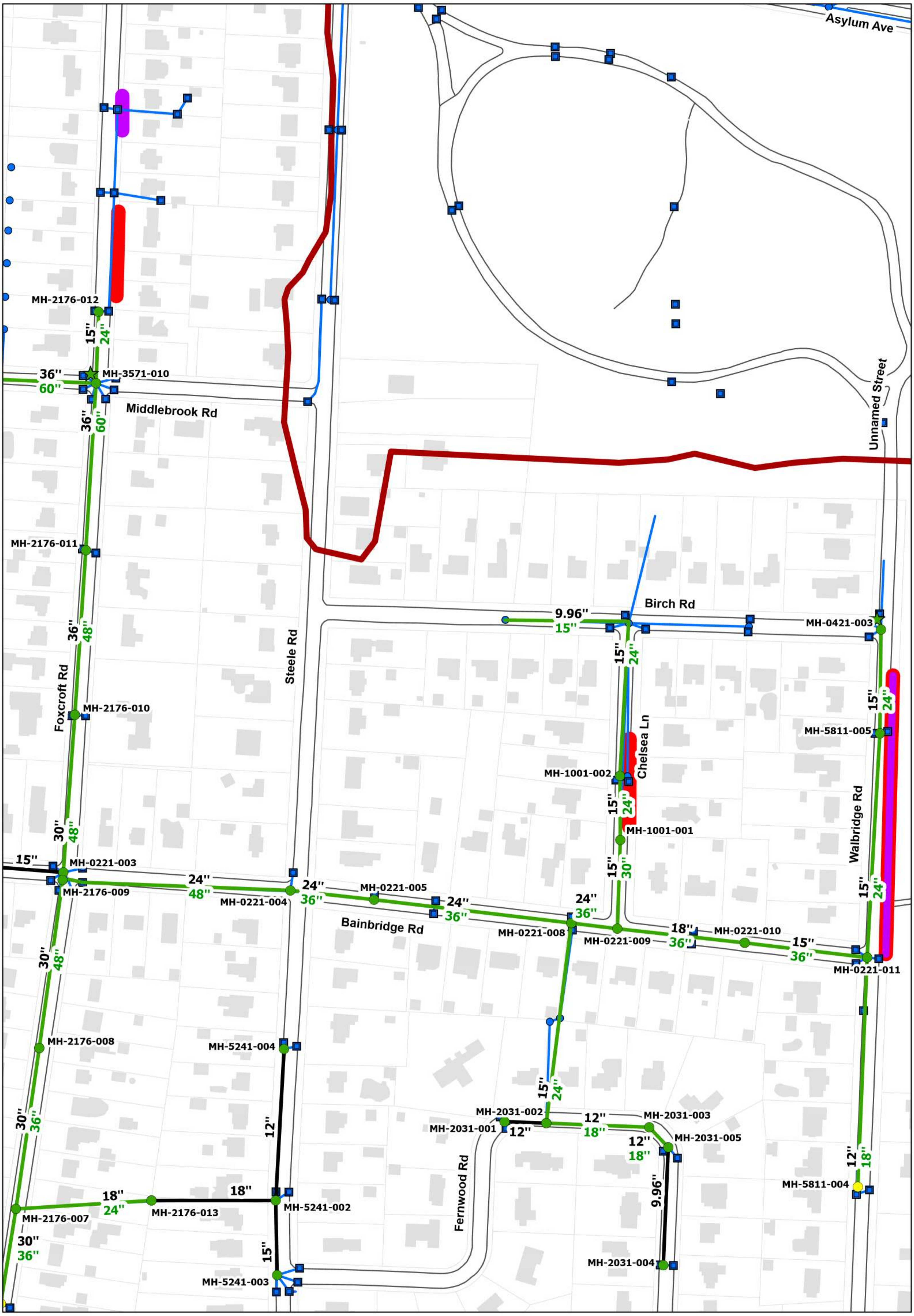
Dorset Road

Two alternative configurations were evaluated for the Dorset Road segment of the FEAT area. The first alternative (Alternative 1) involves replacement pipes for under capacity pipes. The second alternative involves the addition of a diversion relief pipe on Fern Street to connect Areas 1 and 2 (Alternative 3). **Figure 4-3** presents the recommended configuration for Alternative 1 and **Figure 4-4** presents the recommended configuration for Alternative 3.

Due to the relatively small drainage area upstream of the proposed diversion relief in Area 2, the diversion does not divert enough flow to have a significant impact on upstream flooding. Therefore, Alternative 1 (no relief pipe) is recommended for this segment. The recommended pipe improvements for Alternative 1 are shown in **Table 4-3**. The only pipe that requires improvements in this area is located on Farnham Road.

Table 4-3: Hydraulic Improvements in the Dorset Road Segment

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Farnham Road at Dorset	MH-1911-004	MH-1911-006	18	24	179



CDM Smith

Legend

- ● Modeled Surcharged Manhole - HGL within 1 foot of Grade
- ● Modeled Flow Remains in System
- ▬ Modeled Proposed Diameter Change
- ▬ Existing Modeled Storm Pipe
- ▬ GIS Storm Pipe
- ▪ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding

- 🟪 April 17, 2018
- 🟥 September 12, 2018
- ▬ Both Dates
- ★ August 7, 2019
- **18"** Existing Pipe Diameter
- **24"** Proposed Pipe Diameter

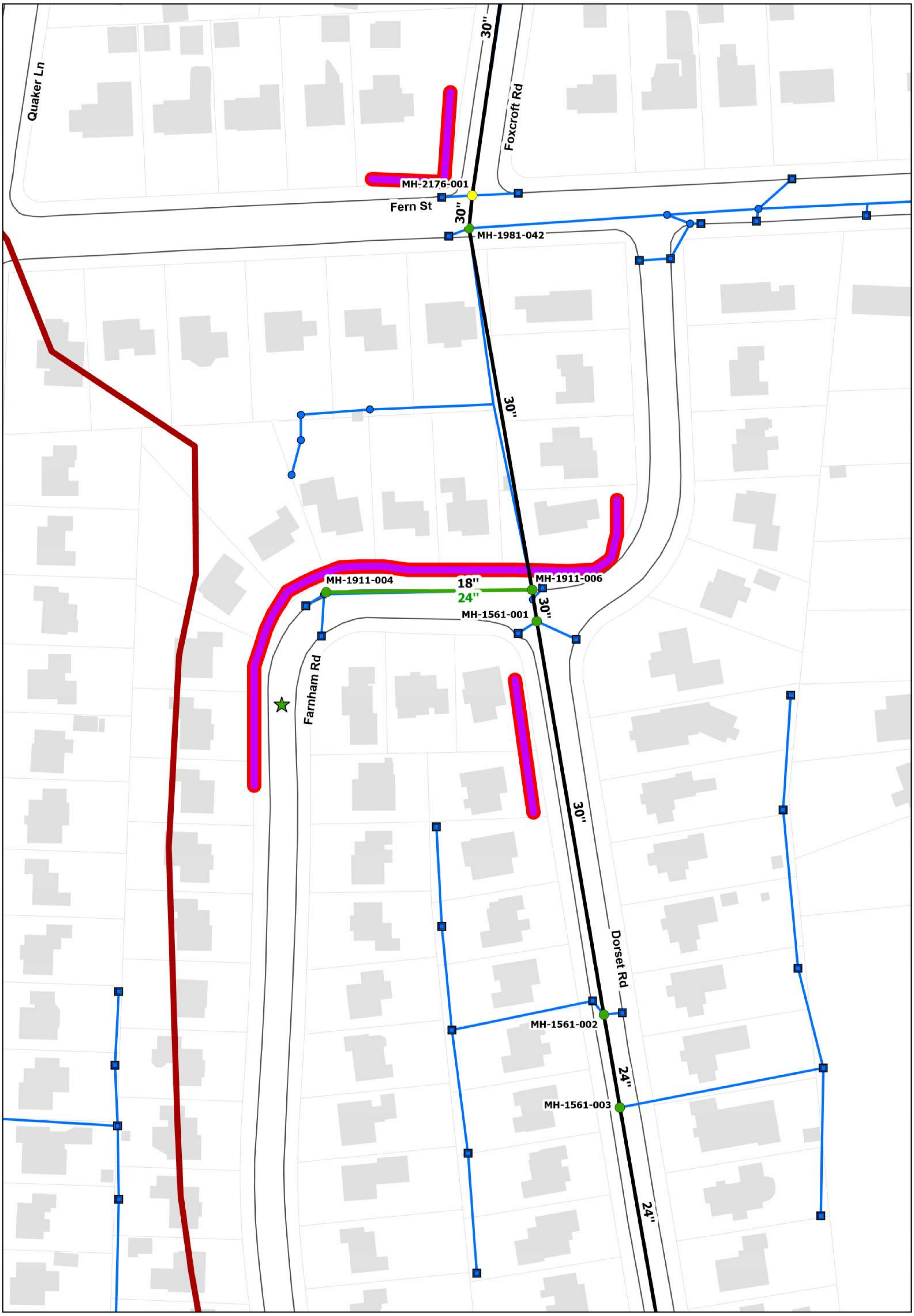
Scale

1 inch = 175 feet

0 87.5 175 Feet

N

Figure 4-2
Proposed Improvements: Bainbridge Road
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020



CDM Smith

Legend

- ● Modeled Surcharged Manhole - HGL within 1 foot of Grade
- ● Modeled Flow Remains in System
- ━ Modeled Proposed Diameter Change
- ━ Existing Modeled Storm Pipe
- ━ GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding

- 🟪 Both Dates
- ★ August 7, 2019
- **18"** Existing Pipe Diameter
- **24"** Proposed Pipe Diameter

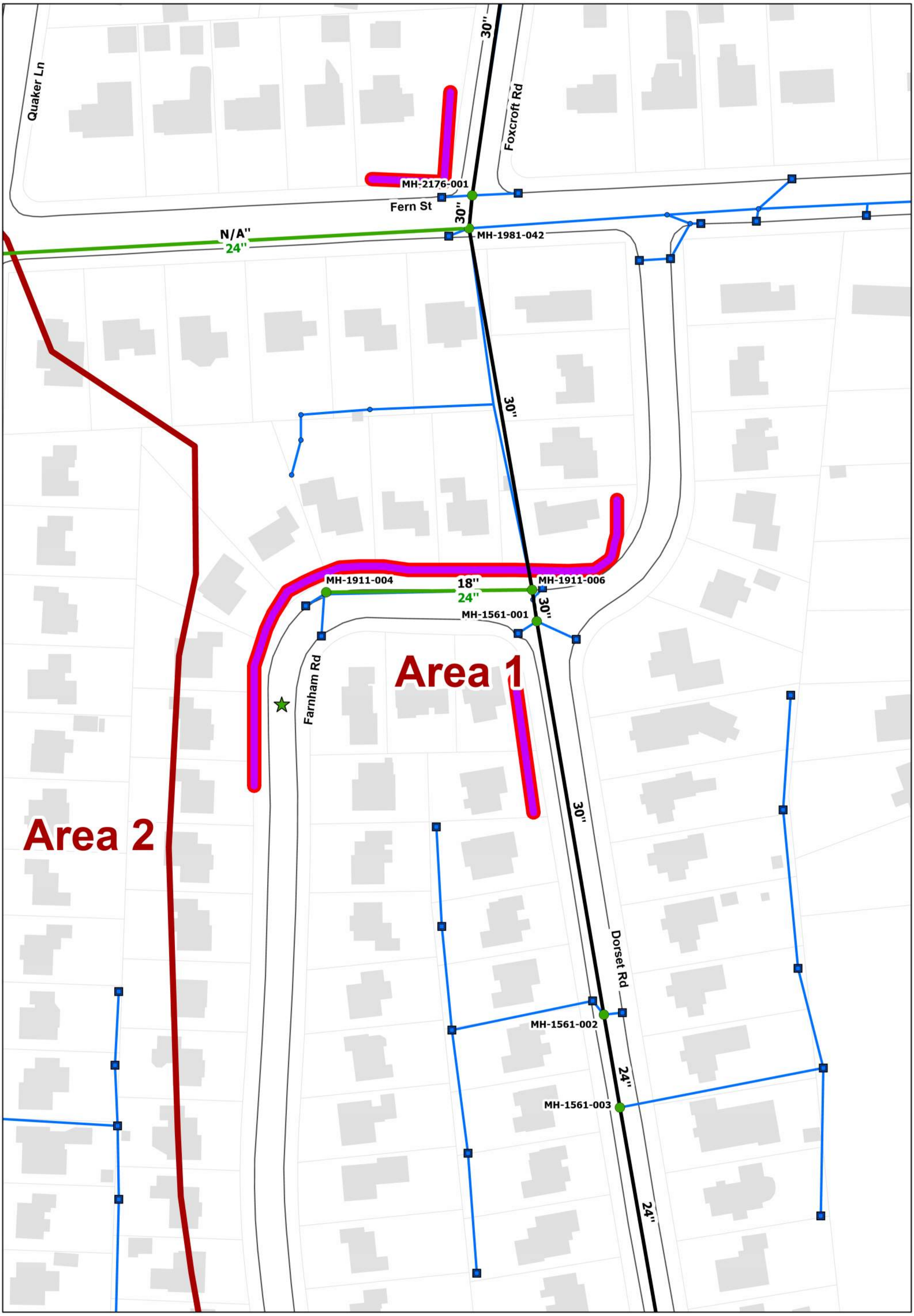
Scale

1 inch = 75 feet

N

0 37.5 75 Feet

Figure 4-3
Proposed Improvements: Dorset Road
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020



CDM Smith

Legend

- ● Modeled Flow Remains in System
- ▬ Modeled Proposed Diameter Change
- ▬ Modeled Existing Storm Pipe
- ― GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding

- ▬ Both Dates
- ★ August 7, 2019

18" Existing Pipe Diameter

24" Proposed Pipe Diameter

Scale

N

1 inch = 75 feet

0 37.5 75 Feet

Figure 4-4

Proposed Improvements: Dorset Road

Alternative 3

Drainage System Evaluations - Trout Brook Watershed

Town of West Hartford, Connecticut

March 2020

Fern Street-Middlebrook Road Section

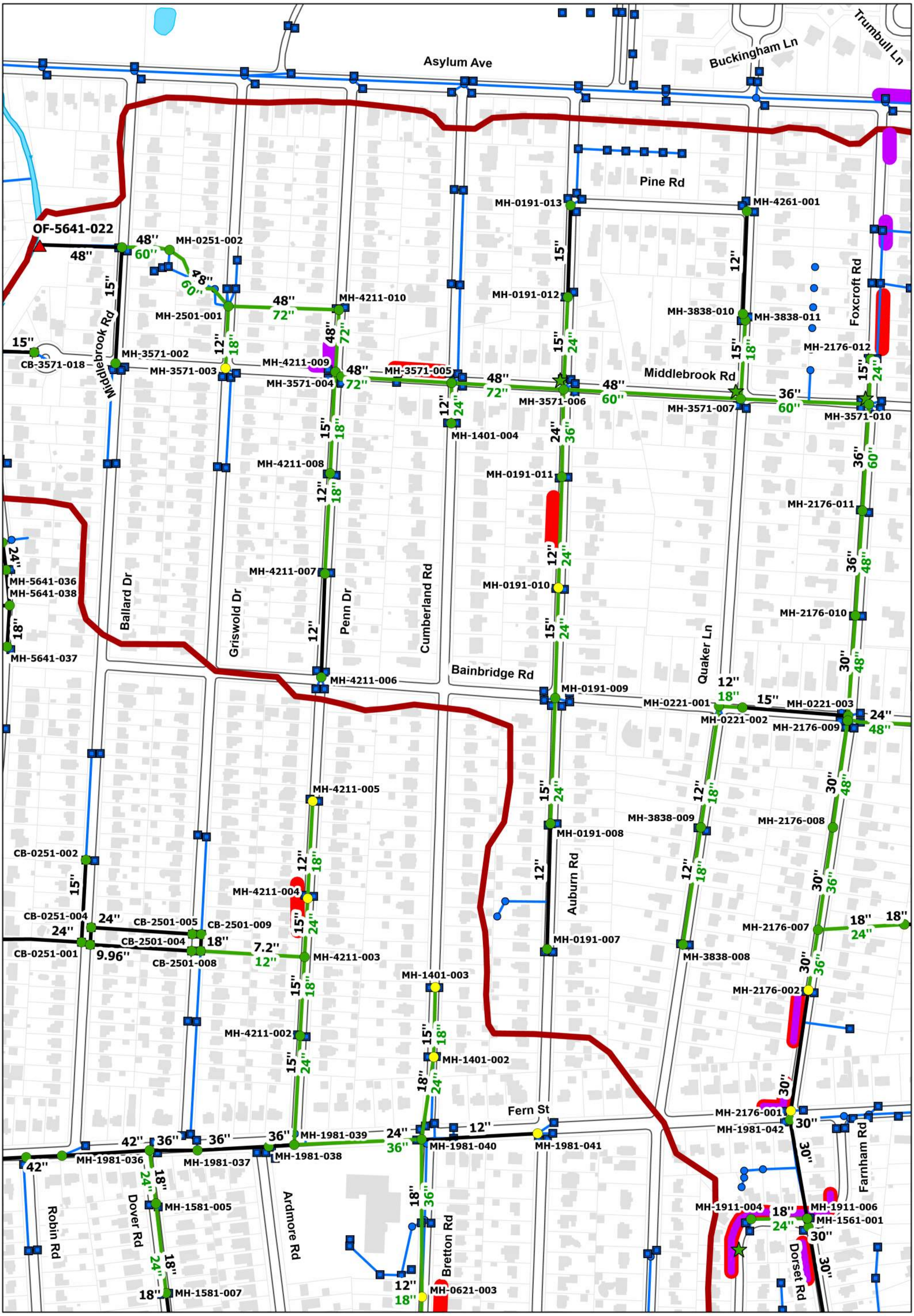
Two alternatives for this section of the FEAT area were evaluated:

- *Alternative 1:* Replace existing under capacity pipes as needed on the FEAT trunk line without adding any relief pipes.
- *Alternative 2:* A pipe extension from the end of the existing system on Middlebrook Road (before the system turns north) down to Trout Brook with replacement of existing under capacity pipes as needed.

Table 4-4 and **Figure 4-5** summarize proposed improvements for Alternative 1 and **Table 4-5** and **Figure 4-6** summarize proposed improvements for Alternative 2.

Table 4-4: Hydraulic Improvements in Fern Street – Middlebrook Road Segment (Alternative 1)

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Cross-Country	MH-0251-002	MH-0251-001	48	60	153
Cross-Country	MH-2501-001	MH-0251-002	48	60	277
Griswold Drive	MH-3571-003	MH-2501-001	12	18	197
Cross-Country	MH-4211-010	MH-2501-001	48	72	352
Penn Drive	MH-4211-009	MH-4211-010	48	72	197
Penn Drive	MH-4211-008	MH-4211-009	15	18	324
Penn Drive	MH-4211-007	MH-4211-008	12	18	320
Middlebrook Road	MH-3571-004	MH-4211-009	48	72	24
Middlebrook Road	MH-3571-005	MH-3571-004	48	72	350
Cumberland Road/Middlebrook Rd	MH-1401-004	MH-3571-005	12	24	129
Middlebrook Road	MH-3571-006	MH-3571-005	48	72	357
Auburn Road North/Middlebrook Rd	MH-0191-012	MH-3571-006	15	24	294
Auburn Road South/Middlebrook Rd	MH-0191-011	MH-3571-006	24	36	278
Auburn Road South/Middlebrook Rd	MH-0191-010	MH-0191-011	12	24	353
Auburn Road South/Middlebrook Rd	MH-0191-009	MH-0191-010	15	24	351
Auburn Road South/Middlebrook Rd	MH-0191-008	MH-0191-009	15	24	400
Middlebrook Road	MH-3571-007	MH-3571-006	48	60	564
Quaker Lane North/Middlebrook Rd	MH-3838-011	MH-3571-007	15	18	250
Quaker Lane North/Middlebrook Rd	MH-3838-010	MH-3838-011	12	18	22
Middlebrook Road	MH-3571-010	MH-3571-007	36	60	408
Foxcroft Road North/Middlebrook Rd	MH-2176-012	MH-3571-010	15	24	144
Foxcroft Road South	MH-2176-011	MH-3571-010	36	60	339
Foxcroft Road South	MH-2176-010	MH-2176-011	36	48	334
Foxcroft Road South	MH-0221-003	MH-2176-010	30	48	320
Foxcroft Road South	MH-2176-009	MH-0221-003	30	48	15
Foxcroft Road South	MH-2176-008	MH-2176-009	30	48	343
Foxcroft Road South	MH-2176-007	MH-2176-008	30	36	329
Foxcroft Road South	MH-2176-002	MH-2176-007	30	36	194
Steele Road/ Cross-Country	MH-2176-013	MH-2176-007	18	24	275
Quaker Lane at Bainbridge Road	MH-0221-001	MH-0221-002	12	18	75
Quaker Lane South/Bainbridge Road	MH-3838-009	MH-0221-001	12	18	390
Quaker Lane South/Bainbridge Road	MH-3838-008	MH-3838-009	12	18	377



CDM Smith

Legend

- ● Modeled Surcharged Manhole - HGL within 1 foot of Grade
- ● Modeled Flow Remains in System
- ▲ Outfalls
- ━ Modeled Proposed Diameter Change
- ━ Existing Modeled Storm Pipe
- ━ GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding

- 🟪 April 17, 2018
- 🟥 September 12, 2018
- 🟥 Both Dates
- ★ August 7, 2019
- **18"** Existing Pipe Diameter
- **24"** Proposed Pipe Diameter

Scale

1 inch = 275 feet

N

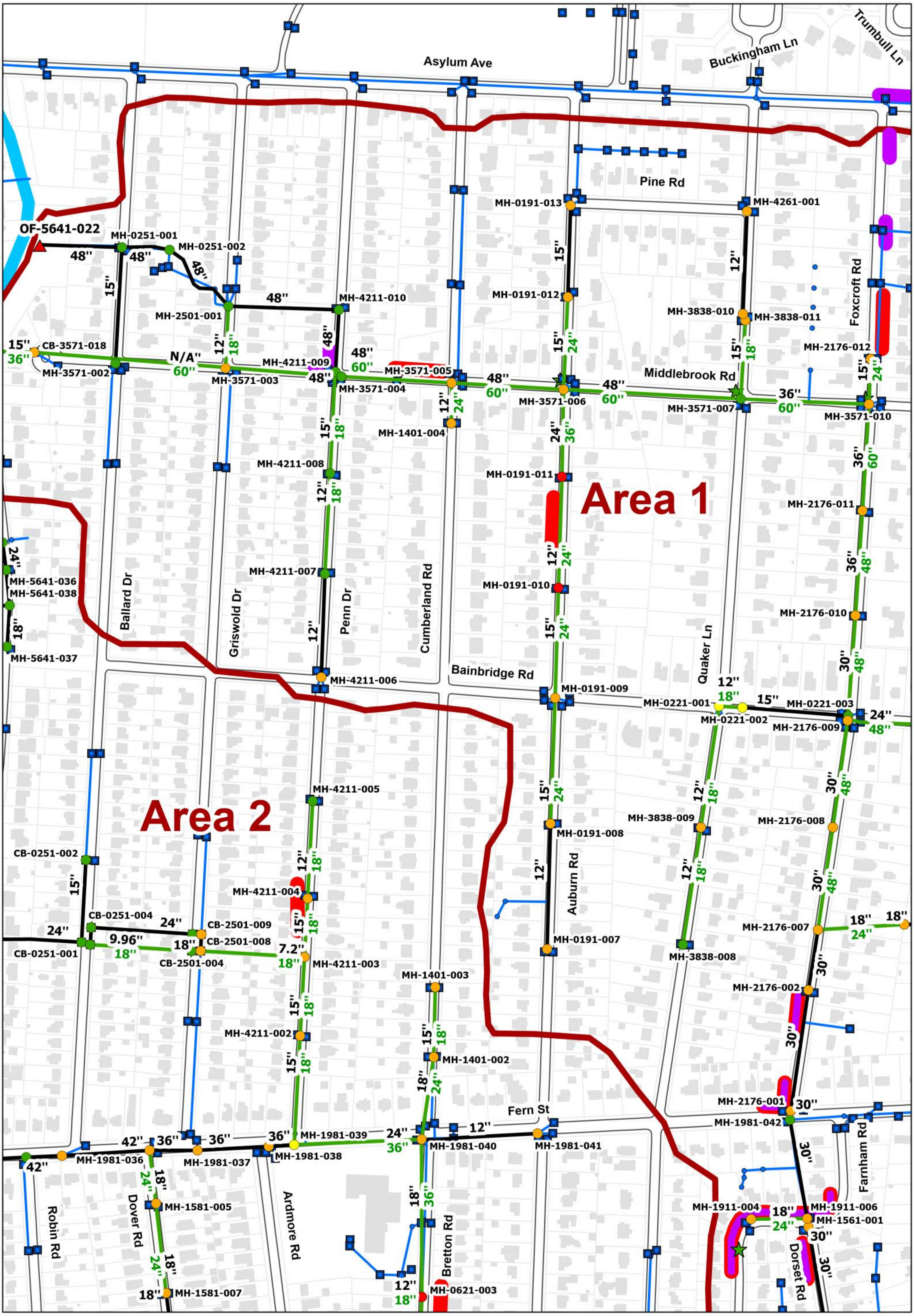
0 137.5 275 Feet

Figure 4-5
Proposed Improvements: Fern-Middlebrook
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

Table 4-5: Hydraulic Improvements in Fern Street – Middlebrook Road Segment (Alternative 2)

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Cross-Country	CB-3571-018	OF-5641-017	15	60	191
Middlebrook Road	MH-3571-002	CB-3571-018	N/A	60	247
Middlebrook Road	MH-3571-003	MH-3571-002	N/A	60	366
Middlebrook Road	MH-3571-009	MH-3571-003	N/A	60	343
Griswold Drive	MH-3571-003	MH-2501-001	12	18	197
Middlebrook Road	MH-3571-004	MH-3571-009	48	60	24
Penn Drive	MH-4211-008	MH-4211-009	15	18	324
Penn Drive	MH-4211-007	MH-4211-008	12	18	320
Middlebrook Road	MH-3571-005	MH-3571-004	48	60	350
Cumberland Road/Middlebrook Rd	MH-1401-004	MH-3571-005	12	24	129
Middlebrook Road	MH-3571-006	MH-3571-005	48	60	357
Auburn Road North/Middlebrook Rd	MH-0191-012	MH-3571-006	15	24	294
Auburn Road South/Middlebrook Rd	MH-0191-011	MH-3571-006	24	36	278
Auburn Road South/Middlebrook Rd	MH-0191-009	MH-0191-010	15	24	351
Auburn Road South/Middlebrook Rd	MH-0191-010	MH-0191-011	12	24	353
Auburn Road South/Middlebrook Rd	MH-0191-008	MH-0191-009	15	24	400
Middlebrook Road	MH-3571-007	MH-3571-006	48	60	564
Quaker Lane North/Middlebrook Rd	MH-3838-011	MH-3571-007	15	18	250
Quaker Lane North/Middlebrook Rd	MH-3838-010	MH-3838-011	12	18	22
Middlebrook Road	MH-3571-010	MH-3571-007	36	60	408
Foxcroft Road North/Middlebrook Rd	MH-2176-012	MH-3571-010	15	24	144
Foxcroft Road South	MH-2176-011	MH-3571-010	36	60	339
Foxcroft Road South	MH-2176-010	MH-2176-011	36	48	334
Foxcroft Road South	MH-0221-003	MH-2176-010	30	48	320
Foxcroft Road South	MH-2176-009	MH-0221-003	30	48	15
Foxcroft Road South	MH-2176-008	MH-2176-009	30	48	343
Foxcroft Road South	MH-2176-007	MH-2176-008	30	48	329
Quaker Lane at Bainbridge Road	MH-0221-001	MH-0221-002	12	18	75
Quaker Lane South/Bainbridge Rd	MH-3838-009	MH-0221-001	12	18	390
Quaker Lane South/Bainbridge Rd	MH-3838-008	MH-3838-009	12	18	377

Based on the model results and constructability concerns related to replacement pipes in the cross-country section at the downstream end of the FEAT area, an additional relief pipe should be added down Middlebrook Road (Alternative 2). This configuration allows the existing cross-country segment to remain at its current size. Therefore, Alternative 2 is preferred over Alternative 1.



Legend

- ● Modeled Surcharged Manhole - HGL greater than 6 feet Below Grade
- ● Modeled Flow Remains in System
- ▲ Outfalls
- ▬ Modeled Proposed Diameter Change
- ▬ Modeled Existing Storm Pipe
- ▬ GIS Storm Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas

Flooding

- 🟪 April 17, 2018
- 🟥 September 12, 2018
- 🟥 Both Dates
- ★ August 7, 2019

18" Existing Pipe Diameter

24" Proposed Pipe Diameter

Scale

1 inch = 275 feet

0 137.5 275 Feet

N

CDM Smith

Figure 4-6
Proposed Improvements: Fern-Middlebrook
Alternative 2
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

Recommended Solution

In general, the recommended FEAT trunk line capacity improvements are comprised of pipe upsizing. Based on the model results and constructability concerns related to replacement pipes in the cross-country section at the downstream end of the FEAT area, an additional relief pipe should be added down Middlebrook Road, allowing the existing cross-country segment to remain at its current size. The relief pipe on Fern Street alternative does not have a significant flood reduction impact because the upstream drainage area is relatively small. Construction of the relief pipe does not yield significant flood reduction benefits on downstream portions of the FEAT trunk line. It should be noted that both alternatives have increased slopes in the downstream reaches therefore providing increased hydraulic capacity, requiring a smaller pipe then an upstream reach. These pipe segments will need to be revisited during final design and could be modified based on site constraints (i.e. utility conflicts, subsurface conditions, etc.) or costs.

4.2.2. Area 2 - Milton Street and Fern Street Area

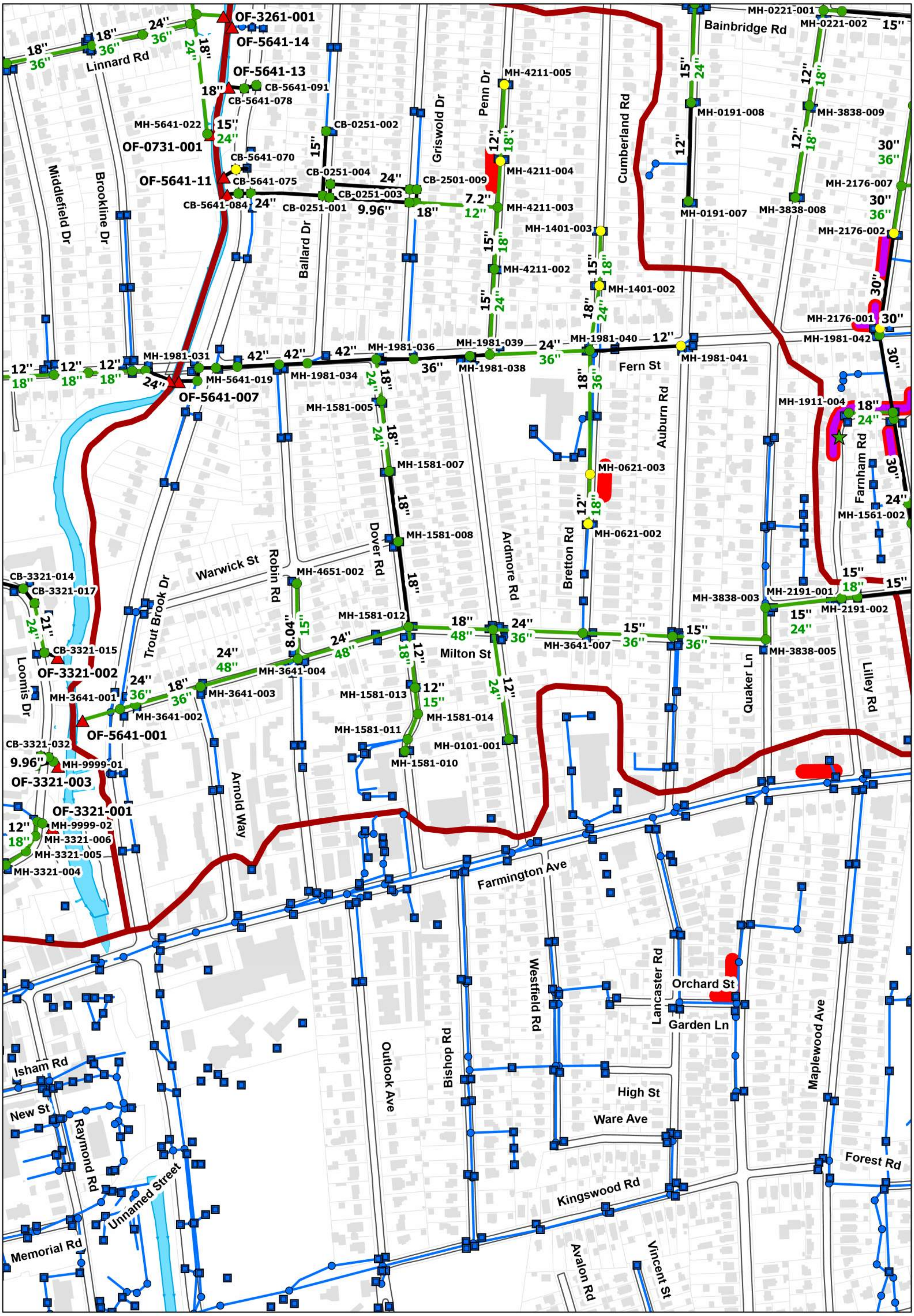
The Milton Street and Fern Street Area (Area 2) includes recommendations for three drainage systems: Milton Street (OF-5641-001), Fern Street (OF-5641-007) and Ballard Drive (OF- 5642-12. The following summarizes the analysis and recommendations within each system.

Milton Street (OF-5641-001)

The Milton Street system is the second largest system in the study area and the largest system within Area 2. The total contributing area is 81 acres. This system consists of 19 pipes ranging in diameter from 10 to 24 inches. There is one diversion with the Fern Street system on Dover Road that serves as a relief pipe during storms. Pipes recommended for replacement are summarized in **Table 4-6** and identified in **Figure 4-7**.

Table 4-6: Hydraulic Improvements in Milton Street

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Milton Street	MH-3641-001	OF-5641-001	24	36	157
Milton Street	MH-3641-002	MH-3641-001	24	36	65
Milton Street	MH-3641-003	MH-3641-002	18	36	273
Milton Street	MH-3641-004	MH-3641-003	24	48	410
Robin Road	MH-4651-002	MH-3641-004	8	15	304
Milton Street	MH-1581-012	MH-3641-004	24	48	466
Dover Road	MH-1581-013	MH-1581-012	12	18	248
Dover Road	MH-1581-014	MH-1581-013	12	15	106
Dover Road	MH-1581-011	MH-1581-014	12	15	111
Dover Road	MH-1581-010	MH-1581-011	10	12	49
Milton Street	MH-3641-006	MH-1581-012	18	48	341
Ardmore Road	MH-0101-001	MH-3641-006	12	24	447
Milton Street	MH-3641-007	MH-3641-006	24	36	364
Milton Street	MH-3641-008	MH-3641-007	15	36	363
Milton Street	MH-3838-005	MH-3641-008	15	36	378
Quaker Lane	MH-3838-003	MH-3838-005	15	36	130
Frederick Road	MH-2191-001	MH-3838-003	15	24	310
Frederick Road	MH-2191-002	MH-2191-001	15	18	64



Legend
● Modeled Surcharged Manhole - HGL within 1 foot of Grade
● Modeled Flow Remains in System
▲ Outfalls
Modeled Proposed Diameter Change
Existing Modeled Storm Pipe
GIS Storm Pipe
■ GIS Catch Basins
● GIS Manholes
☐ Study Areas
Flooding
🟥 September 12, 2018
Both Dates
★ August 7, 2019
18" Existing Pipe Diameter
24" Proposed Pipe Diameter

Scale

1 inch = 350 feet

0 175 350 Feet

N

CDM Smith

Figure 4-7
Proposed Improvements: Milton Street
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

It should be noted that the Milton Street system has increased slopes in the downstream reaches therefore providing increased hydraulic capacity, requiring a smaller pipe then an upstream reach. These pipe segments will need to be revisited during final design and could be modified based on site constraints (i.e. utility conflicts, subsurface conditions, etc.) or costs.

Fern Street East (OF-5641-007)

The Fern Street System is located east of Trout Brook, in the central part of the study area. The system consists of 24 pipe segments ranging in diameter from 12 to 42 inches. The total contributing area to the system is 68 acres. **Figure 4-7** and **Table 4-7** summarize recommended pipe improvements necessary to improve hydraulic capacity of the main trunk and lateral connections.

Table 4-7: Hydraulic Improvements in the Fern Street System (East of Trout Brook)

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Dover Road	MH-1581-005	MH-1981-036	18	24	170
Dover Road	MH-1581-007	MH-1581-005	18	24	287
Penn Drive	MH-4211-002	MH-1981-039	15	24	347
Penn Drive	MH-4211-003	MH-4211-002	15	18	251
Penn Drive	MH-4211-004	MH-4211-003	15	24	187
Penn Drive	MH-4211-005	MH-4211-004	12	18	310
Fern Street	MH-1981-040	MH-1981-039	24	36	405
Bretton Road North	MH-1401-002	MH-1981-040	18	24	264
Bretton Road North	MH-1401-003	MH-1401-002	15	18	222
Bretton Road South	MH-0621-002	MH-0621-003	12	18	201
Bretton Road South	MH-0621-003	MH-1981-040	18	36	502

Ballard Drive (OF-5641-12)

The Fern Street System and Ballard Drive system are interconnected via a 7-inch pipe that goes cross country between Penn Drive and Griswold Drive. This diversion provides some relief but could benefit the Fern Street system if upsized to a 12-inch pipe. **Table 4-8** summarize recommended pipe improvements necessary to improve hydraulic capacity of the Fern Street East main trunk and lateral connections.

Table 4-8: Hydraulic Improvements in the Ballard Drive System

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Cross-Country Penn Drive to Griswold Drive	MH-4211-003	CB-2501-008	7	12	331

4.2.3 Area 3 – East Branch of Trout Brook Confluence

Area 3 consists of eleven outfalls, nine of which show modeled flooding during the design storm and/or historical storm events. The following summarizes the analysis and recommendations for each drainage system.

Loomis Drive (Three Outfalls)

The Loomis Drive system consists of three individual systems with outfalls draining to Trout Brook: Loomis Drive North (OF-3321-002), South (OF-3321-001), and Central (OF-3321-003). The total contributing area to the three systems is 28 acres. The three systems are comprised of 15 pipes ranging in diameter from 7- to 24-inch. Pipe segments recommended for improvement are summarized in **Table 4-9** and shown in **Figure 4-8**.

Table 4-9: Hydraulic Improvements in Loomis Drive System

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Loomis Drive (South)	MH-3321-007	MH-9999-02	15	18	22
Loomis Drive (South)	MH-3321-006	MH-3321-007	15	18	59
Loomis Drive (South)	MH-3321-005	MH-3321-006	15	18	72
Loomis Drive (South)	MH-3321-004	MH-3321-005	12	18	100
Loomis Drive (Central)	MH-9999-01	OF-3321-003	10	12	26
Loomis Drive (Central)	CB-3321-032	CB-3321-033	10	18	33
Loomis Drive (North)	CB-3321-017	CB-3321-015	21	24	205

Fern Street West (OF-1981-009)

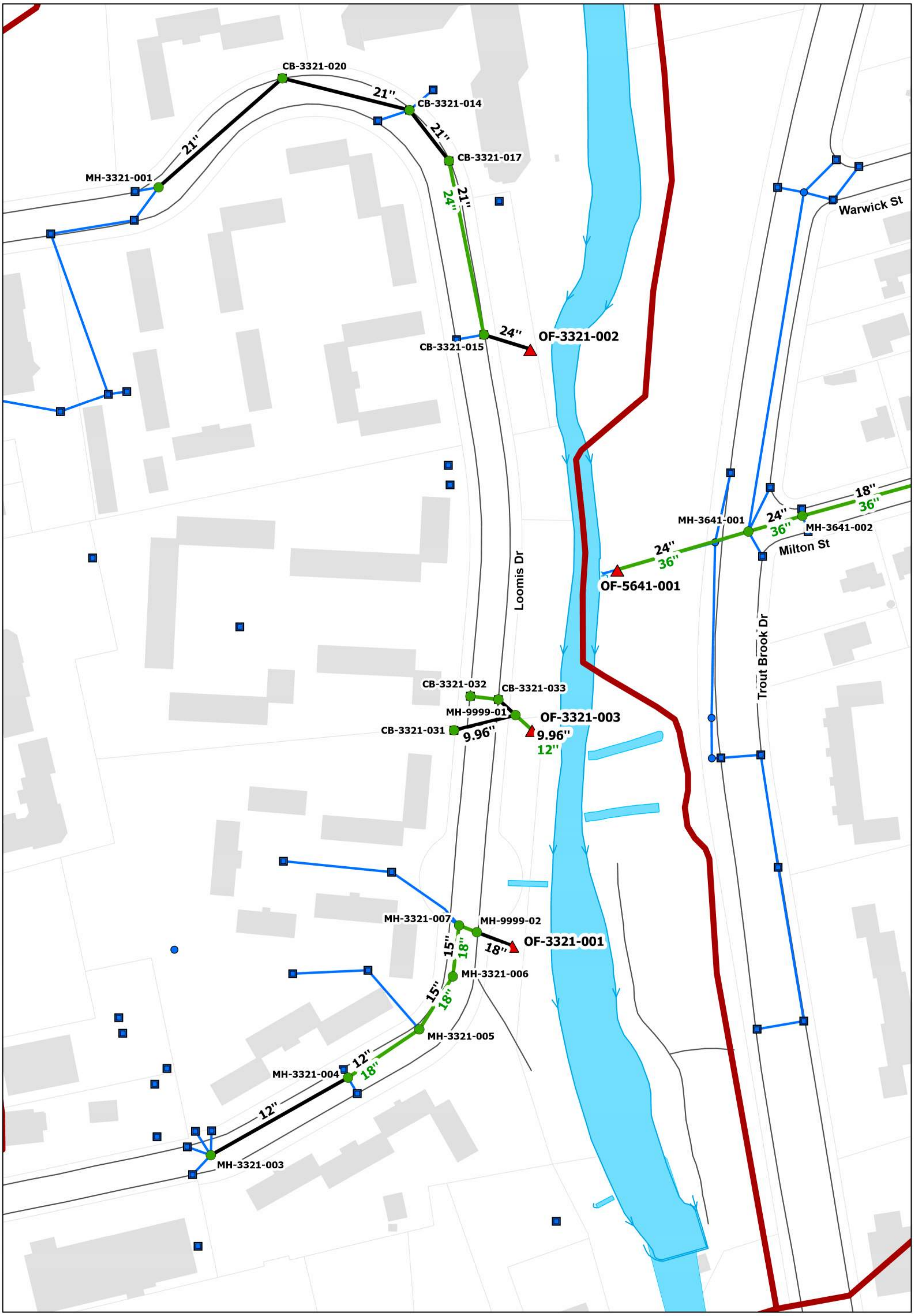
The Fern Street system is located West of Trout Book in Area 3. The system starts at the intersection of Linwold Drive and Fern Street, runs east for approximately 1,100 feet, and empties into Trout Brook. The total contributing area is 16 acres. The system consists of pipes ranging from 12- to 24-inches. Pipe segments recommended for improvement are summarized in **Table 4-10** and shown in **Figure 4-9**.

Table 4-10: Hydraulic Improvements in Fern Street West

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Fern Street West	MH-1981-029	MH-1981-030	12	24	54
Fern Street West	MH-1981-028	MH-1981-029	12	18	178
Fern Street West	MH-1981-027	MH-1981-028	12	18	138
Fern Street West	MH-1981-026	MH-1981-027	12	18	318

Linnard Road (OF-3261-001)

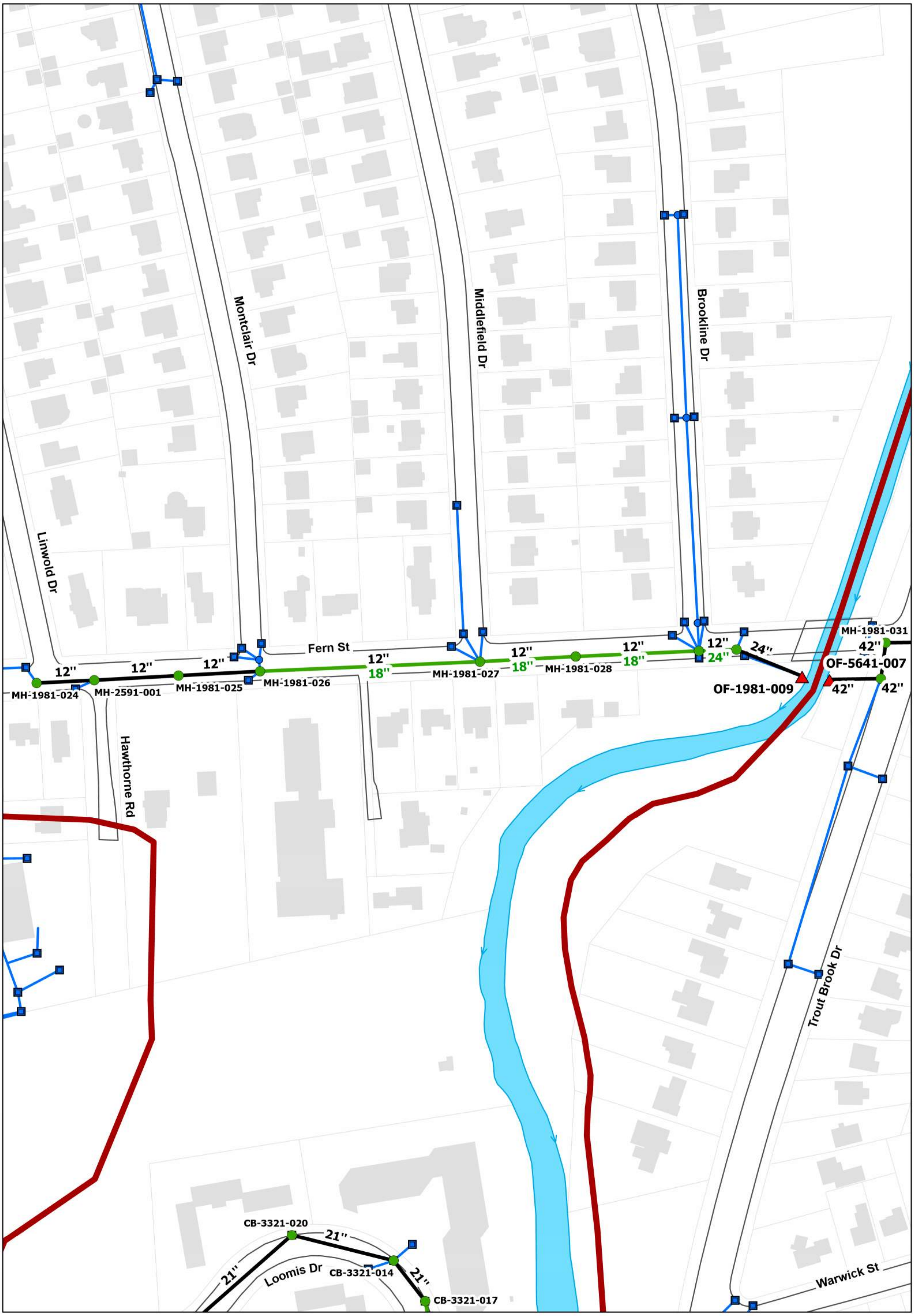
The Linnard Road system is located west of Trout Book in Area 3. The system starts at the intersection of Linwold Drive and Linnard Road, continues east for approximately 1,600 feet, and discharges to Trout Brook. The main trunk of the system consists of 8 pipes ranging from 12 to 24 inches. The total contributing area to the system is 57 acres. Recommended replacement pipes are summarized in **Table 4-11** and **Figure 4-10**.



Legend
● Modeled Flow Remains in System
▲ Outfalls
— Modeled Proposed Diameter Change
— Existing Modeled Storm Pipe
— GIS Storm Pipe
■ GIS Catch Basins
● GIS Manholes
▭ Study Areas
18" Existing Pipe Diameter
24" Proposed Pipe Diameter

Scale
N
1 inch = 100 feet
Feet
0 50 100

Figure 4-8
Proposed Improvements: Loomis Drive
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020



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Legend

- ● Modeled Flow Remains in System
- ▲ Outfalls
- ▬ Modeled Proposed Diameter Change
- ▬ Existing Modeled Storm Pipe
- ▬ GIS Storm Pipe
- ▪ GIS Catch Basins
- ● GIS Manholes
- ☐ Study Areas
- **18"** Existing Pipe Diameter
- **24"** Proposed Pipe Diameter

Scale

1 inch = 125 feet

0 62.5 125 Feet

N

Figure 4-9
Proposed Improvements: Fern Street West
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

Table 4-11: Hydraulic Improvements for Linnard Road System

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Linnard Road	MH-3261-007	OF-3261-001	24	36	108
Linnard Road	MH-3261-006	MH-3261-007	24	36	46
Linnard Road	MH-3261-005	MH-3261-006	24	36	199
Linnard Road	MH-0731-001	MH-3261-005	18	36	208
Linnard Road	MH-3261-004	MH-0731-001	18	36	354
Linnard Road	MH-3261-001	MH-3261-004	15	24	166
Linnard Road	MH-3681-001	MH-3261-001	15	24	181
Linnard Road	MH-3271-001	MH-3681-001	12	18	341

Linbrook Road Area: Montclair Drive, Clifford Drive and Montclair Drive (Six Outfalls)

Linbrook Road, Montclair Drive, Clifford Drive North, Clifford Drive/Cross Country, Hammick Road North, Hammick Road South and Fox Meadow Lane systems are located in the southern part of Area 3. The Linbrook system stretches from west to east on Linbrook Road and discharges to Trout Brook via a 778 feet long pipe going south in a perpendicular direction to the main trunk. The main trunk line consists of four pipe segments ranging from 12 to 18 inches. The total contributing watershed area is 27 acres. The Montclair Drive, Clifford Drive, Hammick Road, and Fox Meadow Lane stormwater systems are located along the West Branch of Trout Brook and all four systems discharge to Trout Brook. Each system consists of one and more pipe segments. The total contributing watershed area to these systems is 59 acres with pipe diameters ranging between 12 and 24 inches.

The recommended replacement pipes to improve hydraulic capacity and flooding due to stormwater are summarized in **Table 4-12** and shown in **Figure 4-10 (Section 4.6)**.

Table 4-12: Recommended Hydraulic Improvements for Linbrook Road Area Systems

Pipe Location	Inlet Manhole	Outlet Manhole	Existing Diameter (inches)	Recommended Diameter (inches)	Existing Length (feet)
Linbrook Road at Outfall	MH-5641-022	OF-0731-001	15	24	15
Linbrook Road/ Cross Country	MH-3231-004	MH-5641-022	18	24	778
Linbrook Road	MH-3681-005	MH-3231-004	15	18	433
Linbrook Road	MH-3231-002	MH-3681-005	12	18	345
Montclair Drive	MH-3681-003	OF-3681-001	12	24	211
Clifford Drive/ Cross-Country	CB-2547-001	OF-2547-001	15	24	131
Clifford Drive/ Cross-Country	CB-2547-002	CB-2547-001	15	24	28
Clifford Drive/ Cross-Country	CB-1091-008	CB-2547-002	15	24	275
Clifford Drive	CB-2171-001	CB-2171-006	18	24	75
Clifford Drive	CB-1091-014	CB-2171-001	18	24	144

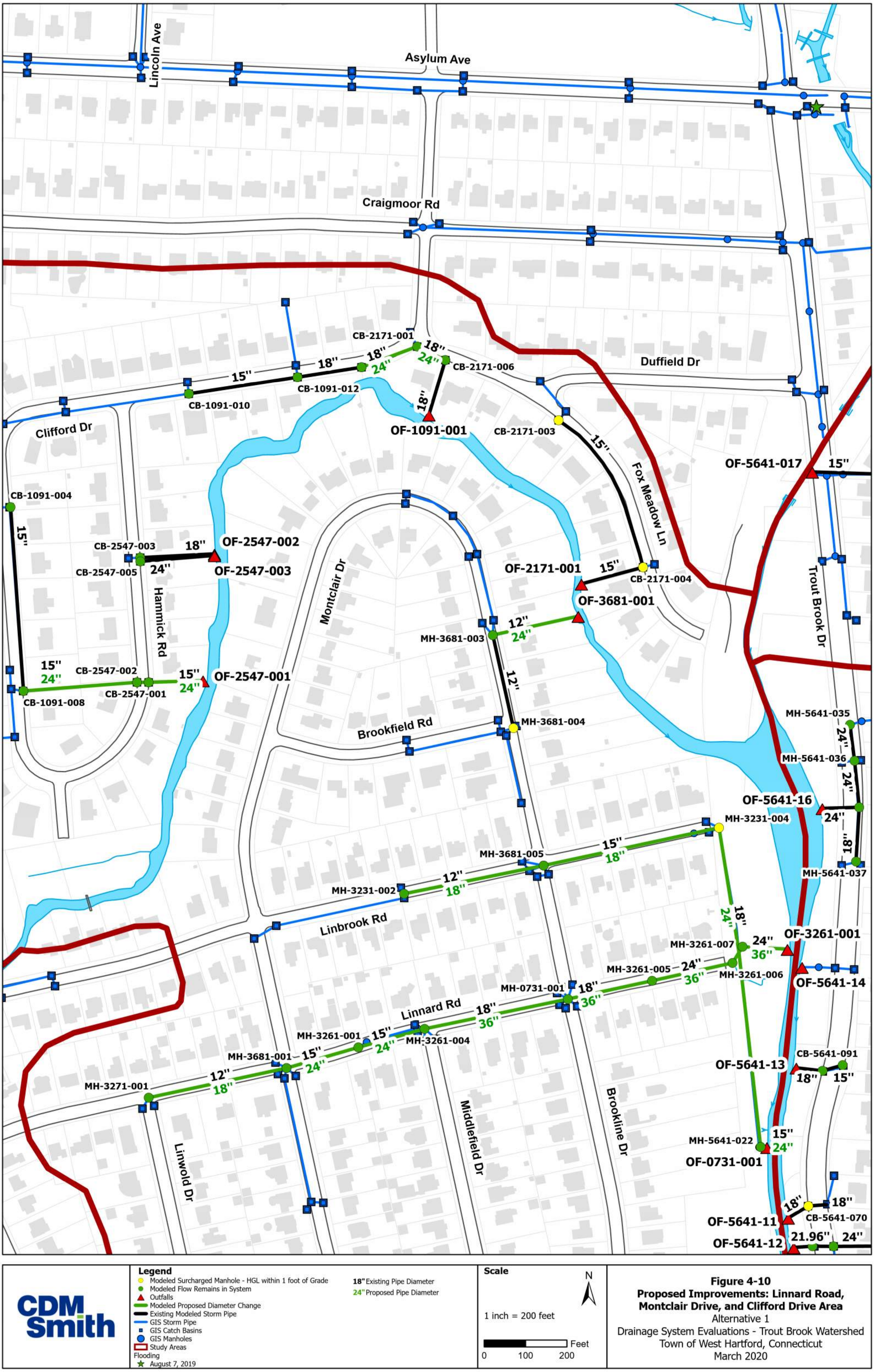

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Figure 4-10
Proposed Improvements: Linnard Road, Montclair Drive, and Clifford Drive Area
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

4.3 Prioritization Summary

Recommendations were developed for thirteen of the 21 outfalls based on modeled flooding during design storm and/or historical storms. Using the results of the existing conditions assessment, each recommendation was put into one of three major priority tiers:

- *Tier 1 - High Priority*: These drainage areas include systems that either had flooding reports, flooded during Hurricane Irene and Tropical Storm Lee and/or during historical storm events and during the design storm.
- *Tier 2 - Moderate Priority*: These areas include systems that the model predicted flooding during Hurricane Irene/Tropical Storm Lee, but no documented or modeled flooding occurred during the historical storm events in 2018 and 2019.
- *Tier 3 – Low Priority*: These areas include systems that the model predicts flooding during the design storm, but the Town does not have a record of reported flooding during Hurricane Irene/Tropical Storm Lee or during the historical storm events

The model was used to evaluate whether flooding is predicted for the 10-year design storm as well as for the four historical events considered in this study. **Table 4-13** presents a summary of each of the 21 outfall systems with an indication of whether the model predicts flooding under the different storm events and whether recommendations are proposed

Table 4-13: Modeled Flooding and Prioritization Recommendation Summary

Area	Outfall	Location	Design Storm	Tropical Storm Lee	Historical 2018 Storms	August 2019	Tier
Area 1	OF-5641-022	FEAT – Trunk line	√	√	√	√	1
Area 1	OF-5641-017	Middlebrook Road					
Area 2	OF-5641-007	Fern Street East	√	√	√	√	1
Area 2	OF-5641-001	Milton Street	√	√	√	√	2
Area 2	OF-5641-16	Trout Brook Drive East of Linbrook Rd					
Area 2	OF-5641-14	Trout Brook Drive East of Linnard Rd					
Area 2	OF-5641-13	Trout Brook Drive Central					
Area 2	OF-5641-11	Trout Brook Drive South					
Area 2	OF-5641-12	Ballard Drive	√				3
Area 3	OF-1091-001	Clifford Drive North	√				3
Area 3	OF-0731-001	Linbrook Road	√				3
Area 3	OF-3261-001	Linnard Road	√	√	√	√	2
Area 3	OF-1981-009	Fern Street West	√	√	√	√	2
Area 3	OF-3681-001	Montclair Drive	√	√	√	√	1
Area 3	OF-2171-001	Fox Meadow Lane					
Area 3	OF-3321-002	Loomis North	√				3
Area 3	OF-3321-001	Loomis South	√				3
Area 3	OF-2547-002	Hammick Road North					
Area 3	OF-2547-003	Hammick Road South					
Area 3	OF-3321-003	Loomis Central	√				3
Area 3	OF-2547-001	Clifford Drive Cross- County	√	√	√	√	2

The following summarizes the documentation supporting the prioritization of recommendations for selected drainage systems. Tier prioritization is based on hydraulic capacity of the existing drainage system and does not take into consideration constructability, phasing or logistics. Once projects are identified to move forward to final design and construction, projects should be selected by the Town so that downstream projects are constructed prior to construction of projects in upstream areas.

Tier 1A: Walbridge Road and Farnham Road

The FEAT trunk line and areas around Walbridge Road and Farnham Road have documented flooding during the historical events evaluated during this study, as well as flooding during the 10-year design storm. Replacement of undersized pipes in the Walbridge Road system is recommended after the FEAT trunk line capacity issues have been addressed. All improvements to secondary tributary drain lines are recommended to be implemented after the FEAT trunk line capacity issues have been resolved.

Tier 1B: Montclair Drive

The Montclair Drive neighborhood, bounded by Brookfield Road and Trout Brook, drains to a 24-inch storm drain that discharges to Trout Brook. In addition to capacity constraints in the drainage system, reported flooding in the area may be related to high groundwater elevations

Additional recommended investigations related to groundwater are described in **Section 3.4**. This area is characterized by high groundwater elevations that cause periodic basement flooding. The recommended infrastructure improvements on Montclair Drive include a replacement of undersized pipes, the construction of additional storm drain inlets, and the installation of approximately 1,000 linear feet of pipe.

Tier 1C Areas

Tier 1C areas represent the remaining high priority areas not included in Tiers 1A and 1B. Tier 1C areas include:

- Birch Road and Chelsea Lane (Area 1)
- Auburn Road at Middlebrook Road (Area 1).
- Middlebrook Road and Penn Drive (Area 1)
- Fern Street at Foxcroft Road (Area 1)
- Foxcroft Road at Middlebrook (Area 1)
- Bretton Road (Area 2)
- Penn Drive (Area2)

It is recommended that the Town should address flooding within areas Tiers 1A and 1B before addressing flooding within Tier 1C.

Tier 2 (Moderate Priority)

Tier 2 includes recommendations to address modeled flooding during the Hurricane Irene/ Tropical Storm Lee and pipe capacity issues in areas with no documented flooding.

There are several systems included in Tier 2 recommendations: Milton Street, Fern Street West, Linnard Road, Clifford Drive/Cross-Country, and Fernwood Road. All other areas do not have a record of reported flooding and the model does not predict flooding during Hurricane Irene/Tropical Storm Lee. Replacement of undersized pipes is recommended to address modeled and reported flooding during the peak 10-year 24-hour NRCS Type III design storm.

Tier 3: Low Priority

Drainage areas contained in Tier 3 consist of areas that are predicted to flood during the 10- year design storm but do not have any documented flooding during the historical storm events evaluated in this study nor modeled flooding during Hurricane Irene/Tropical Storm Lee. Drainage areas in Tier 3 include:

- The cross-country drainage system in Area 2 tributary to OF-5641-12
- Clifford Drive in Area 3
- Linbrook Road in Area 3
- Loomis Drive (North, Central, and South) in Area 3

Since the 10-year design storm is conservative, there have been no reported flooding concerns during the historical events and there is no modeled flooding during Tropical Storm Lee, drainage improvements in these areas are likely not required in the near term. These should be completed after Tier 1 and Tier 2 improvements are in place if that is appropriate with respect to constructability, phasing, and logistics and/or if recorded flooding occurs during events beyond a 10-year storm.

4.3 Groundwater Evaluation Recommendations

A review of current and past conditions within the Groundwater Screening Site showed that the neighborhood west of Trout Brook (including Montclair Drive, Linbrook Road, and Linnard Road) is prone to low depth to groundwater conditions and that prior to development in the early 20th Century the Noyes River ran through the neighborhood. Soil borings indicate that bedrock is shallow and the predominant soils are fill and till, which do not readily transmit water.

A passive solution to lower the water table, such as a buried perforated pipe that collects groundwater and discharges to Trout Brook, could be an option here, though the technical feasibility of implementing such a solution could be limited by the low permeability of the soils, the presence of shallow bedrock in the western portion of the site, and the hydraulic grade lines needed to discharge to Trout Brook. A perforated pipe laid in low permeability till would likely have a limited radius of capture compared to one laid in gravel. To better understand these limitations, a step wise approach is recommended to investigate the eastern portion of Linbrook Road first, and use the information collected there to draw inferences about the potential for passive groundwater lowering systems throughout the Groundwater Screening Site.

The following steps are recommended for future investigations:

- Install three groundwater monitoring wells along the eastern portion of Linbrook Road from Montclair Drive to the end of the road near Trout Brook.

- Record the water level elevations (and depth to water) in the newly installed monitoring wells as well as the water level of Trout Brook.
- Perform slug testing at these monitoring wells to estimate the permeability of the soils.
- Reassess the site conditions and potential for groundwater lowering.
- If deemed promising, perform a pilot test by designing and installing one perforated groundwater collector pipe along Linbrook Road from Montclair Drive to Trout Brook.
- Monitor depth to groundwater at the three monitoring wells along Linbrook Road along with the discharge to Trout Brook at the outfall for enough time to determine the effectiveness of the pilot test.
- Assess the value of expanding the program to cover more areas.

4.3 Collector Drainage Systems

The collector drainage system recommendations have been evaluated for the drainage study to consider conceptual layouts for redirecting sump pump and foundation discharge from the MDC sewer system to the drain system. As summarized in Section 3, there are a significant number of confirmed private inflow connections in the study area that will require new mainline drain extensions, manholes, catch basins and collector drains in the public right-of- way to facilitate redirection to the drain system. These recommendations are separate from the improvements and recommendations for the existing drain system and will require coordination with the MDC and private property owners to implement.

The conceptual layouts for private inflow removal that were developed by CDM Smith for the MDC in 2018-19 in the study area were further evaluated using the latest West Hartford storm drain GIS data (February 2020) and the existing drain system recommendations. Additionally, portions of Area 1 and Area 2 that overlap with sewer subarea WH34 that were evaluated using the same approach to develop the conceptual layout for the entire area.

The estimated number of private inflow removal buildings, collector drains, drain extensions and new drain structures have been summarized for the three study areas on a street-by- street basis. Figures have been developed to show the conceptual layouts for collector drainage systems and connections to the existing drain system in the study areas. The conceptual layouts show the proposed collector drains, new drain extensions and new drain structures in the public right-of-way that have been used to develop estimated construction costs. The work on private property was not evaluated since that component requires site visits which are typically performed during the final design and construction phases.

Area 1

Area 1 includes 325 buildings that are recommended for private inflow removal on 22 streets. Nearly all the existing storm drains in this area are located within the FEAT drain outfall system (OF-5641-017) that overlaps with MDC sewer subareas WH31 and WH34. The conceptual layout for Area 1 includes 17,493 feet of collector drain, 3,788 feet of new storm drain extensions and 27 new storm drain structures. **Table 4-14** summarizes the private inflow removal totals for Area 1 on a street-by-street basis. **Figure 4-10** shows the conceptual layout for new drain extensions, structures and collector drains in Area 1.

Table 4-14: Area 1 Collector Drainage System Recommendations

Study Area	Sewer Subarea	Street	I/I Removal Buildings	Collector Drain (Lf)	Drain Extensions (Lf)	Drain Structures
Area 1	WH31	AUBURN RD	23	1,535	0	0
	WH31/WH34	BAINBRIDGE RD	22	1,394	10	2
	WH31	BALLARD DR	2	160	0	0
	WH34	BIRCH RD	9	571	0	0
	WH34	CHELSEA LA	8	325	0	0
	WH31	CUMBERLAND RD	22	1,052	744	5
	WH34	DORSET RD	13	415	0	0
	WH34	EDMUND PL	6	368	0	0
	WH34	FARNHAM RD	19	321	0	0
	WH34	FERN ST	11	899	177	1
	WH34	FERNWOOD RD	12	954	0	0
	WH34	FOXCROFT RD	38	2,010	19	1
	WH31	GRISWOLD DR	21	1,044	765	3
	WH31	MIDDLEBROOK RD	9	264	0	0
	WH31	N QUAKER LA	22	1,195	919	5
	WH31	PENN DR	21	1,207	495	2
	WH31	PINE RD	4	194	146	1
	WH34	STEELE RD	27	1,373	28	1
	WH31	TROUT BROOK DR	1	15	0	0
	WH34	VANDERBILT RD	11	585	198	3
	WH34	WALBRIDGE RD	11	1,067	0	0
	WH34	WALKLEY RD	13	545	287	3
		Area 1 Totals	**325**	**17,493**	**3,788**	**27**

Area 2

Area 2 includes 222 buildings that are recommended for private inflow removal on 19 streets. Most of the existing storm drains in this area are located within the Fern Street East (OF- 5641-005) and Milton Street (OF-5641-001) drain outfall systems that overlap with MDC sewer subareas WH29, WH30, WH31 and WH34. The remaining storm drains in the area are part of smaller drain outfall systems located along Trout Brook Drive. The conceptual layout for Area 2 includes 13,491 feet of collector drain, 3,559 feet of new storm drain extensions and 24 new storm drain structures. **Table 4-15** on the following page summarizes the private inflow removal totals for Area 2 on a street-by-street basis. **Figure 4-11** shows the conceptual layout for new drain extensions, structures and collector drains in Area 2.

Area 3

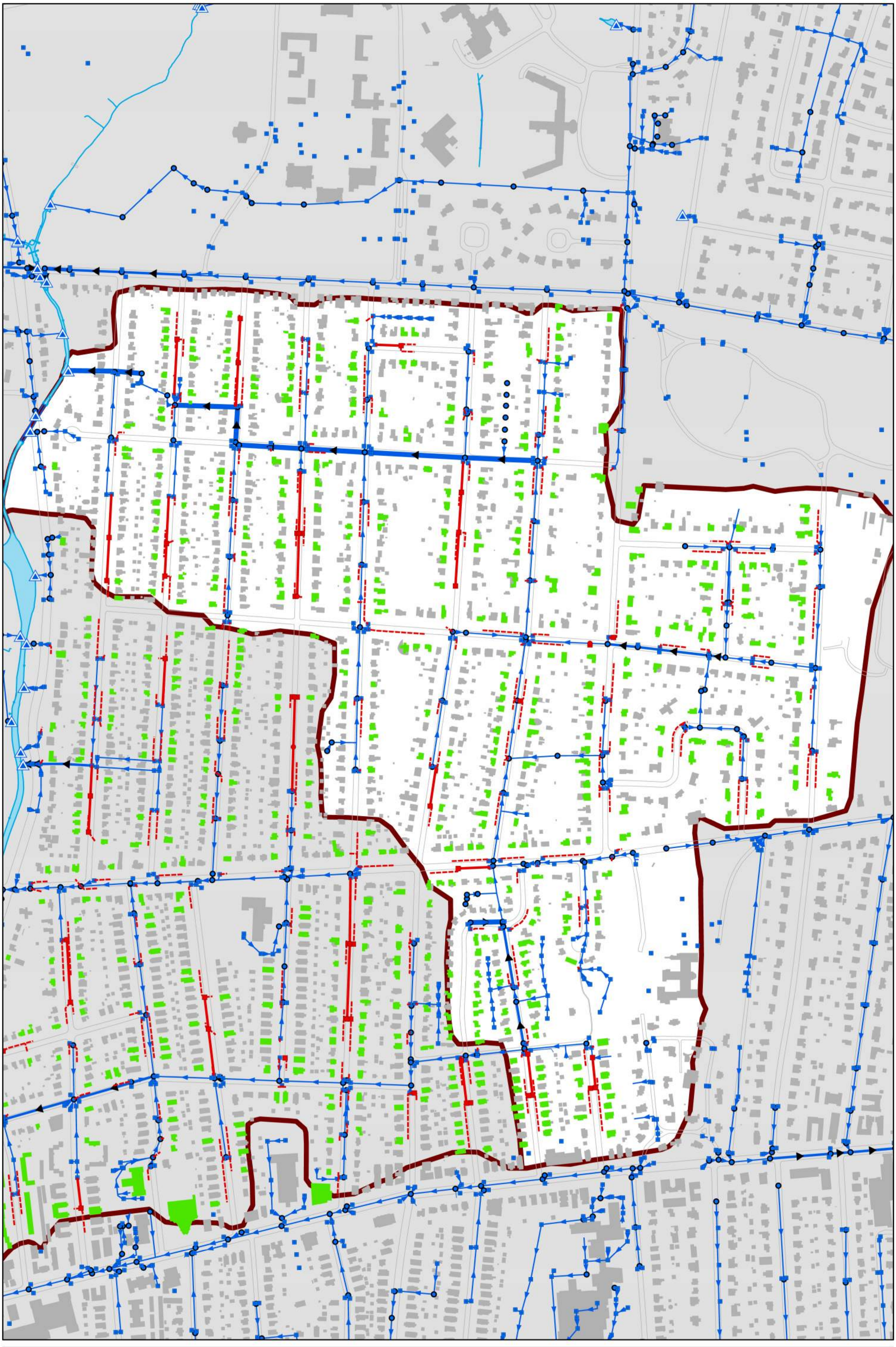
Area 3 includes 114 buildings that are recommended for private inflow removal on 12 streets. Most of the existing storm drains in this area are located within the Linnard Road (OF-0731-001), Fern Street West (OF-1981-009) and Montclair Drive (OF-3681-001) drain outfall systems that overlap with MDC sewer subareas WH29, WH30, WH31 and WH34. The conceptual layout for Area 2 includes 13,491 feet of collector drain, 3,559 feet of new storm drain extensions and 24 new storm drain structures. **Table 4-16** on the following page summarizes the private inflow removal totals for Area 2 on a street-by-street basis. **Figure 4-12** shows the conceptual layout for new drain extensions, structures and collector drains in Area 2.

Table 4-15: Area 2 Collector Drainage System Recommendations

Study Area	Sewer Subarea	Street	I/I Removal Buildings	Collector Drain (Lf)	Drain Extensions (Lf)	Drain Structure (Each)
Area 2	WH29	ARDMORE RD	13	1,120	441	2
	WH30	ARNOLD WAY	4	549	0	0
	WH29	AUBURN RD	23	1,413	853	6
	WH29	BAINBRIDGE RD	3	0	0	0
	WH30	BALLARD DR	18	1,015	375	2
	WH29	BRETTON RD	9	540	0	1
	WH29	CUMBERLAND RD	9	488	556	4
	WH29	DOVER RD	17	994	0	0
	WH29	FARMINGTON AVE	1	108	0	0
	WH29	FERN ST	16	979	0	0
	WH31/WH34	FREDERICK RD	2	30	0	0
	WH29	GRISWOLD DR	16	1,059	266	1
	WH34	LILLEY RD	13	565	289	3
	WH29/WH30	MILTON ST	9	460	0	0
	WH34	N QUAKER LA	17	695	27	1
	WH29	PENN DR	18	959	0	0
	WH29/WH30	ROBIN RD	13	1,097	553	3
	WH30	TROUT BROOK DR	14	997	0	0
	WH30/WH31	WARWICK ST	7	424	200	1
		Area 2 Totals	**222**	**13,491**	**3,559**	**24**

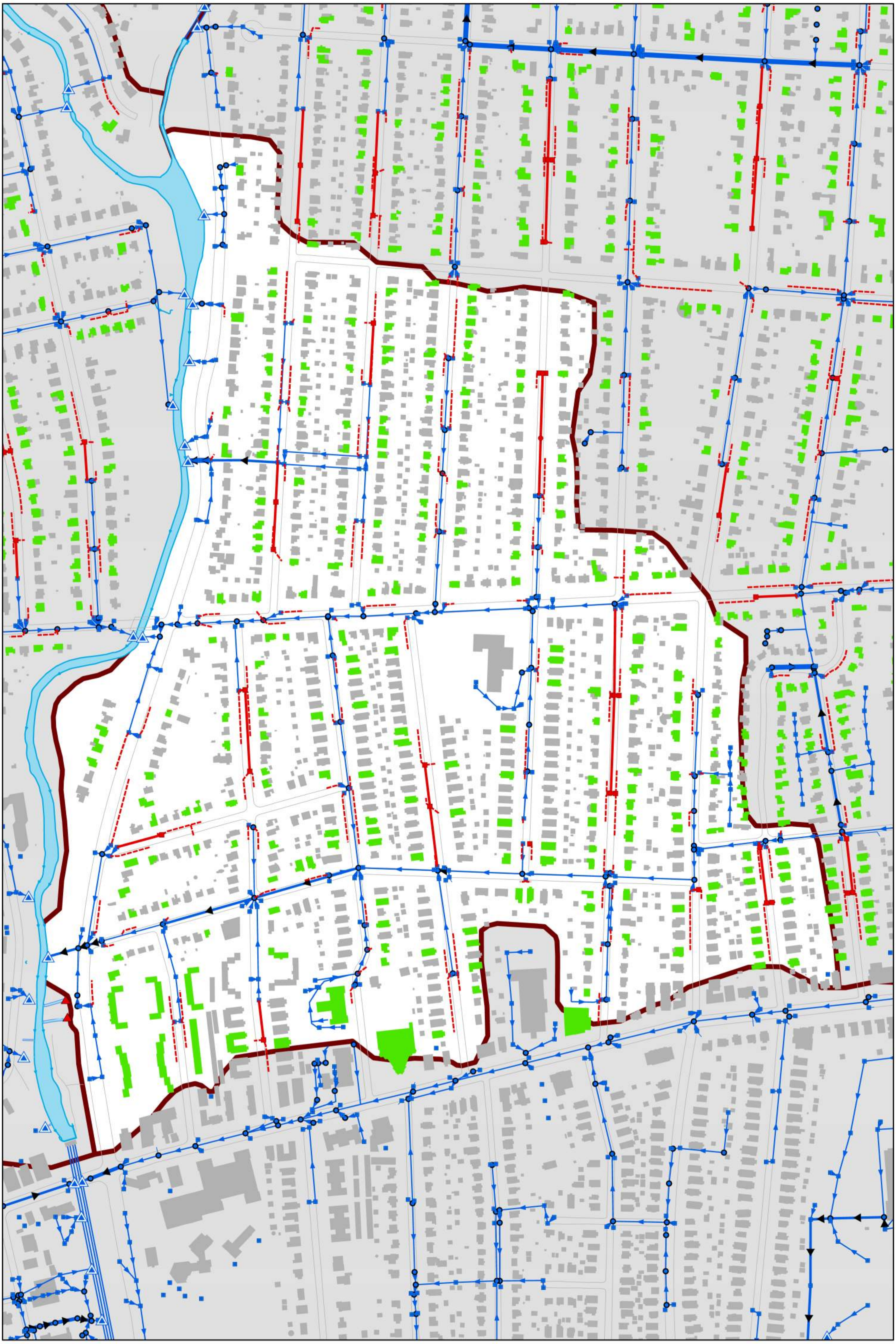
Table 4-16: Area 3 Collector Drainage System Recommendations

Study Area	Sewer Subarea	Street	Private I/I Removal Buildings	Collector Drain (Lf)	Drain Extensions (Lf)	Drain Structure (Each)
Area 3	WH30	BROOKFIELD RD	5	215	0	0
	WH30	BROOKLINE DR	14	822	168	1
	WH31	CLIFFORD DR	4	242	0	0
	WH30	FERN ST	6	316	0	0
	WH31	FOX MEADOW LA	2	230	0	0
	WH31	HAMMICK RD	1	80	0	0
	WH30	LINBROOK RD	6	645	0	0
	WH30	LINNARD RD	12	729	0	0
	WH30	LINWOLD DR	9	493	817	3
	WH30	MIDDLEFIELD DR	18	967	666	4
	WH30	MONTCLAIR DR	31	1,176	877	5
	WH30	N MAIN ST	6	269	0	0
		Area 3 Totals	**114**	**6,184**	**2,528**	**13**



CDM Smith

Figure 4-11
Area 1 Collector Drain System
Alternative 1
Town of West Hartford, Connecticut
March 2020



Legend

- 24" and Larger Drain Pipe
- 6"-20" Drain Pipe
- Abandoned/Inactive Drain
- Catch Basin
- Drain Manhole
- Drain Outfall

Private Inflow Removal

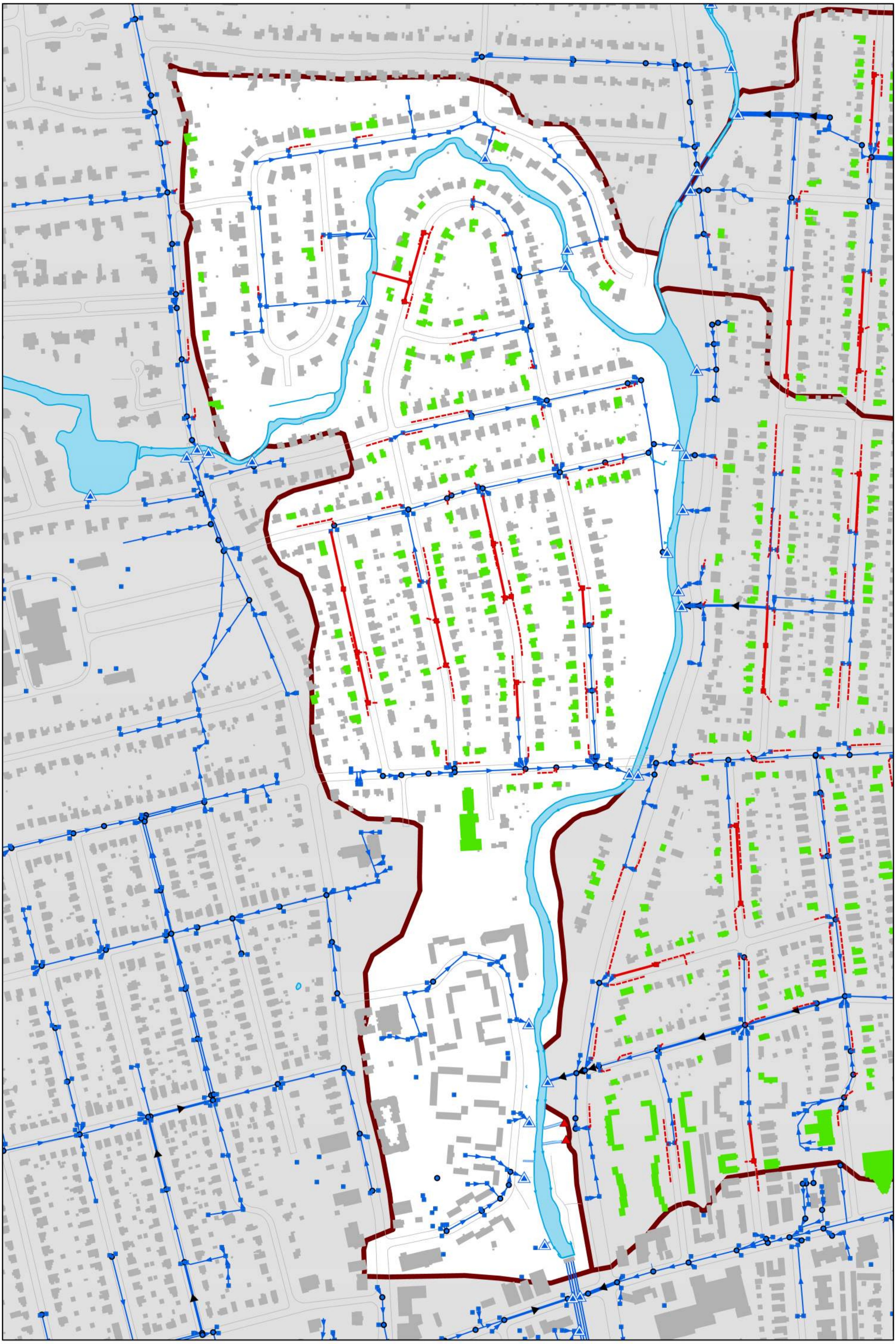
- 🟩 Private Inflow Removal Building
- New Drain Extension
- New Collector Drain
- New Catch Basin
- Drain Manhole

0 200 400
Feet

N

CDM Smith

Figure 4-12
Area 2 Collector Drain System
Alternative 1
Town of West Hartford, Connecticut
March 2020



Legend

- 24" and Larger Drain Pipe
- 6"-20" Drain Pipe
- Abandoned/Inactive Drain
- Catch Basin
- Drain Manhole
- Drain Outfall

Private Inflow Removal

- 🟩 Private Inflow Removal Building
- New Drain Extension
- New Collector Drain
- New Catch Basin
- Drain Manhole

0 200 400
Feet

N

CDM Smith

Figure 4-13
Area 3 Collector Drain System
Alternative 1
Town of West Hartford, Connecticut
March 2020

Section 5 – Cost Estimate

This section provides conceptual costs for storm drain system improvements and collector drainage system improvements for each drain outfall, and the proposed cost for a groundwater survey. The recommended improvements to the drainage system are described in **Section 4**.

5.1 Capacity Improvements

Section 4 summarized the recommendations for improving the public drainage system to accommodate at 10 year storm and prioritized the project implementation. **Table 5-1** summarizes the costs for each alternative. If the Town implemented improvements to all areas the total cost in 2020 dollars is estimated to be in the range of $42 to $45 million.

Table 5-1: Conceptual Design Costs for Storm Drain System Replacements

Area	Outfall	Location	Alternative 1	Alternative 2	Alternative 3	Tier
Area 1	**OF-5641-022**	FEAT Trunk Line	$25,700,000	$23,800,000	$24,200,000	1A, 1C, 2
Area 2	**OF-5641-007**	Fern Street East	$4,200,000			1C
Area 2	**OF-5641-001**	Milton Street	$7,800,000			2
Area 2	**OF-5641-12**	Ballard Drive	$300,000			3
Area 3	**OF-3681-001**	Montclair Drive	$300,000			1B
Area 3	**OF-0731-001**	Linbrook Road	$1,100,000			1B
Area 3	**OF-3261-001**	Linnard Road	$2,300,000			2
Area 3	**OF-2547-001**	Clifford Cross Country	$600,000			2
Area 3	**OF-1981-009**	Fern Street West	$800,000			2
Area 3	**OF-1091-001**	Clifford Drive	$300,000			3
Area 3	**OF-3321-002**	Loomis North	$271,000			3
Area 3	**OF-3321-003**	Loomis Central	$60,000			3
Area 3	**OF-3321-001**	Loomis South	$277,000			3

For the drainage system improvements, unit costs based on pipe diameter and length were developed from construction contracts in the greater Hartford area awarded in the last 10 years. Since the alternatives were developed to a conceptual level, costs for engineering and contingency totaling 45% were added to the base totals.

The conceptual costs include new drain pipes, manholes, and catch basins installed in the public right-of-way with earthwork, pavement replacement, surface restoration, police, maintenance and protection of traffic, and miscellaneous work. No rock excavation allowance was included.

The age, material, and condition of pipes was not considered in this analysis. Older pipes may need to be lined or replaced due to condition if they are in the construction area. The minimum new drain pipe size is 12-inch diameter but existing 10 inch diameter pipes will remain if they meet capacity.

5.2 Collector Drainage Systems

Section 4 summarizes the collector drainage system recommendations for the three study areas on a street-by-street basis. This information has been further developed to identify the collector drainage system costs for each storm drain outfall area as summarized in **Table 5-2**. The collector drainage system cost estimates are based on the following assumptions:

6" PVC Collector Drain:	$150 per foot
12-15" RCP Storm Drain Extensions:	$400 per foot
New Storm Drain Structures:	$5,000 each
Engineering and Contingency:	45%

The total conceptual cost estimate, for collector drainage systems in the priority areas listed in **Table 5-2** is $13,786,000, including engineering and contingency totaling 45%. The conceptual layout within priority drainage systems includes 36,309 feet of collector drains, 9,379 feet of new storm drain extensions and 61 new storm drain structures. The estimated collector drainage system costs do not include costs for work on private property (sump pumps/pits, interior discharge pipe, exterior service pipe, etc.). Based on recent construction costs from the Four Mile Road Area and Greenhurst Road Area projects, the cost for work on private property ranges from $13,000 to $15,000 per property.

Table 5-2: Conceptual Design Costs for Collector Drainage Systems

Outfall	Location	Private I/I Removal Buildings	Collector Drain (Lf)	Drain Extensions (Lf)	Drain Structure (Each)	Total Costs[1]
OF-5641-022	FEAT - Trunk line	292	15,281	3,303	21	$5,392,00
OF-5641-007	Fern Street East	87	5,615	1,789	12	$2,346,000
OF-5641-001	Milton Street	129	7,872	1,614	15	$2,758,000
OF-5641-12	Cross Country System Area 2	35	2,106	641	3	$853,000
OF-3681-001	Montclair Drive	9	350	0	0	$77,000
OF-0731-001	Linbrook Road	8	645	0	0	$141,000
OF-3261-001	Linnard Road	45	2,489	1,700	8	$1,586,000
OF-2547-001	Clifford Drive Cross Country	4	256	0	0	$56,000
OF-1981-009	Fern Street West	26	1,440	332	2	$521,000
OF-1091-001	Clifford Drive	4	256	0	0	$56,000
OF-3321-002	Loomis North	0	0	0	0	$0
OF-3321-003	Loomis Central	0	0	0	0	$0
OF-3321-001	Loomis South	0	0	0	0	$0
	Totals	**639**	**36,309**	**9,379**	**61**	**$13,786,000**

1. Total costs include 45% for engineering and contingency.

2. Total costs do not include work on private property.

The work on private property includes the 639 buildings as summarized in **Table 5-2** and 22 additional properties that are within areas without drainage system capacity improvements that have been identified through completed building inspections. For these 661 properties, the estimated cost for work on private property is $9.2 million. Including engineering and contingency of 45%, the opinion of probable cost for these properties is $13.3 million as summarized in **Table 5-3**. While priority is given to the drainage systems with modeled flooding, there are 22 additional buildings identified for private inflow removal that are not represented in **Table 5-2**. These buildings are located near smaller, drainage systems that are lower priorities, but have been utilized as connection points for local collector drains at these properties.

The study area also includes properties with incomplete building inspections that may require private inflow removal. For these 280 properties, the estimated costs for work on private property is $3.9 million. Including engineering and contingency of 45%, the opinion of probable cost for the additional properties is $5.7 million. The total opinion of probable cost for private inflow removal including the additional properties is approximately $19.0 million.

5.3 Groundwater Study

Section 4 summarized the recommendations for investigating the potential for groundwater lowering within the Groundwater Screening Site. Due to the uncertainty involved, a stepwise approach is recommended. The first sets of steps would involve the installation and testing of monitoring wells and a reassessment of the subsurface conditions within the Groundwater Screening Site. These tasks have been estimated to cost approximately $50,000. If these analyses result in initiation of additional steps, including pilot testing a perforated groundwater collector pipe, cost estimates for these activities will be developed at that time.

5.4 Summary

Recommendations and costs have been developed for the various drainage system deficiencies. The proposed drainage improvements fall into four cost categories:

> **Pipe Replacements** – Drainage system replacements increase the capacity of the existing pipes in the public right-of-way to convey the 10-year storm.
>
> **Collector Drains** – These are smaller diameter pipes that collect private property storm drain connections and do not convey street drainage
>
> **Drain Extensions** – These are the improvements to the drainage infrastructure (pipes, catch basins and manholes), typically on side streets, to convey public and private stormwater
>
> **Private Disconnects** – Private infrastructure improvements (on private property) to convey storm flow to the public drain, collector drain or drain extensions.

Table 5-3 provides a summary of costs for each improvement by outfall and prioritization tier. The prioritization tiers previously presented in Section 4-1 have been expanded to include drain extensions, collector drains and private disconnects as summarized below. The summation of improvements area are presented on **Figure 5-1, Figure 5-2** and **Figure 5-3**.

Tier 1A – High priority drainage system replacements as presented in Section 4. These areas had modeled flooding during historical storm events and the design storm.

Tier 1B – High priority drainage system replacements as presented in Section 4. These areas had modeled flooding during historical storm events and the design storm.

Tier 1C – High priority drainage system replacements as presented in Section 4. These areas had modeled flooding during historical storm events and the design storm.

Tier 1D – High priority private disconnects and collector drains within areas where the drainage system has capacity and drainage system replacements are not recommended.

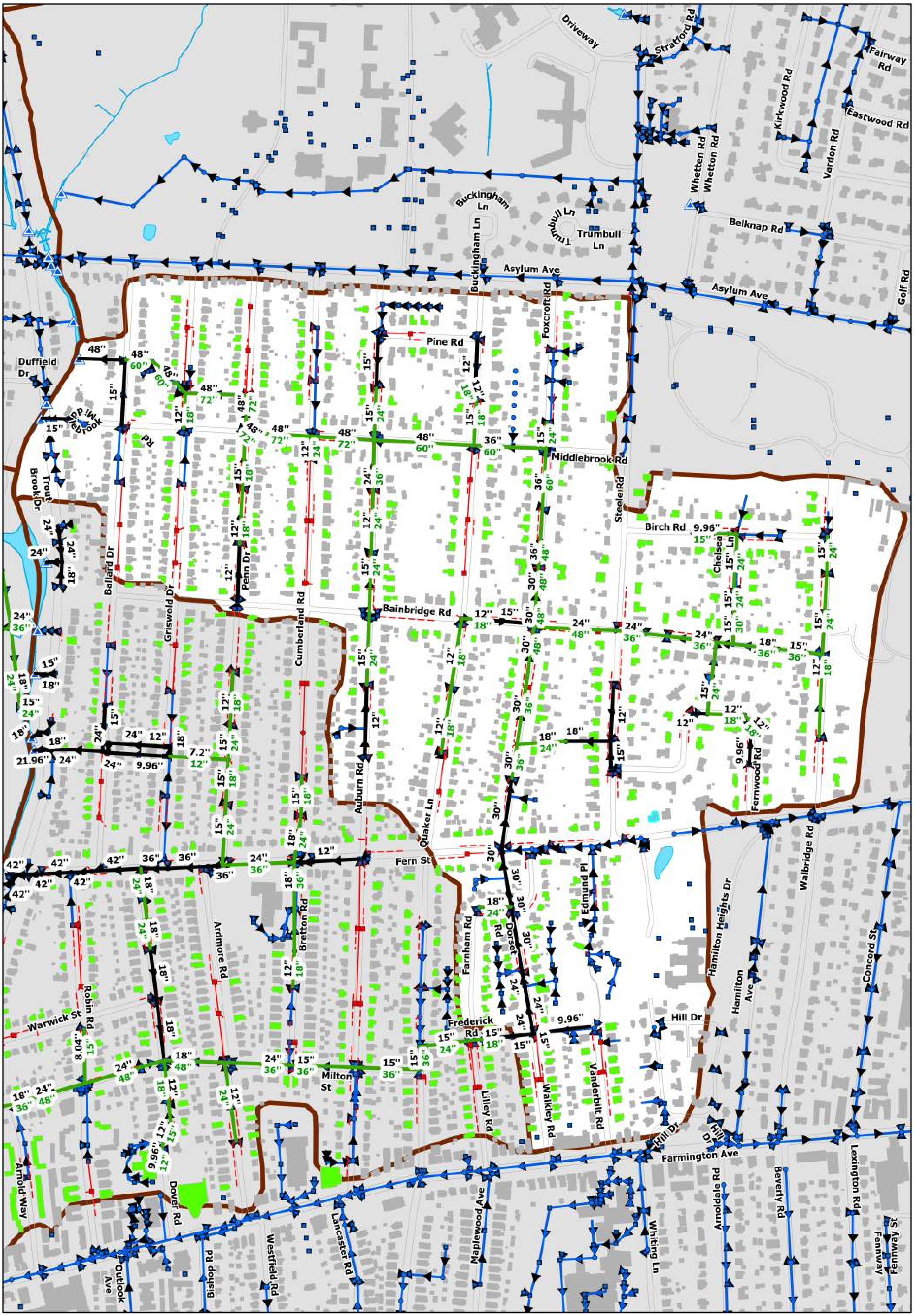
Tier 2A – Medium priority drainage system replacements as presented in Section 4. These systems did not have modeled flooding during historical events but did have modeled flooding during the design storm.

Tier 2B – Medium priority private disconnects and collector drains within areas where drainage extensions are required for private properties to connect to the new system.

Tier 3 – Low priority drainage system replacements as presented in Section 4. These areas did not have modeled flooding during historical storm events or the design storm.

Table 5-3: Conceptual Design Cost Summary

Outfall	Locations	Project Area	Pipe Replacements	Collector Drains	Drain Extensions	Private Disconnects
High Priority						
Tier 1A – Pipe Capacity Improvements						
OF-5641-022	FEAT (Alternative 2)	1	$23,800,000	$3,324,000	$2,068,000	$5,928,000
Tier 1B – Pipe Capacity Improvements						
OF-3681-001	Montclair Drive	3	$300,000	$77,000	-	$183,000
OF-0731-001	Linbrook Road	3	$1,100,000	$141,000	-	$163,000
Tier 1C – Pipe Capacity Improvements						
OF-5641-007	Fern Street East	2	$4,200,000	$1,222,000	$1,125,000	$1,767,000
Tier 1D – Collector Drains without Capacity Problems						
OF-5641-017	Middlebrook Road	1	-	$5,000	-	$21,000
OF-5641-16	Trout Brook Drive East of Linbrook Road	2	-	$5,000	-	$21,000
OF-5641-14	Trout Brook Drive East of Linnard Road	2	-	$14,000	-	$21,000
OF-5641-11	Trout Brook Drive South	2	-	$9,000	-	$21,000
OF-2171-001	Fox Meadow Lane	3	-	$38,000	-	$21,000
OF-2547-003	Hammick Road South	3	-	$18,000	-	$21,000
OF-1091-001	Clifford Drive North	3	-	$56,000	-	$82,000
OF-2547-001	Clifford Cross Country	3	-	$10,000	-	$21,000
High Priority Total Cost			**$29,400,000**	**$4,919,000**	**$3,193,000**	**$8,270,000**
Medium Priority						
Tier 2A – Pipe Capacity Improvements						
OF-5641-001	Milton Street	2	$7,800,000	-	-	-
OF-3261-001	Linnard Road	3	$2,300,000	-	-	-
OF-2547-001	Clifford Cross Country	3	$600,000	-	-	-
OF-1981-009	Fern Street West	3	$800,000	-	-	-
Tier 2B – Collector Drains with Drainage Extensions						
OF-5641-001	Milton Street	2	-	$1,713,000	$1,046,000	$2,619,000
OF-5641-12	Ballard Drive	2	-	$459,000	$394,000	$711,000
New Outfall	Montclair Drive West	3	-	$96,000	$310,000	$264,000
OF-3261-001	Linnard Road	3	-	$542,000	$1,044,000	$914,000
OF-1981-009	Fern Street West	3	-	$314,000	$208,000	$528,000
Medium Priority Total Cost			**$11,500,000**	**$3,124,000**	**$3,002,000**	**$5,036,000**
Low Priority						
Tier 3 – Pipe Capacity Improvements						
OF-5641-12	Ballard Drive	2	$300,000	-	-	-
OF-1091-001	Clifford Drive North	3	$300,000	-	-	-
OF-3321-002	Loomis North	3	$271,000	-	-	-
OF-3321-003	Loomis Central	3	$60,000	-	-	-
OF-3321-001	Loomis Court	3	$277,000	-	-	-
Low Priority Total Cost			**$1,208,000**	**-**	**-**	**-**
TOTAL COSTS						
TOTAL PROJECT COSTS			**$42,108,000**	**$8,043,000**	**$6,195,000**	**$13,306,000**



CDM Smith

Legend

- ▶ 24" and Larger Drain Pipe
- → 6"- 20" Drain Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- △ GIS Outfall
- Modeled Proposed Diameter Change
- Existing Modeled Storm Pipe

Private Inflow Removal

- 🟩 Private Inflow Removal Building
- New Drain Extension
- New Collector Drain
- 🟥 New Catch Basin
- ● Drain Manhole
- **18"** Existing Pipe Diameter
- 24" Proposed Pipe Diameter

Scale

N

1 inch = 488 feet

0 245 490 Feet

Figure 5-1
Proposed Improvements: Area 1
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

CDM Smith

Legend

- ▶ 24" and Larger Drain Pipe
- → 6"- 20" Drain Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- △ GIS Outfall
- Modeled Proposed Diameter Change
- Existing Modeled Storm Pipe

Private Inflow Removal

- 🟩 Private Inflow Removal Building
- New Drain Extension
- New Collector Drain
- ■ New Catch Basin
- ● Drain Manhole
- **18"** Existing Pipe Diameter
- **24"** Proposed Pipe Diameter

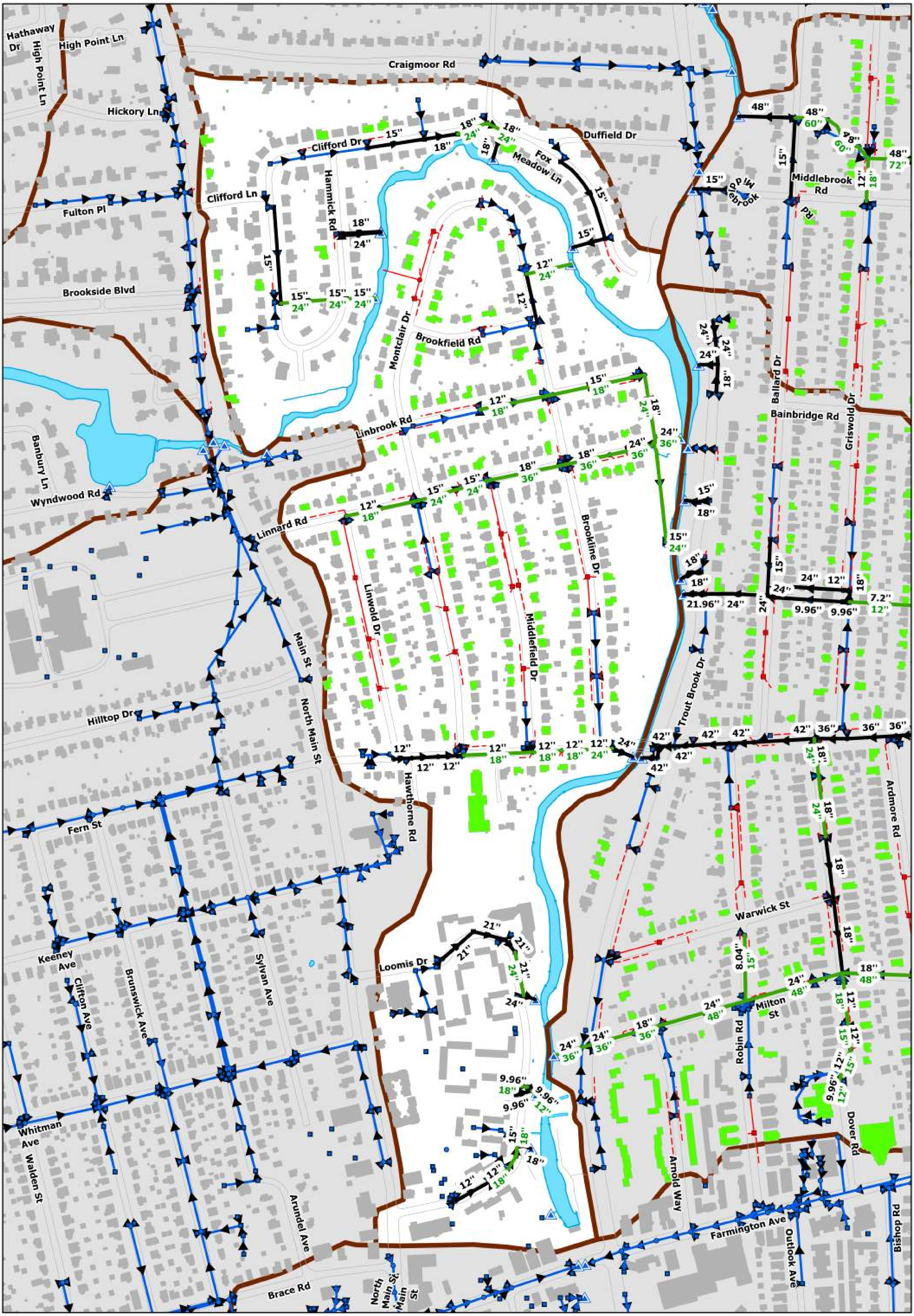
Scale

1 inch = 350 feet

0 175 350 Feet

N

Figure 5-2
Proposed Improvements: Area 2
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020



CDM Smith

Legend

- ▶ 24" and Larger Drain Pipe
- → 6"- 20" Drain Pipe
- ■ GIS Catch Basins
- ● GIS Manholes
- △ GIS Outfall
- Modeled Proposed Diameter Change
- Existing Modeled Storm Pipe

Private Inflow Removal

- 🟩 Private Inflow Removal Building
- New Drain Extension
- New Collector Drain
- 🟥 New Catch Basin
- ● Drain Manhole
- **18"** Existing Pipe Diameter
- **24"** Proposed Pipe Diameter

Scale

N

1 inch = 400 feet

0 200 400 Feet

Figure 5-3
Proposed Improvements: Area 3
Alternative 1
Drainage System Evaluations - Trout Brook Watershed
Town of West Hartford, Connecticut
March 2020

Appendix A

Summary of Calibrated Model Parameters Calibration Plots

Appendix A

Summary of Calibrated Model Parameters

Calibration Plots

The value for each calibration variable across the five metered areas and the values assumed for Areas 2 and 3 are summarized in Tables A-1 through A-3.

Table A-1: Range of Principal Hydrologic Calibration Variables by Meter Area

Meter	Imperviousness (Percent)		Width (ft)		Slope (Percent)		Percent Routed		Hydraulic Conductivity (in/hour)
	Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	
1	32	10-49	52	5-208	1.4	0.2-4.0	30	22-40	0.86
2	25	9-39	50	16-120	1.9	0.3-4.5	33	27-40	0.86
3	19	10-35	56	18-144	1.9	0.2-5.5	36	28-40	0.15
4	41	33-49	27	2-94	0.7	0.3-2.0	32	27-36	0.86
5	28	9-50	48	20-93	2.8	1.5-3.4	32	22-40	0.86
Area 2	42	13-71	40	5-124	2.2	0.3-6.8	25	12-38	0.86
Area 3	37	17-67	35	4-138	3.2	0.6-8.3	28	14-36	0.86

Table A-2: Range of Principal Hydraulic Calibration Variables by Meter Area

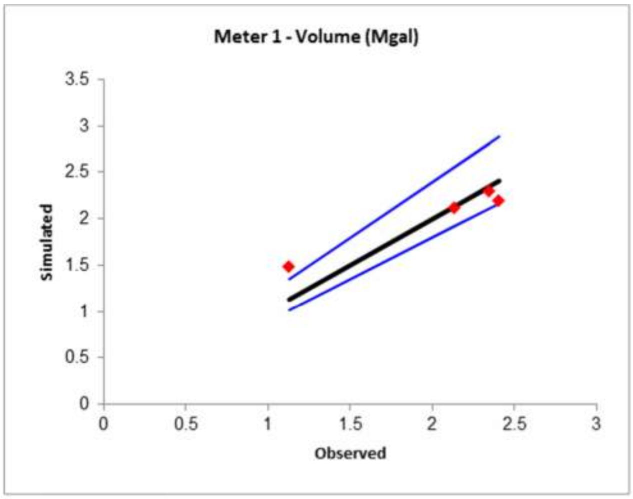
Meter	Manning's N		Form Losses[1]	
	Average	**Range**	**Average**	**Range**
1	0.013	0.013-0.015	0.48	0-1.33
2	0.013	0.013-0.015	0.47	0.08-1.33
3	0.013	0.013-0.015	0.72	0.08-1.33
4	0.014	0.014	0.36	0-1.33
5	0.014	0.014	0.71	0.08-1.33
Area 1 & 2	0.013	0.012-0.014	0.35	0-1.33

Notes: 1. Form losses were based principally on pipe geometry and calibrated to match observed depth and velocity in Area 1.

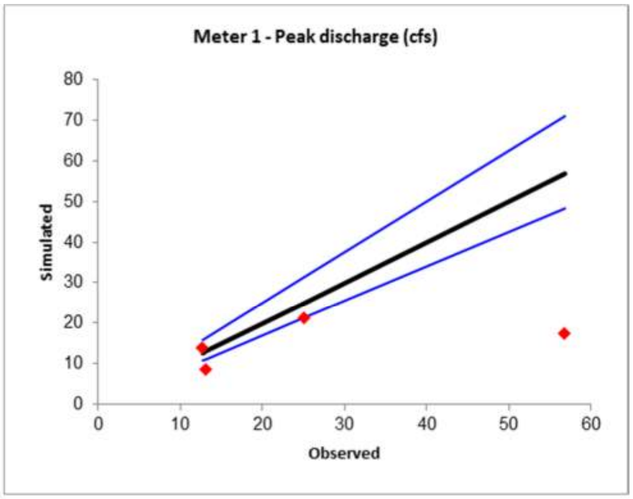
Table A-3: Aquifer Parameters adopted from MDC Sanitary Sewer Model

Property	Description	Value
Porosity	Volume of voids to total soil volume	0.4
Wilting Point	Minimum soil moisture at which plants cannot survive	0.15
Field Capacity	Ability of soil to hold water in well-drained soils	0.33
Conductivity Slope (in/hr)	Slope of log(conductivity) vs. soil moisture deficit curve	40
Aquifer thickness (ft)	Thickness of the water bearing layer	20

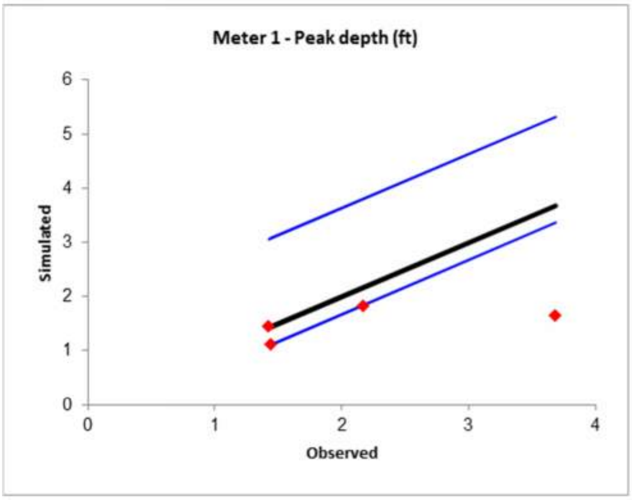
Calibrated scatterplots and hydrographs are presented below.



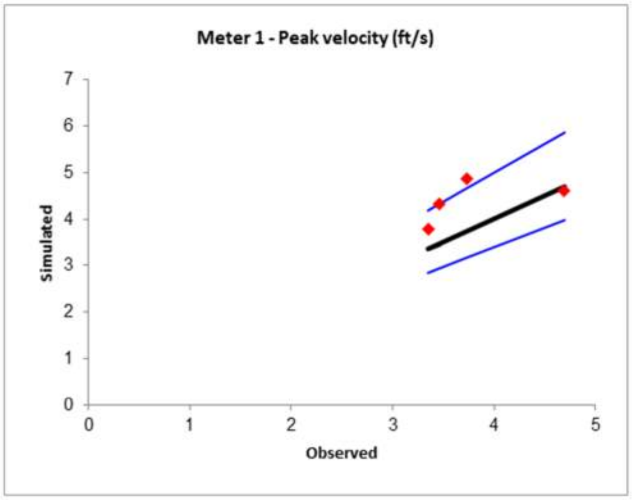
Meter 1 - Volume (Mgal)



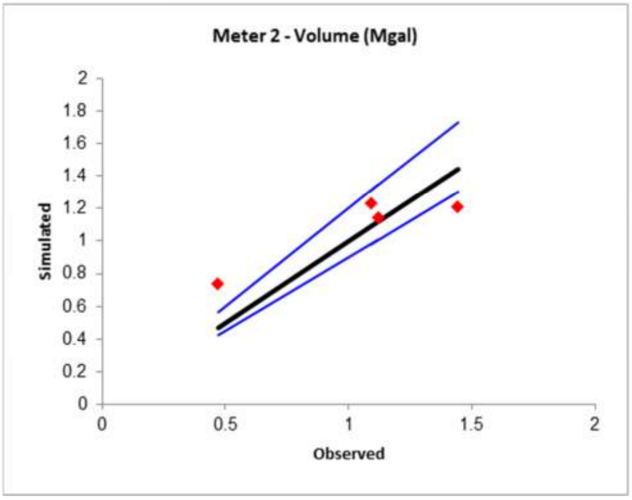
Meter 1 - Peak discharge (cfs)



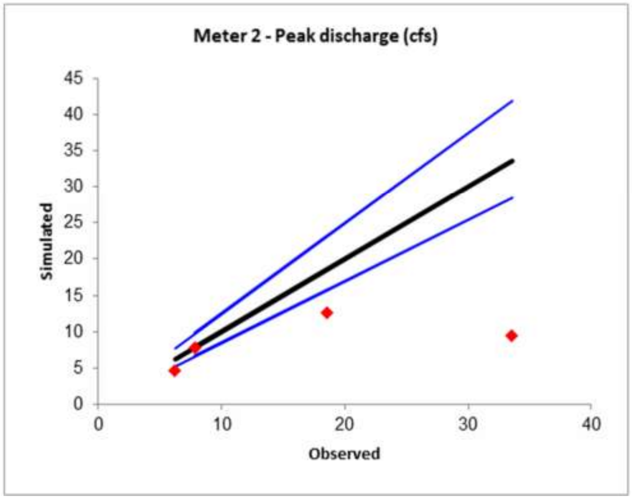
Meter 1 - Peak depth (ft)



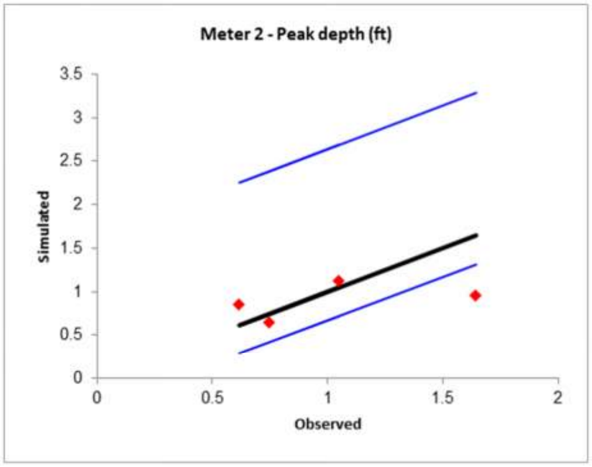
Meter 1 - Peak velocity (ft/s)



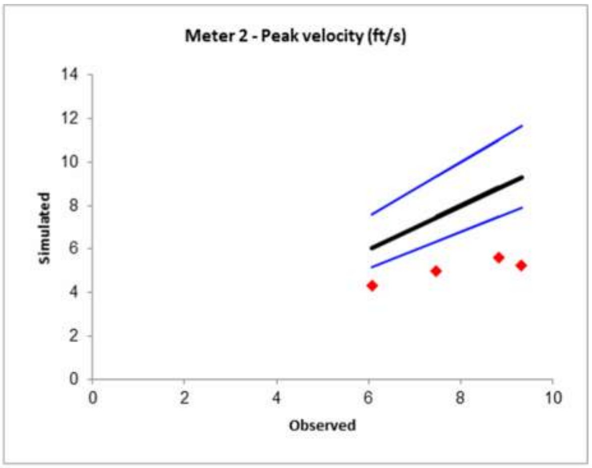
Meter 2 - Volume (Mgal)



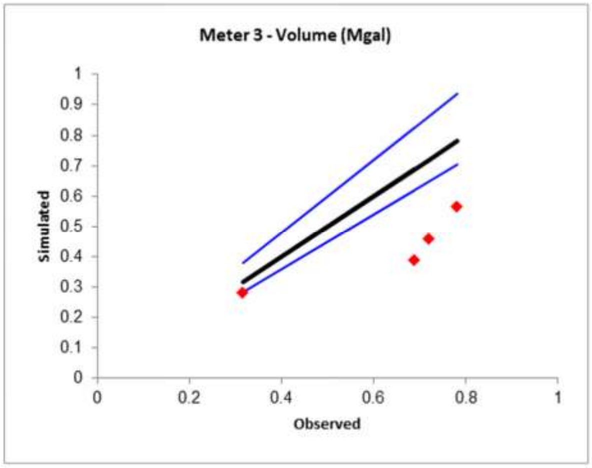
Meter 2 - Peak discharge (cfs)



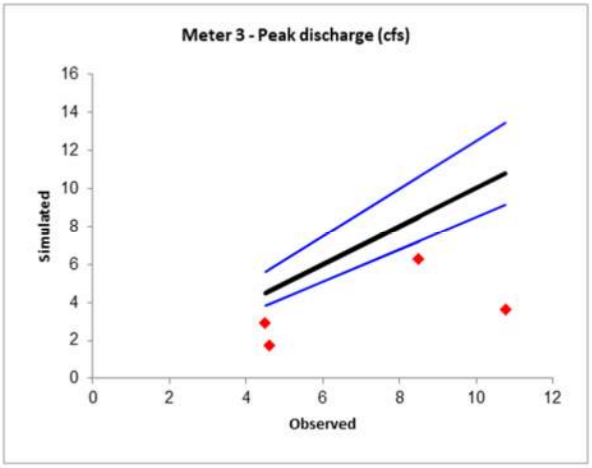
Meter 2 - Peak depth (ft)



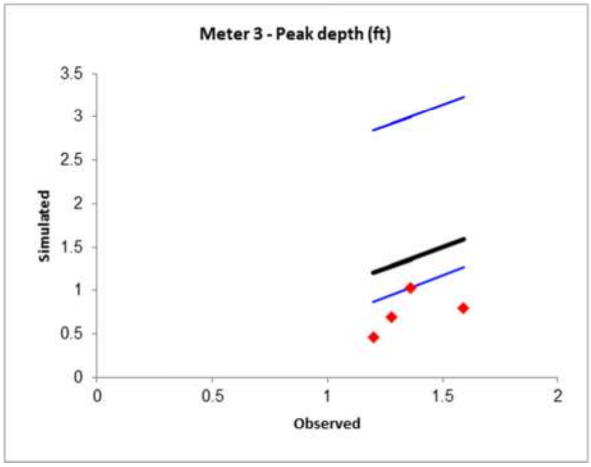
Meter 2 - Peak velocity (ft/s)



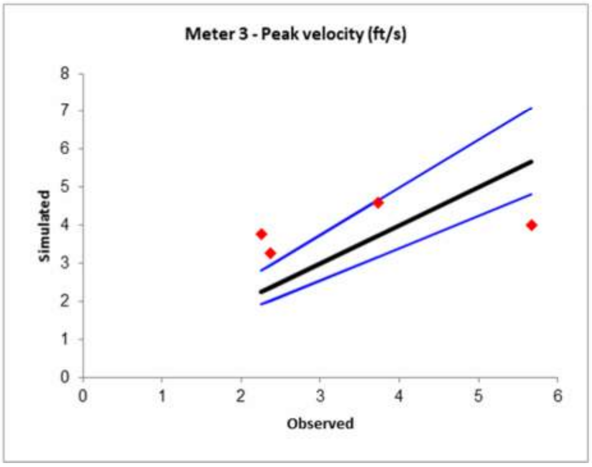
Meter 3 - Volume (Mgal)



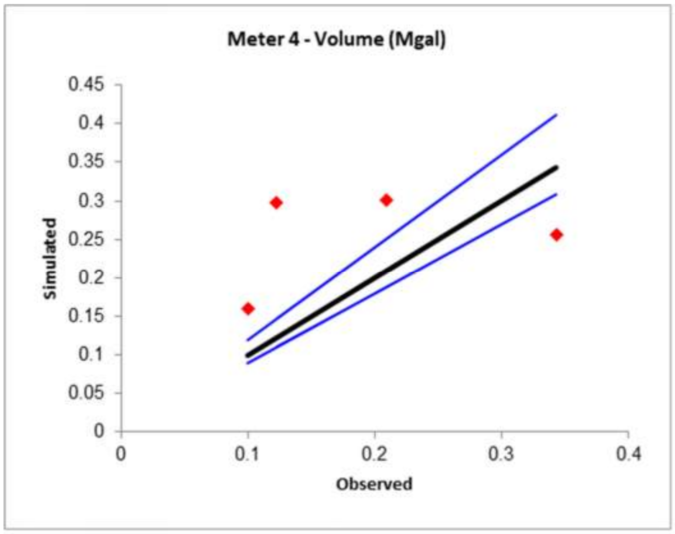
Meter 3 - Peak discharge (cfs)

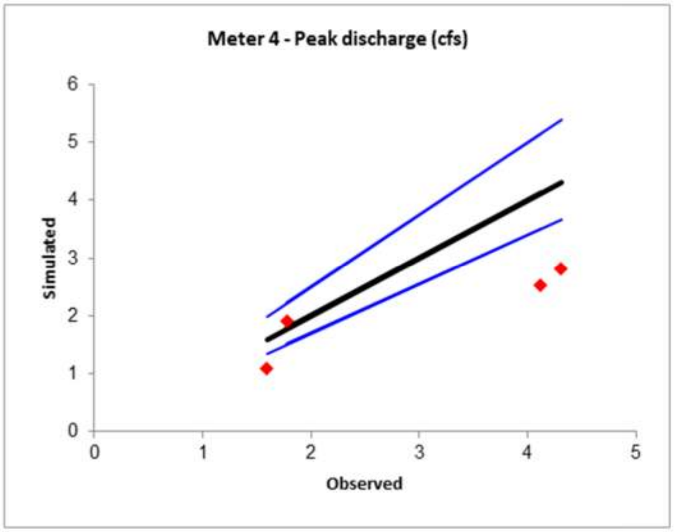


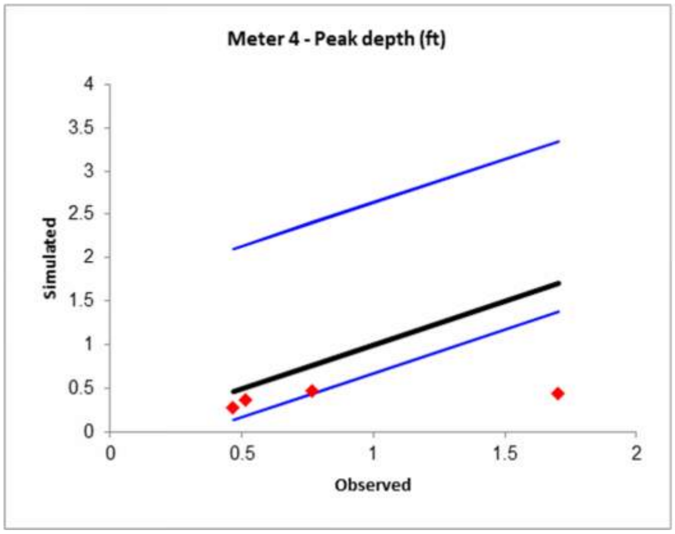
Meter 3 - Peak depth (ft)

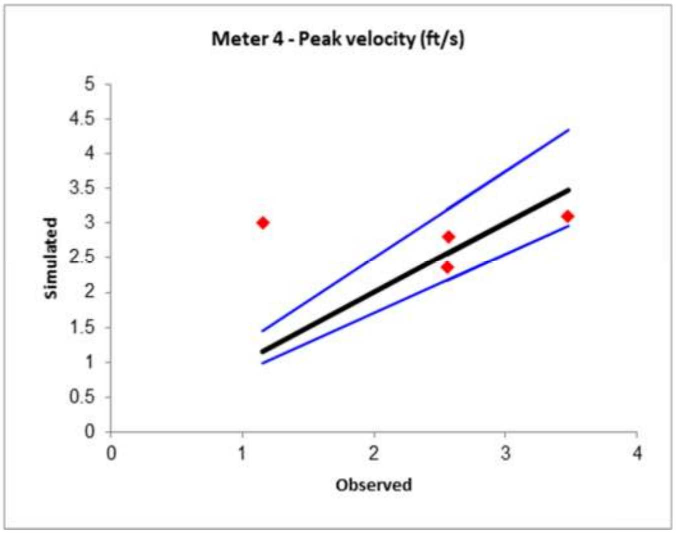


Meter 3 - Peak velocity (ft/s)


Meter 4 - Volume (Mgal)
Simulated
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0
0.1
0.2
0.3
0.4
Observed


Meter 4 - Peak discharge (cfs)
Simulated
0
1
2
3
4
5
6
0
1
2
3
4
5
Observed


Meter 4 - Peak depth (ft)
Simulated
0
0.5
1
1.5
2
2.5
3
3.5
4
0
0.5
1
1.5
2
Observed


Meter 4 - Peak velocity (ft/s)
Simulated
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
1
2
3
4
Observed

Appendix B

Soil Borings

APPENDIX A
GEOTECHNICAL REPORT

SITE LLC
Sub-surface Investigations, Technology & Experience

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com SITElog® Report

Friday, 18 March 2011

Jessica Coelho
The Metropolitan District
555 Main Street
Hartford, CT 06142

Re: **Soil Borings**
Montclair Drive, West Hartford, CT

Dear Jessica,

Enclosed is the SITElog® Report for the work completed at the above referenced site.

Thank you for providing us the opportunity to serve you. We hope the work our company has performed exceeded your expectations and that you are pleased. If so, recommending us to your associates would be appreciated.

Should you have any questions or concerns, please feel free to contact us at (203) 490-4777.

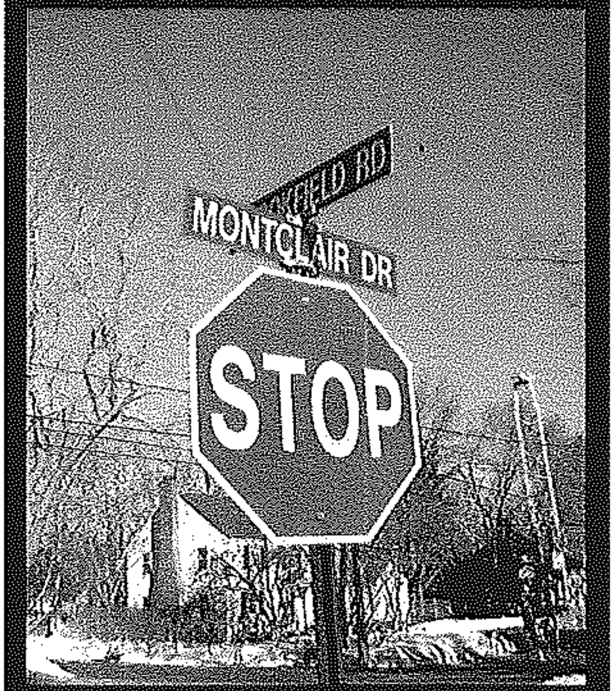
We look forward to working with you again in the near future.

Visit us on the web! www.site-llc.com

Sincerely,
SITE, LLC
John A. DeAngelis, Jr.
John A. DeAngelis, Jr.
Managing Member

SITE LLC

Sub-surface Investigations, Technology & Experience



Client:

The Metropolitan District

Project:

Montclair Drive, West Hartford, CT

Date:

Thursday, 3 March 2011

Sub-surface Investigations, Technology + Experience

Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

SITE LLC

Sub-surface Investigations Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

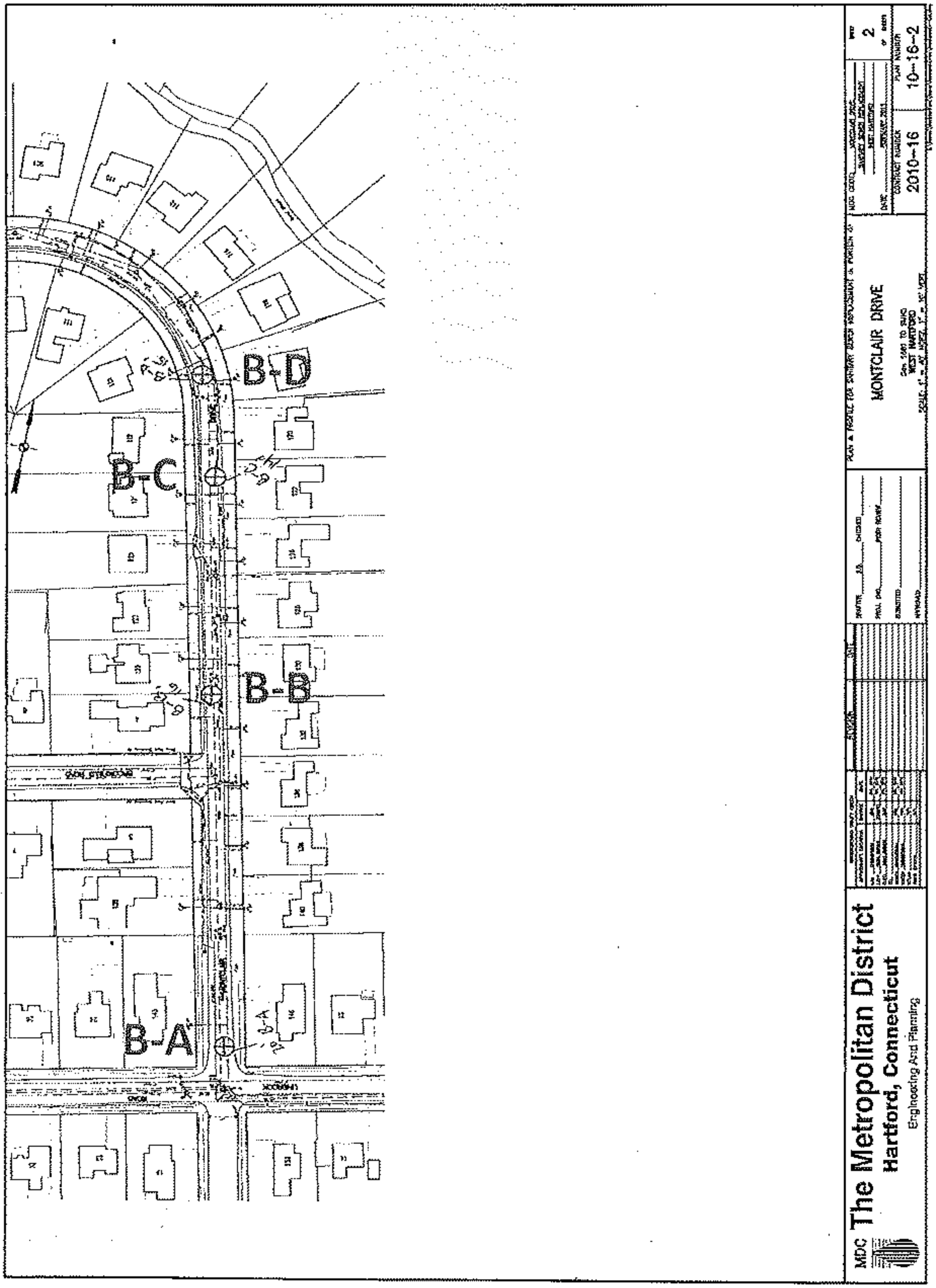
Project: Montclair Drive, West Hartford, CT

Date: Thursday, 3 March 2011

Project Manager: *Jessica Coelho* Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **SITEmap**



SITE LLC
Sub-surface Investigations Technology & Experience

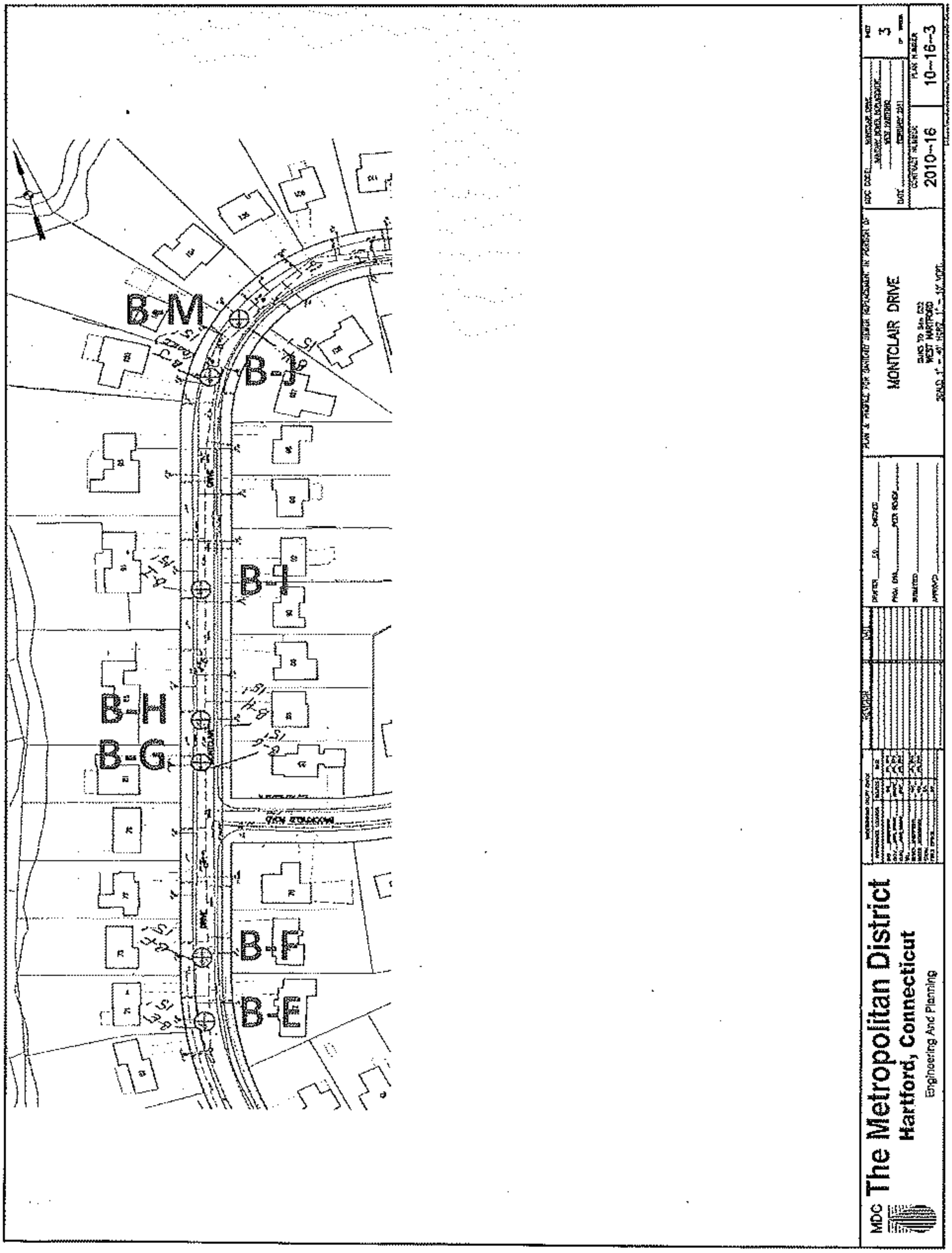
Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

Project: Montclair Drive, West Hartford, CT

Date: Thursday, 3 March 2011

Project Manager: Jessica Coelho Contract #2009 19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com SITElog® Report **SITEmap**



Client:

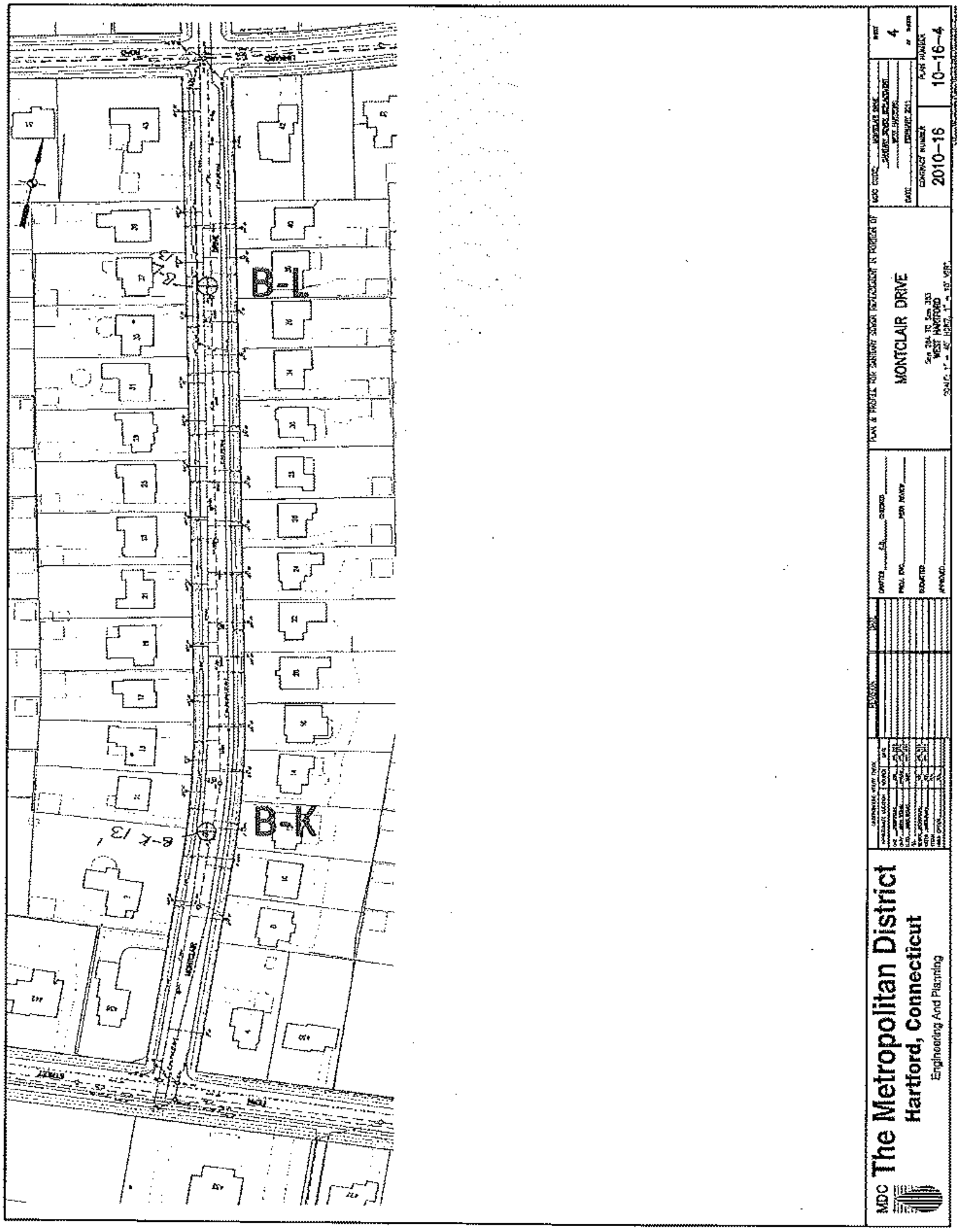
THE METROPOLITAN DISTRICT
555 MAIN STREET
HARTFORD, CT 06142

Project: Montclair Drive, West Hartford, CT

Date: Thursday, 3 March 2011

Project Manager: *Jessica Coelho* Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com SITElog® Report **SITEmap**



Sub-surface Investigations, Technology + Experience

Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

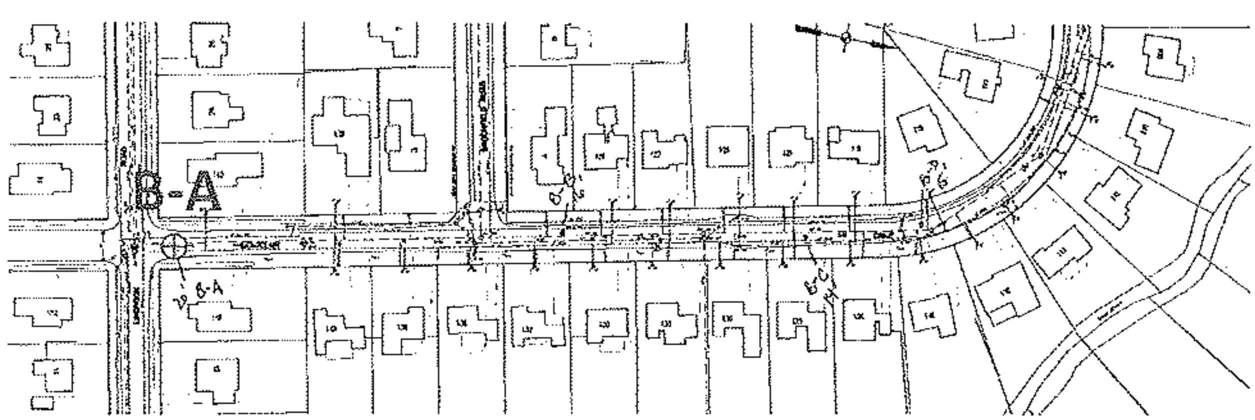
Project: 146 Montclair Drive, West Hartford, CT
Date: Thursday, 3 March 2011
Water: 1'-8"
Ground Elev.:
Project Manager: Jessica Coelho
Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-A**

Depth	Blows per 6"				Moisture		Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
1' to 3'	8	8	5	4	Wet		0.50	bl	**ASPHALT (6" thick)**		1	24"	8"
						▼	1.00	og	**STONE (Processed Basalt)**	FILL			
							2.75	br	**SAND(c-f), little Gravel, Stone**				
								og/rb	**CLAY varved w/Silt (thin beds)**				
5' to 7'	2	2	3	3	Wet						2	24"	23"
10' to 12'	2	3	4	3	Wet			rb	**CLAY layered w/Silt, occas. Pebbly/Sandy zone**	FINES	3	24"	19"
							13.00						
								rb	**SILT, trace Pea-Stone, Clay**				
15' to 17'	3	6	8	11	Damp						4	24"	22"
							16.50						
								rb	**SAND & SILT, some Basalt & Sandstone Fragments, trace Clay**				
20' to 22'	16	53	26	25	Wet					TILL	5	24"	18"
							22.00						
									End of Exploration @ 22.00				

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill	▨
Organics	■
Subsoil	▨
Silt	▨
Silty Sand	▨
Clay	▨
Sand	∴
Gravel	••
Cobble	●
Till	▨
Rock	▨
Water	▼
SPT	▯
Curb Box	▨
Riser	▯
Bentonite	▨
Screen	▯

GPS Coor: 41°46.443N 72°44.357W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord, descriptions and boundaries are not guaranteed.

Sub-surface Investigations, Technology + Experience

Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

SITE LLC
Sub-surface Investigations Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

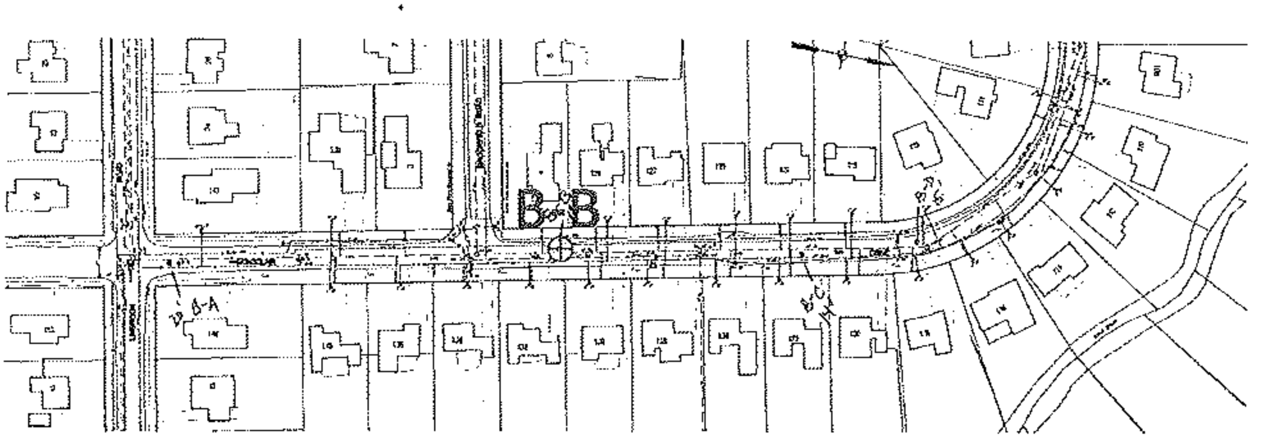
Project: 132 Montclair Drive, West Hartford, CT
Date: Thursday, 3 March 2011
Water: 5'-0"
Ground Elev.:
Project Manager: Jessica Coelho
Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-B**

Depth	Blows per 6"				Moisture		Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
1' to 3'	11	6	4	5	Damp		0.25	bl	**ASPHALT (3" thick)**		1	24"	16"
							0.58	gy	**STONE (Oiled?)**				
							1.50	og	**SAND, little Processed Basalt Stone**	FILL			
								l,rb/tn	**SILT, little Clay**				
5' to 7'	2	2	3	2	Wet	▼	5.50				2	24"	16"
							5.75	d.br	**SAND m/w Silt, Pebbles**				
								rb	**CLAY, some Silt**				
10' to 12'	0	1	1	1	Wet			rb/gy	**CLAY varved w/Silt**	FINES	3	24"	24"
								rb	**CLAY varved w/Silty Clay**				
							14.00						
15' to 17'	5	6	7	7	Damp			rb	**SILT, little Pebble-Gravel, trace Clay**		4	24"	23"
										TILL			
							17.00						
									End of Exploration @ 17.00				

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill ▨
Organics ■
Subsoil ▨
Silt ▨
Silty Sand ▨
Clay ▨
Sand ∴
Gravel •
Cobble ●
Till ▨
Rock ▨
Water ▼
SPT ▭
Curb Box
Riser
Bentonite
Screen

GPS Coor: 41°46.506N 72°44.373W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER- Some GPS coord., descriptions and boundaries are not guaranteed.

SITE LLC
Sub-surface Investigations Technology & Experience

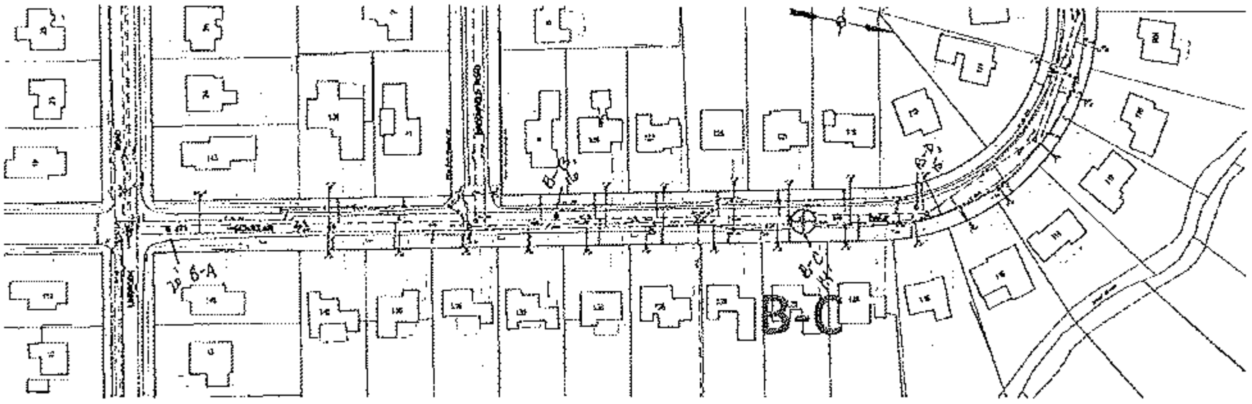
Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

Project: 122 Montclair Drive, West Hartford, CT
Date: Thursday, 3 March 2011
Water: 6'-6"
Ground Elev.:
Project Manager: Jessica Coelho Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com SITElog® Report **B-C**

	Depth	Blows per 6"				Moisture		Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
	1' to 3'	7	5	7	7	Damp		0.29	bl	***ASPHALT (3½" thick)***		1	24"	19"
								0.92	d.gy	***STONE (Basalt - Oiled?)***				
								1.08	og	***SAND, little Processed Stone (Dust)***				
									d.br/gy	***SILT, some Sand, trace Gravel, Wood***				
5'	5' to 7'	1	2	3	3	Moist				***SILT & CLAY, little Sand, Pebble-Gravel***		2	24"	21"
							▼				FILL			
10'	10' to 12'	2	4	4	4	Wet		10.25	d.gy	***SILT, some Sand***		3	24"	14"
									d.rb	***SAND(c-f), little Gravel(f-m), Clay***				
	12' to 14'	2	2	3	4	Wet		12.25				4	24"	20"
									rb	***SILT & CLAY***	FINES			
								14.00						
15'										***End of Exploration @ 14.00***				
20'														
25'														
30'														
35'														

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill	▨
Organics	■
Subsoil	
Silt	
Silty Sand	
Clay	
Sand	∴
Gravel	•-
Cobble	●
Till	
Rock	
Water	▼
SPT	
Curb Box	
Riser	
Bentonite	
Screen	

GPS Coor: 41°46.542N 72°44.382W

Driller Name: J. DeAngelis, III

Helper Name: J. DeAngelis, Jr.

Drill Equip: CME 75

Hammer Wgt: 140# CME Auto

Sampler: 2" O.D. Lynac

Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord, descriptions and boundaries are not guaranteed.

Client:	**THE METROPOLITAN DISTRICT** **555 MAIN STREET** **HARTFORD, CT 06142**
Project:	115 Montclair Drive, West Hartford, CT
Date:	Friday, 4 March 2011
Water:	5'-6"
Ground Elev.:	
Project Manager:	Jessica Coelho

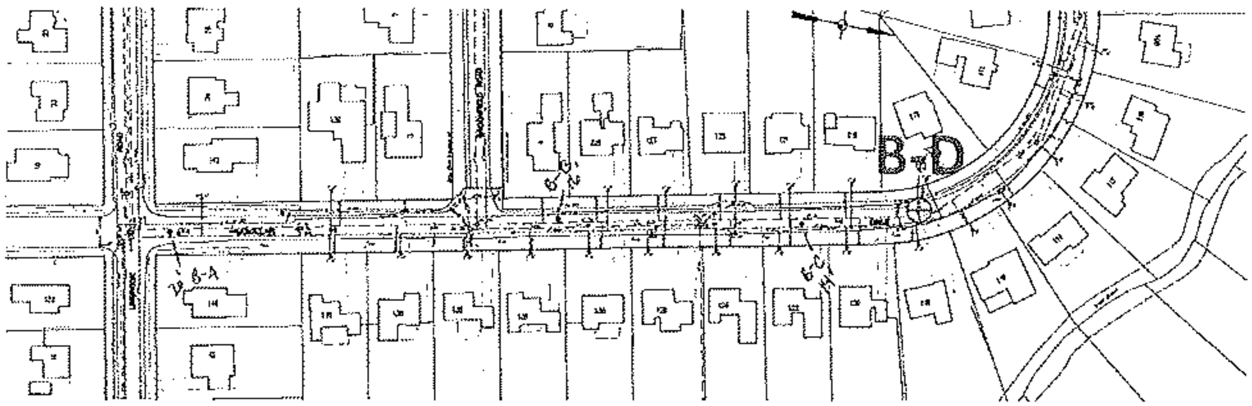
Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-D**

	Depth	Blows per 6"				Moisture		Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
	1' to 3'	13	6	6	6	Damp		0.25	bl	***ASPHALT (3" thick)***		1	24"	20"
								0.58	gy	***STONE (Processed Basalt - Oiled)***				
								0.92	gy	***SAND, little Processed Basalt Stone***				
								1.25	og	***SAND, little Processed Stone***				
5'	*5' to 7'*	1	1	2	2	Moist			d.zb/gy	***SILT, some Sand(f), little Gravel, Wood***		2	24"	15"
							▼		br	***CLAY, some Silt, Sand, trace Gravel***				
											FILL			
10'	*10' to 12'*	2	3	2	2	Wet		10.50	gy	***CLAY, trace Gravel***		3	24"	15"
								10.75	d.gy	***SAND(m-f), trace Fibers***				
									xb	***SAND, some Gravel, Clay***				
	13' to 15'	2	3	3	5	Moist		13.00				4	24"	16"
									xb	***SILT, trace Clay, Gravel(f)***	TILL			
15'								15.00						
										End of Exploration @ 15.00				
20'														
25'														
30'														
35'														

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



- Fill
- Organics
- Subsoil
- Silt
- Silty Sand
- Clay
- Sand
- Gravel
- Cobble
- Till
- Rock
- Water
- SPT
- Curb Box
- Riser
- Bentonite
- Screen

GPS Coor:	41°46.558N 72°44.393W
Driller Name:	J. DeAngelis, III
Helper Name:	J. DeAngelis, Jr.
Drill Equip:	CME 75
Hammer Wgt:	140# CME Auto
Sampler:	2" O.D. Lynac
Casing:	2.25" H.S.A.

DISCLAIMER: Some GPS coord., descriptions and boundaries are not guaranteed.

Sub-surface Investigations, Technology + Experience

Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

SITE LLC
Sub-surface Investigations Technology & Experience

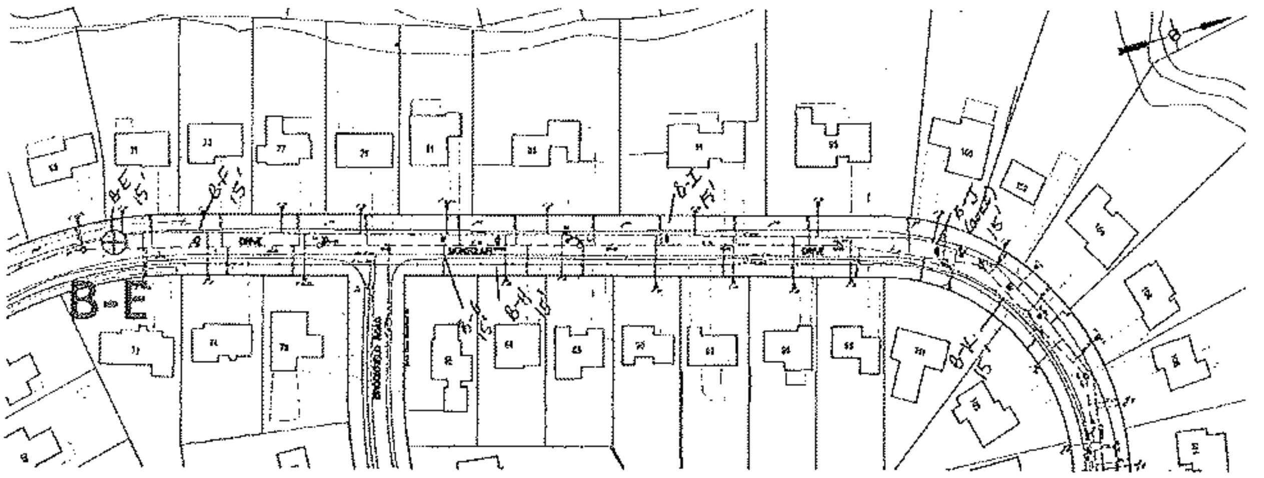
Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

Project: 72 Montclair Drive, West Hartford, CT
Date: Thursday, 3 March 2011
Water: 9'-9"
Ground Elev.:
Project Manager: Jessica Coelho
Contract #2009-19

(203) 490-4777   63 Lancaster Drive, Beacon Falls Connecticut 06403   www.site-llc.com   SITElog® Report **B-E**

	Depth	Blows per 6"				Moisture		Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
	1' to 3'	12	21	18	12	Damp		0.29	bl	**ASPHALT (3½" thick)**		*1	24"	16"
								0.62	og	**STONE, little Sand**				
	3' to 5'	15	10	10	9	Damp		0.92	og	**SAND, little Processed Stone (Dust)**		*2	24"	11"
									rb	**SAND & SILT, some Weathered Stone Fragments (some large)**	FILL			
5'	5' to 7'	5	3	2	2	Damp						3	24"	3"
	7' to 9'	5	9	15	10	Dry						4	24"	15"
								7.50						
	9' to 11'	15	9	13	24	Wet			rb	**SILTSTONE (Highly Fragmented?)**		5	24"	22"
10'							▼				ROCK			
	11' to 11'-3"	50/3"						11.00				6	3"	3"
								12.00	rb	**SILTSTONE (Firmer)**				
										Auger Refusal @ 12.00				
15'														
20'														
25'														
30'														
35'										*** 3" Spoon**				

KEY   bl - black   w - white   gy - grey   tn - tan   ro - rust/orange   ob - olive/brown   og - olive/grey   d. - dark   l. - light   l/w - layered with   m/w - mixed with



Fill	▨
Organics	■
Subsoil	▨
Silt	▨
Silty Sand	▨
Clay	▨
Sand	∴
Gravel	•-
Cobble	●
Till	▨
Rock	▨
Water	▼
SPT	▯
Curb Box	▨
Riser	▯
Bentonite	▨
Screen	▨

GPS Coor: 41°46.452N 72°44.513W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord, descriptions and boundaries are not guaranteed.

SITE LLC
Sub-surface Investigations, Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

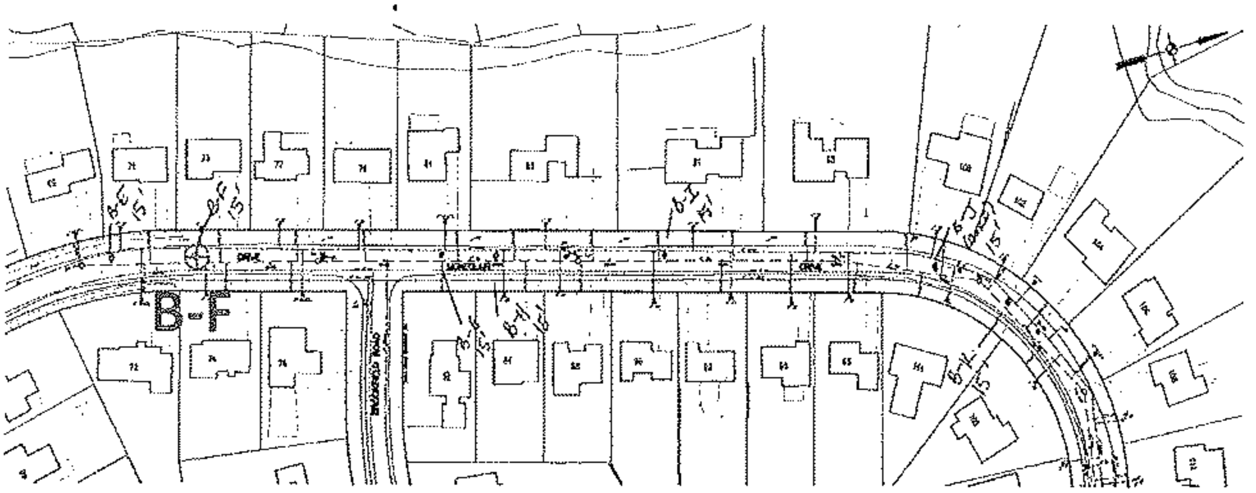
Project: 74 Montclair Drive, West Hartford, CT
Date: Monday, 7 March 2011
Water: 8'-6"
Ground Elev.:
Project Manager: Jessica Coelho Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com SITElog® Report **B-F**

	Depth	Blows per 6"				Moisture		Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
	1' to 3'	11	12	11	11	Damp		0.25	bl	**ASPHALT (3" thick)**		1	24"	20"
								0.50	gy	**STONE (Oiled)**				
								0.83	br	**SAND, some Processed Basalt Stone**				
								1.00	og	**SAND, trace Stone(f) (Dust)**	FILL			
5'	5' to 7'	1	1	3	1	Moist		5.00	rb	**SAND & SILT & Frag. Siltstone (some large)**		2	24"	11"
									rb	**SAND & SILT, little Clay, Stone**				
	7' to 9'	4	4	6	4	Wet		7.00				3	24"	6"
									rb	**SILTSTONE Rock Fragments, little Sand & Clay**				
							▼				FRACTURED			
10'	10' to 11'	13	55/6"			Wet					ROCK	*4	12"	12"
								10.75						
	12' to 17'	C	O	R	E	Min.		12.00	d.rb	**SILTSTONE (less fractured)**		**5	60"	60"
						4.50			d.rb	**Auger Refusal @ 12.00**				
						3.00				** Nx Cored 12.00 to 17.00	COMPETENT			
15'						4.50				**Recovered 60" of slightly fractured**	ROCK			
						4.00				**Siltstone/Shale**				
						3.50		17.00		**RQD = 75%**				
										End of Exploration @ 17.00				
20'														
25'														
30'														
35'														

*** 3" Spoon**
**** Rock Core Strength Test Performed**

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill	▨
Organics	■
Subsoil	▨
Silt	▨
Silty Sand	▨
Clay	▨
Sand	∴
Gravel	•-
Cobble	●
Till	▨
Rock	▨
Water	▼
SPT	▯
Curb Box	▨
Riser	▨
Bentonite	▨
Screen	▨

GPS Coor: 41°46.460N 72°44.515W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 4.25" H.S.A.

DISCLAIMER: Some GPS coord, descriptions and boundaries are not guaranteed.

SITE LLC
Sub-surface Investigations, Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

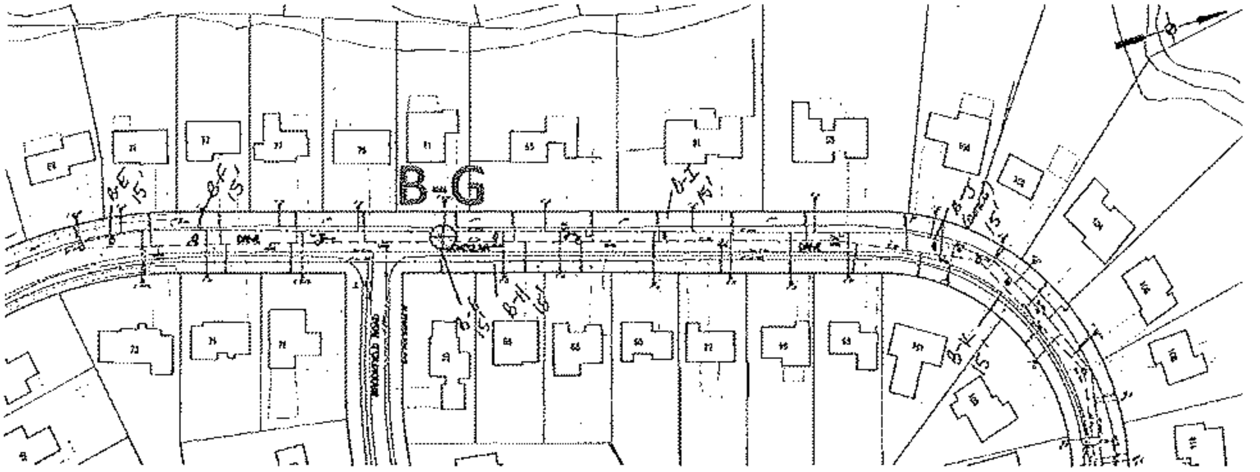
Project: 81 Montclair Drive, West Hartford, CT
Date: Friday, 4 March 2011
Water: 9'-0"
Ground Elev.:
Project Manager: Jessica Coelho Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-G**

	Depth	Blows per 6"				Moisture	Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
	1' to 3'	19	15	6	6	Damp	0.25	bl	**ASPHALT (3" thick)**		1	24"	16"
							0.83	gy	**STONE (Coarse Basalt - Oiled)**	FILL			
							1.67	og	**STONE, some Sand**				
								rb	**SILT & SAND(f), some Gravel**				
5'	5' to 7'	6	5	4	6	Damp			**SILT & SAND & Fragmented SILTSTONE, tr. Clay**		2	24"	12"
										FILL			
	7' to 8'-4"	18	9	50/4"		Damp			**SILTSTONE Rock Fragments, little Silty Sand**		3	16"	12"
							8.00						
								rb	**SILTSTONE**				
10'	10' to 10'-2"	50/2"				Dry				ROCK	4	2"	2"
							10.75						
									Auger Refusal @ 10.75				
15'													
20'													
25'													
30'													
35'													

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill	▨
Organics	▨
Subsoil	▨
Silt	▨
Silty Sand	▨
Clay	▨
Sand	∴
Gravel	•-
Cobble	●
Till	▨
Rock	▨
Water	⊻
SPT	▨
Curb Box	▨
Riser	▨
Bentonite	▨
Screen	▨

GPS Coor: 41°46.490N 72°44.497W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord., descriptions and boundaries are not guaranteed.

SITE LLC
Sub-surface Investigations Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

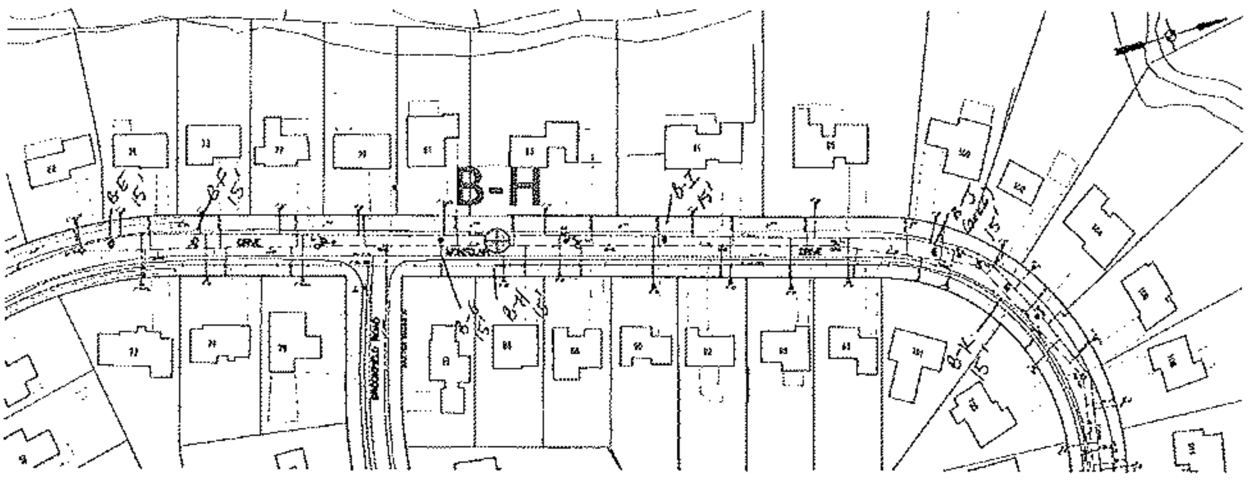
Project: 85 Montclair Drive, West Hartford, CT
Date: Thursday, 3 March 2011
Water: None
Ground Elev.:
Project Manager: Jessica Coelho Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-H**

	Depth	Blows per 6"				Moisture	Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
	1' to 3'	14	10	8	7	Damp	0.21	bl	**ASPHALT (2½" thick)**		1	24"	3"
							0.54	bl	**STONE (Oiled)**	FILL			
							1.25	og	**STONE (Processed Basalt), little Sand**				
								rb	**SILT & SAND, some Weathered Siltstone Frags.,**				
5'	5' to 7'	4	8	9	29	Moist			**trace Clay**	TILL	2	24"	22"
							6.50						
								rb	**SILTSTONE**				
										ROCK			
10'	10' to 10'-2"	50/2"				Dry	10.42				3	2"	2"
									Auger Refusal @ 10.42				
15'													
20'													
25'													
30'													
35'													

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill ▨
Organics ■
Subsoil
Silt
Silty Sand
Clay
Sand ∴
Gravel •-
Cobble ●
Till ▨
Rock ▨
Water ▼
SPT ▯
Curb Box
Riser
Bentonite
Screen

GPS Coor: 41°46.498N 72°44.494W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord., descriptions and boundaries are not guaranteed.

Sub-surface Investigations, Technology + Experience
Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

Project: 91 Montclair Drive, West Hartford, CT
Date: Friday, 4 March 2011
Water: 6'-0"
Ground Elev.:
Project Manager: Jessica Coelho Contract #2009-19

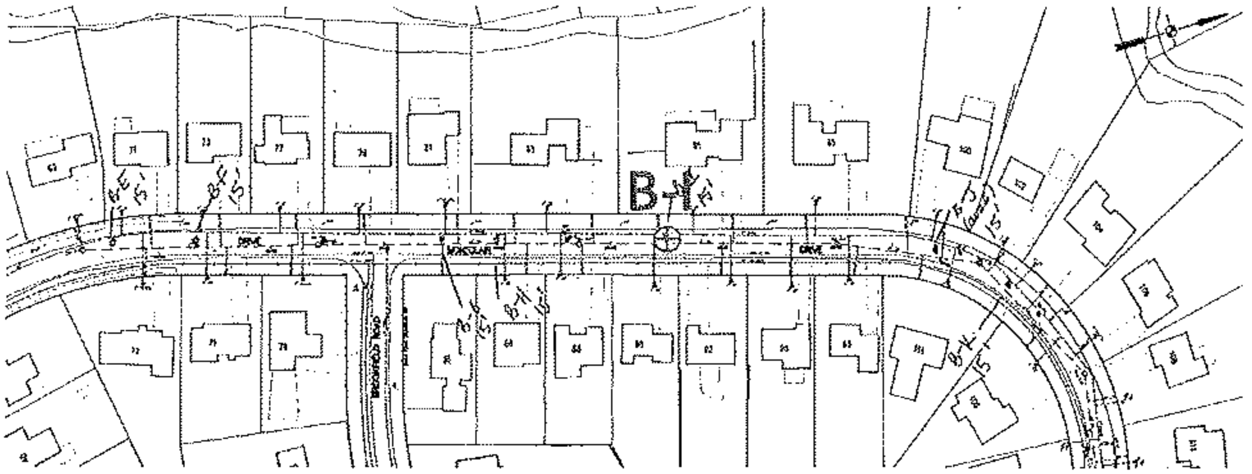
(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-1**

Depth	Blows per 6"				Moisture	Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
1' to 3'	5	8	7	8	Damp	0.25	bl	**ASPHALT (3" thick)**		1	24"	22"
						0.67	gy/br	**STONE, little Sand (Oiled)**				
						1.17	og	**SAND, little Processed Stone**	FILL			
						2.50	rb	**SAND(f) & SILT, little Stone**				
5' to 7'	3	4	5	8	Moist	4.00	br	**SAND(f), some Silt, little Gravel**		2	24"	23"
							br	**SILT, trace Clay**				
							rb	**SILT, trace Clay**	FINES			
						7.75						
							rb	**SAND & SILT, some Fragmented Stone, Clay**				
10' to 10'-9"	8	50/3"			Wet				TILL	3	9"	9"
						10.50						
						11.50	rb	**SILTSTONE**	ROCK			
								Auger Refusal @ 11.50				

5'
10'
15'
20'
25'
30'
35'

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill
Organics
Subsoil
Silt
Silty Sand
Clay
Sand
Gravel
Cobble
Till
Rock
Water
SPT
Curb Box
Riser
Bentonite
Screen

GPS Coor: 41°46.524N 72°44.485W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord., descriptions and boundaries are not guaranteed.

Sub-surface Investigations, Technology + Experience

Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

SITE LLC
Sub-surface Investigations Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

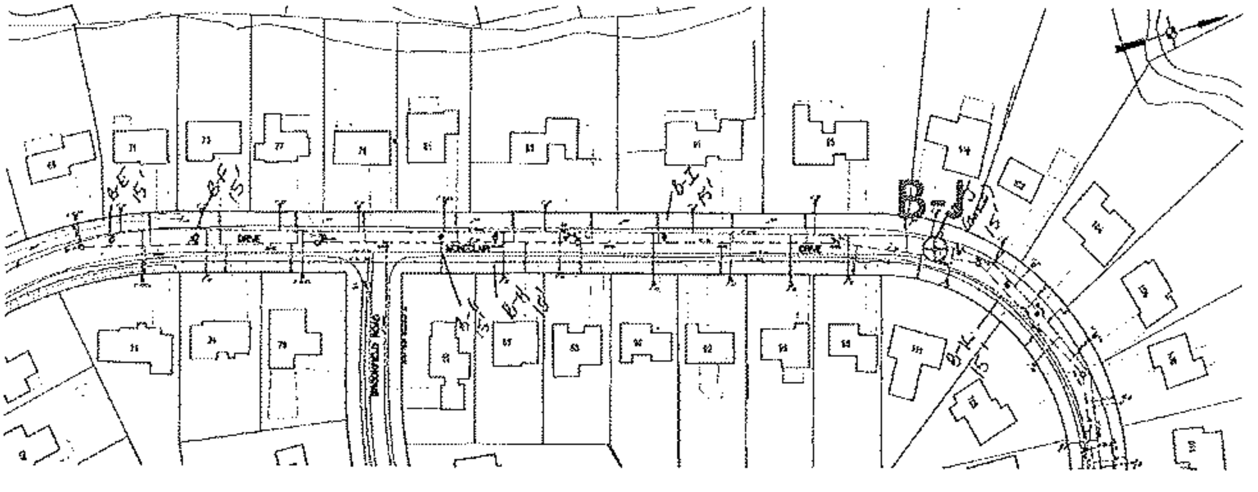
Project: 100 Montclair Drive, West Hartford, CT
Date: Monday, 7 March 2011
Water: 1'-3" * Parched?
Ground Elev.:
Project Manager: Jessica Coelho
Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-J**

	Depth	Blows per 6"				Moisture		Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
	1' to 3'	5	5	4	2	Wet	▼	0.33	bl	**ASPHALT (4" thick)**		1	24"	17"
								0.67	gy	**STONE (Basalt - Oiled)**				
								1.50	og	**SAND, some Processed Basalt Stone**				
									xb	**SILT & SAND, some Stone, little Clay**	FILL			
5'	5' to 7'	0	1	1	1	Wet				**CLAY & SILT, some Sand, little Gravel**		2	24"	7"
								8.00						
									xb	**SAND(f) & SILT, some Stone Fragments**				
10'	10' to 12'	11	21	25	36	Damp				**(Siltstone & Basalt)**	TILL	3	24"	22"
								12.17						
									xb	**SILTSTONE**				
	14' to 19'	C	O	R	E	Min.		14.00				4	60"	60"
15'						4.00			d.xb	**Auger Refusal @ 14.00**				
						3.50				* Nx Cored 14.00 to 19.00	ROCK			
						3.00				**Recovered 60" of moderately fractured**				
						3.00				**Siltstone/Shale**				
						4.00		19.00		**RQD = 31%**				
20'										**End of Exploration @ 19.00**				
25'														
30'														
35'										*** Rock Core Strength Test Performed**				

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



- Fill ▒
- Organics █
- Subsoil
- Silt
- Silty Sand
- Clay
- Sand ∴
- Gravel ▪
- Cobble ●
- Till ▓
- Rock
- Water ▼
- SPT
- Curb Box
- Riser
- Bentonite
- Screen

GPS Coor: 41°46.546N 72°44.460W

Driller Name: J. DeAngelis, III

Helper Name: J. DeAngelis, Jr.

Drill Equip: CME 75

Hammer Wgt: 140# CME Auto

Sampler: 2" O.D. Lynac

Casing: 4.25" H.S.A.

DISCLAIMER: Some GPS coord., descriptions and boundaries are not guaranteed.

Sub-surface Investigations, Technology + Experience
Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

SITE LLC

Sub-surface Investigations Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

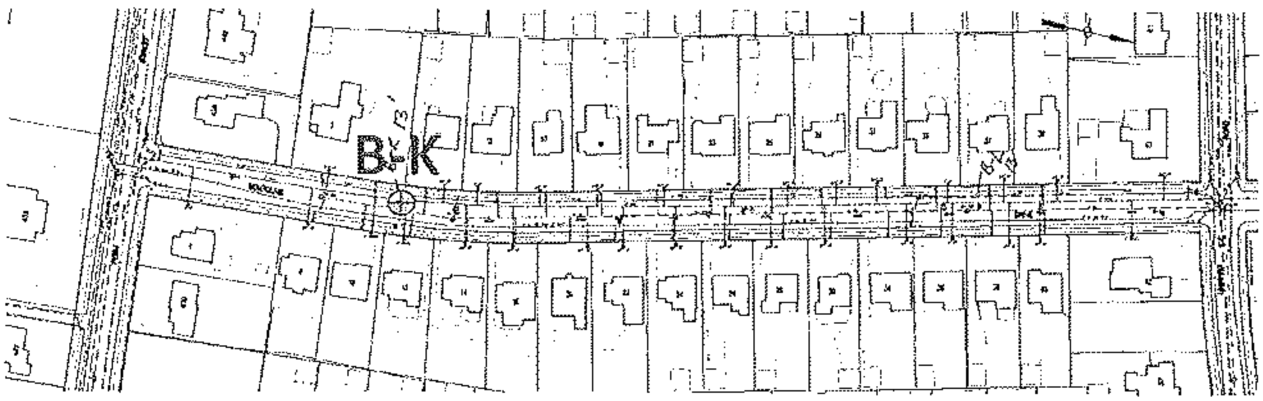
Project: 11 Montclair Drive, West Hartford, CT
Date: Friday, 4 March 2011
Water: 10'-6"
Ground Elev.:
Project Manager: Jessica Coelho Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-K**

Depth	Blows per 6"				Moisture	Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
1' to 3'	6	6	8	8	Damp	0.21	bl	**ASPHALT (2½" thick)**		1	24"	19"
						0.58	gy/br	**STONE (Processed Basalt), little Sand**	FILL			
						2.50	br	**SAND(c-f), trace Gravel**				
							rb	**SAND & SILT, little Stone Fragments**				
5' to 7'	7	8	15	16	Damp					2	24"	24"
									FILL			
10' to 12'	15	15	18	68	Damp			**SAND(f) & SILT & Fragmented STONE (Siltstone)**		3	24"	23"
					▼							
						11.75						
						12.50	rb	**SILTSTONE**	ROCK			
								Auger Refusal @ 12.50				

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill ▨
Organics ▨
Subsoil ▨
Silt ▨
Silty Sand ▨
Clay ▨
Sand ∴
Gravel
Cobble ●
Till ▨
Rock ▨
Water ▼
SPT ▨
Curb Box
Riser
Bentonite
Screen

GPS Coor: 41°46.212N 72°44.452W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord., descriptions and boundaries are not guaranteed.

Sub-surface Investigations, Technology + Experience

Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

SITE LLC
Sub-surface Investigations Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

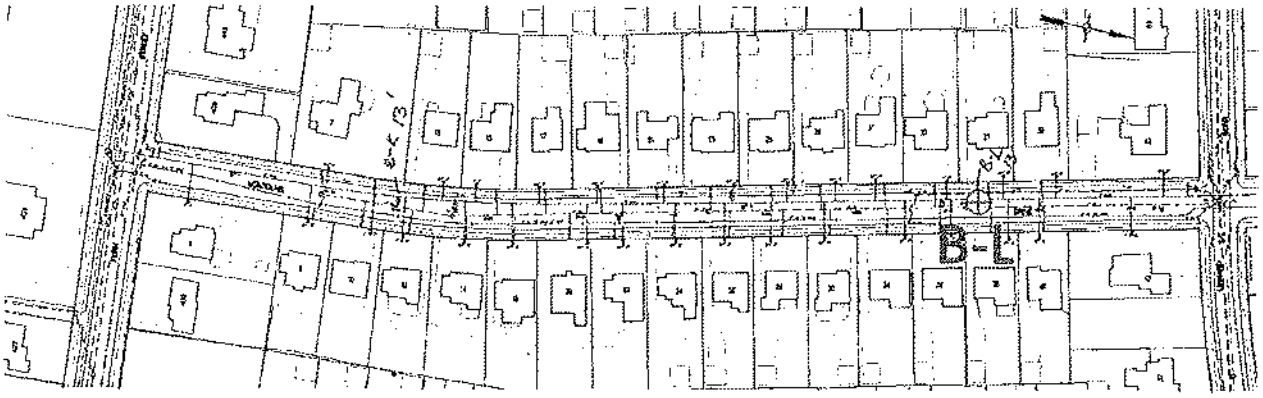
Project: 38 Montclair Drive, West Hartford, CT
Date: Friday, 4 March 2011
Water: 8'-6"
Ground Elev.:
Project Manager: Jessica Coelho Contract #2009 19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-L**

	Depth	Blows per 6"				Moisture	Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
	1' to 3'	7	7	24	14	Damp	0.25	bl	**ASPHALT (3" thick)**		1	24"	15"
							0.58	d.br	**SAND, some Silt, Basalt Stone**				
								rb/br	**SAND & SILT, little Stone, Gravel, occas. Cobble**	HB			
5'	5' to 7'	4	6	7	10	Damp	4.50				2	24"	24"
								rb	**SILT, trace Gravel, Clay**				
	7' to 9'	12	17	21	18	Damp	6.75				3	24"	22"
								rb	**SAND, some Silt, Stone Fragments**				
10'	10' to 12'	6	7	9	8	Wet			**SAND(c-f), some Silt, Gravel, little Clay**	HB	4	24"	23"
	12' to 14'	12	18	26	23	Moist			**SAND(m-f) & SILT, some Stone Frags., trace Clay**		5	24"	23"
							14.00						
15'									**End of Exploration @ 14.00**				
20'													
25'													
30'													
35'													

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill ▒
Organics ■
Subsoil
Silt
Silty Sand
Clay
Sand ∴
Gravel •
Cobble ●
Till
Rock
Water ▼
SPT
Curb Box
Riser
Bentonite
Screen

GPS Coor: 41°46.313N 72°44.474W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord, descriptions and boundaries are not guaranteed.

Sub-surface Investigations, Technology + Experience
Soil Borings * Rock Coring * Concrete Coring * Monitor Wells * Geoprobe * Recovery Wells * SITELog Reports

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

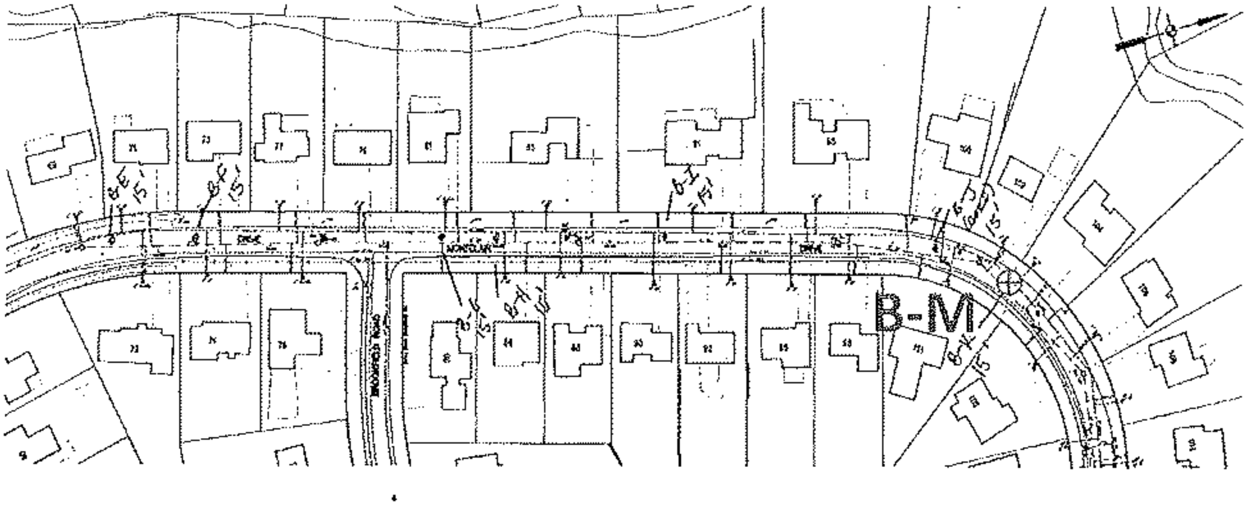
Project: 101 Montclair Drive, West Hartford, CT
Date: Friday, 4 March 2011
Water: 8'-3"
Ground Elev.:
Project Manager: Jessica Coelho Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com

SITElog® Report **B-M**

Depth	Blows per 6"				Moisture	Changes	Color	DESCRIPTION OF FINDINGS	General	No.	Pen.	Rec.
1' to 3'	10	15	12	7	Dry	0.37	bl	**ASPHALT (4½" thick)**		1	24"	3"
						0.83	gy/br	**STONE, little Sand (Oiled)**				
						2.50	og	**SAND, some Processed Basalt Stone**				
5' 5' to 7'	5	3	2	2	Dry	5.50	rb	**SAND, some Gravel, Clay**	FILL	2	24"	16"
						8.75	br	**SAND(c-m), little Gravel(f)** **Bedding Material?**				
10' 10' to 11'-9"	8	8	17	50/3"	Wet	11.00	d.rb	**SAND & Fragmented SILTSTONE, Clay**	TILL	3	21"	18"
						12.50	rb	**SILTSTONE**	ROCK			
15'								**Auger Refusal @ 12.50**				
20'												
25'												
30'												
35'												

KEY bl - black w - white gy - grey tn - tan ro - rust/orange ob - olive/brown og - olive/grey d. - dark l. - light l/w - layered with m/w - mixed with



Fill	▨
Organics	■
Subsoil	▨
Silt	▨
Silty Sand	▨
Clay	▨
Sand	∴
Gravel	••
Cobble	●
Till	▨
Rock	▨
Water	▼
SPT	▯
Curb Box	▨
Riser	▯
Bentonite	▨
Screen	▯

GPS Coor: 41°46.568N 72°44.455W
Driller Name: J. DeAngelis, III
Helper Name: J. DeAngelis, Jr.
Drill Equip: CME 75
Hammer Wgt: 140# CME Auto
Sampler: 2" O.D. Lynac
Casing: 2.25" H.S.A.

DISCLAIMER: Some GPS coord, descriptions and boundaries are not guaranteed.

MT Group
MATERIALS
TESTING

Client:	Site, LLC 63 Lancaster Drive Beacon Falls, CT 06403	**Report #:** **Date** **WO#**	001 03/11/11
Project:	Montclair Drive West Hartford, CT Project # 11005		
Sample:	Mudstone/Shale Stone Core		
Sampled By:	Client, John DeAngelis	**Lab #:**	10358
Inspector	Core samples were supplied by client		

CONCRETE CORE SAMPLES COMPRESSION TEST

PROCEDURE: The submitted samples were tested dry

Core #	Dia. Inch.	Original length Inch.	Length Capped Inch.	L/D Ratio	Area sq. Inch	Max. Load lbs.	P.S.I	L/D Factor	Comp. Strength Psi
BF	1.87	8.50	3.53	1.89	2.75	17370	6320	1.00	6320
BJ-1	1.87	5.75	2.85	1.52	2.75	22570	8210	0.96	7880
BJ-2	1.87	4.50	2.85	1.52	2.75	31380	11410	0.96	10950

Reported To: Site, LLC

Submitted By: MT Group, LLC

STATE OF CONNECTICUT
PAUL J. HESSE
No. [illegible]
LICENSED PROFESSIONAL ENGINEER

SITE LLC

Sub-surface Investigations Technology & Experience

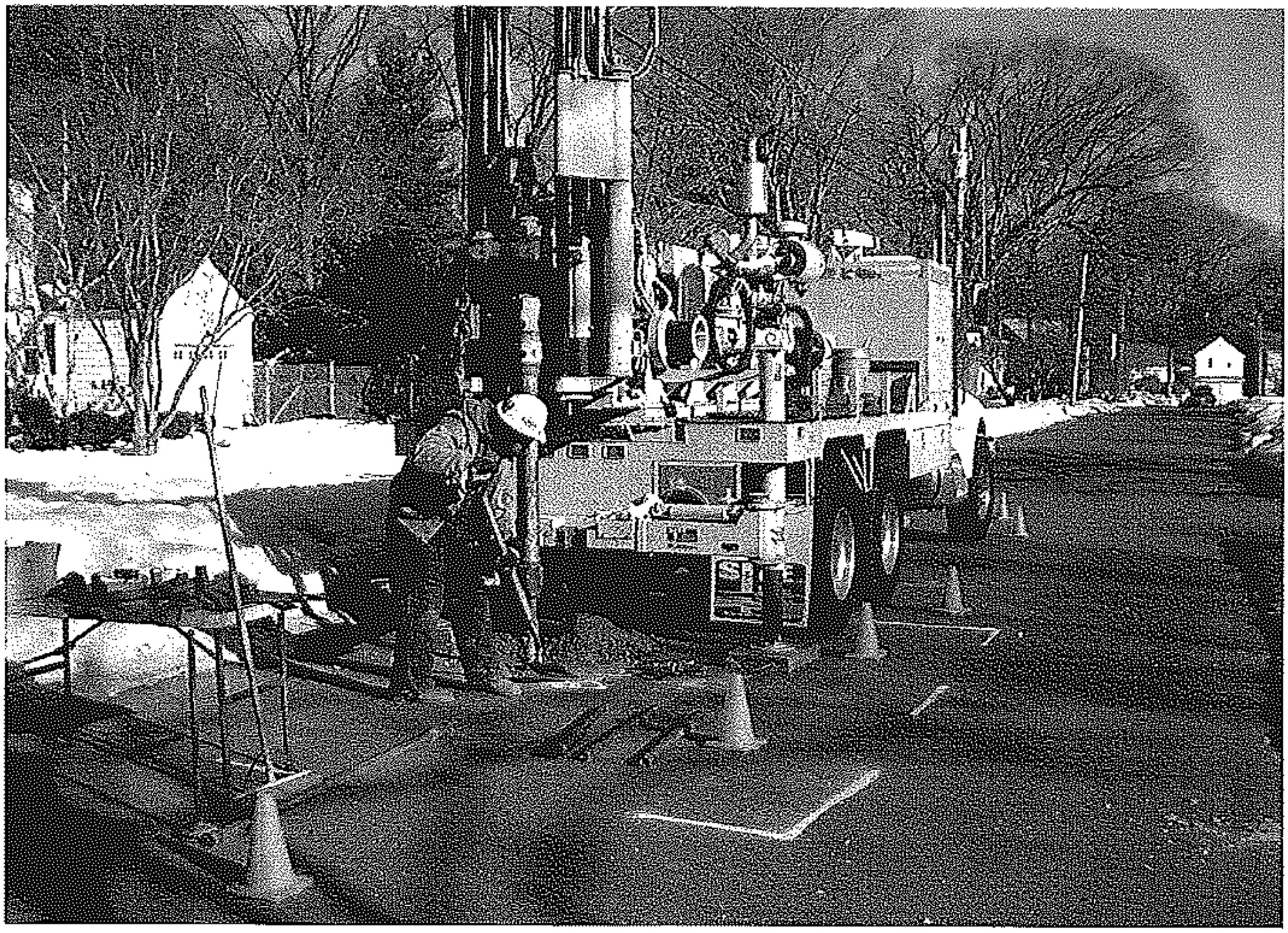
Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

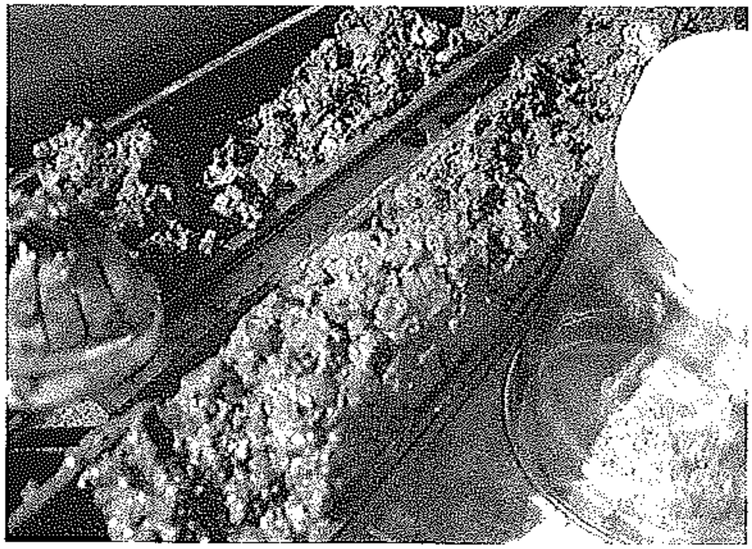
Project: Montclair Drive, West Hartford, CT

Date: Thursday, 3 March 2011

Project Manager: Jessica Coelho Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com SITElog® Report **SITEpics**





SITE LLC
Sub-surface Investigations Technology & Experience

Client: **THE METROPOLITAN DISTRICT**
555 MAIN STREET
HARTFORD, CT 06142

Project: Montclair Drive, West Hartford, CT
Date: Thursday, 3 March 2011

Project Manager: *Jessica Coelho* Contract #2009-19

(203) 490-4777 63 Lancaster Drive, Beacon Falls Connecticut 06403 www.site-llc.com SITElog® Report **SITEpics**