RESILIENCY FOR DOWNTOWN FAIRFIELD USING GREEN INFRASTRUCTURE

February 2018; Revised July 2018

Resiliency for Downtown Fairfield using Green Infrastructure

Fairfield, Connecticut
February 2018
(Revised July 2018)

MMI #1342-21-08

Prepared for:
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Table of Contents

Table of Figures

Table of Tables

Table of Maps

Appendices

1. Introduction

1.1 Project Summary

The goal of this project is to help the Town of Fairfield (the town) develop a resiliency strategy for downtown Fairfield using a Green Infrastructure (GI) approach. GI is an approach to managing runoff that relies directly on natural ecosystem services or natural design concepts to assist, enhance, and, in some cases, replace "grey" infrastructure like catch basins and stormwater conveyance systems. The area of focus for the study is depicted on Map 1 on the following page.

The GI assessment is a comparative analysis of existing and proposed conditions. As a comparative study, the goal is to determine to what extent GI reduces total runoff and peak flows in the stormwater system and the flooding associated with the system. The most important aspect of this kind of study is correctly simulating the hydrology. This was accomplished with soil borings and a detailed delineation of drainage areas in the downtown area. The assessment provides a reasonable planning-level estimate of the impacts of GI on runoff for both existing and proposed conditions.

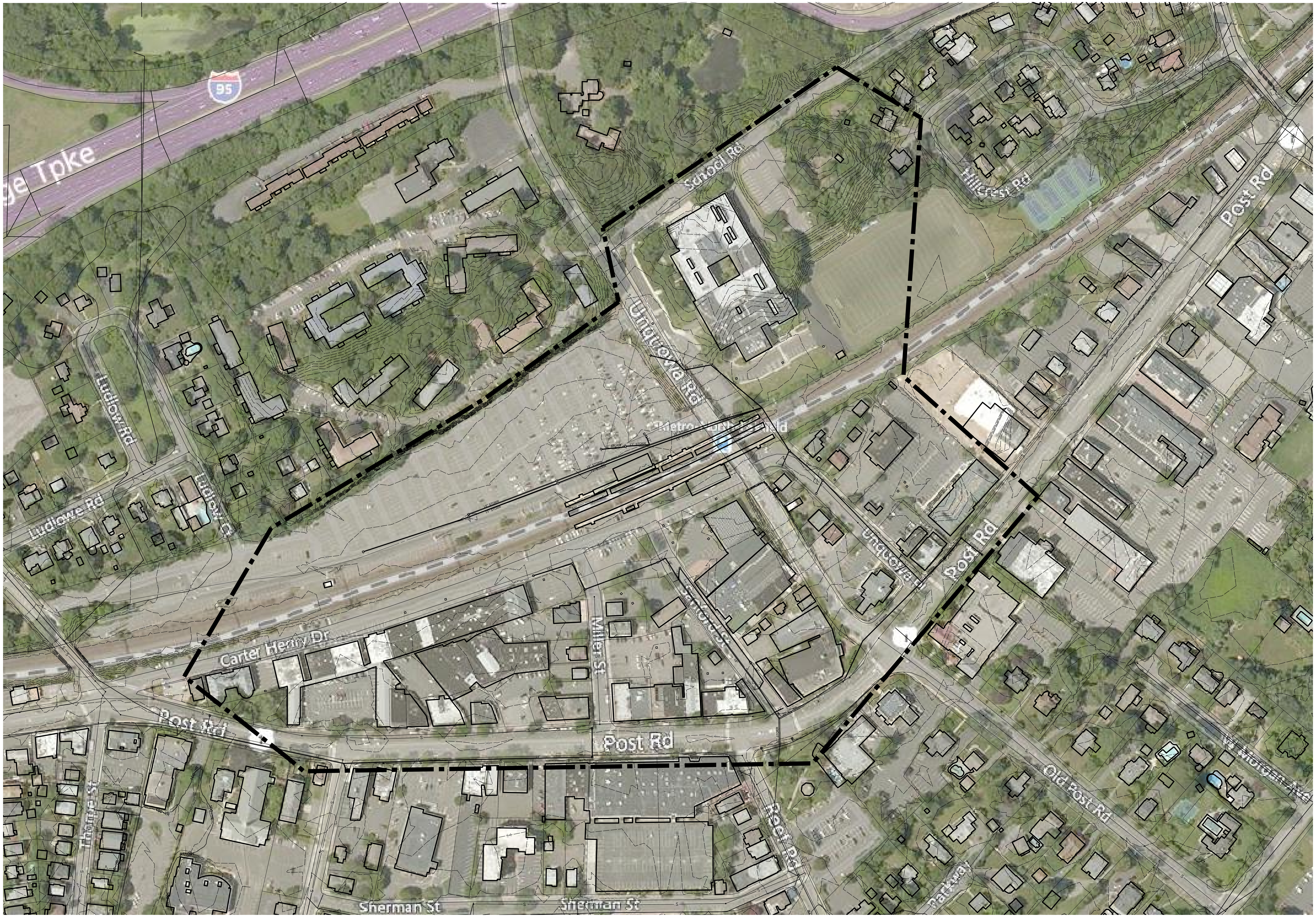
This assessment is based on a field assessment of drainage areas, a set of exploratory borings, and the stormwater system mapping. The project included the following:

- Limited utility investigation
- Subsurface investigation to collect data on surficial geology and depth to groundwater
- Development of design hyetographs from National Oceanic and Atmospheric Administration (NOAA) Atlas 14
- Preparation of existing conditions *Storm Water Management Model* (SWMM) model
- Development of various GI best practice scenarios

While extensive, the assessment does not cover all system details. For example, this assessment does not include structure inverts, nor has every inlet and connection and ultimate flow destination been traced in the field. Because this is a comparative assessment, these limitations likely do not affect the general findings of the study. For instance, general stormwater design practice offsets the inverts of catch basins and manholes 3 to 5 feet below ground surface. Stormwater design tends to provide pipes with roughly a 1% slope to facilitate solids movement in the pipes. Design aims to provide reasonable pipe slopes for conveyance and tends to parallel, as much as it can, ground slope.

This study found the following:

- The storm sewer that carries stormwater from the north side to the south side of the railroad tracks appears to be undersized.
- In most areas, soil and groundwater conditions are favorable to GI approaches.
- Few Best Management Practices (BMPs) are already in place in downtown Fairfield.
- A GI approach could help significantly reduce runoff peak flows and total volume.
- Upsizing the undersized pipes and implementing a set of GI BMPs could completely eliminate flooding from the 1-year and 2-year rain events and cut flooding from the 100-year rain event by 50% to 75%.
- Due to the downtown's dense development, a GI approach will require a combination of retrofits and redevelopment projects.



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Area of Focus

PROJECT C - RESILIENCY FOR DOWNTOWN FAIRFIELD USING GREEN INFRASTRUCTURE

FAIRFIELD, CONNECTICUT

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SCALE: 1"=100'

DATE: AUGUST 26, 2016

PROJECT NO.: 1342-21

SHEET NO.: 01 OF 01

SHEET NAME: **Map 1**

- The town should consider an approach to GI implementation that includes the following:
  - Creation of a stormwater utility 1) development fee based on managed or unmanaged impervious area; 2) dedicate revenue to stormwater management; and 3) provide fee relief for properties that install/retrofit GI onto the site to manage impervious area runoff to help spur retrofits and redevelopment use of GI
  - Development of revised postconstruction design standards

Finally, the town can lead the way by making the use of GI a requirement for itself for all capital improvement projects in the town of a certain size and with appropriate subsurface conditions.

1.2 Project Funding

The Town of Fairfield was awarded a Community Development Block Grant – Disaster Recovery (CDBG-DR) through the state Department of Housing's (DOH) Post-Sandy Disaster Relief Allocation through Housing and Urban Development (HUD) for $100,000 in planning funds for a "Downtown Green Infrastructure" study. The money was allocated to HUD through the 2013 Disaster Relief Appropriations Act, which designated aid assistance for communities affected by Hurricane Sandy. This grant is intended for planning and conceptual design purposes only. Construction funding for any of the alternatives identified in this study or further developed by the town will need to be identified and applied for independently of this study.

1.3 Connection to Other Planning and Design Projects

In 2014, the South Central Regional Council of Governments (SCRCOG) and Metropolitan Connecticut Council of Governments (MetroCOG), of which Fairfield is a member, were selected by the U.S. Department of the Interior as recipients of a $700,000 Hurricane Sandy Coastal Resiliency Competitive Grant. The funding allowed SCRCOG, MetroCOG, and The Nature Conservancy to create a *Regional Framework for Coastal Resilience in Southern Connecticut.* Through this collaboration, there was an assessment and advancement of opportunities to reduce risk from large-scale storm events and increase the viability and resiliency of natural ecosystems. The participating municipalities contributed and conceptually developed coastal and noncoastal GI projects that were included in a regional plan. Several of the municipalities participating in the regional framework were heavily interested in including noncoastal GI projects such as those developed for downtown Fairfield. At the time of the plan development (2015-2016), Fairfield had not yet completed this study. If the *Regional Framework for Coastal Resilience in Southern Connecticut* is updated periodically as intended, the Town of Fairfield will be able to include its downtown GI projects in the update.

The Town of Fairfield has administered a number of CDBG-DR grants resulting from the Hurricane Sandy appropriations. Relative to the Ash Creek/Riverside Drive flood mitigation/coastal resiliency study and conceptual plan (also known as "Project A"), minimal coordination with the downtown GI study has been needed. Use of GI in downtown Fairfield will reduce runoff that flows into and through the coastal floodplain that would be partly protected by an Ash Creek/Riverside Drive flood protection system. Reducing stormwater flooding and coastal flooding are well-aligned goals, but GI will not preclude the need for coastal flood protection and/or coastal property flood mitigation. Map 2 shows the northern periphery of the coastal floodplain, which is located only one to two blocks south of Post Road.

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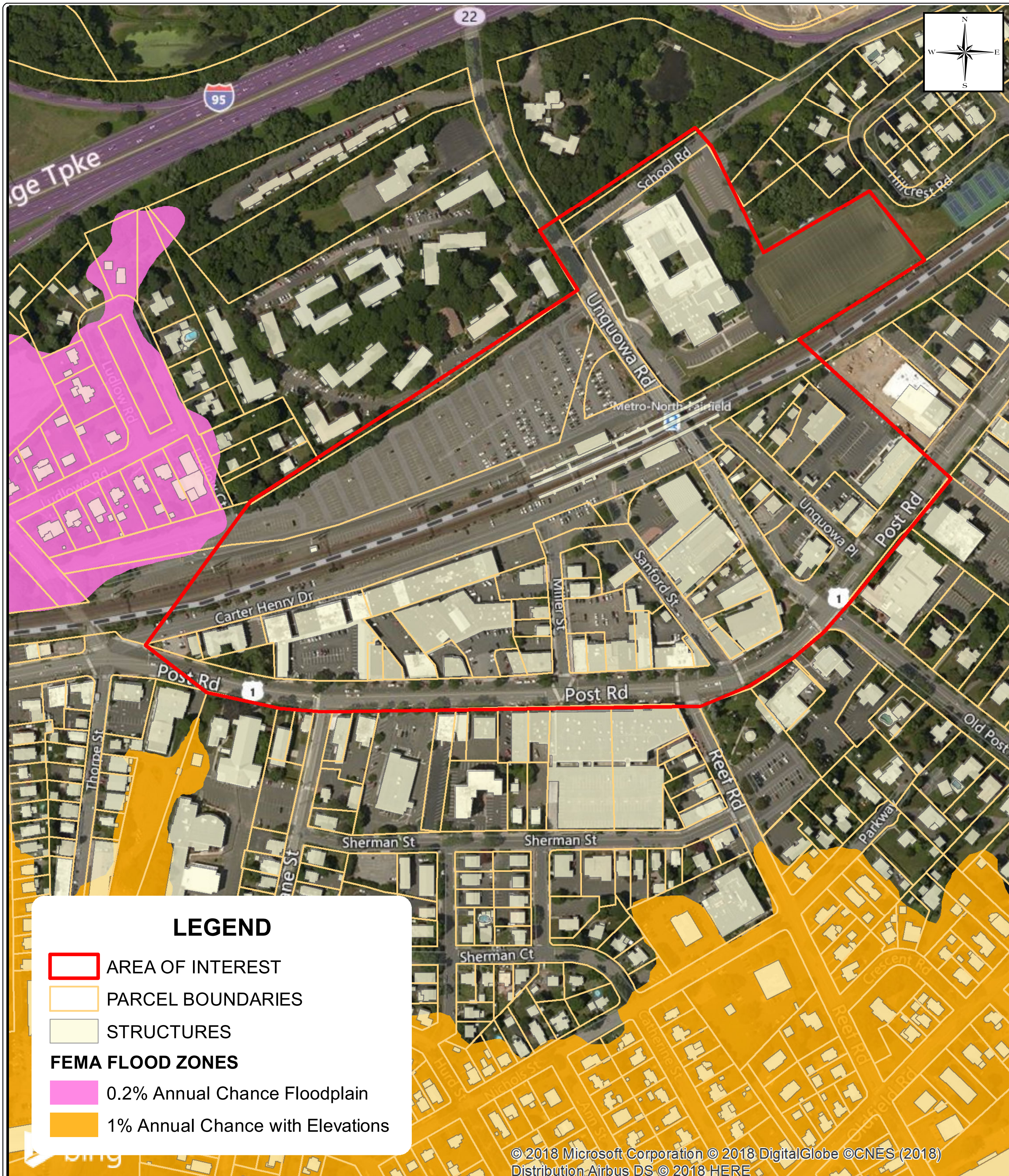

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Northern Periphery of Coastal Floodplain

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Map 2		

However, reducing runoff can reduce the need for pumping stormwater caught landward of coastal flood protection. Therefore, implementation of the results of the downtown GI study will be highly beneficial for the success of the South Benson pumping station (also known as "Project B"). Use of GI in downtown Fairfield will reduce stormwater runoff to the coastal flood zone in the South Benson Road area, thereby reducing the amount of water that could be necessary to evacuate with the proposed pumping station. While it would have been interesting to include reduced runoff scenarios in the design of the pumping station, it would not have been prudent as a conservative, worst-case scenario. In other words, assuming that future conditions will include GI upstream is not a prudent design criteria for the pumping station since the use of GI cannot be guaranteed.

1.4 Connection to Federal Emergency Management Agency Community Rating System (CRS)

The Town of Fairfield was admitted to the CRS program in 2016 with a rating of 8, corresponding to a 10% reduction in flood insurance premiums. The points contributing to the rating were assigned from the CRS categories that are typically pursued in Connecticut within series 300, 400, and 500. Several properties in the downtown study area are covered by flood insurance policies and are currently enjoying the 10% discount but may be experiencing flooding.

If GI projects are pursued in the downtown and if GI requirements are incorporated into local regulations and standards, points may be available in the future in series 450 (Stormwater Management) as follows:

- SMR – Stormwater Management Regulations – Although the town already has stormwater management regulations, additional points may be possible for more stringent and forward-looking regulations for GI.
- WMP – Watershed Master Plan – This study can provide a foundation for a "watershed management plan" associated with the stormwatersheds of the downtown area. This should not be confused with the nine-element watershed management plans developed with Section 319 funding throughout the state (with several in and near Fairfield).

2. Green Infrastructure Background

2.1 Stormwater and Green Infrastructure

Benefits of Stormwater Management

Effective stormwater management can aid in the ability for a community to reduce the risk of nuisance flooding and even flash flooding and street erosion caused by heavy rainfall events. Stormwater is generated when rainfall or snowmelt is not infiltrated into the ground and instead flows over the surface. This water will follow the path of least resistance to the nearest catch basin, natural depression, or body of water. Some stormwater runoff is natural during heavy rain events as certain soils have limited ability to infiltrate moisture; however, the majority of native forest land in Connecticut has the ability to infiltrate water from even the heaviest rain events. When large portions of the land are covered in impervious surfaces, such as asphalt, concrete, or shingled roofs, the water that normally would have infiltrated into the ground instead runs off the surface and flows into the storm sewer system.

Typical Definitions of Green Infrastructure (GI)

EPA: Green Infrastructure (GI) uses vegetation, soils, and natural processes to manage water and create healthier urban environments.

American Rivers: GI is an approach to water management that protects, restores, or mimics the natural water cycle. GI is effective, economical, and enhances community safety and quality of life. GI incorporates both the natural environment and engineered systems to provide clean water, conserve ecosystem values and functions, and provide a wide array of benefits to people and wildlife. GI solutions can be applied on different scales, from the house or building level, to the broader landscape level. On the local level, GI practices include rain gardens, permeable pavements, green roofs, infiltration planters, trees and tree boxes, and rainwater harvesting systems. At the largest scale, the preservation and restoration of natural landscapes (such as forests, floodplains, and wetlands) are critical components of green infrastructure.

The Nature Conservancy: GI solutions are planned and managed natural and semi-natural systems that can provide more categories of benefits when compared to traditional gray infrastructure. GI solutions can enhance or even replace a functionality that is traditionally provided by man-made structures. GI solutions aim to build upon the success that nature has had in evolving systems that are inherently sustainable and resilient. GI solutions employ ecosystem services to create more resource-efficient systems involving water, air, and land use. GI solutions are designed to fulfill a specific need, such as water purification or carbon sequestration, while often offering location-specific and valuable co-benefits, such as enhanced habitat for wildlife.

GI describes the processes of using various techniques that seek to mimic the natural ability of the soil's natural ability to infiltrate runoff. This is important as climate change projections for New England generally predict warmer temperatures with increasingly strong storms and high precipitation events (refer to Section 2.2 below). This can cause the seemingly paradoxical effects of increased drought from the high temperatures while also increasing the risk of flooding from the strong storm events. GI can help negate both consequences by taking water that would otherwise runoff, swelling brooks and rivers, and instead allowing that water to infiltrate into the ground or be captured and used directly.

The Town of Fairfield is currently experiencing challenges relating to an excess of urban stormwater runoff coupled with a restrictive storm drainage system that is inadequate to handle the large volume of runoff generated by the town's impervious surfaces. Due to the high-density surface and subterranean infrastructure, it is impossible to fully condition the storm drainage system to handle the current and future stormwater volumes. Additionally, climate change projections indicate that future storms may be more intense, with greater rainfall totals in shorter amounts of time.

Many GI techniques can prevent stormwater from being generated, reduce total runoff volume, and/or can sequester stormwater runoff and allow it to infiltrate into the ground without entering a municipal stormwater system. This not only reduces flood threats but also reduces pollutant loading into water bodies and can help recharge groundwater aquifers. The figure below depicts 10 years of hypoxic conditions in Long Island Sound; note that Fairfield is located adjacent to an area with 30% to 50% hypoxic years in the decade (1994 to 2004).

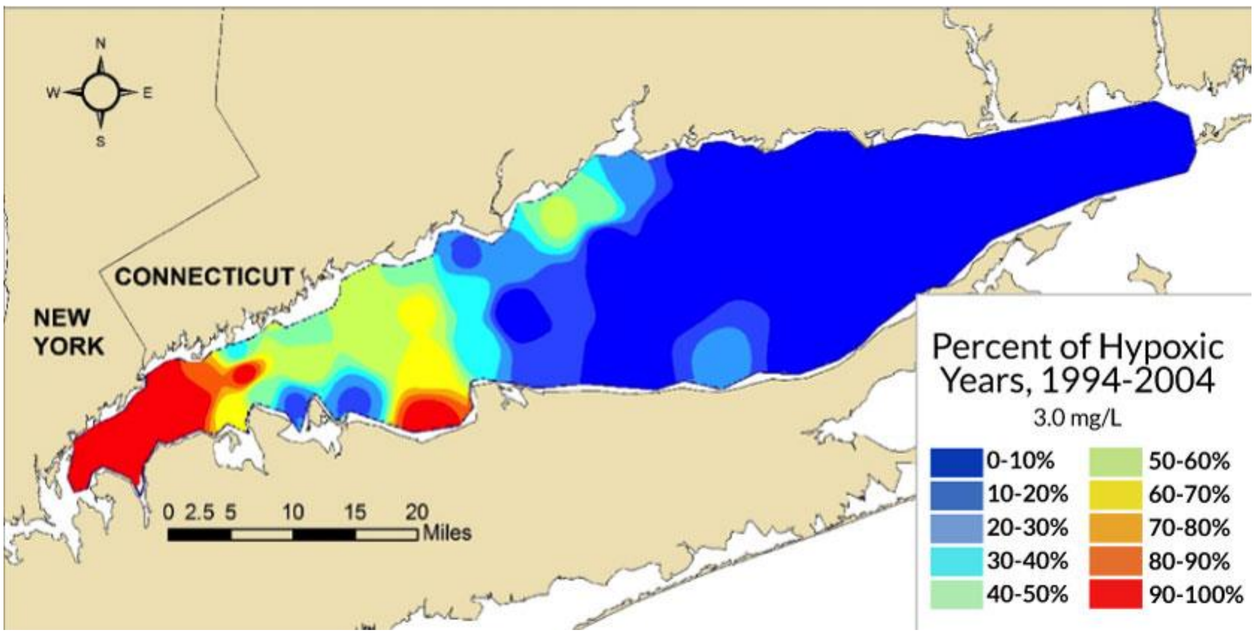

Figure 1 – Map of hypoxia in Long Island Sound
(Connecticut Department of Energy & Environmental Protection)

Aside from the direct environmental benefits, GI can make financial sense for municipalities and private entities. Some stormwater capture devices can save money on water and other utility bills while green roofs can provide natural temperature buffering for buildings. GI can also help construction sites and large facilities satisfy permit requirements for stormwater runoff as well as sediment and erosion control.

Criteria for Green Infrastructure Site Selection

The criteria for selecting sites to implement GI solutions can be straightforward, but several factors should be considered to ensure that the GI project balances form and function and also serves as an educational tool for the community. The areas that best make use of GI are typically sites with large areas of impervious surface. Surfaces like rooftops, asphalt parking lots, and highly compressed soils (such as that of a dirt/gravel driveway) cause water to simply run off into low-lying areas and storm drains. This leads to poor drainage flooding such as what has been seen in Fairfield.

When choosing sites to implement GI, publicly owned sites should be prioritized when possible as they allow community members to see the infrastructure in action, and they have a dedicated maintenance resource. Map 3 depicts privately owned and town-owned parcels. For example, a town hall or public school with a large parking lot might offer an excellent opportunity to install rain gardens or vegetated swales. This would allow for consistent public access in the hope that private residents might consider GI on their own property. The benefits of function vs. visibility should be weighed so that the area with the most function, but also the most visible to the public, should be considered. This will allow the GI to serve a dual purpose of stormwater management and public outreach and awareness.

Sites should also be prioritized based on infiltration capacity of the native soil. Map 4 depicts the surficial geology of the study area. In order for structures such as pervious pavers and rain gardens to work properly, there must be a layer of soil present that is capable of infiltrating the water that is collected. Fortunately, there are federal resources such as the Web Soil Survey that have mapped the soil composition throughout Connecticut. Simple field tests, such as those demonstrated by the University of Connecticut Extension program, can verify that the site soils are appropriate for certain types of GI. However, a high percentage of most downtown areas will consist of urban fill. The content and physical properties of such fill can vary greatly over even short distances. Field testing must be performed to conclusively identify the properties of fill that is present.

Another simple but effective rule is to keep the ratio of the drainage area to the GI BMP area between five and 10. The design ratio needs to be a function of both the soil infiltration capacity (higher infiltration capacity equals higher drainage area to BMP area ratio) and the watershed's capacity to generate runoff sediment. The recommended ratio should be lower for watersheds generating relatively higher sediment runoff loads in order to try and prolong GI porosity.

Lastly, flow paths and inlet and outlet design is crucial to BMP cost effectiveness; i.e., water has to get to the BMP and get stored and/or infiltrated along with a positive outlet that can carry any excess drainage safely away from the BMP.

2.2 Effects of Climate Change

In 2010, a report was issued by Climate Change Connecticut, which suggested the following summary conclusions:

- Connecticut could see a temperature increase of 4°F to 7.5°F by the end of the 21st century.
- Precipitation in Connecticut could increase by 5% to 10% by the end of the century and redistribute itself so that more of this increase occurs during winter months.
- Drought frequency may increase as well as duration and intensity.

Since then, climate change has been addressed in the *Connecticut Natural Hazard Mitigation Plan Update* (2014) and the *State Water Plan* (2017).

The *Connecticut Natural Hazard Mitigation Plan Update* notes that climate change studies have indicated that although precipitation is projected to increase throughout this century, it will be in the form of short duration, intense, and less frequent events. More intense rainfall, the result of climate change, is likely to increase peak flooding, particularly in urban environments in the future. The magnitude of this increase is dependent on the level and rate of greenhouse gas emissions through the end of the century.

Connecticut will continue to be at risk for flood events due to the geographic location along the Northeast Atlantic seaboard, abundance of waterways, and future projections by climate change models and studies that project an increase in more intense precipitation events punctuated by periods of drought conditions. Furthermore, it is projected that the frequency and intensity of both long-term and short-term droughts in Connecticut and throughout the Northeast will increase throughout the century with the impacts beginning to occur with a greater degree of frequency beginning in the mid century (2050s).

The *State Water Plan* included a climate change analysis. Results of a "hybrid delta ensemble" (HDe) analysis were presented in the plan. Four scenarios were the focus of the analysis: "warm/dry," "warm/wet," "hot/dry," and "hot/wet." Summary output included a.) monthly time series plots of average temperature and total precipitation, b.) mean monthly temperature and precipitation bar charts, and c.) monthly temperature and precipitation percentile plots. The first summarizes the raw output and illustrates month-to-month variability, the second provided insight into the seasonality of the projected changes, and the third showed the full range of projected changes including extreme months. Differences across sets of ensemble plots highlighted the variability and uncertainty associated with the climate model projections and potential differences associated with greenhouse gas emissions pathways. For example, the "hot/dry" ensemble projects a mean monthly temperature change of 4.5 ˚C and a mean monthly precipitation change of 10 mm/month while the "warm/wet" ensemble projects a temperature change of 2.6 ˚C and a precipitation change of 17 mm/month.

The *State Water Plan* notes that there is general consensus in the climate models for a hotter and wetter future. Mean annual temperature changes for the 2080 planning horizon, compared to historical baseline, range from approximately +0.5 ˚C to + 6.5 ˚C. Mean annual precipitation changes range from approximately -5% to +30%, with most of the projections predicting an increase in mean annual precipitation.

All model ensembles project an increase in temperature for all calendar months. Projected temperature changes appear relatively consistent across calendar months and percentile levels for each of the ensemble scenarios. In other words, both summer and winter temperatures are projected to increase by similar amounts, and a similar shift is observed for both extreme cold and extreme hot months. Precipitation projections are more variable although consistently projecting a generally wetter future for all four scenarios. The largest precipitation increases are projected for the wetter months (higher percentiles) including extreme wet months. The seasonality plots in the plan show that winter and spring precipitation changes are projected to be larger than summer and autumn changes. Drier months are generally projected to remain about the same in terms of both frequency and rainfall level. Small decreases in extreme dry month precipitation were projected for the "hot/dry" scenario.

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Privately Owned and Town-Owned Parcels

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FAIRFIELD, CT

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Map 3

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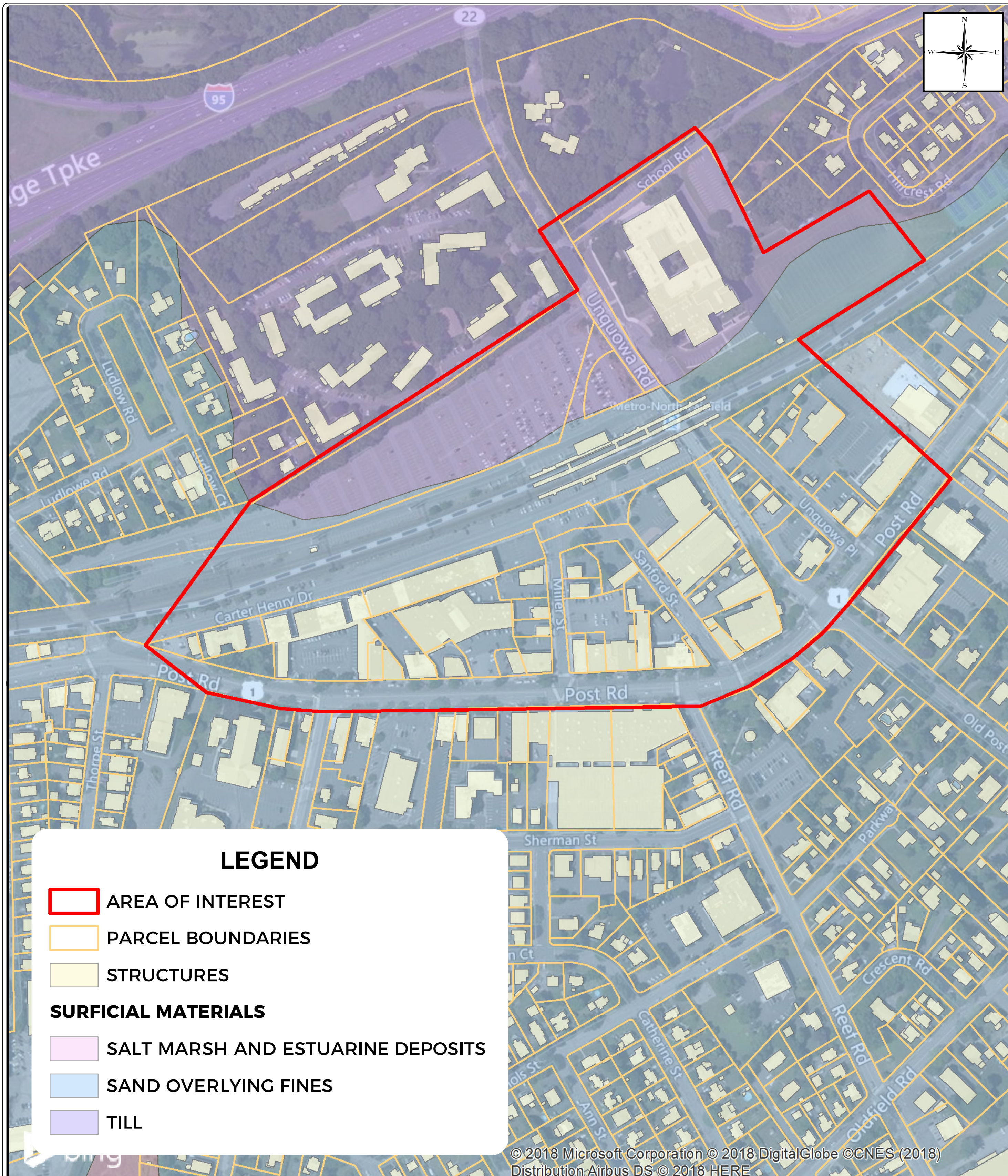

Surficial Geology of the Study Area

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Map 4

Implied by the results presented in the *State Water Plan* is the potential for decreased water availability due to significantly higher temperatures and evapotranspiration losses. However, this dynamic would be offset to a certain extent by increased rainfall. Typical climate forecasts tend to suggest that increased temperatures coupled with increased annual precipitation generally correspond to higher intensity storms (greater flood risk) and longer dry periods in the summer months (more frequent and/or intense droughts).

The conditions projected in the *Connecticut Natural Hazard Mitigation Plan Update* and the *State Water Plan,* and in other climate change studies in general, underscore the importance of using innovative techniques to reduce runoff and flood risk such as GI. However, the studies also suggest that the GI methods must be as resilient as possible under changing climate conditions, with vegetation selected to be hardy under warmer conditions and flashy droughts.

2.3 Study Approach

Using GI to provide resiliency in the face of potentially larger, more devastating storms is a key strategy for any community facing an uncertain future. However, adopting a legitimately effective GI approach in the downtown area of Fairfield, marked by a very high percentage of impervious area, will take not only an effective plan, but willpower, funding, and follow-through.

In one brand of GI, runoff is shunted to planted BMPs, the least expensive brand of BMPs. However, there is little existing green space downtown, and the green space there is either small and/or populated by large, mature trees or telephone poles and probably some underground infrastructure as well. This is not to say planted BMPs cannot be implemented, but in this environment, it will not be as simple as creating a shallow depression and repopulating it with deep-rooted plants.

The best way to mitigate impervious surface runoff is to reduce the extent of impervious surfaces. This is likely not going to be an option applied extensively downtown. The two strategies that suggest themselves immediately for downtown are green roofs and the replacement of ground-level impervious hardscape with pervious hardscape. This is not to say planted BMPs are not an option, only that it is likely they will be a small percentage of the on-the-ground BMP area. One green hybrid that does suggests itself are tree planters that provide aggregate and/or structural soil storage. In other scenarios, most of the existing hardscape can be replaced with hardscape, but local infiltration and storage can occur underneath the surface.

Many of these strategies will occur in or around roads, driveways, and parking lots. In the long term, enacting these kinds of practices could be done in conjunction with other projects that reconstruct roads or lots or install or replace other kinds of infrastructure like sewers and water lines. Making GI a requirement of all projects would help reduce the burden of cost over time and would help distribute GI both downtown as well as across the rest of the town.

Lastly, the other aspect that this project emphasizes is maintenance. If new surfaces are added that infiltrate water, then Fairfield will have to commit to the kinds of maintenance activities necessary to keep these surfaces functional. This is part of the long-term strategy that must be addressed to reap the benefits of GI for decades.

3. Existing Conditions Assessment

The existing conditions assessment included the following field and desktop assessments of existing conditions:

- Base mapping, including compilation of Geographic Information System (GIS)-based data from the Town of Fairfield, including buildings, parcels, utilities, stormwater infrastructure, town-owned land, open space, and topography
- Review of soils and surficial geology, including United States Geological Survey and Natural Resources Conservation Service (NRCS) reports to describe soil types and surficial geology
- Visual assessment of storm drainage systems, including determination of stormwatersheds and catchments and review system mapping available from the town
- Utility systems assessment, with review of aboveground and belowground utilities to identify potential conflicts
- Subsurface to characterize field soils and geology

The existing conditions assessment also included preparation of a linked rainfall-runoff and hydraulic model of downtown Fairfield using the United States Environmental Protection Agency (USEPA) freeware *SWMM.* The website for downloading the model software and documentation can be found here: https://www.epa.gov/water-research/storm-water-management-model-swmm

There is also a very active Users Group that can be accessed via a *Listserv* created by the University of Guelph. This *Listserv* allows subscribers to ask questions and exchange information. To subscribe, send an email message to listserv@listserv.uoguelph.ca with the words "subscribe swmm-users" (without the quotes) in the body followed by your name. Based on our experience, every question receives input from users and often useful suggestions on how to address or solve particular model issues and often design issues too.

SWMM is a dynamic rainfall-runoff-routing simulation model used for a single event or long-term (continuous) simulation of runoff quantity and quality. It is best suited to simulations in urban areas. The runoff component of *SWMM* operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of *SWMM* transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators. *SWMM* tracks the quantity and quality of runoff generated within each subcatchment and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps. *SWMM* is one of the most respected and tested stormwater models in the world and forms the basis for many other private software packages such as *PC-SWMM*, *XP-SWMM,* and *MIKE-SWMM.*

3.1 Subsurface Investigation

Review of the NRCS soils mapping revealed that the entire area is classified as "Urban Land." However, review of the surficial materials (Map 4) indicated that the northern portion of the project area (including the train station, Tomlinson Middle School, and Mosswood Condominiums) is classified as "Thin Till." The area to the south of (and including) the railroad tracks is classified as "Sand and Gravel overlying Fines."

To validate these findings, soil layers and surficial material were evaluated through a series of 11 soil borings conducted on January 1 and 2, 2017. The target depth for each boring was 20 feet. The location of the borings is shown in Map 5. The boring reports can be found in Appendix A.

Boring #1 was taken in the railroad parking lot. It was assumed this boring was indicative of subsurface conditions under the entire lot. The boring was only 6 feet deep and hit a crushed schist bedrock only 8 inches below the surface. The two other borings that hit refusal were in Sherman Green, south of the study area. Before hitting refusal, the Sherman Green borings went through mostly fine, medium, and coarse sand with some gravel and trace cobble fragments. The boring on the east side of the park hit bedrock at about 6 feet while the boring on the west side hit bedrock at around 13 feet below ground surface. Groundwater was noted at approximately 3.5 feet below the surface for all three of these borings.

The remainder of the borings did not hit bedrock down to the target depth and were almost entirely composed of a combination of fine, medium, and coarse sand with some gravel and trace of cobble. They showed dampness at about 10 feet below the ground surface with groundwater noted at between 10 feet to 15 feet below the ground surface.

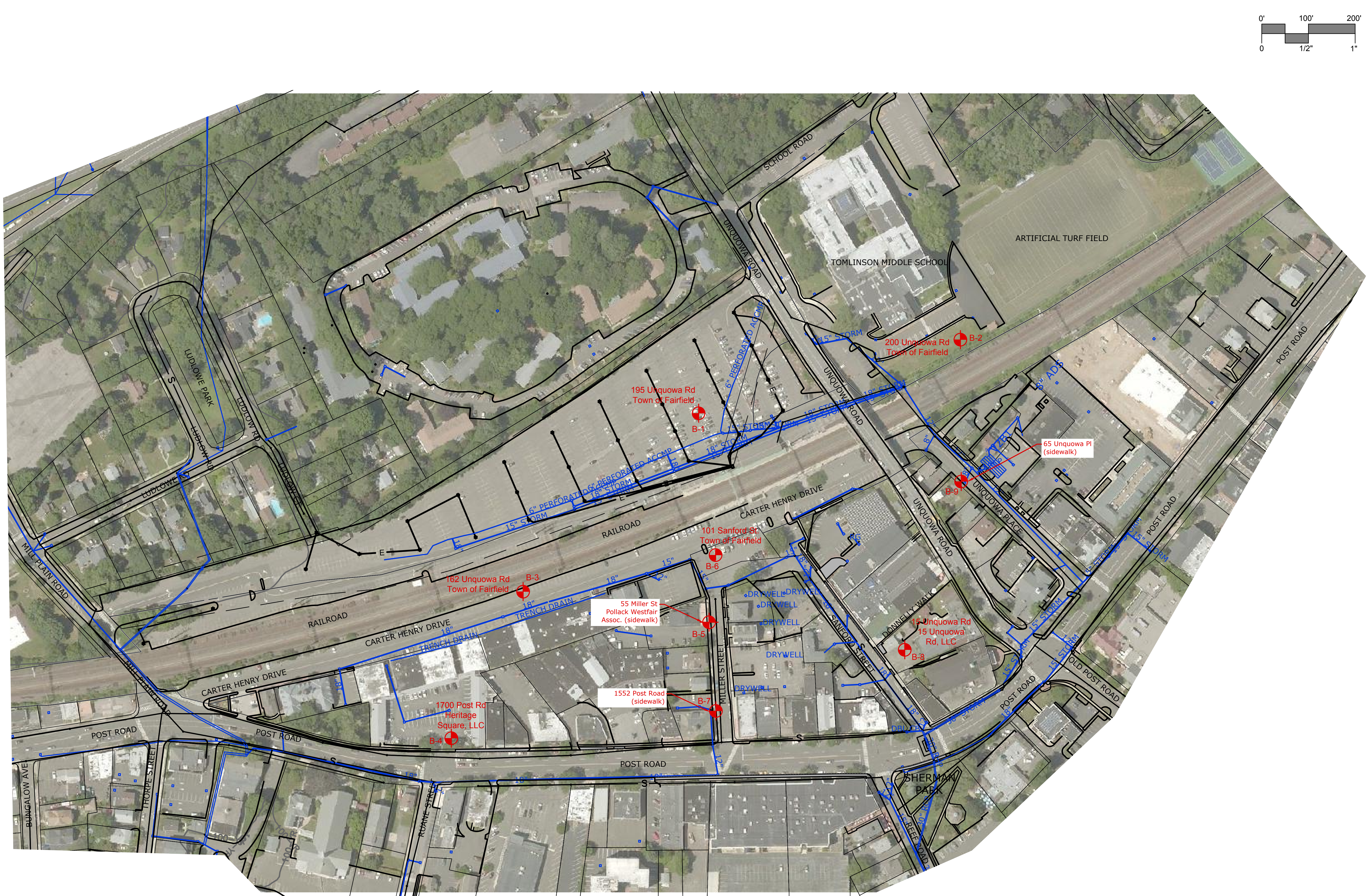
Overall, the findings in the core of the study area showed surficial material consisting of a fill layer (fine to medium sand with little gravel and trace silt) overlying a sand and gravel layer. This material is suitable for drainage with moderate to high infiltration rates and will accommodate GI practices.

3.2 Utility Investigation

The town provided detailed stormwater system mapping of the study area and adjacent parts of the downtown. The stormwater systems are depicted on Map 6. A review of the mapping reveals two challenges: the train station parking lot's drainage is routed under the tracks in one single pipe, and this water is combined with additional stormwater from the Unquowa Road/Unquowa Place to be routed under the Boston Post Road in one single pipe toward Reef Road. A small portion of stormwater from the study area is routed to the west and south toward Thorne Street.

Field investigation of the entire subsurface storm drainage system, including existing drywells within the project area, confirmed the results of the boring reports, showing no standing water in each drywell. This helps confirm that the underlying soils have good permeability and can be used to improve drainage and reduce surface flooding in the project area.

However, after observing all nondrywell catch basins within the project area, nearly all of the catch basins were either filled with water or filled with sediment above the elevation of the connecting pipe inverts. Vegetation was observed growing in many of the project area catch basins, confirming that the catch basins are not regularly inspected or cleaned out. Additional field investigation and mapping provided by the town also indicated a number of large pipes that discharge to smaller pipes downstream. These elements are likely causing backups in the downtown drainage system.



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REVISIONS

Boring Locations

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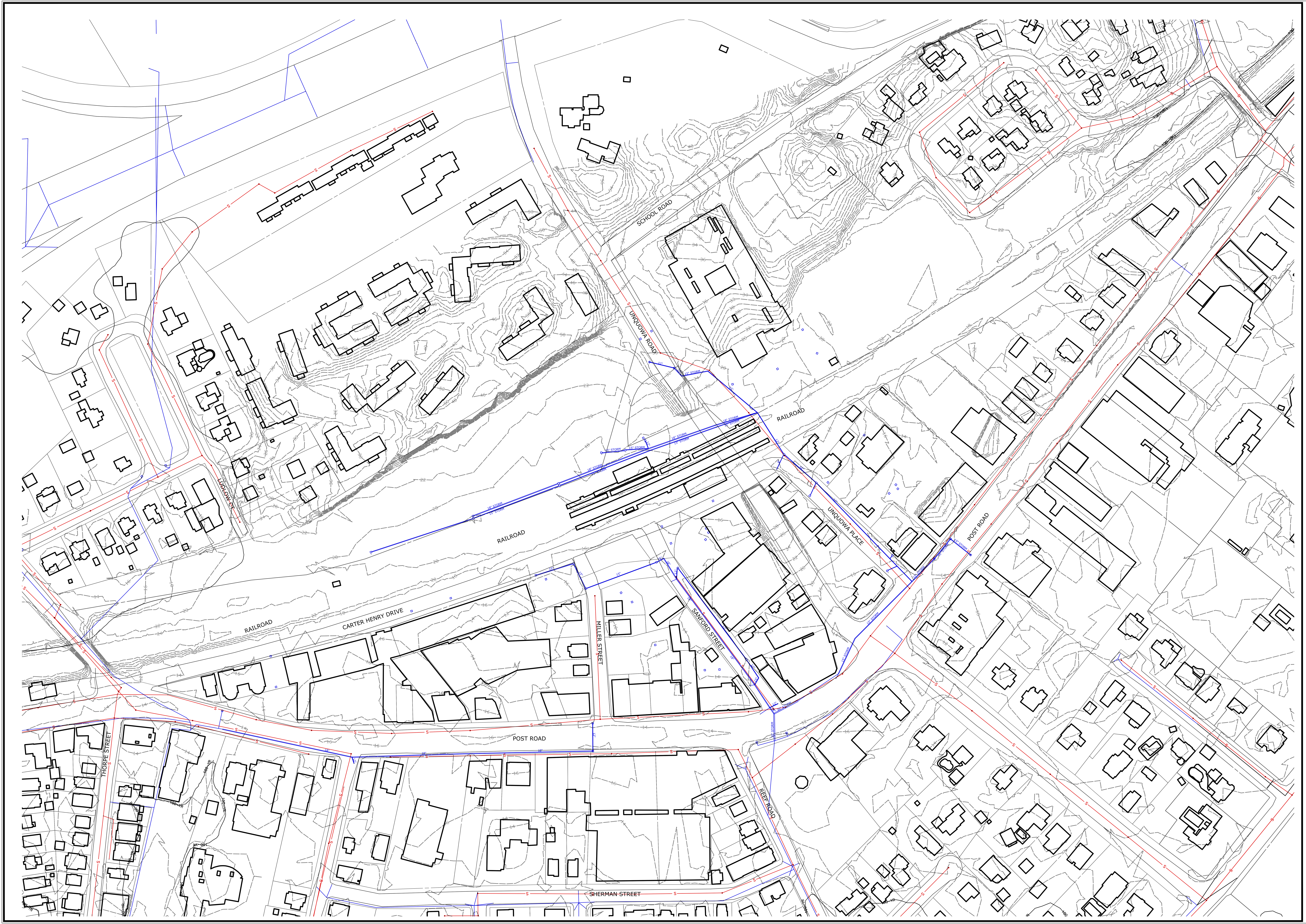
SHEET NO.: **Map 5**



Stormwater Systems

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SCALE: 1"=100'

DATE: AUGUST 26, 2016

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SHEET NAME: Map 6

3.3 Precipitation

The underlying data for the Annual Exceedance Probabilities (AEP) analyses are grids of observed precipitation data and precipitation frequency estimates at 30-arc second resolution for a range of durations and AEPs.

Observed Precipitation Data

Whenever possible, gridded precipitation data are developed for a range of durations from measurements collected from rain gauges reporting at the time when the map is created. Rain gauges are usually from the National Centers for Environmental Information's (NCEI) Climate Data Online. When rain gauges do not provide sufficient information to depict spatial patterns, the NCEI's multisensor Stage IV QPE Product and radar-based NEXRAD Precipitation product are also used to represent observed precipitation data.

Precipitation Frequency Estimates

Except for the six states that have no NOAA Atlas 14 coverage (Idaho, Montana, Oregon, Texas, Washington, Wyoming), precipitation frequency estimates for the AEP analyses come from the NOAA Atlas 14 *CONUS* product. This product combines NOAA Atlas 14 precipitation frequency estimates for durations between 60 minutes and 7 days and AEPs down to 1/1000 (or average recurrence intervals up to 1,000 years) from NOAA Atlas 14 volumes that cover contiguous United States. The estimates along the volumes' boundaries were altered to reduce discrepancies, which are unavoidable as each volume was completed independently and at a different time (for more information, see Section 5 of the NOAA Atlas 14 documents).

Water Quality Volume

Some stormwater regulations include special requirements for handling of the Water Quality Volume (WQV). Although the specific definition will vary, the WQV is commonly considered to be the runoff volume that includes 90% of all rainfall events in a given year. Since the majority of all rainfall typically occurs in relatively small events, managing the discharge of the WQV is considered to be a cost-effective standard for minimizing overall pollutant discharge.

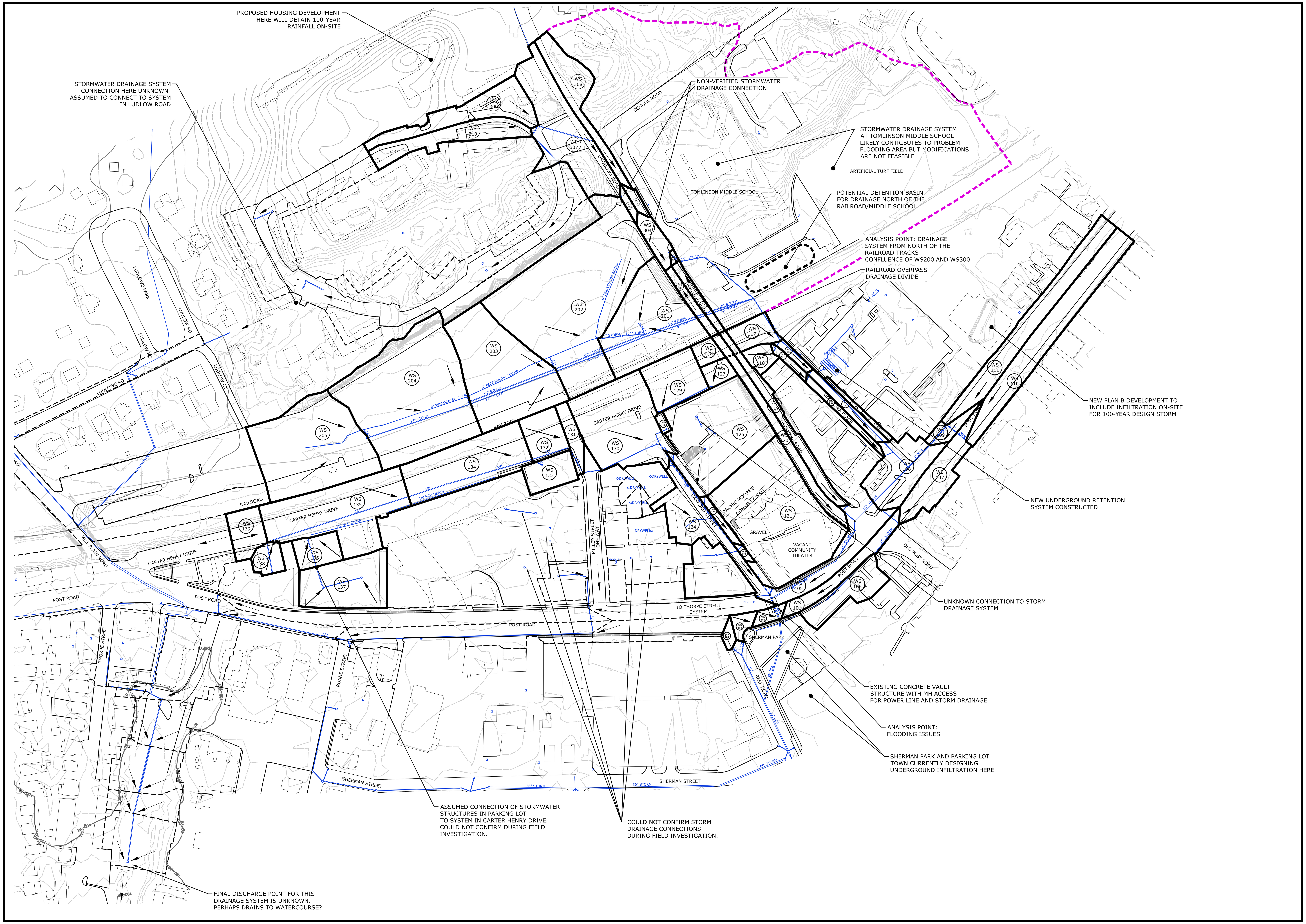
Data Used for Model			
Agency	Event	Depth (in)	Max Intensity (in/hr)
Table 5 p.129	50-year, 24 hc	3.98	
Table 5 p.129	0.5yr 6hr		
Table 5 p.129	6hr, 1 yr		
Table 5 p.129	6 hour,100yr	1.18	
Table 5 p.129	24hr, 0.5yr		
Table 5 p.129	24hr, 0.75		
Table 5 p.129	1	2.85	0.950
Fig 6 p.84	2	3.48	1.57296
Fig 6 p.86	10	5.36	2.55136
Fig 6 p.87	25	6.53	2.95156
Fig 6 p.89	100	8.34	3.76968

Percentile	Rainfall (Inches)
50%	0.15
60%	0.23
70%	0.38
80%	0.56
90%	0.865

3.4 Existing Conditions Model Analysis

To determine the potential for and types of GI improvements, the study required that the area be divided into distinct watersheds that can be analyzed. The watersheds illustrate areas of contributing stormwater flows within and toward the downtown project boundaries. A majority of this drainage is conveyed through the 30-inch-diameter pipe that crosses under Boston Post Road and ties into the 15-inch-diameter pipe beneath Reef Road, continuing toward the intersection of Sherman Street. This intersection was identified as a historically floodprone area.

The contributing subwatersheds were delineated based on the stormwater system mapping, existing topography based on the state's 2016 digital elevation model (DEM), and visual observations of drainage inlets and slopes. Map 7 depicts the subwatersheds, and Map 8 depicts the general fate of stormwater (the yellow boundary outlines areas that drain toward the Reef Road system, and the red boundary outlines areas that drain toward other discharge locations). For reporting and summarizing analysis results, the downtown area was divided into an area north of the railroad tracks and an area south of the tracks. This is a convenient break to consider system performance, but it is also coterminous with subwatershed boundaries.



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Subwatersheds

PROJECT C - RESILIENCY FOR DOWNTOWN FAIRFIELD USING GREEN INFRASTRUCTURE

FAIRFIELD, CONNECTICUT

DESIGNED	DRAWN	CHECKED
---	BAM	DM

SCALE: 1"=100'

DATE: OCTOBER 31, 2016

PROJECT NO.: 1342-21

SHEET NO.: 01 OF 01

SHEET NAME: **Map 7**

General Fate of Stormwater

Map 8 July 27, 2018

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Stormwater system pipe sizes, but not pipe inverts, were available. Therefore, the study assumes that for the most part the pipes paralleled the ground at roughly the same depth. While the inverts and pipe length determine slope, and pipe slope together with size determine flow capacity, for the most part this is a comparative and not an absolute analysis. It is mainly the differences between existing and proposed conditions that need to be quantified.

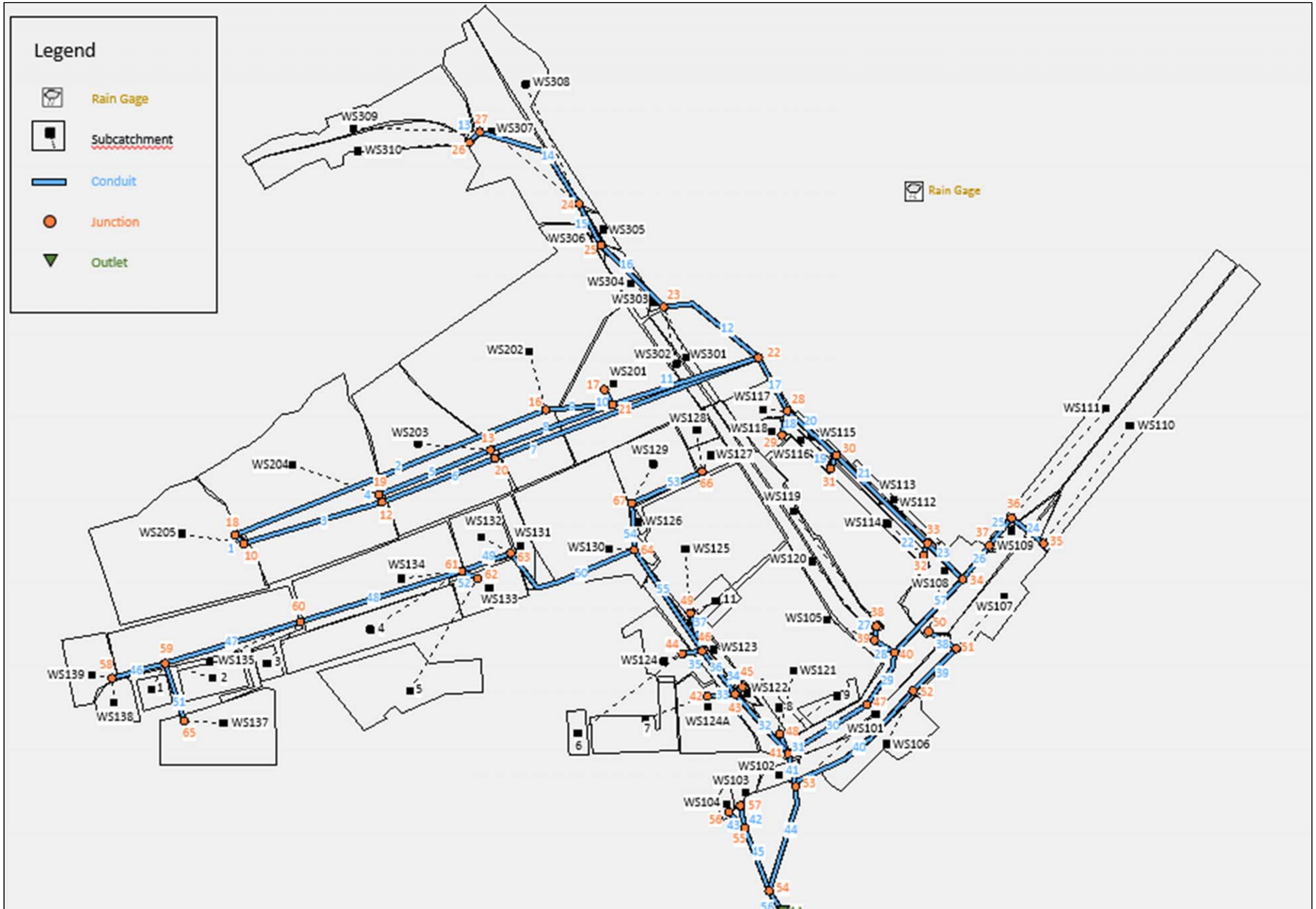
A schematic of the model working within the *SWMM* software is shown in Map 9. The model, composed of its various elements – subwatersheds (the center of the subwatershed is represented as a filled square), rain gauge (cloud image in the upper right of the schematic), nodes (either manholes, catch basins, storages, or outlets shown as filled circles), and links (pipes or open channels shown as lines between nodes) – make up the majority of the schematic. In the bottom right hand of the image, an example subwatershed dialog box is shown where data is entered for that element. The triangle node at the bottom represents the model system outlet. For the outlet, the analysis assumed a free water surface and that there was not a backwater condition.

The most important input for the model is impervious area. In *SWMM*, impervious area is modeled as Directly Connected Impervious Area (DCIA). The term DCIA means that the impervious area is directly connected to storm sewer; that is, runoff generated over the impervious area flows over that impervious area directly to storm sewer either via gutter/downspout or over driveway, roadway, or parking lot. Most of the subwatersheds in this area were assumed to be 100% DCIA.

The other critical input is infiltration rate. For all model simulations, the Green-Ampt infiltration calculation routine was used. The Green-Ampt routine is a more precise way to investigate the effect of both antecedent moisture conditions and potential soil storage on runoff than a method like TR-55. While a model like TR-55 can be a convenient way to calculate runoff, particularly in urban areas, it is an empirically based method that simply "abstracts," that is, removes a set volume for dry, moderate, and moist antecedent moisture conditions. Depending on how areas are delineated, it also averages the effects of pervious and impervious areas together, losing the benefits that can accrue when impervious area runoff flows over pervious areas.

Under the railroad parking lot, it was assumed that the infiltration rate was 0.01 inches/hour. This is reflective of the poor native soils, use of fill, and compacted nature of the subsurface beneath a heavily used parking lot. Everywhere else, the infiltration rate was set between 1 to 2 inches per hour, a reasonable value for sandy soils. Other inputs like depression storage (microtopography that can hold some water) were left at model defaults for pervious and impervious areas. Inputs like area, slope, and width were calculated directly from GIS data for each area.

Rainfall depths for the 1-year, 10-year, 25-year, and 100-year return rainfall events were taken directly from NOAA's Atlas 14 for the Northeastern states including Connecticut.



Map 9

Schematic Model within *SWMM* Software

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OCTOBER 31, 2016

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3.5 Existing Conditions Findings

The most prominent finding of the modeling of existing conditions is that the model projects that flooding will occur downtown for all the design rainfall events. Table 1 and Figure 2 below summarize the model results for peak flows out of the system, the total volume that flows out of the system for a given event and total system flooding. In *SWMM*, flooding occurs and is calculated at the nodes. Flooding is simulated when the calculated water surface elevation exceeds the ground surface elevation. As long as this condition continues, *SWMM* keeps a running total of the volume of water flooding out of the node.

Tables 2 and 3 summarize node flooding and pipe surcharging for the 1-year storm event. . The 1-year design event is the smallest volume event simulated in the model. As Table 1 and Figure 2 show, system-wide flooding increases in a nonlinear fashion as the storm event return interval increases. Therefore, the 1-year flooding and pipe surcharging show the most limited areas in the system relative to capacity. Flooding in these areas only increases with the event size. In addition, many additional areas flood as the event size goes up.
The stormwater system mapping appears to show that the main pipe carrying flows from the north half of the area under the railroad is a 1.25-foot-diameter pipe. Until this pipe transitions to the 2.5-foot-diameter storm sewer, it appears to be undersized.

While both diameter and slope directly impact flow capacity, the capacity issue of this pipe is so acute that just increasing pipe slope is not sufficient. The model has set the slope at about 1%. Peak flow through the pipe for all events is around 4 cubic feet per second (cfs). Even if the model was to double the pipe slope, total flow under gravity flow conditions would still only increase to 5 cfs and not be sufficient to pass all the flow from the north area without pipe surcharging and node flooding.

The beginning of the undersized sewer is shown in Figure 3 below. This figure highlights model links/conduits that represent the storm sewers that have capacity issues. The pipes with the most acute capacity issues are highlighted in red. Pipes with secondary issues are highlighted in yellow. Model nodes – manholes or inlets – that have the greatest flooding issues are highlighted in red, with secondary node issues highlighted in yellow. Numbers in squares are model node identifiers. Identifiers preceded with a 'w' are subwatersheds. The other number identifiers are model conduits.

It is link #17 that is the main source of capacity issues in this area. It is, in fact, one of the most critical conduits/pipes in the system. It basically functions as the "outlet" for the railroad parking lot and the remainder of the north drainage area. There does not appear to be any GI or stormwater BMPs in this north area, so all of the impervious area has to drain through this one pipe. This constriction acts on the upstream area, and there is even some flooding simulated in the parking lot and just upstream of the railroad off Unquowa Road.

Even though the pipe appears to get slightly larger south of Route 1, there still appears to be capacity issues in the pipe under Unquowa Place. While pipe surcharging was also identified in some of the pipe under Post Road (*SWMM* conduit 57), the model did not identify any node flooding for any events on Post Road for existing conditions.

TABLE 1
***SWMM* Model Results for Existing conditions**

Design Event	North Area Outlet		System Outlet			
	Peak (cfs)	Total Volume Out (Ac-ft)	Peak (cfs)	Total Volume Out (Ac-ft)	Flooding Volume (Ac-ft)	Flooding as % of Outflow
1-yr	3.87	2.40	29.42	5.98	1.1	18%
2-yr	3.89	2.89	31.35	7.07	1.6	23%
10-yr	3.94	4.22	35.85	10.16	3.2	32%
25-yr	3.99	4.94	38.27	11.93	4.3	36%
100-yr	4.12	5.67	39.95	14.20	6.4	45%

cfs = cubic feet per second
Ac-ft = acre-feet

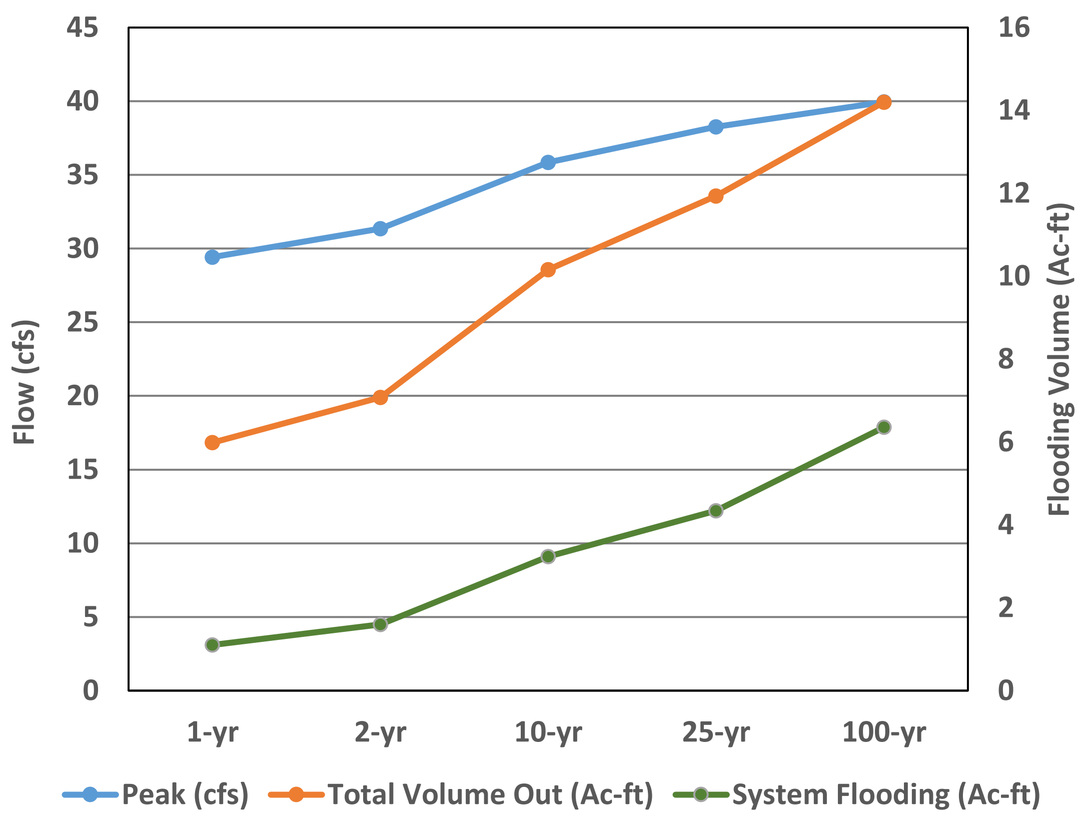


Figure 2 – Comparison of system outflow and system flooding for existing conditions

TABLE 2
Model Node Flooding for 1-Year Storm Event under Existing Conditions

Node	Hours Flooded	Max Rate (CFS)	Time of Flooding	Flooding Volume (Gal x 10^6)	Depth of Flooding (ft)
10	0.01	4.33	11:34	0	0
12	0.01	5.7	11:34	0	0
13	0.3	5.59	11:33	0.007	0
16	3.5	4.92	11:59	0.052	0.317
17	3.25	3.02	11:50	0.024	0.294
18	0.01	3.53	11:35	0.001	0
19	0.01	4.46	11:34	0	0
20	0.03	6.42	11:34	0	0
21	4.67	10.31	11:35	0.066	0.79
22	4.67	8.78	11:46	0.113	0.679
28	0.42	0.77	11:59	0.004	0
30	0.43	0.16	11:52	0.002	0
33	0.43	1.25	11:51	0.013	0
34	0.31	0.57	11:59	0.004	0
37	0.01	1.01	11:33	0	0
49	0.01	0.08	11:37	0	0
58	0.01	0.93	11:37	0	0
59	0.03	3.26	11:37	0.001	0
60	0.4	3.47	11:36	0.022	0
61	0.39	3.77	11:51	0.036	0
62	0.01	0.52	11:36	0	0
63	0.01	0.27	11:36	0	0
64	0.28	0.52	11:37	0.001	0
65	0.01	3.74	11:37	0	0

TABLE 3
Model Conduits Surcharged During 1-Year Storm Event
(Note: Significant surcharging (>4 hours) is highlighted in yellow.)

Conduit	Hours Both Ends Full	Hours Upstream Full	Hours Downstream Full	Hours Surcharged	Hours Capacity limited
3	4.67	4.67	4.69	0.36	0.39
4	4.67	4.67	4.67	0.05	1.24
11	4.87	4.9	4.87	21.9	4.85
17	4.91	5.14	4.91	5.39	4.9
20	4.91	4.91	4.97	4.44	4.41
21	4.97	4.97	5.22	4.43	4.4
23	5.07	5.22	5.07	5.05	4.75
27	0.58	0.58	0.58	0.63	0.49
29	0.46	1.09	0.46	4.74	0.46
32	0.43	0.43	0.49	0.42	0.41
36	0.43	0.48	0.43	0.74	0.43
37	0.56	0.56	0.71	0.46	0.46
44	0.01	0.3	0.01	0.51	0.01
48	0.53	0.53	0.55	0.31	0.01
49	0.61	0.63	0.61	0.69	0.6
55	0.48	0.54	0.48	0.86	0.48
57	1.09	4.68	1.09	5.06	1.09

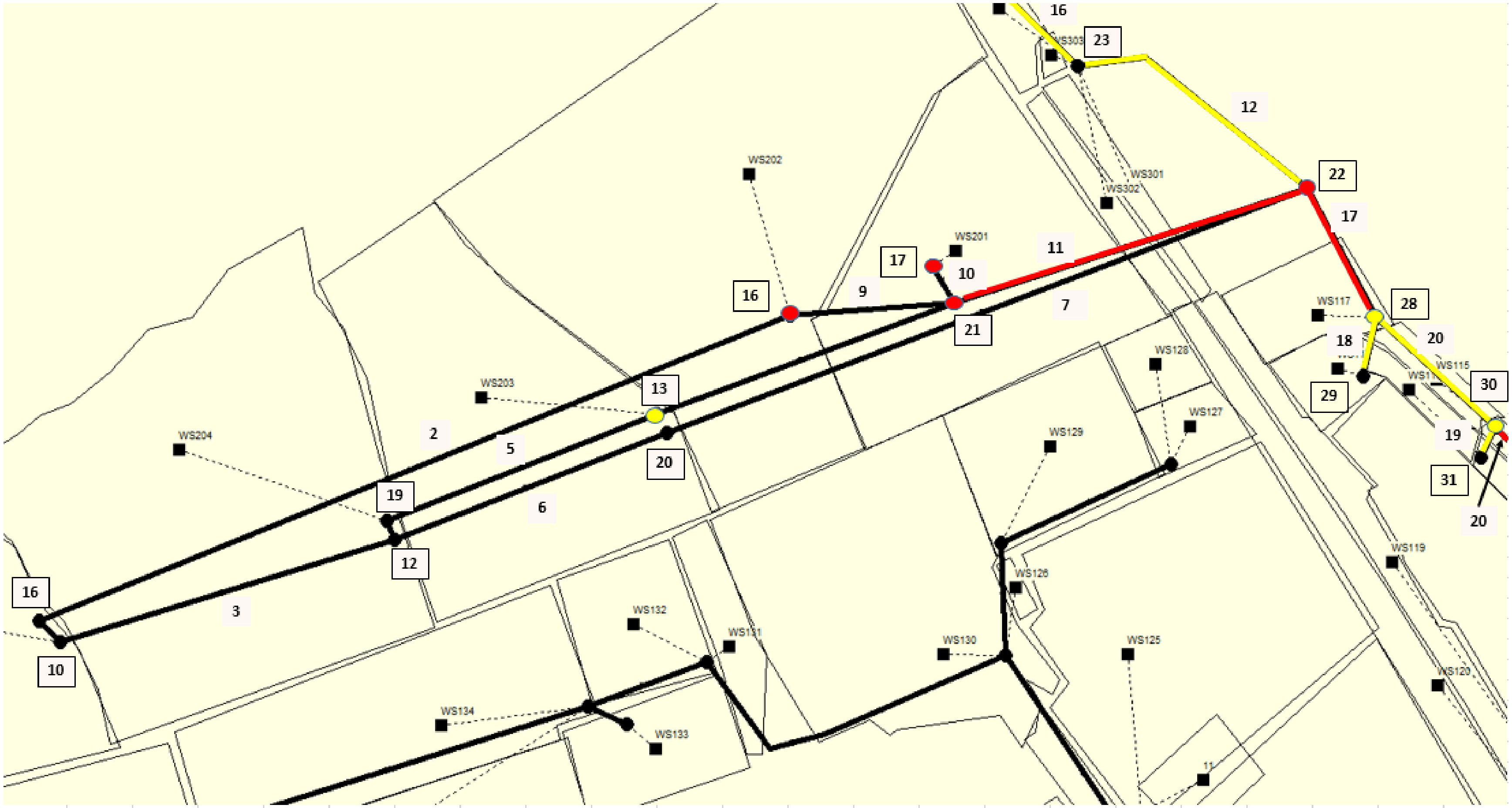


Figure 3 – Partial *SWMM* model schematic

4. Green Infrastructure Assessment

The GI assessment is a comparative analysis of existing and proposed conditions. The goal is to determine the effectiveness and types of GI that make sense in downtown Fairfield and reduce total runoff and peak flows in the stormwater system that lead to flooding. Best practice options can include a wide range of techniques to address the generation of runoff and the capture, treatment, and removal of runoff.

The overriding philosophy of GI is to emulate the way natural systems manage water. For instance, runoff can be thought of as a "waste" of water in a natural landscape. A natural landscape tends to conserve water; it is a natural cooling system, a natural material/food delivery system, a cleansing system, and a cell structural maintenance system among other things. The water cycle is nature's way of collecting, storing, and timing the redistribution of water across landscapes. Runoff is water that is not captured by upland landscapes for their needs.

Ultimately, GI could ameliorate human impacts on the water cycle and ecological systems by more closely emulating natural landscape use and distribution of water. In general, there are essentially two ways to control rainfall and runoff – "permanent removal" and detention. Removal means either putting the water back into the ground or letting it return to the air. Removal can also be called 'abstraction' because rainfall/runoff is removed permanently from runoff conveyance and storage systems. There are only three processes by which removal/abstraction takes place: infiltration, evaporation, and evapotranspiration.

The second way to control runoff is simply to detain it. This kind of control can help convert very substantial increases in both runoff volume and flow rate that occur when a natural landscape is converted from a pervious surface, like a forest or prairie, into an impervious surface, like a rooftop, parking lot, driveway, or road. Detention is a holding volume that intercepts runoff and temporarily holds it to reduce peak flows and, in some cases, provide it time to evapotranspire or infiltrate. Whether removal or detention, there is a simple method that can be used to estimate how capable a particular BMP will be for detaining, treating, or removing rainfall and runoff from its contributing drainage area. There is now enough operational and research history for both conventional stormwater BMPs, like detention ponds, and GI BMPs, like bioretention or porous paving systems, to conduct a planning process by setting some reasonable constraints on proposed BMP sizing.

For instance, studies have shown that in order to have an impact on settling solids, dry or wet detention ponds have to be sized so that the pond's area (footprint) is at least 3% to 5% of its total impervious drainage area. For GI BMPs to have an impact on runoff peak flows or total runoff volume, they need to be roughly between 5% to 20% of their drainage area. The differences between sizing a GI BMP as 5% of its drainage area and as 20% are due to BMP type, underlying soils, depth to confining layer or groundwater, the level of pollutant delivery from the watershed, and the quality and frequency of maintenance.

One way to extend the usefulness and effectiveness of GI BMPs is to link them in treatment trains, that is, design the BMPs in series. For instance, if a particular BMP has sizing limitations due to site constraints, two or more BMPs can be applied so that the upstream BMP outlet flows into the downstream BMP. An upstream BMP that cannot infiltrate into the ground because it is limited by a confining layer could still detain water and then deliver it more slowly to a downstream BMP that alone could not handle the undetained water. The upstream BMP "draws out" the runoff signal enough that the downstream BMP has sufficient time to infiltrate more water than it otherwise would.

4.1 Green Infrastructure Options

Due to the highly developed nature of downtown Fairfield, the town's options for GI implementation are somewhat limited. Besides Sherman Town Green and the greenspaces around Tomlinson Middle School, there is not much open space. Downtown Fairfield does have an abundance of roads, parking lots, driveways and, with the exception of the railroad parking lot, also appears to have fairly deep (≥ 10 feet) well-drained soils.

Given these constraints and possibilities, public rights-of-way appear to present the best opportunity for getting GI into the ground. In downtown Fairfield, it is likely that most of the runoff is either generated in the streets or runs into the streets. Fairfield's downtown streets are mostly two-lane roads with on-street parking on one or both sides. There are also many parking lots. The parking lots themselves are also good opportunities to capture runoff. Existing dry wells were identified in a few parking lots during the field assessment and exemplify this point.

Given the character of downtown Fairfield, the need for abundant parking, the street and sidewalk layout, and overhead power lines, GI BMPs that do not disrupt or occupy streets, structures, parking spaces, and utilities would clearly be preferred. Based on the foregoing, BMPs that appear well suited to downtown Fairfield could include the following:

- Permeable paving systems:
  - Porous asphalt
  - Porous concrete
  - Permeable pavers (see Figure 5 below)
- Dry wells
- Tree wells:
  - Suspended pavement systems; e.g., Silva cells (Figure 6)
  - Built with structural soils (Figure 7)
- Tree trenches (see Figure 8)
- Sidewalk planters
- Bioretention basins
- Infiltration swales
- Green roofs
- Underground storage/infiltration systems
- Downspout disconnection to landscaped areas or rain gardens
- Downspout connection to underground storage or infiltration systems

Appendix D contains a map of parcels in the study area and a matrix of GI options that are suitable for each parcel based on occupancy, configuration, presence of buildings vs. pavement, etc. The Harvey Ball approach is used, similar to methods in the Consumer Reports publication, to allow for comparison between parcels.

While true "green" BMPs, like tree wells/trenches, sidewalk planters, and bioretention, have been recommended, their application in Fairfield will be limited by available open (nonparking, nonstreet) space and utilities such as overhead power lines. However, part of creating resiliency revolves around regreening the landscape. Fairfield should not only make runoff control a priority but also make regreening a priority. The benefits of regreening include the following:

- Mitigation of the heat island effect
- Adsorption/capture of gases and air-borne particulates
- Carbon sequestration
- Energy conservation effect for nearby or co-located buildings
- Windbreaks
- Screening
- Improved aesthetics
- Stress relief, among others

While the opportunities to regreen Fairfield may seem scant at first, they may exist. The tree wells along the streets and in many of the parking lots have very small tree wells, and many trees appear stressed.

Figure 4 – Stressed tree with small tree well on Unquowa Place

Some GI techniques increase the tree well soil volume without changing the tree well footprint. There are tree well systems that use either structural soils (engineered soils that have high structural strength but sufficient pore space for root growth) or suspended soil systems that provide both load-bearing capacity and underground storage. In this case, sidewalks, entry ways, etc., can be built or rebuilt and interspersed with trees that are rooted into these systems. Not only can these systems help with storage and infiltration of runoff, they have also been shown to improve the vigor of urban trees.

Figure 5 – Porous paver strips (Source: GEI)

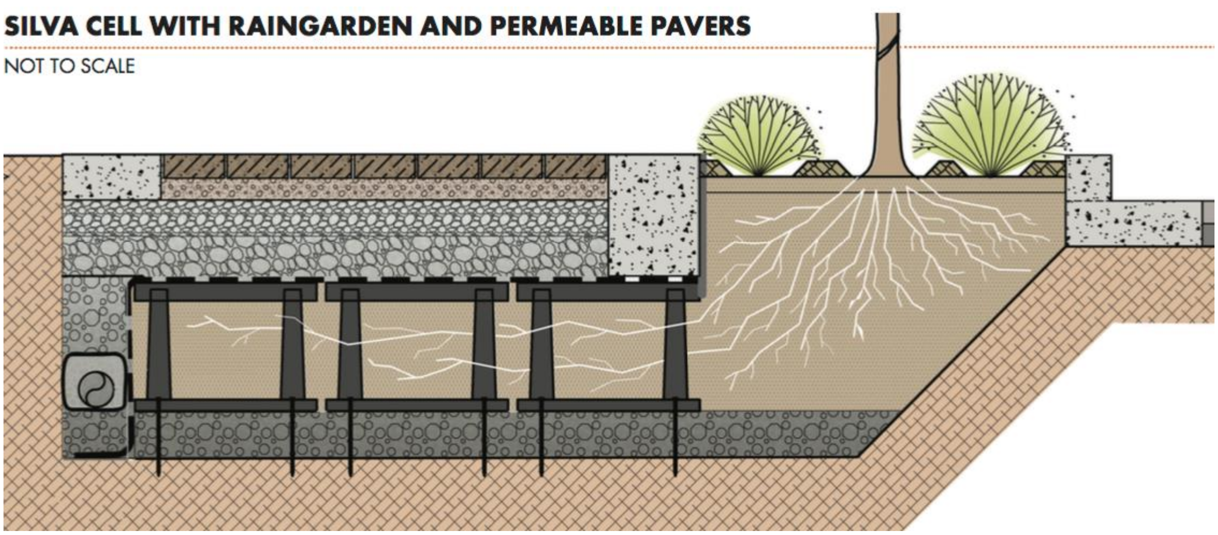


Figure 6 – Example of a Silva cell used to support permeable pavers and vegetation (Wabi buren, 2016)

Other options that are already used in Fairfield include underground storage/infiltration systems and dry wells. Green roofs, while unable to take advantage of downtown's soils, may still be a viable option, particularly if paired with other BMPs that do infiltrate. Rooftop rainfall can be managed with green roofs, or downspouts can be directed to dry wells or underground storage/infiltration systems. For example, see Figure 12 below for an example of rooftop drainage going to belowground storage in a bioretention basin. This kind of rooftop connection could just as easily be made to dry wells or underground storage/infiltration systems[1].

Figure 7 – Tree planter

There are certainly other kinds of options, particularly for new development and for areas with higher percentages of open space. One of the most important lessons for new development adopting a GI approach is that development should be designed to suit the site and not alter the site to suit the development.

It should be noted that one of the most cost-effective ways to manage impervious area runoff is to simply direct water to open green areas. The vegetation of these landscaped areas matters. For instance, there is a significant and growing body of evidence that prairies and forests are two of the most water-conserving landscapes in the world. There is also a growing body of literature that demonstrates that intensively managed landscapes, such as cropland and manicured lawns, tend to limit the maximum potential of surface soils to store and infiltrate water. Going forward, the Town of Fairfield should look for opportunities to direct water to small wooded areas.

[1] The City of Ann Arbor has rebuilt several streets with open-graded aggregate below the street that can handle rooftop runoff.

Figure 8 – Parking lot tree trench with trench drain inlets
(Source: Google earth street view)

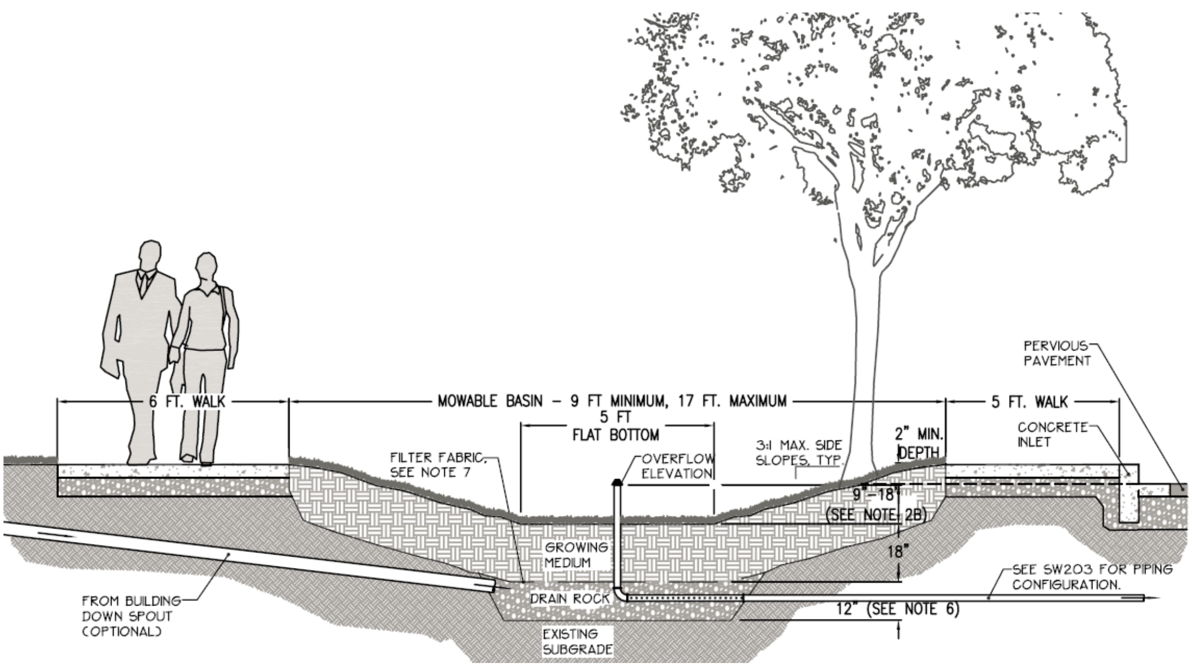


Figure 9 – Example of an infiltration BMP taking rooftop drainage
(Source: USEPA)

4.2 Proposed Conditions Assessment

Based on the existing conditions assessment, including the field drainage assessment and subwatershed delineation, and working from the menu of BMP choices noted above and in Appendix D, a set of GI BMPs was proposed. GI options were grouped into 11 areas (Areas A through K) as depicted on Map 10. Map 11 shows the layout of the proposed BMP scheme, and Map 12 shows potential tree locations.

GI BMPs were then added to the *SWMM* model and assessed. Performance was tested by running the same rainfall design events that were run for the existing conditions assessment. The downtown watershed area was split into a north half containing 10.35 acres of impervious area and a south half containing 15.9 acres of impervious area, and overall performance was assessed at the outlets for each area. Individual GI BMP performance was also assessed. Several variations of designs were run to optimize system and individual BMP performance. Performance metrics included peak and total volume reduction, reduction in system flooding, and cost effectiveness. Cost effectiveness was evaluated with a cost-per-volume reduction per BMP using the 1-year design event as a representative storm.

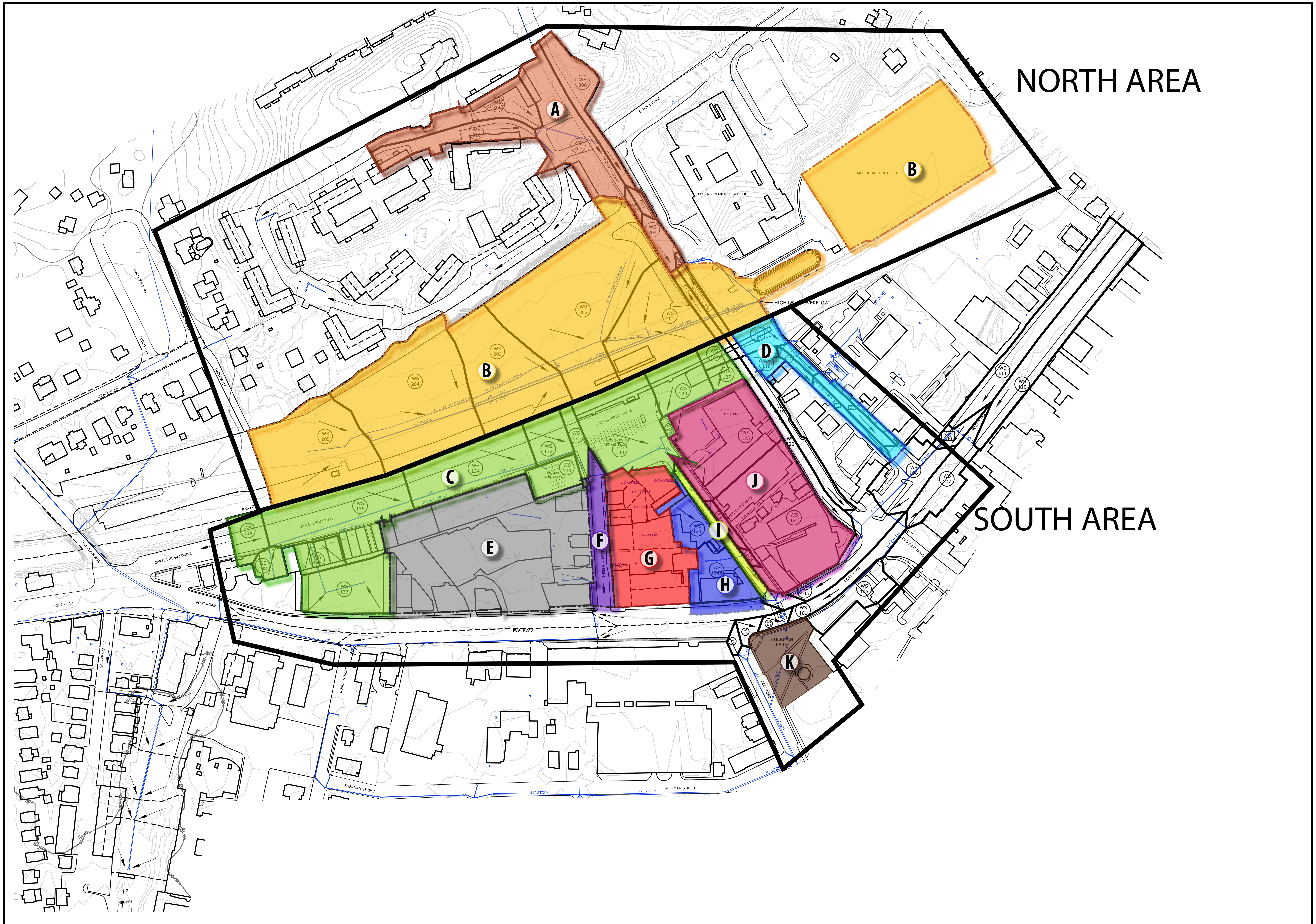
Note that upsizing the stormwater pipe under the railroad and to the south were also evaluated. The pipe sizing evaluation was run both separately from the GI evaluation as well as with a set of runs that combined GI BMPs with pipe upsizing scenarios.

4.2.1 North Area Results

Area A

Area A contains seven subwatersheds. Located at the northern edge of the study area, stormwater within these subwatersheds flows south along Unquowa Road in stormwater pipes.

- To limit stormwater flows contributing from the Mosswood Condominium complex, it may be possible to work with the condominium property owner and association to install decorative permeable brick pavers in the parking spaces along the northern entrance drive. Permeable pavers capture initial rainfall during storm events and adds a decorative entry feature for the condominium complex.
- The town could also work with the condominium to install a large infiltration basin at the entrance to the site. The basin could be planted with colorful perennial plants and small native flowering shrubs. The infiltration basin would receive stormwater sheet flow from the asphalt drive entrance as well as provide a means of overflow protection for heavier rain events where stormwater is not absorbed by the permeable pavers. The infiltration basin would create a colorful, textural gateway feature into the condominium complex and, along with the permeable pavers would create a marketing element highlighting the property as a sustainable, forward-thinking site – not to mention capturing stormwater that would otherwise enter Unquowa Road.
- Because of a lack of storm drains along the eastern side of Unquowa Road, the town could consider adding linear infiltration swales along the east side of Unquowa Road. Breaks can be cut in the curb to allow runoff to flow into the infiltration swales.
- The town could consider installing Low-Impact Development (LID) planters (where lawn currently exists) and porous bituminous concrete (in the current yellow-striped area along the curb) at the school drop off area. These GI features act as a secondary overflow system for runoff coming from the upper portions of Unquowa Road and could provide an important aesthetic and educational element to the site.



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GREEN INFRASTRUCTURE OPPORTUNITY AREAS

PROJECT C - RESILIENCY FOR DOWNTOWN FAIRFIELD USING GREEN INFRASTRUCTURE

FAIRFIELD, CONNECTICUT

DESIGNED	DRAWN	CHECKED
JCW	LM	DM

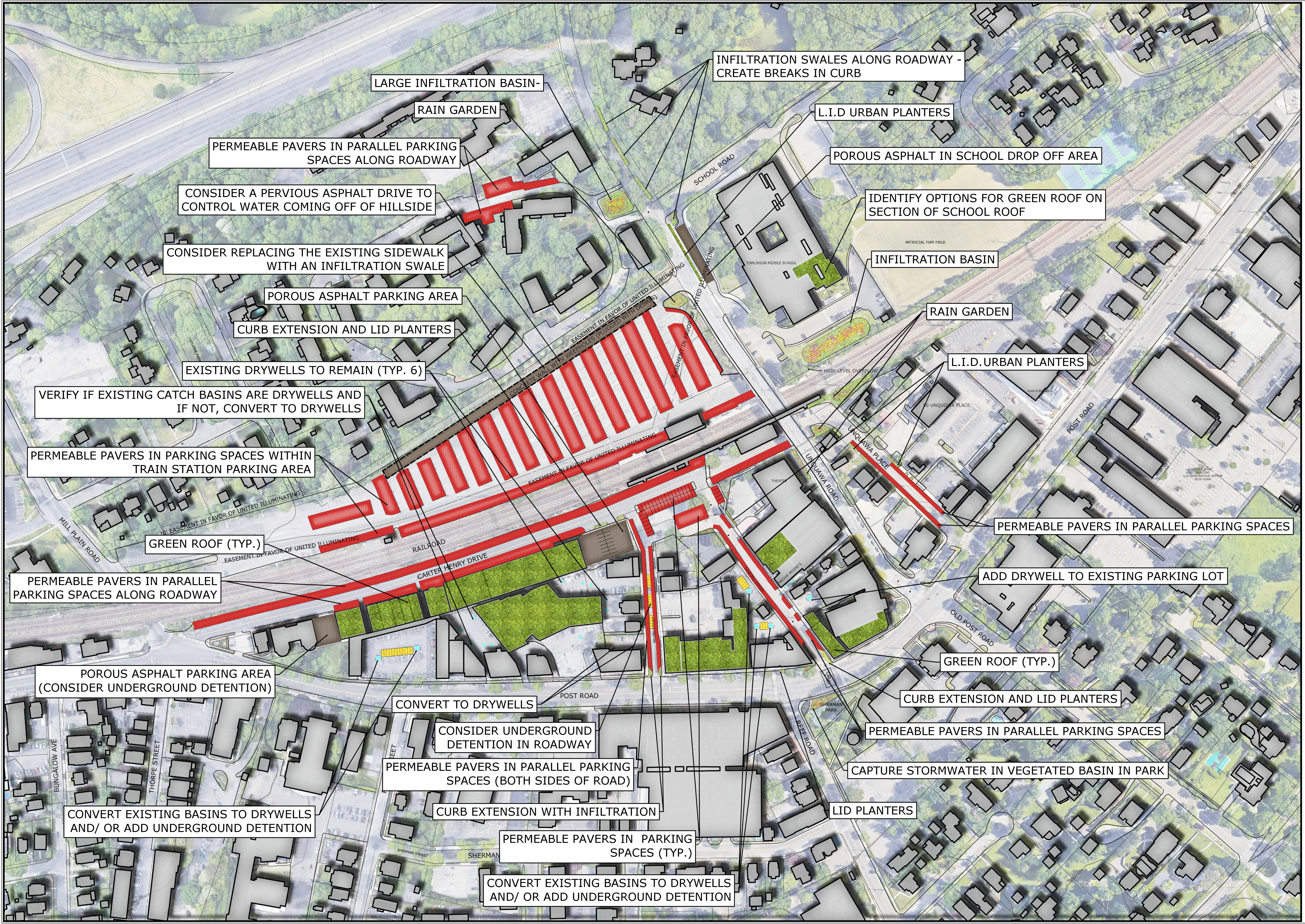
SCALE 1"=100'

DATE JULY 28, 2017

PROJECT NO. 1342-21

SHEET NO. 01 OF 01

SHEET NAME MAP 10



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DESCRIPTION	DATE	BY

CONCEPTUAL PLAN FOR GREEN INFRASTRUCTURE

RESILIENCY FOR DOWNTOWN FAIRFIELD USING GREEN INFRASTRUCTURE

DOWNTOWN FAIRFIELD
FAIRFIELD, CONNECTICUT

JCW	LM	JCW
DESIGNED	DRAWN	CHECKED

SCALE 1"=100'

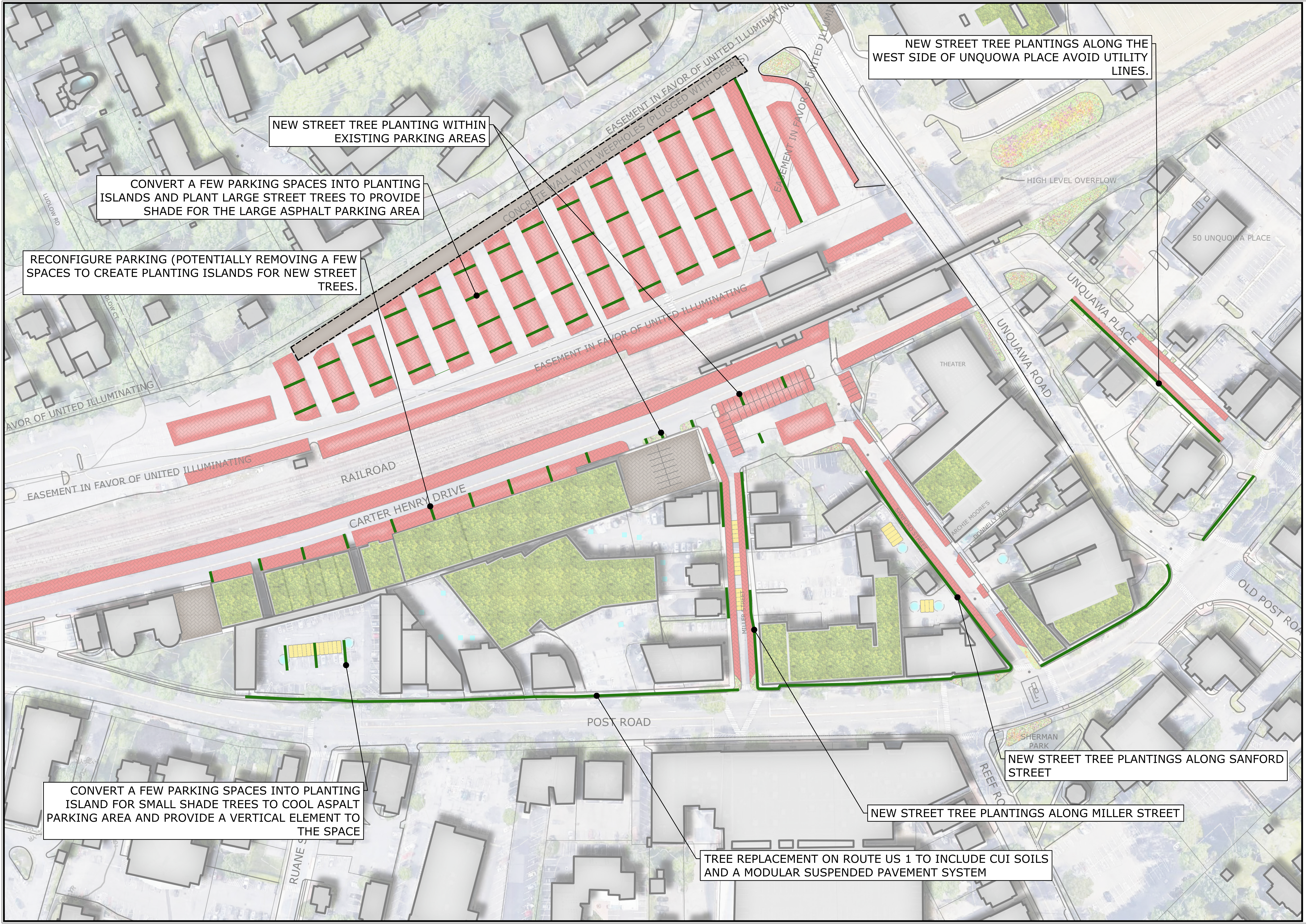
DATE FEBRUARY 20, 2018

PROJECT NO. 1342-21

SHEET NO.

MAP 11

SHEET NAME



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DESCRIPTION	DATE	BY

Potential Tree Locations

RESILIENCY FOR DOWNTOWN FAIRFIELD USING GREEN INFRASTRUCTURE

**DOWNTOWN FAIRFIELD
FAIRFIELD, CONNECTICUT**

JCW	LM	JCW
DESIGNED	DRAWN	CHECKED

SCALE: 1"=60'

DATE: FEBRUARY 20, 2018

PROJECT NO.: 1342-21

SHEET NO.:

SHEET NAME: **MAP 12**

Existing and Potential Conditions – School Drop-Off Area
Install planters where lawn currently exists and porous bituminous concrete in the current yellow-striped area along the curb at the school drop-off area.

If Area A is analyzed independently for reduced volume runoff percentages, it is estimated there will be a 73% and 51% reduction, respectively, for a 1-year and 100-year rain event.

<u>Area B</u>

Area B is mostly composed of the railroad parking lot and the southern portion of Tomlinson Middle School. At almost 8 acres in size, the train station parking lot is more than 75% of the total delineated impervious area of the north half of the assessment area. This area had one boring that showed a base and several feet of aggregate and decomposed bedrock. The lone boring in the parking lot met refusal at about 6 feet below the ground surface. There appear to be no BMPs (GI or traditional) detaining water for the lot, and the lot drains to the east to the flow-limited, 12-inch storm sewer that flows under the railroad. Working under the assumption that the parking lot cannot afford to lose parking spaces leaves only a few options. Because the parking lot is so large and just about every square inch is devoted to parking or getting into and out of spaces, any storage would need to be underground.

A porous paving system was simulated. Structurally, porous paving materials work best outside of main drive lanes and are best used in straight stretches. Pavers that are installed in turns must endure the additional centrifugal force that can "ripple" the pavers in the turnover time. Parking stalls, either in parking lots or in on-street parking, are an ideal use of porous paving systems.

The results from a model simulation of a porous paving system are as applicable for permeable asphalt and permeable concrete as it is for porous pavers. The runoff control performance can be considered the same for all three types of paving materials. Four different parking lot permeable paving alternatives were simulated. The first alternative shows 100% of the parking stall area in the lot repaved with a permeable paving system. Scenarios with 75%, 50%, and 25% of the stall area covered in pavers were also tested.

In addition to the parking lot scenarios, concepts were assessed with some permeable paving north of the lot, along with two bioretention basins, and one infiltration swale along Unquowa Road just north of Tomlinson Middle School. Additionally, an ecobasin concept design was developed that would be installed on the south side of Tomlinson Middle School. This would have a total footprint of about 8,000 square feet and would be about 7 feet deep. Water would be passively directed to the basin via a weir in the manhole upstream, alleviating capacity on the storm pipe on Unquowa Place. A boring right at the basin shows about 10 feet of sand before hitting groundwater, making an infiltration element in this area ideally suited.

Installing underground storage instead of the ecobasin was also evaluated. The underground storage can potentially have a larger footprint and less depth. Both the underground storage and the ecobasin would have an inlet and an outlet that would be relatively close together. Both basins would have to be fed by a control manhole with an inlet into the basin that is controlled up to a certain peak flow. Anything beyond that peak flow would then bypass the storage inlet. In order for the system to work properly and passively, the head in the control manhole has to always be above the storage, which always has to be above the downstream storm sewer manhole receiving basin outflows. If it is possible that the basin elevation can be even with or even exceed the control manhole's maximum design elevation, water could potentially back up. We developed both the ecobasin and the underground storage scenarios because they utilize a different kind of storage; that is, the ecobasin relies on a more depth-dependent storage while the underground basin relies on a more areal-dependent storage.

The results for Areas A and B are broken out for (a) the railroad area only (Table 6), (b) the entire north area (Table 7), and (c) the impact of the north area improvements on the total system flows (Table 8). Based on the one boring, the study assumes the entire parking lot was underlain by very poorly draining soils. The infiltration rate below the porous paving system into the underlying soil was 0.01 inches/hour, and the total storage in the open graded aggregate below the paving system was 18 inches deep.

Table 6 shows that no matter how large the porous paving system, there was little to no impact on peak flows out of the lot. This is because the flow out of the lot is more limited by the undersized storm sewer pipe conveying water under the railroad to the south than by the size of the parking lot BMP system. There is slightly more impact on total flow out, but when the upstream BMPs are added in, there is significantly more impact on total volume control. This is mostly a function of the ecobasin, which takes a portion of the entire north area flows, detains, and infiltrates a large portion of them.

The eco basin, in terms of total runoff infiltrated into the ground, was the most effective BMP of all the BMPs modeled for downtown Fairfield. For instance, for the 1-year rain event, the ecobasin infiltrated over 15,000 cubic feet (CF) while the next largest infiltration volume was just over 5,000 CF. There are at least three important reasons for this outcome as follows:

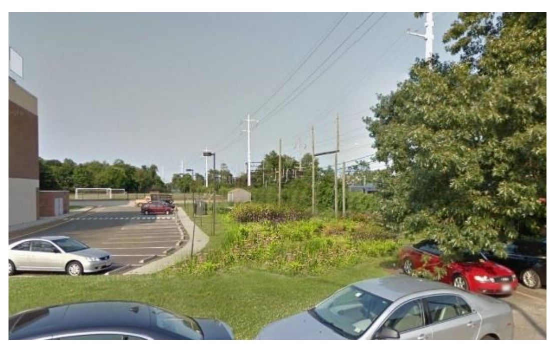
- The ecobasin accepts the most water of any BMP. While the ecobasin is "off-line" it takes some portion of all the north area flows.
- The conceptual design of the ecobasin has it at 7 feet deep. This means that not only can the basin hold a lot of water, there is a head pressure driving water into the ground
- Concept design has an influent control manhole with a weir offset 2 feet above the manhole invert. The basin would also have its own forebay area and would be lined with deep-rooted native vegetation. The combination of these design aspects should be the capacity for the basin to remove most solids ahead of the infiltrating surfaces and for the plants to maintain a high infiltration capacity due to the impacts of their rooting zones. Therefore, the basin should be able to maintain or even increase the infiltration rate over time.

This storage may be possible to install below grade, allowing the ground surface to continue to be used for other purposes.

One important finding is that while the combined north area BMPs do not show much impact on the simulated peak flows through the north area outlet, they do however have a significant impact on overall flooding volumes in the study area. The lack of impact on the peak flow is nevertheless due to insufficient flow capacity in the outlet pipe.


Existing and Potential Conditions – Train Station Parking Lot

To maintain the quantity of parking spaces, install permeable brick pavers within the parking spaces of the train station parking area. Consider capturing stormwater entering from the hillside north of the parking area by installing an infiltration swale in the present location of the unused sidewalk and paving the northern access drive in pervious asphalt. Additional elements to consider include paving the drive lines with new pervious asphalt and providing shade to the parking lot by removing some of the parking stalls and planting trees within curbed islands. The islands can also double as rain gardens for additional surface infiltration.

Existing and Potential Conditions – Middle School "Ecobasin" or Underground Storage

Creation of a large infiltration basin south of the school in the existing location of the ropes course to assist with stormwater collection from the existing storm drainage system within Unquowa Road.

It is likely that a significant portion of stormwater that leaves the existing synthetic turf field enters the existing storm drainage system on Unquowa Road. The town could consider capturing this volume in the proposed detention basin and/or install underground storage below the existing roadway and parking area south of the school.

If Area B is analyzed independently for runoff volume removal, there would be an estimated 40% and 24% reduction, respectively, for a 1-year and 100-year rain event.

Table 4
Summary of Runoff Volume Removal Percentages for North Area BMPs, Independent of Other BMP areas, for a 1-Year and 100-Year Event

Area	Subarea	% Runoff Removal	
		1-Year Event	100-Year Event
North BMPs	A	73	51
	B	40	24

4.2.2 Results for South Area

For the South Area, we investigated the potential BMP improvements by analyzing the change in runoff volume as well as investigating the changes in peak flows at key locations in the storm sewer system. These analyses were run without any BMPs or pipe enlargements in the North Area so that the comparison of effectiveness by BMP by area would be consistent.

AREA C

Area C is Carter Henry Drive and adjacent areas. Options include the following:

- Stormwater runoff generation along Carter Henry Drive could be reduced by installing permeable brick pavers along the north and southern portions of the roadway within the existing parallel parking spaces.
- Town-owned parcels that contain parking lots could be converted into porous asphalt paving with permeable pavers (as a decorative/functional treatment) installed within the parking stalls.
- In existing parking areas, consider directing stormwater from existing catch basins to underground detention systems.
- Consider installing green roof systems on buildings within the subwatershed
- Install curb extensions where practical, and direct stormwater into GI planters within the curb extensions.

These BMPs result in 42% and 31% reduction in total runoff volume for the 1-year and 100-year rain events, respectively.

Peak reductions just downstream of Area C were also analyzed. In a future conditions scenario, this storm sewer includes the BMPs for Areas E and F (reported on pages 47 and 48). Therefore, the peak flow reductions reported here include the BMPs in Areas C, E, and F. For the 1-year and 100-year events, the peak-flow reductions are 41% and 13% respectively.


Existing and Potential Conditions – Carter Henry Drive
Capture stormwater runoff along Carter Henry Drive by installing permeable brick pavers along the north side of the roadway within the existing parking spaces.


Existing and Potential Conditions – Carter Henry Drive
Capture stormwater runoff along Carter Henry Drive by installing permeable brick pavers along the north side of the roadway within the existing parking spaces.


Existing and Potential Conditions – Parking Lots

In existing parking areas, consider directing stormwater from existing catch basins to underground detention systems.

Existing and Potential Conditions – Grassy Areas
Install curb extensions where practical and direct stormwater into GI planters within the curb extensions.

Existing and Potential Conditions – Parking Lots
Town-owned parcels that contain parking lots could be converted into porous asphalt paving.

<u>AREA D</u>

Area D is primarily Unquowa Place. Options include the following:

- Stormwater at the north end of Unquowa Place could be captured in two rain gardens. One rain garden could be located along the toe of slope of the railroad tracks, and the other could be located in a small lawn space at the corner of Unquowa Place and Carter Henry Drive occupied by Garner Golf. At the small open lawn, potential impacts to basements would need to be evaluated.
- Mitigate stormwater runoff along Unquowa Place by installing GI urban planters behind the curb in the existing lawn amenity strip adjacent to the sidewalk.
- Stormwater runoff could be reduced by installing permeable brick pavers within the parallel parking spaces along Unquowa Place.

Area D does not receive runoff from other areas. The BMPs for Area D reduce the total runoff volume for the 1-year and 100-year events by 52% and 41%, respectively. Presumably, these reductions would benefit the stormwater pipe conveying water from north of the railroad tracks to Reef Road as this pipe is located beneath and parallel to Unquowa Place.


Existing and Potential Conditions – Corner of Unquowa Place and Carter Henry Drive
Potential rain garden at Garner Golf on the corner of Unquowa Place and Carter Henry Drive

AREA E

Area E is mostly impervious rooftops and parking lots with little landscaping. Options include the following:

- Due to the lack of any naturalized spaces that would afford the opportunities to create exposed GI, such as rain gardens, the town could consider contacting property owners and providing incentives for the installation of green roofs to assist with reducing stormwater generation and slowing down the initial runoff from roofs.
- Existing drywells within this area should remain and should be monitored with sediment removed on an annual basis or more frequently as needed.
- Because catch basin inverts could not be identified during fieldwork, the directional flow of some existing catch basin could not be confirmed. To limit the volume of stormwater entering the existing stormwater system, consider converting these catch basins into drywells.

For the Area E BMP scenario, the analysis assumed that 100% of the roof area was converted to green roofs. The outflow from the green roofs was then directed to a series of enlarged drywells for underground infiltration. These drywells were assumed to be located in the footprint Area C; nevertheless, the evaluation views total runoff reduction in the combination of green roofs and drywells. The total runoff volume reduction was 87% and 65%, respectively, for the 1-year and 100-year rain events. It is important to note that these runoff volume reductions are due to runoff being directed into drywells, and that green roofs do however reduce the runoff rate.

AREA F

Area F is Miller Street. Stormwater catch basins are not located along Miller Street. Options include the following:

- Consider directing existing stormwater from Miller Street into underground detention chambers or drywells below the roadway.
- Install permeable brick pavers within the parallel parking spaces along the sides of this one-way road.
- Provide curb extensions at the corner of Post Road on both sides of Miller Street to screen the ends of cars from pedestrians walking and driving along Post Road and provide rain garden/ infiltration areas within the curb extensions.

The Area F BMPs would feed directly into Area C, so the reductions for Area F are contained in the Area C reductions described above. However, if Area C is analyzed independently of Area C, the approximate runoff volume reductions would be 53% and 41%, respectively, for the 1-year and 100-year rain events.

Existing and Potential Conditions – Miller Street
Install permeable brick pavers within the parallel parking spaces along the sides of this one-way road.

Existing and Potential Conditions – Miller Street
Install permeable brick pavers within the parallel parking spaces along the sides of this one-way road.

Existing and Potential Conditions – Miller Street and Boston Post Road
Provide curb extensions at the corner of Post Road on both sides of Miller Street to screen the ends of cars from pedestrians walking and driving along Post Road and provide rain garden/infiltration areas within the curb extensions.

AREA G

Area G includes parcels on the east side of Miller Street. Existing catch basins within the parking areas have all been (with the exception of two) converted to drywells and appear to be functioning properly. Options include the following:

- Because existing catch basin within the parking areas have been converted to drywells and appear to be functioning properly, property owners should be encouraged to regularly maintain drywells to prevent siltation.
- Existing buildings along Post Road could implement green roofs to assist in roof runoff reduction and improve water quality.

The Area G BMPs result in a total runoff volume reduction of 87% and 65% for the 1-year and 100-year rain events, respectively. The peak-flow reduction is measured just downstream of Area G, but this evaluation point also includes runoff reductions from all the other areas.

Total peak-flow reduction for all south areas are 23% and 1%, respectively, for the 1-year and 100-year rain events.

AREA H

Area H includes parcels on the west side of Sanford Street. Options include the following:

- Convert existing catch basins that contribute stormwater loads to Sanford Street to drywells and/or provide underground detention below the parking area to keep stormwater on site.
- Consider adding green roofs to building along Post Road.
- Install GI planters within existing parallel parking spaces on the north side of Post Road.

The BMPs for Area H result in 8% and 6% reductions in the total runoff volume for the 1-year and 100-year rain events, respectively. As noted, Area H peak-flow reductions are measured downstream of all the BMP contributions from the other South Area BMPs. Total peak flow reduction for all the south areas are 23% and 1%, respectively, for the 1-year and 100-year rain events.

Existing and Potential Conditions – Boston Post Road
Install GI planters within existing parallel parking spaces on the north side of the road.

AREA I

Area I is Sanford Street. Drainage infrastructure within Sanford Street includes the pipes carrying stormwater from Area C and Area H. Options for Area I include the following:

- Provide curb extensions and/or GI planters at the corner of Sanford Street and Post Road.
- Install curb extensions with rain garden/infiltration areas on Sanford Street to match those on Miller Street.
- Install permeable pavers along the sides of Sanford Street in the parallel parking spaces.
- Consider providing underground detention below the roadway to slow stormwater from entering the existing storm drainage system, which contributes to flooding on Reef Road.
- Working with property owners, consider adding GI urban stormwater planters along the eastern sidewalk at the north end of Sanford Street.

If Area I is analyzed independently, it is estimated that the runoff volume removals would be 96% and 76%, respectively, for a 1-year and 100-year rain event.

Existing and Potential Conditions – Sanford Street
Consider providing underground detention below the roadway to slow stormwater from entering the existing storm drainage system, which contributes to flooding on Reef Road.

Existing and Potential Conditions – Sanford Street
Consider providing underground detention below the roadway to slow stormwater from entering the existing storm drainage system, which contributes to flooding on Reef Road.

AREA J

Area J includes parcels between Sanford Street and Unquowa Road. Options include the following:

- Install drywells to existing catch basins within the private parking areas.
- Retrofit select roofs with green roof elements to reduce stormwater generation and improve initial storage during severe rain events that contribute to flooding.
- Install a rain garden on the west side of Unquowa Road.

For the BMPs in Area J, total runoff reductions are 64% and 47% for the 1-year and 100-year rain events, respectively. Total Area J peak-flow reductions are combined with the other area peak-flow reductions. Total peak-flow reduction for the combined south areas are 23% and 1%, respectively, for the 1-year and 100-year rain events.

Existing and Potential Conditions – West Side of Unquowa Road
Install a rain garden.

AREA K

Area K is Sherman Green. Borings completed in Sherman Green demonstrated relatively shallow depth to bedrock, making underground detention difficult or impossible. Options include the following:

- Develop infiltration garden treatments within Sherman Green. Due to its prominent location, infiltration gardens should become an aesthetic feature. Infiltration gardens could incorporate educational signage.

Table 5
Summary of Runoff Volume Removal Percentages for South Area BMPs, Independent of Other BMP areas, for a 1-Year and 100-Year Event

Area	Subarea	% Runoff Removal	
		1-Year Event	100-Year Event
South BMPs	C	46	31
	D	44	33
	E*	0	0
	F	53	41
	H	72	26
	I	96	76
	J	8	5
	K	No BMPs due to shallow bedrock	No BMPs due to shallow bedrock

**Subarea E BMPs are Green Roofs only, we assumed 0 ET; therefore, there was no volume loss. However, green roofs do reduce peak flow rate.*

4.2.3 Results for North and South Areas Combined

This section summarizes the model evaluations for the north and south areas and compares results with and without pipe upsizing.

TABLE 6
***SWMM* Model Results for Railroad Parking Lot with Four Porous Paving Coverage Scenarios for the 1-Year Design Storm Event**
(Assumed 1.25-foot pipe under railroad)

% Stall Area in Pavers	North Area			
	Peak (cfs)	% Reduction from Existing	Volume Out (Ac-ft)	% Reduction from Existing
0%	3.87		2.41	
25%	3.8	1.8%	2.34	2.7%
50%	3.78	2.3%	2.27	5.8%
75%	3.79	2.1%	2.18	9.4%
100%	3.8	1.8%	2.10	12.8%

TABLE 7
***SWMM* Model Results for North Area with Full GI BMP Scenario for North Area Only**

Design Rain Event	Peak (cfs)	% Reduction from Existing	Total Volume Out (Ac-ft)	% Reduction from Existing
1-yr	3.84	0.8%	1.67	30.4%
2-yr	3.91	-0.5%	2.09	27.7%
10-yr	3.99	-1.3%	3.22	23.7%
50-yr	4.01	-0.5%	3.74	24.3%
100-yr	4.00	2.9%	4.48	20.9%

TABLE 8
***SWMM* Model Results for System Outlet with Full GI BMP Scenario for North Area Only**

Design Rain Event	Peak (cfs)	% Reduction from Existing	Total Volume Out (Ac-ft)	% Reduction from Existing	Flooding Volume (Ac-ft)	% Reduction from Existing
1-year	29.27	0.07%	4.93	13.0%	0.23	78.3%
2-year	31.31	-0.19%	5.88	12.0%	0.57	63.2%
10-year	35.71	0.00%	8.55	10.8%	1.18	62.8%
25-year	38.23	0.00%	10.04	10.8%	1.97	53.9%
100-year	39.95	0.00%	12.21	8.7%	3.31	47.3%

TABLE 9
***SWMM* Model Results for System Outlet with Full GI BMP Scenario for North and South Areas**

Design Rain Event	Peak (cfs)	% Reduction from Existing	Total Volume Out (Ac-ft)	% Reduction from Existing	Flooding Volume (Ac-ft)	% Reduction from Existing
1-year	22.54	23.0%	3.60	36.4%	0.00	100.0%
2-year	27.96	10.5%	4.69	29.9%	0.00	100.0%
10-year	35.51	0.6%	7.34	23.4%	0.47	85.2%
25-year	38.08	0.4%	8.99	20.1%	1.58	63.1%
100-year	39.88	0.2%	10.95	18.1%	3.40	45.9%

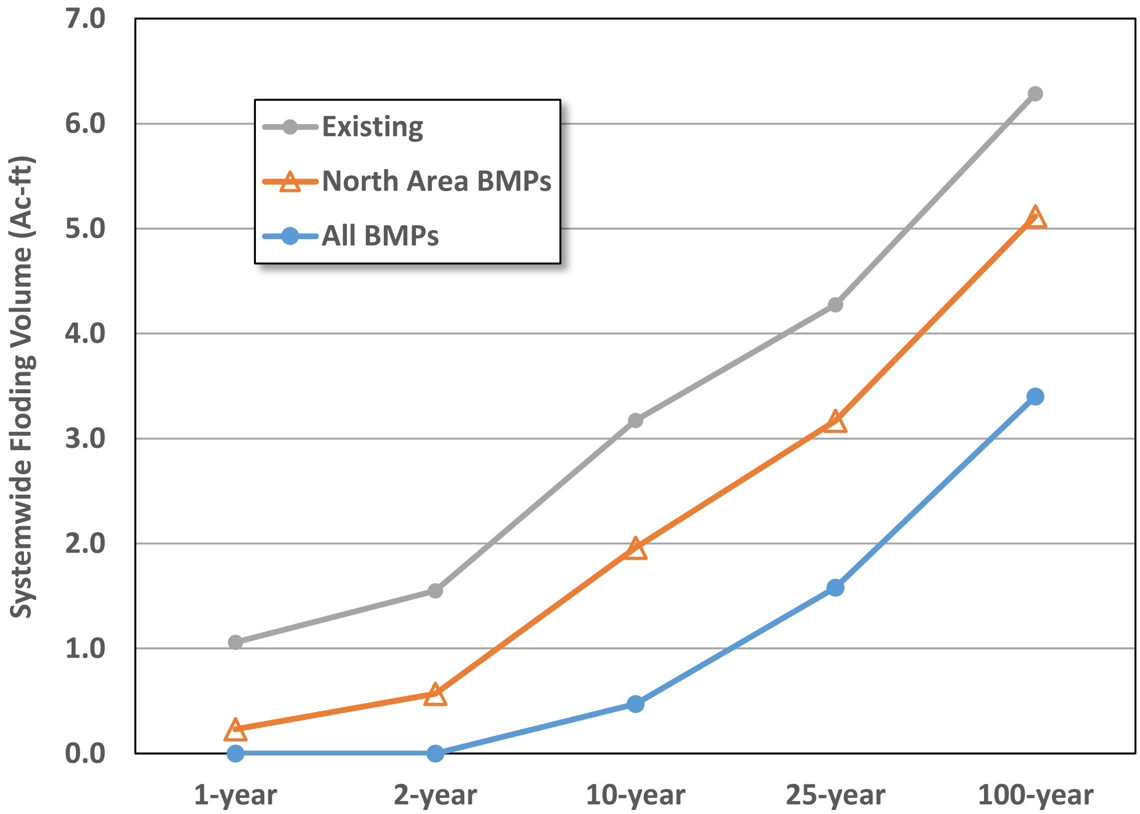


Figure 10 – Comparison of existing and proposed conditions scenario system-wide flooding

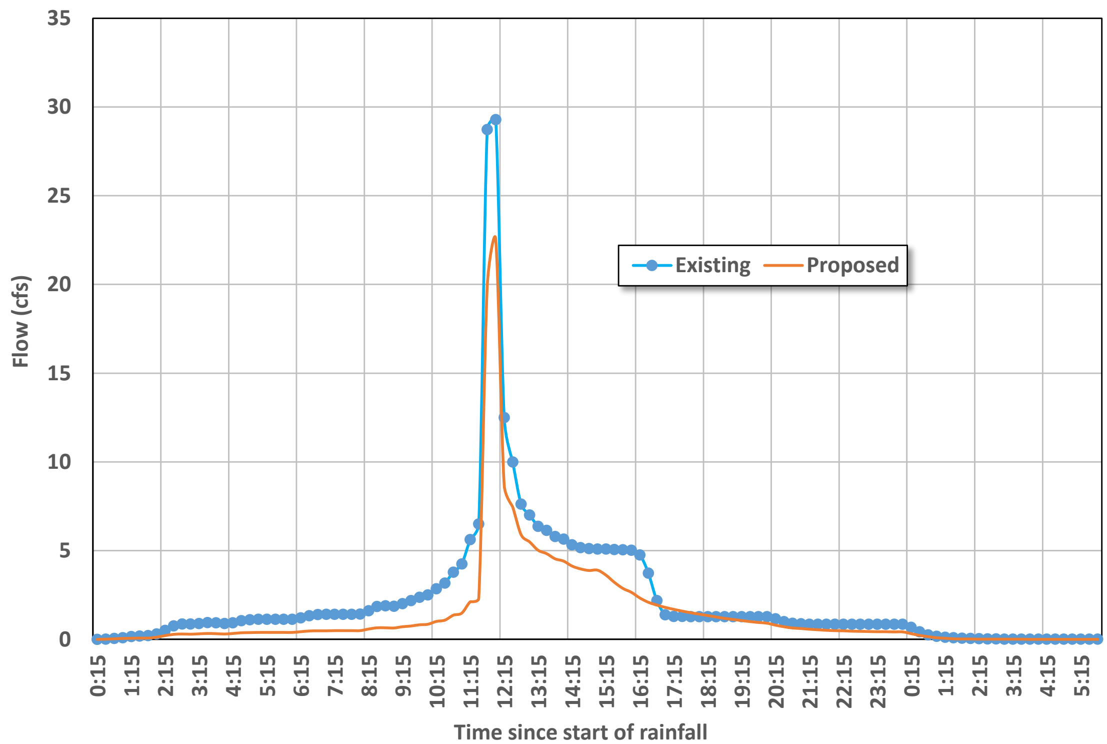


Figure 11 – Comparison of system-wide existing and proposed conditions for the 1-year rain event

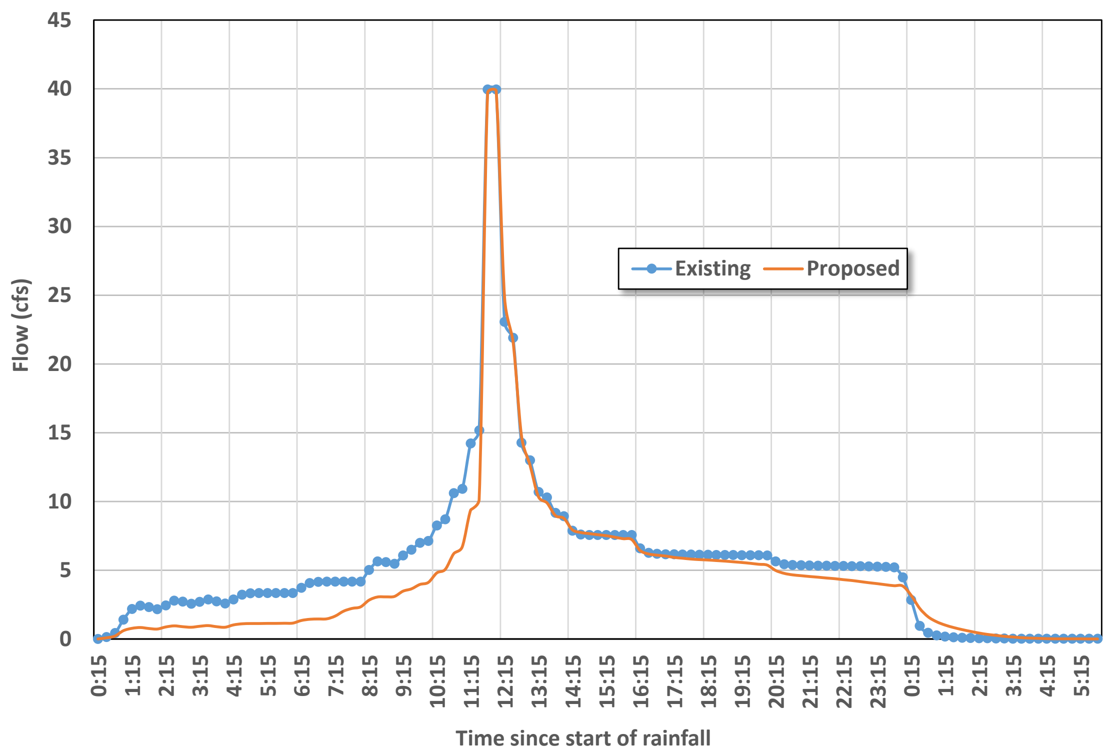


Figure 12 – Comparison of system-wide existing and proposed conditions for the 100-year rain event

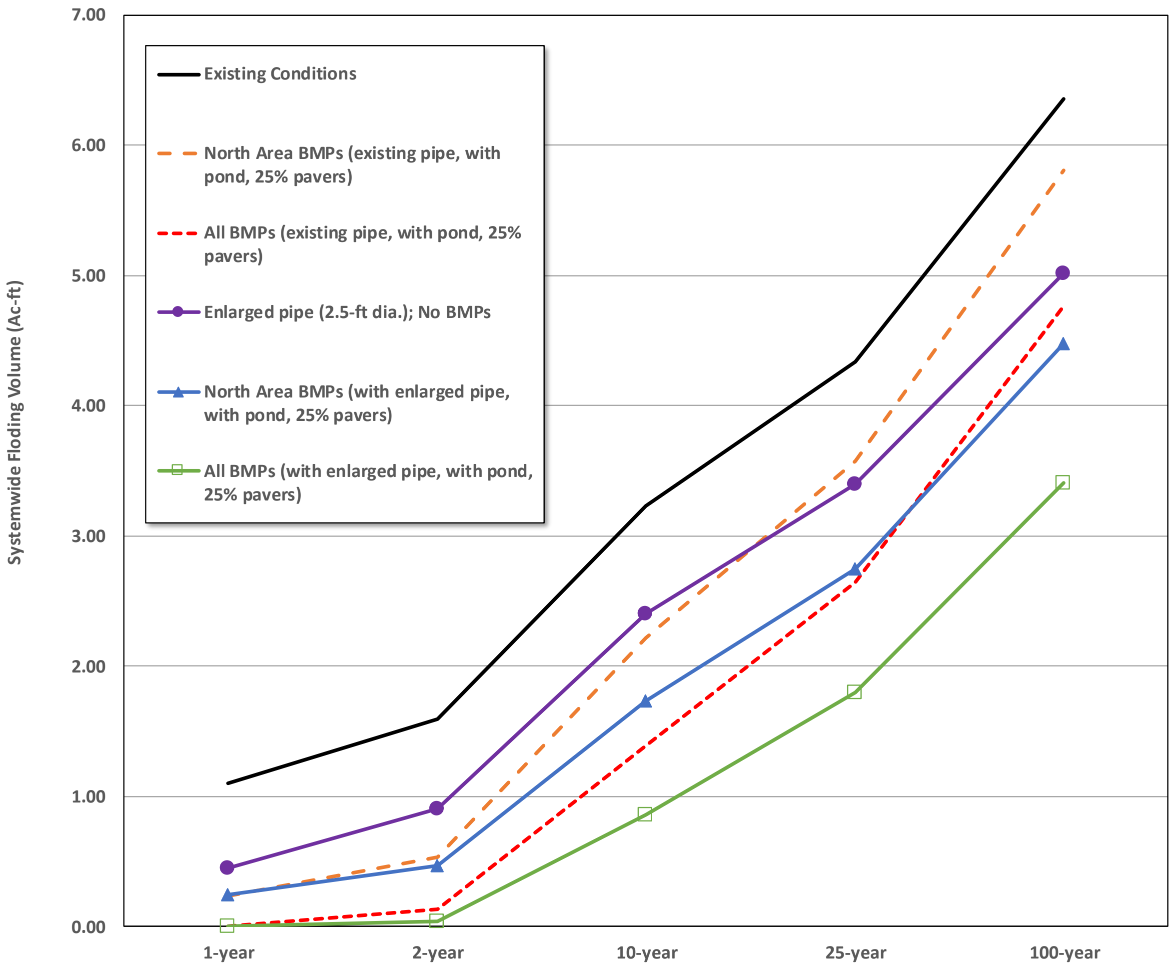


Figure 13 – Comparison of 100-year flooding in downtown Fairfield with and without GI BMPs and targeted storm sewer upsizing

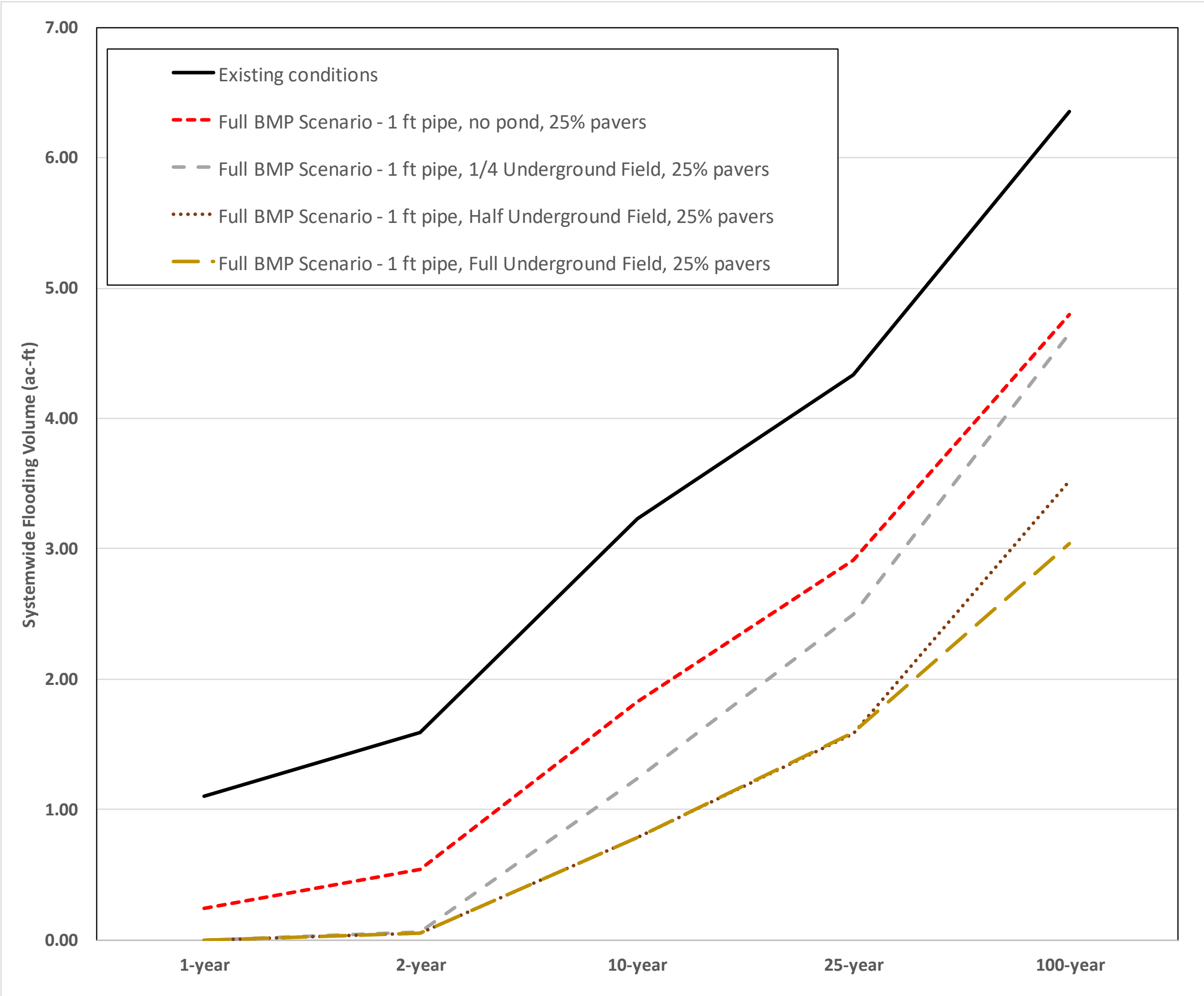


Figure 14 – Estimated cost effectiveness (per cubic foot of runoff capture) of BMPs for the 1-year storm event for proposed conditions in downtown Fairfield

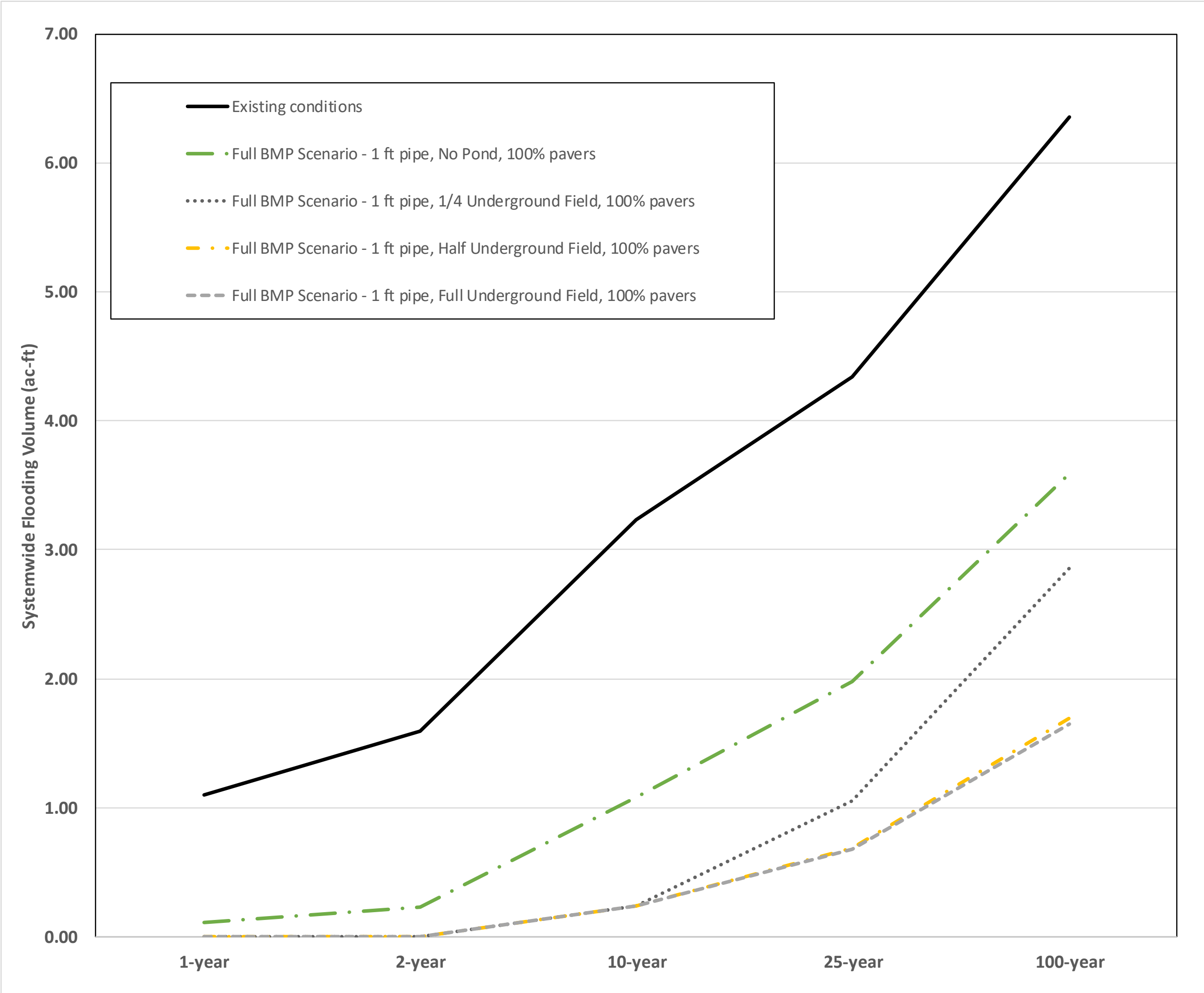


Figure 15 – Comparison of flooding volumes in downtown Fairfield with GI BMPs (including underground storage, 100% paver coverage in the railroad parking lot, and no eco-pond) without upsizing the pipe under the railroad

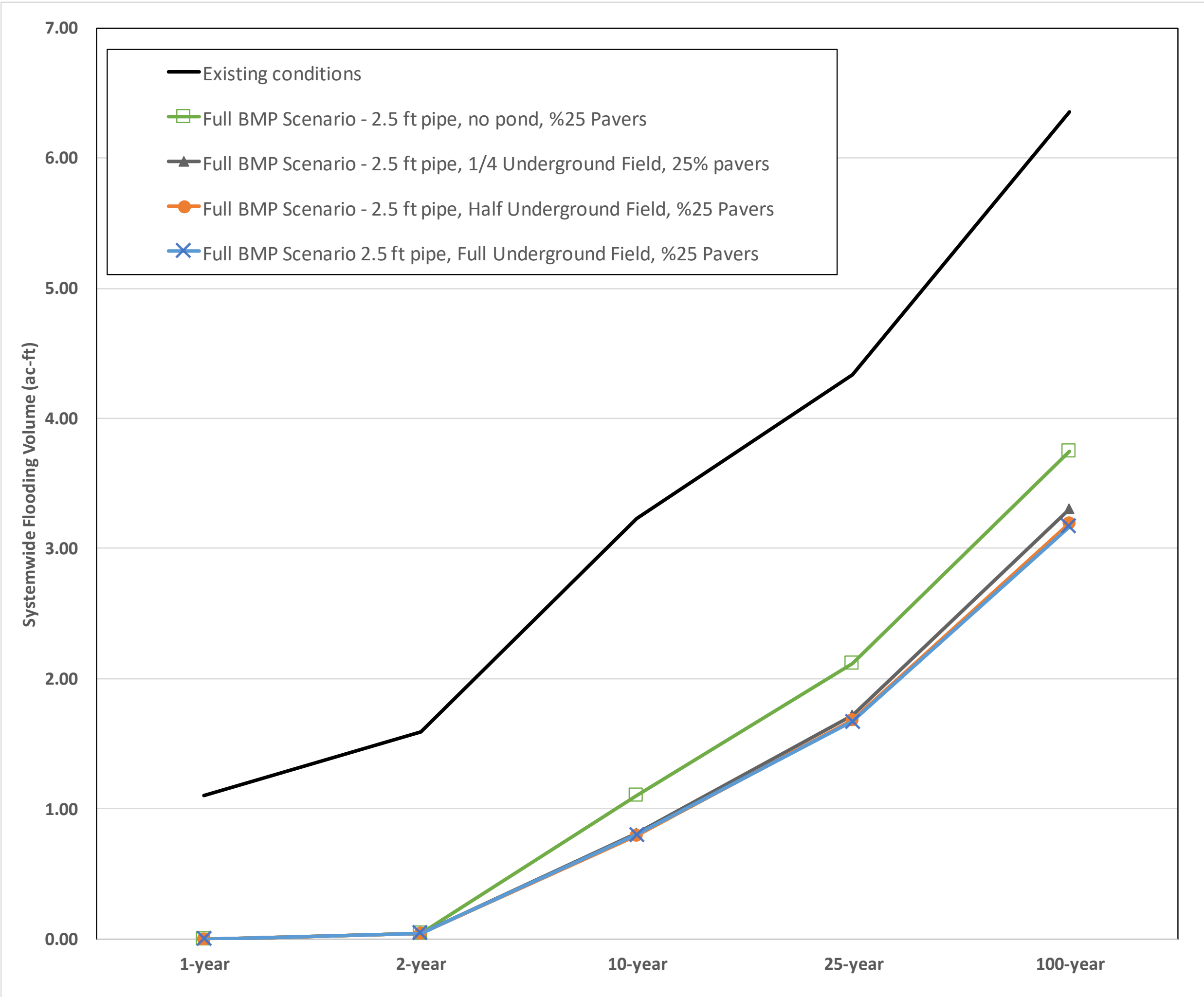


Figure 16 – Comparison of Flooding volumes in downtown Fairfield with GI BMPs (including underground storage, 25% paver coverage in the railroad parking lot, and no eco-pond) along with upsizing the pipe under the railroad

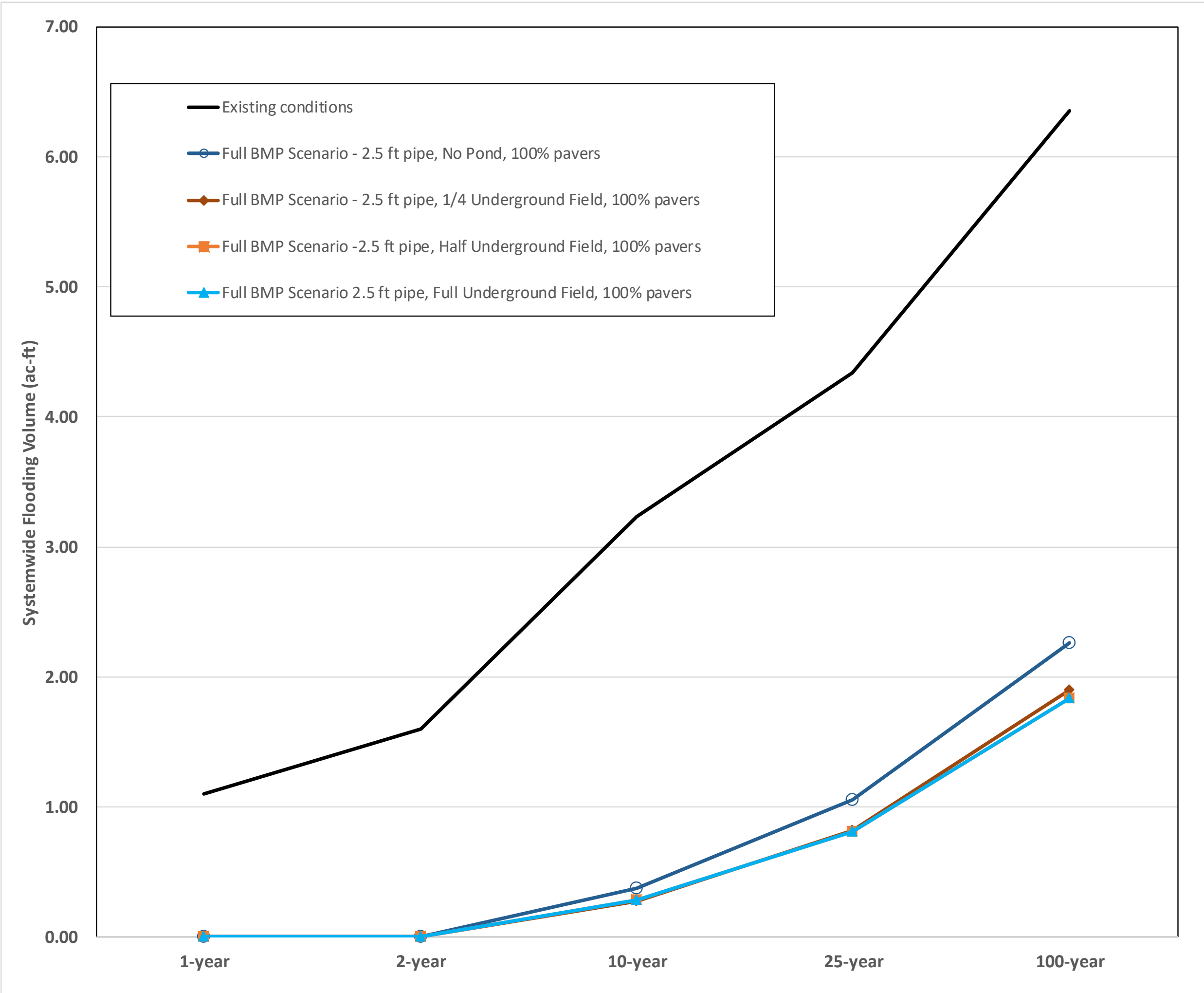


Figure 17 – Comparison of Flooding volumes in downtown Fairfield with GI BMPs (including underground storage, 100% paver coverage in the railroad parking lot, and no eco-pond) along with upsizing the pipe under the railroad

4.2.4 BMP Performance and Cost Summary

TABLE 10
Estimated Costs for North Area BMPs

WS ID	Area (Ac)	Description	% Imp Treated	BMP Area as a % of Imp Area	Pavers (SF)	Bio-retention (SF)	Swales (SF)	Eco-Basin (SF)	Area Costs
205	1.32	RR parking lot	25	3	1,866				$33,594
204	1.90	RR parking lot	100	9	7,253				$130,550
203	1.22	RR parking lot	100	12	6,243				$112,372
202	2.33	RR parking lot	100	10	10,446				$188,025
201	1.00	RR parking lot	100	6	2,399				$43,176
205	1.32	RR parking lot	25	13	7,490				$134,820
204	1.90	RR parking lot	100	35	29,720				$534,960
203	1.22	RR parking lot	100	47	24,680				$444,240
202	2.33	RR parking lot	100	41	41,880				$753,840
201	1.00	RR parking lot	100	22	9,690				$174,420
310	0.41	Mosswood Condos	75	25	1,767				$31,808
309	0.50	Mosswood Condos	75	25	2,171				$39,084
308	0.39	Unquowa Rd	100	15			2,546		$25,457
307	0.87	Mosswood Condos	50	25		2,509			$37,630
306	0.03	Unquowa Rd	100	33	264				$4,755
305	0.04	Unquowa Rd	100	20		199			$2,992
304	0.14	Unquowa Rd	50	25	391				$7,047
NA								8000	$160,000
						Alt 1 - 25% of Lot Stall Area:			$816,489
						Alt 2 - 100% of Lot Stall Area:			$2,351,051

TABLE 11
Estimated Costs for South Area BMPs

WS ID	Area (ac.)	Description	% Imp Treated	BMP Area as a % of Imp Area	Pavers (SF)	Bio-retention (SF)	Green Roof (SF)	Dry Wells (SF)	Area Costs
139	0.22	Carter Henry Drive	100	25	2,367				$42,597
138	0.12	Parking lot	100	100				157 SF/ft	$16,000
137	0.60	Parking lot	100	100				628 SF/ft	$64,000
136	0.19	Rooftops	80	100			6,774		$81,283
135	1.07	Carter Henry Drive	100	11	10,000		2,958		$215,496
134	0.81	Carter Henry Drive	100	33	10,000		23,862		$466,344
133	0.22	Parking lot	100	100				314 SF/ft	$32,000
132	0.26	Carter Henry Drive	50	25	1,395				$25,106
131	0.13	Miller Street, north end	50	25	719				$12,935
130	0.95	Carter Henry Drive & parking	25	20	2,074				$37,335
129	0.38	Carter Henry Drive & parking	50	25	2,069				$37,233
127	0.10	Carter Henry Drive	50	25	518				$9,322
126	0.03	Parking lot	100	100	1000				$18,000
125	1.14	Theater roof/parking	8	25	991		4,935		$77,064
124	0.55	Sanford St & parking	15	25	892		3,031	628 SF/ft	$62,422
124A	0.40	Corner bank	100	100			14,031	628 SF/ft	$232,372
123	0.06	Sanford Street	100	25	653				$11,759
122	0.02	Sanford Street	100	25	245				$4,406
121	1.58	Archie Moores, Donnelly Walk, Vacant Theater	10	20			1,378		$16,530
118	0.10	Unquowa Road & Unquowa Place	75	50		831			$12,459
116	0.05	Unquowa Place	100	18.75	397				$7,152
114	0.10	Unquowa Place	100	25	1,039				$18,698
113	0.13	Unquowa Place	100	25	1,363				$24,534
105	1.35	Post Road + Sanford Street	33	12	2,325				$41,848
								Subtotal:	**$1,566,893**

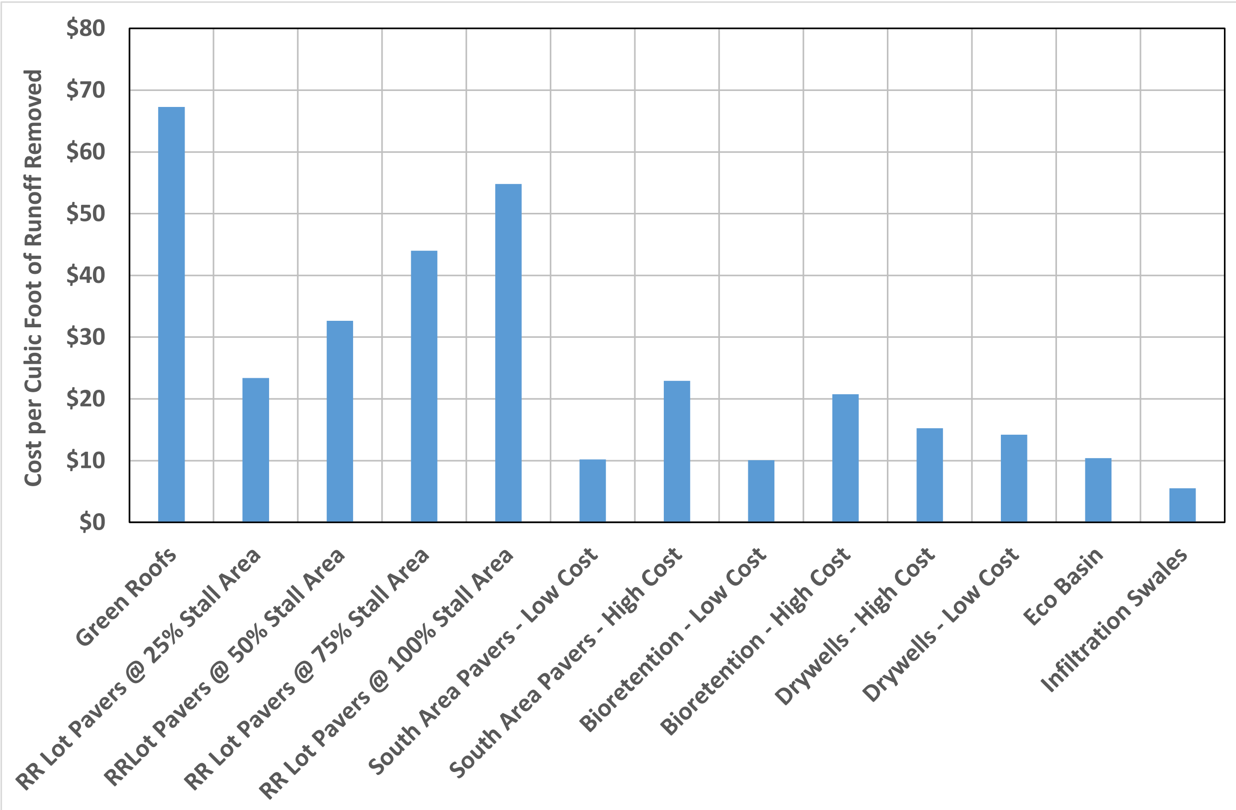


Figure 18 – Estimated cost effectiveness (per cubic foot of runoff capture) of BMPs for the 1-year storm event for proposed conditions in downtown Fairfield

5. Implementation Considerations

5.1 Stormwater Utility

A stormwater utility provides a dedicated funding source to support an administrative organization that plans, designs, constructs, and maintains a stormwater management system, sediment and flood control programs and projects, and provides stormwater education. Laying the education groundwork and making sure the community understands the connection between rainfall and water quality is a crucial first step before setting up a stormwater utility. Fostering a connection between stormwater and Long Island Sound forms the basis for peoples' willingness to pay for stormwater system improvements because they understand the water quality benefits. Partnership opportunities can begin with the public schools for stormwater education. The utility rate structure can give property owners an opportunity to use their property to improve water quality and get recognized for their efforts. These residents can then become ambassadors to their neighbors about the benefits of rain barrels, rain gardens, and other strategies to manage stormwater on site.

5.2 Adoption of Standards for Town Projects

Adoption of GI standards for town-owned and town-sponsored projects can have several benefits including reducing stormwater runoff from the specific areas and setting an example for other property owners in Fairfield.

An example of a public policy for implementing GI on its municipally owned projects comes from the City of Ann Arbor, Michigan. Based on a 2013 resolution and ordinance, the city requires that any city project that disturbs impervious area shall implement GI as feasible:

> "Public Streets Construction and Reconstruction projects in the City of Ann Arbor shall utilize Green Infrastructure to infiltrate stormwater runoff from impervious areas that are disturbed. At a minimum, infiltration techniques implemented on the project shall be similar to those described in the Low Impact Development Manual for Michigan, Sept. 2008. This policy does not apply to maintenance and/or resurfacing projects."
>
> "Based on an analysis of the soil borings, the project manager shall determine the area(s) of the project with the most favorable infiltration potential. Within the potential infiltration area(s), the infiltration rate(s) shall be determined by lab test or field test. The infiltration test location and depth shall be determined by the designers anticipated green infrastructure improvement."
>
> "The infiltration standard shall be calculated for the entire project area and shall be determined using the following site condition factors:
>
> Site Conditions Infiltration Standard
>
> - Within the floodplain, or
>   - Slopes > than 20%, or
>   - Soil infiltration rate < 0.6 in/hr First 1 inch
> - Not in the floodplain, and

    - Slopes < than 20%, and
    - Soil infiltration rate between 0.6 in/hr – 2.0 in/hr 50% annual chance - 24 hour event (2.35")
- Not in the floodplain, and
    - Slopes < than 20%, and
    - Soil infiltration rate >2.0 in/hr 10% annual chance – 24 hour event (3.26") Notes: Soil Infiltrations Rates are based on A and B soil classifications in the Soil Survey of Washtenaw County, Michigan (1977). Rainfall frequency estimates are derived from NOAA Atlas 14 Volume 8 (2013)."
    -

The Town of Fairfield could consider the same type of approach through ordinance. At the present time, GI is already somewhat incorporated in the Town of Fairfield Zoning Regulations as follows:

- 28.10 *Construction:* This regulation under Section 28, regulations for off-street parking and loading, requires compliance with the Connecticut Department of Energy & Environmental Protection (CTDEEP) *Storm Water Quality Manual* and also encourages LID applications.
- 28.11.3 *Shade Trees:* This regulation acknowledges the incorporation of tree planting islands into parking lot construction. While the regulation does not directly identify stormwater management as a benefit, there is room for specific language incorporation.
- 28.2 *General:* This general statement for off-street parking and loading regulations acknowledges that these regulations look to achieve multiple goals including "increase permeability to mitigate storm runoff."
- 28.10 *Construction:* This regulation requires design compliance with the CTDEEP *Storm Water Quality Manual* while encouraging LID applications.

Additional considerations are described in the following sections below and enumerated in Appendix E.

5.3 Recommendations for Zoning Regulations

The Fairfield Zoning Regulations, last amended May 23, 2017, require all new construction of parking lots comply with the CTDEEP *2004 Storm Water Quality Manual* or any amendment thereto. Additionally, the Zoning Regulations encourage the use of LID BMPs. Examples of BMPs listed include vegetated swales, buffers and filter strips, bioretention, rain gardens, and permeable surfaces (Page 113, Section 28.10). Potential modifications include the following:

- The Zoning Regulations should additionally require or recommend that all new construction, not just parking lot construction, utilize LID BMPs.
- The Zoning Regulations should include a provision for requiring test borings for all new development to determine if soil characteristics are appropriate for GI. This is especially relevant in a town like Fairfield, which does not have widespread septic systems to use as a reference point for infiltration.
- In the landscaping requirements of residential zones, such as in Section 12.6.4, the Zoning Regulations could require or recommend the implementation of GI.

In Section 32.0, *Flood Protection*, the Zoning Regulations could require new construction in flood zones, or adjacent to flood zones, to have reduced impervious surfaces and/or increased stormwater infiltration abilities. This would potentially reduce contributions to flooding, foster a roughening of the floodplain, and decrease nonpoint pollution.

In Section 37.0, *Erosion and Sediment Control*, the regulations could specifically encourage GI stormwater management methods that infiltrate water or allow it to be reused in landscaping rather than detention basins, which often simply slow the flow of runoff.

Appendix E provides examples of specific amendments.

5.4 Recommendations for Subdivision Regulations

Currently, the Subdivision Regulations (amended to July 8, 2014) do not include any reference to GI. There are several sections of the document that could be amended to encourage or require the implementation of BMPs.

- Section 1, *Procedures* – This section outlines the design requirements set forth by the town. A developer must submit plans including grading and contour plans, flood protection, traffic studies, and others before the potential development is considered by the commission. Among the more progressive requirements is the demonstration that passive solar energy techniques be used in the design of the subdivision in Section 1.1.13. Following this section, a mandate of the consideration of GI and the minimization of impervious surfaces would be another sensible requirement that could be included in the subdivision regulations.
- Section 2, *Map Design Standards* – Section 2.1.7 of the map design standards describes the turnaround requirements for cul-de-sac turnarounds. Currently, the regulations state that "such subdivider shall install curbs and sidewalks…" A possible design requirement or recommendation could include GI at the center or around the perimeter of the turnaround instead of curbing. This would be especially relevant if the road slopes downwards toward the turnaround. The center of the turnaround could house a rain garden or bioretention basin while the perimeter of the cul-de-sac might be suitable for vegetated swales, pervious pavers, or other vegetated buffers.
- Section 2.3, *Open Space* – The open space requirement currently requires greater than 10 percent of any subdivision of five lots (or 4 acres) or greater to be dedicated open space. This section could contain a requirement or recommendation that a percentage of the open space be used for GI.
- Section 3.3, *Street Construction*, could require pervious pavement to be installed on roadways in town, especially in areas that have a high percentage of impervious areas.
- In Section 3.4.1.4, *Discharge*, the current regulations state that "the discharge of all storm water shall be into suitable streams or rivers…" This section could provide a requirement or recommendation that GI be installed near outfalls or other stormwater discharge points.
- Section 3.10 describes the requirements for sidewalk construction. This section could include a recommendation or requirement that GI be used. Pervious pavers could be required in areas like village squares and historic districts, and vegetated swales or rain gardens could be used to line sidewalks.

Appendix E provides examples of specific amendments.

The Town of Fairfield Stormwater Detention Requirements (last updated February 1, 2018) specify the general guidelines for single-lot development stormwater systems. This document uses the Soil Conservation Service TR-55 method to calculate runoff volumes and requires that all new construction require detention for up to and including a 100-year storm event. For every 100 square feet of impervious area, 28.3 square feet of storage must be installed. Fairfield has provisions for attaching to town drainage via a high-level overflow pipe with backflow prevention installed. A permit is required through the town Engineering Department for this arrangement. A potential improvement to this arrangement might be that some form of GI must be installed as a first-line remedy before an attachment to town drainage is allowed. This would be an impetus to reduce stormwater generated from impervious services and would reduce the total volume of stormwater released into the system.

5.5 Recommendations for Town Roadway Design Standards and Streetscaping Projects

The Town of Fairfield "Roadway Design Standards" can be found in the Subdivision Regulations under Section 3.0 ("Improvements"). Although the Subdivision Regulations apply mainly to new development, the principles can be utilized in the downtown area. Refer to the narrative above under "Recommendations for Subdivision Regulations" and the suggested amendments listed in Appendix E. In addition, the Town of Fairfield may wish to develop a separate guidance document for roadway design standards and streetscaping; this document could be used outside the context of the Subdivision Regulations.

5.6 Review of Regulatory Permit Requirements

In some communities and states, regulatory approvals may be needed for GI and other innovative stormwater management techniques. A review was conducted to identify specific regulatory approvals that could be needed to implement GI in downtown Fairfield. This review does not attempt to address the larger question of which approvals are needed for site development or redevelopment since the existing local review processes set in Zoning Regulations would apply depending on the zoning district and proposed parcel use. Instead, this review focuses on the potential for specific GI projects that could be implemented.

<u>State of Connecticut and Town of Fairfield</u>

For land disturbance greater than 1 acre to less than 5 acres in size, a Phase II National Pollutant Discharge Elimination System Stormwater Pollution Prevention Control Plan is required and must be approved by the Town of Fairfield Engineering Department. Land disturbance greater than 5 acres in size requires a DEEP Phase II Stormwater Pollution Prevention Control Plan and must be approved by the State of Connecticut. If GI were proposed on an existing site and the typical Planning and Zoning Commission approvals were not needed due to the nature of the project, it is possible that these stormwater permits would nevertheless apply.

The state's coastal boundary is located along the south side of Post Road in the vicinity of Thorpe Street. Therefore, it is possible that GI in this area, if proposed, may need to be reviewed as part of the Coastal Site Plan Review. An application would be made to the Fairfield Planning and Zoning Commission, with a copy forwarded to CT DEEP for a parallel review.

<u>Town of Fairfield Zoning Regulations</u>

The following specific approvals are cited in the Zoning Regulations:

2.17 <u>Public Trees</u>: Planting or removal of any tree or shrub on any Town of Fairfield property or right-of-way requires a permit from the town tree warden pursuant to Section 23.59 of the Connecticut General Statutes.

24.0 Land Excavation and Fill Regulations

24.1 Special Permit Required: The excavation, movement, alteration, or filling of any earth, loam, topsoil, clay, or stone affecting any premises located in any Zoning District of the town shall require a Special Permit in accordance with these Land Excavation and Fill Regulations.

Town of Fairfield Subdivision Regulations

The following specific approvals are cited in the Subdivision Regulations:

3.6 Special Structures: Plans for bridges, retaining walls, box culverts, deep manholes, detention ponds, weirs, headwalls, and other special structures shall be subject to the approval of the town engineer.

Road and Railroad Approvals

The Connecticut Department of Transportation (CTDOT) will typically require approvals related to projects on state roads. For example, GI adjacent to Post Road will likely need an encroachment permit from CTDOT. CTDOT will need to be contacted to determine whether they require this coordination for the GI located along town roads that intersect with Post Road.

The Town of Fairfield will typically require approvals related to projects on town-owned roads. However, the town will tend to be the proponent (and potentially the applicant) for GI projects described in this report.

GI adjacent to the north and south sides of the railroad tracks will not result in impacts to the railroad or its embankment. However, the GI construction process would necessitate the use of excavation equipment in close proximity. Therefore, work in these areas may need a review regarding the potential for impacts to the railroad right-of-way.

6. References

American Rivers, 2016. When a bandaid's not enough: Implementing Storm Water Utilities in the Great Lakes. Community Outreach Tools, Sample Utility Ordinance Language and Guidance for Building Public Support, https://s3.amazonaws.com/american-rivers-website/wp-content/uploads/2016/08/25163628/StormwaterUtilityToolkit_Complete-PDF_3.30.16.pdf

https://ctmirror.org/2015/02/25/a-storm-rages-over-cts-stormwater/

Connecticut Natural Hazard Mitigation Plan Update, 2014.

State Water Plan, 2017.

Town of Fairfield Subdivision Regulations. § 3.6 Special Structures

Town of Fairfield Zoning Regulations, Revised May 23, 2017. § 12.6.4 Landscaping, § 2.17 Public Trees, § 24.0 Land Excavation and Fill Regulations, § 24.1 Special Permit Required, § 28.10 Construction, § 28.11.3 Shade Trees, § 28.2 General, § 32.0 Flood Protection

Urban, J., 2017. Growth Rates and Performance of Trees in Silva Cells, Deeproot. http://www.deeproot.com/silvapdfs/resources/SC2/articles/Growth-Rates-and-Performance-of-Trees-in-Silva-Cells.pdf

Wabi Burien: Events and Advocacy for a Walk/Bike Community, 2016. Des Moines, IA. Website accessed: July, 2017. http://www.wabiburien.org/then-now-the-true-story-of-sidewalks-in-burien/

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APPENDIX A

BORING LOGS

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-1 Lat: 41 8.581 Long: 73 15.575
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/11/17 Finish: 1/11/17
MMI Inspector: Peter Shea	Location: 195 Unquowa Rd	Type: Geoprobe Soil Boring

Ground Water Obs:		Drilling Details:					
DTW: ~4	Time:	Method:	GP	Hammer Wt: NA		Sampler: Macro-Core	
DTW:	Time:	Casing:	2"	Hammer Fall: NA		Misc.:	

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	39		asphalt	Dry	0-6" asphalt and base material (black sand and gravel)
				glacial till	Wet	6-8" f-m SAND, little silt, trace gravel
				bedrock		8-39" crushed schist bedrock (weathered)
						competent bedrock refusal at 6'1"
						BOB - bedrock refusal at 6'1"

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-2 Lat: 41 8.613 Long: 73 15.414
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/11/17 Finish: 1/11/17
MMI Inspector: Peter Shea	Location: 200 Unquowa Rd	Type: Geoprobe Soil Boring

Ground Water Obs:	Drilling Details:		
DTW: ~14 Time:	Method: GP	Hammer Wt: NA	Sampler: Macro-Core
DTW: Time:	Casing: 2"	Hammer Fall: NA	Misc.:

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	42		top soil	Dry	0-6" dark brown f-m SAND, some organic, trace silt
				Fill	Dry	6-16" crushed cobble, some gravel
				Fill	Dry	16-42" dark brown f-m SAND, little gravel, trace silt
5-10	NA	47		Fill	Dry	0-4" dark brown f-m SAND, little gravel, trace silt
				S. Drift	Dry	4-36" orange/brown c-m SAND, little gravel
					Dry	36-47" ligth brown c-m SAND, little gravel
10-15	NA	50		S. Drift	Moist	0-22" light brown c-m SAND, little gravel
				S. Drift	Wet	22-50" orange/brown c SAND, little gravel, trace cobble (fragment)
15-20	NA	48		S. Drift	Wet	0-48" orange/brown c SAND, trace gravel
						BOB-Target Depth (no refusal)

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-3 Lat: 41 8.524 Long: 73 15.612
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/11/17 Finish: 1/11/17
MMI Inspector: Peter Shea	Location: 162 Unquowa Rd	Type: Geoprobe Soil Boring
Ground Water Obs: DTW: ~10 Time: 7:30	Drilling Details: Method: GP Hammer Wt: NA Sampler: Macro-Core	
DTW: Time:	Casing: 2" Hammer Fall: NA Misc.:	

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	41		Asphalt	Dry	0-4" Asphalt
				Fill	Dry	4-15" black sand and gravel (road base)
				Fill	Dry	15-24" light brown m SAND, trace gravel
				S. Drift	Damp	24-41" brown f-m SAND, trace silt
5-10	NA	44		S. Drift	Moist	0-4" brown f-m SAND, trace silt
					Moist	4-6" black m-c SAND, trace silt, slight petroleum odor
						6-43" light brown m-c SAND, some gravel, little cobble (fragments)
10-15	NA	44		S. Drift	Wet	0-28" light brown m-c SAND
						28-44" light brown f-m SAND
15-20	NA	46		S. Drift	Wet	0-46" light brown m SAND, little coarse sand
						BOB - Target depth (no refusal)

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM®

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-4 Lat: 41 8.471 Long: 73 15.650
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/12/17 Finish: 1/12/17
MMI Inspector: Peter Shea	Location: 1700 Post Rd	Type: Geoprobe Soil Boring

Ground Water Obs:		Drilling Details:			
DTW: ~12	Time:	Method: GP	Hammer Wt: NA	Sampler: Macro-Core	
DTW:	Time:	Casing: 2"	Hammer Fall: NA	Misc.:	

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	42		asphalt	Dry	0-6" asphalt
				Fill	Dry	6-47" dark brown f-m SAND, little gravel, trace silt
5-10	NA	47		Fill	Dry	0-12" dark brown f-m SAND, little gravel, trace silt
				S. Drift	Dry	12-47" light brown c-m SAND, little gravel
10-15	NA	48		S. Drift	Wet	0-20" orange/brown c SAND
				S. Drift		20-48" light brown c-m SAND
15-20	NA	46		S. Drift	Wet	0-46" orange/brown m-c SAND
						BOB-Target Depth (no refusal)

Notes:

SS = split spoon 24-inch

HSA = hollow stem auger

MC = macro core

NA = not applicable

MILONE & MACBROOM

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-5 Lat: 41 8.514 Long: 73 15.529
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/11/17 Finish: 1/11/17
MMI Inspector: Peter Shea	Location: 55 Miller St	Type: Geoprobe Soil Boring

Ground Water Obs:		Drilling Details:					
DTW: ~12	Time: 9:00	Method:	GP	Hammer Wt: NA		Sampler: Macro-Core	
DTW:	Time:	Casing:	2"	Hammer Fall: NA		Misc.:	

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	47		Asphalt	Dry	0-4" Asphalt
				Fill	Dry	4-11" black f-m SAND and gravel (base material)
				Fill	Dry	11-41" dark brown f-m SAND, some silt, little cobbles, trace gravel
				S. Drift	Dry	41-47" light brown c SAND, some gravel
5-10	NA	47		S. Drift	Dry	0-47" light brown m-c SAND, some cobble (fragments) little gravel
10-15	NA	47		S. Drift	wet	0-47" light brown m-c SAND
15-20	NA	46		S. Drift	Wet	0-46" light brown m-c SAND
						BOB - Target detph (no refusal)

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM®

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-6 Lat: 41 8.537 Long: 73 15.526
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/11/17 Finish: 1/11/17
MMI Inspector: Peter Shea	Location: 101 Sanford St	Type: Geoprobe Soil Boring

Ground Water Obs:		Drilling Details:			
DTW: ~15	Time: 8:30	Method:	GP	Hammer Wt: NA	Sampler: Macro-Core
DTW:	Time:	Casing:	2"	Hammer Fall: NA	Misc.:

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	40		Asphalt	Dry	0-9" Asphalt
				Fill	Dry	9-40" light brown m-c SAND, some cobbles, little f sand
5-10	NA	47		S. Drift	Dry	0-26" light brown m-c SAND, little gravel, little cobble (fragments)
						26-47" brown m-c SAND
10-15	NA	47		S. Drift	Moist	0-47" light brown m-c SAND
15-20	NA	46		S. Drift	Wet	0-13" dark brown c SAND
						13-32" reddish brown c SAND, some gravel
						32-46" tan m-c SAND
						BOB - Target detph (no refusal)

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-7 Lat: 41 8.486 Long: 73 15.526
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/11/17 Finish: 1/11/17
MMI Inspector: Peter Shea	Location: 1552 Post Rd	Type: Geoprobe Soil Boring

Ground Water Obs:	Drilling Details:		
DTW: ~12 Time: 9:00	Method: GP	Hammer Wt: NA	Sampler: Macro-Core
DTW: Time:	Casing: 2"	Hammer Fall: NA	Misc.:

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	38		Asphalt	Dry	0-6" Asphalt
				Fill	Dry	6-16" black f-m SAND and gravel (base material)
				Fill	Dry	16-33" dark brown f-m SAND, some silt, little cobbles, trace gravel
				Fill	Moist	33-38" gray f-m SAND, some silt, trace organics (roots), slight odor
5-10	NA	47		Fill	Moist	0-4" gray f-m SAND, some silt, trace oganics, slight odor (sewer)
				S. Drift		4-45" light brown c SAND, little cobbles (fragments), little gravel
				S. Drift	Wet	45-47" gray m-c SAND
10-15	NA	47		S. Drift	Wet	0-47" orange/brown c SAND
15-20	NA	46		S. Drift	Wet	0-47" light brown/orange m-c SAND
						BOB - Target detph (no refusal)

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM®

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-8 Lat: 41 8.518 Long: 73 15.411
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/12/17 Finish: 1/12/17
MMI Inspector: Peter Shea	Location: 15 Unquowa Rd	Type: Geoprobe Soil Boring
Ground Water Obs: DTW: ~10 Time: 7:30 DTW: Time:	Drilling Details: Method: GP Hammer Wt: NA Sampler: Macro-Core Casing: 2" Hammer Fall: NA Misc.:	

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	32		Asphalt	Dry	0-6" Asphalt
				Fill	Dry	6-11" light brown fine SAND, some silt
				Fill	Dry	11-26" crushed concrete fragments, brick fragments, metal pieces, some
						light brown fine sand, trace gravel
				Fill	Dry	26-32" light brown fine SAND, some Silt
5-10	NA	46	(7-8)	S. Drift	Dry	0-29" light brown fine SAND, some silt, trace gravel
					damp	29-46" brown c-m SAND, some gravel, trace cobble
10-15	NA	48	(10-11)	S. Drift	Wet	0-48" light brown/orange c-m SAND, trace gravel
						BOB - Target depth (no refusal)

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM®

MMI Job No.: 1342-21	MILONE & MACBROOM® 99 Realty Drive Cheshire, CT 06410		Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure		Hole ID: B-9 Lat: 41 8.564 Long: 73 15.411
Operator: John D'Angelis	Town: Fairfield, CT		Date Start: 1/11/17 Finish: 1/11/17
MMI Inspector: Peter Shea	Location: 65 Unquowa Place		Type: Geoprobe Soil Boring
Ground Water Obs: DTW: ~12 Time:	Drilling Details: Method: GP	Hammer Wt: NA	Sampler: Macro-Core
DTW: Time:	Casing: 2"	Hammer Fall: NA	Misc.:

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	47		Asphalt	Dry	0-6" Asphalt
				Fill	Dry	6-8" black f-m SAND and gravel (base material)
				Fill	Dry	8-26" dark brown f-m SAND, trace gravel
				S. Drift	Dry	26-47" light brown c-m SAND, some cobble (fragment), little gravel
5-10	NA	46		S. Drift	Moist	0-22" light brown c-m SAND, some cobble (fragment), little gravel
				S. Drift	Wet	22-46" light brown c SAND
10-15	NA	48		S. Drift	Wet	0-48" orange/brown c SAND
15-20	NA	46		S. Drift	Wet	0-46" light brown/orange m-c SAND
						BOB - Target detph (no refusal)

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM®

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-10 Lat: 41 8.443 Long: 73 15.423
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/12/17 Finish: 1/12/17
MMI Inspector: Peter Shea	Location: 1460 Post Rd (western boring in park)	Type: Geoprobe Soil Boring
Ground Water Obs: DTW: ~3.5 Time:	Drilling Details: Method: GP Hammer Wt: NA Sampler: Macro-Core	
DTW: Time:	Casing: 2" Hammer Fall: NA Misc.:	

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	49		top soil	Dry	0-4" dark brown f-m SAND, some organic, trace silt
				top soil	Dry	4-9" tree root
				fill	Dry	9-30" dark brown f-m SAND, some silt, some roots
				S. Drift	Dry	30-49" orange/brown c-m SAND, some gravel, trace cobble (fragments)
5-10	NA	50		S. Drift	Damp	0-6" orange/brown c-m SAND, some gravel, trace cobble (fragments)
						6-8" cobble (crushed fragments)
						8-12" orange/brown c-m SAND, some gravel
						12-14" cobble (crushed fragments)
						14-22" tan f-m SAND, some silt
						22-48" orange/brown c-m SAND
						48-50" rusty orange c SAND, trace gravel
10-15	NA	23		S. Drift		0-10" orange/brown f-m SAND, trace gravel
				Till		10-20" tan f-m SAND, some silt, trace cobble
				Bedrock		20-23" bedrock (schist)
						BOB - Bedrock refusal at 13'

Notes:

SS = split spoon 24-inch

HSA = hollow stem auger

MC = macro core

NA = not applicable

MILONE & MACBROOM

MMI Job No.: 1342-21	MILONE & MACBROOM 99 Realty Drive Cheshire, CT 06410	Sheet: 1 of 1
Drilling Co.: SITE, LLC	Project Name: Downtown Greeen Infrastructure	Hole ID: B-11 Lat: 41 8.450 Long: 73 15.412
Operator: John D'Angelis	Town: Fairfield, CT	Date Start: 1/12/17 Finish: 1/12/17
MMI Inspector: Peter Shea	Location: 1460 Post Rd (eastern boring in park)	Type: Geoprobe Soil Boring

Ground Water Obs:	Drilling Details:		
DTW: ~3.5 Time:	Method: GP	Hammer Wt: NA	Sampler: Macro-Core
DTW: Time:	Casing: 2"	Hammer Fall: NA	Misc.:

Depth: (feet)	Blows: 0-6",6-12",12-18"	Recovery: (inches)	Sample: (feet)	Strata Description:	Moisture:	Field Description:
0-5	NA	49		top soil	Dry	0-4" dark brown f-m SAND, some organic, trace silt
				top soil	Dry	4-9" tree root
				fill	Dry	9-30" dark brown f-m SAND, some silt, some roots
				S. Drift	Dry	30-49" orange/brown c-m SAND, some gravel, trace cobble (fragments)
5-10	NA	50		S. Drift	Damp	0-4" orange/brown c-m SAND, some gravel, trace cobble (fragments)
				Bedrock		4-14" weather bedrock (schist)
						BOB - Bedrock refusal at 6'10"

Notes:
SS = split spoon 24-inch
HSA = hollow stem auger
MC = macro core
NA = not applicable

MILONE & MACBROOM

APPENDIX B

MODEL INPUT

APPENDIX C

MODEL OUTPUT

APPENDIX D

PARCEL-BY-PARCEL COMPARISON OF GREEN INFRASTRUCTURE OPTIONS

		PAVED AREA	Green Roofs	Rooftop Detention	Pervious Pavement (includes pavers)	Rain Barrels	Vegetated Swales	Rain Gardens	Tree Soil Structure Systems	Curb Extension Infiltration Areas	LID Urban Planters	Underground Detention/ Dry Wells
15404	1262 POST ROAD	28000	◒ (red)	◒ (red)	● (red)	◒ (red)	● (red)	○	○	○	● (red)	◒ (red)
15405	1280 POST ROAD	45000	○	◒	● (red)	◒ (red)	● (red)	○	◒ (red)	◒ (red)	● (red)	◒ (red)
15406	1326 POST ROAD	7400	○	●	◒ (red)	● (red)	● (red)	●	○	●	● (red)	◒
15408	50 UNQUOWA PLACE	20000	● (red)	● (red)	● (red)	◒ (red)	● (red)	○	○	○	● (red)	● (red)
15410	78 UNQUOWA PLACE	10000	●	●	◒ (red)	● (red)	● (red)	● (red)	● (red)	●	● (red)	◒
15411	1366 POST ROAD	14000	●	●	● (red)	● (red)	● (red)	● (red)	● (red)	●	● (red)	◒
15412	41 UNQUOWA PLACE	5500	●	●	◒ (red)	● (red)	◒ (red)	○	○	●	● (red)	◒
15413	53 UNQUOWA PLACE	2000	●	●	◒ (red)	● (red)	◒ (red)	○	○	●	● (red)	●
15414	65 UNQUOWA PLACE	1000	●	●	○	◒	◒ (red)	◒ (red)	◒ (red)	●	● (red)	◒ (red)
15415	79 UNQUOWA PLACE	2000	●	●	○	● (red)	◒ (red)	◒ (red)	◒ (red)	●	● (red)	◒
15416	90 UNQUOWA ROAD	1350	●	●	●	●	● (red)	● (red)	● (red)	●	● (red)	○
15417	70 SANFORD STREET	11000	●	●	● (red)	◒ (red)	● (red)	● (red)	● (red)	○	● (red)	◒
15418	50 SANFORD STREET	0	◒	◒	●	◒	○	◒ (red)	○	●	● (red)	◒
15419	15 UNQUOWA ROAD	4000	●	●	○	◒	◒ (red)	● (red)	◒ (red)	●	● (red)	◒
15420	1410 POST ROAD	500	●	●	●	◒	◒ (red)	◒ (red)	◒ (red)	●	● (red)	●
15421	14 SANFORD STREET	0	○	○	●	○	●	●	●	●	● (red)	●
15422	1460 POST ROAD	0	○	○	●	◒	○	●	●	●	● (red)	●
15423	1474 POST ROAD	5000	◒	◒	◒ (red)	◒	◒	◒	●	●	● (red)	◒
15424	1494 POST ROAD		○	○	●	○	●	●	●	●	◒ (red)	●
15425	1508 POST ROAD	16000	◒ (red)	◒ (red)	◒ (red)	○	◒ (red)	◒ (red)	○	○	● (red)	○
15426	1520 POST ROAD	1200	◒ (red)	◒ (red)	◒	○	◒	◒	◒	●	◒ (red)	●
15427	1530 POST ROAD	0	◒ (red)	◒ (red)	●	○	◒	◒	◒	●	◒ (red)	●
15429	54 MILLER STREET	4300	●	●	◒ (red)	◒ (red)	◒ (red)	◒ (red)	◒ (red)	●	● (red)	○
15430	69 SANFORD STREET	7500	●	●	◒ (red)	◒ (red)	◒ (red)	◒ (red)	◒ (red)	○	◒ (red)	○
15431	59 SANFORD STREET	5500	●	●	◒ (red)	◒ (red)	◒ (red)	◒ (red)	○	○	◒ (red)	○
15432	55 MILLER STREET	7500	●	●	● (red)	◒ (red)	◒ (red)	○	○	○	◒ (red)	○

		PAVED AREA	Green Roofs	Rooftop Detention	Pervious Pavement (includes pavers)	Rain Barrels	Vegetated Swales	Rain Gardens	Tree Soil Structure Systems	Curb Extension Infiltration Areas	LID Urban Planters	Underground Detention/ Dry Wells
15433	33 MILLER STREET	2500	●	●	◓	🔴	◓	○	○	●	◓	○
15434	23 MILLER STREET	1800	●	●	◓	🔴	◓	○	○	●	◓	○
15435	1552 POST ROAD	5400	●	●	◓	🔴	◓	○	○	●	◓	○
15436	1560 POST ROAD	2700	●	●	◓	🔴	◓	◒	○	●	◓	○
15437	1568 POST ROAD	23000	◓	◓	🔴	◒	◓	◓	○	○	🔴	○
15438	1596 POST ROAD	4600	◓	◓	◓	◓	◓	○	○	●	◓	○
15439	1610 POST ROAD	15000	◓	◓	🔴	◓	◓	◓	◓	◓	🔴	○
15440	1630 POST ROAD	0	◓	◓	●	●	●	●	●	●	🔴	○
15441	1636 POST ROAD	0	◓	◓	●	●	●	●	●	●	🔴	○
15442	1700 POST ROAD	30000	◓	◓	🔴	◓	◓	◓	◓	○	🔴	○
15452	1720 POST ROAD	3000	●	●	◓	◓	◓	◓	◓	●	◓	◓
15470	1710 POST ROAD	0	●	●	●	●	🔴	🔴	🔴	●	●	●
15471	1740 POST ROAD	2000	●	●	🔴	◓	◓	🔴	🔴	●	🔴	○
15472	101 SANFORD STREET	9000	●	●	🔴	●	🔴	🔴	🔴	●	🔴	○
15473	100 SANFORD STREET	4000	●	●	🔴	●	🔴	🔴	🔴	●	🔴	○
15481	165 UNQUOWA ROAD	200000	◒	◒	🔴	🔴	🔴	🔴	🔴	●	🔴	🔴
15482	200 UNQUOWA ROAD	40000	🔴	🔴	🔴	🔴	🔴	🔴	🔴	○	🔴	🔴
15483	190 HILLCREST ROAD	500	●	●	◓	🔴	🔴	🔴	🔴	●	●	●
15484	182 HILLCREST ROAD	1000	●	●	◓	🔴	🔴	🔴	🔴	●	●	●
15485	176 HILLCREST ROAD	1000	●	●	◓	🔴	🔴	🔴	🔴	●	●	●
15502	230 UNQUOWA ROAD	0	●	●	●	●	🔴	🔴	●	●	●	●
15503	155 UNQUOWA ROAD	14600	●	●	🔴	●	🔴	🔴	🔴	●	🔴	◓
15504	195 UNQUOWA ROAD	225600	●	●	🔴	●	🔴	🔴	🔴	●	🔴	◓
21682	107 ROUND HILL ROAD	40000	●	●	🔴	●	🔴	🔴	🔴	●	🔴	◓
106756	40-220 CARTER HENRY DRIV	9200	◓	◓	◓	○	◓	◓	◓	●	🔴	◒
106909	46 MILLER STREET	1500	○	◒	◓	◓	◓	◓	◓	●	🔴	◒

PID	ADDRESS	OWNNAME	DESCRIPTION	PAVED AREA	PARCEL SIZE
15404	1262 POST ROAD	LJG 1262 POST ROAD FAIRFIELD LLC C/O LJG	LARGE BRICK BUILDING WITH LARGE PARKING LOT. COMPLETELY IMPERVIOUS	28000	1.15
15405	1280 POST ROAD	TORTORA CARMEN A FLMY LTD PTSH	LARGE BRICK BUILDING AND SMALL OUTBUILDING WITH LAGRGE PARKING LOT. COMPLETELY IMPERVIOUS	45000	1.38
15406	1326 POST ROAD	MERCURIO BETTY R & ETAL	BRICK BUILDING WITH PARKING LOT. SMALL GRASSY STRIP AROUND PARKING LOT	7400	0.3
15408	50 UNQUOWA PLACE	UNQUOWA PLACE PARTNERS 50 LLC	OFFICE BUILDING WITH LARGE PAVED LOT	20000	0.6
15410	78 UNQUOWA PLACE	NORTON MARJORIE E	PRIVATE RESIDENCE WITH BARN. SMALL WOODED AREA BETWEEN LAND AND TRAIN TRACKS.	10000	0.32
15411	1366 POST ROAD	FLEET NATIONAL BANK OF MASS. ATT CORP RE	OFFICE BUILDING WITH PAVED LOT, SOME GRASS AROUND PARKING LOT AND DRIVEWAY	14000	0.47
15412	41 UNQUOWA PLACE	FELIS AUSTIN S TRUSTEE C/O GIA FELIS WAT	SMALL OFFICE BUILDING WITH PAVED PARKING LOT. SOME VEGETATION AND LANDSCAPING AROUND BUILDING	5500	0.17
15413	53 UNQUOWA PLACE	PATTEN CORP	SMALL OFFICE BUILDING WITH PAVED PARKING LOT. SOME VEGETATION AND LANDSCAPING AROUND BUILDING	2000	0.09
15414	65 UNQUOWA PLACE	UNITED ILLUMINATING CO ACCOUNTS PAYABLE	ELECTRICAL SUBSTATION BUILDING WITH GRASSY LOT	1000	0.11
15415	79 UNQUOWA PLACE	STATION DEPOT ASSOCIATES LLC C/O MICHAEL	SMALL STORE/APARTMENT BUILDING	2000	0.07
15416	90 UNQUOWA ROAD	STATE OF CONNECTICUT C/O DEPT OF TRANSPO	DOT OUTBUILDINGS WITH GRASS YARD	1350	0.06
15417	70 SANFORD STREET	FAIRFIELD TOWN OF	THEATER WITH PAVED PARKING LOT. SMALL GRASSY ISLAND AT EDGE OF LOT.	11000	0.78
15418	50 SANFORD STREET	50 SANFORD LLC	COMMERCIAL COMPLEX. BUILDING COVERS ALMOST ENTIRE LOT	0	0.61
15419	15 UNQUOWA ROAD	15 UNQUOWA ROAD LLC	COMMERCIAL COMPLEX WITH NUMEROUS BUILDINGS. SMALL GRASSY AREA BETWEEN BUILDINGS. BUILDINGS COVER 75% OF PARCEL.	4000	0.48
15420	1410 POST ROAD	DAVID D POLLACK ASSOCIATES LLC	COMMERCIAL COMPLEX. BUILDING COVERS ALMOST ENTIRE LOT	500	0.43
15421	14 SANFORD STREET	BURKE MARY E 1/2 & DOMINICK F 1/2	COMMERCIAL COMPLEX. BUILDING COVERS ALMOST ENTIRE LOT	0	0.08
15422	1460 POST ROAD	1460 POST ROAD LLC	RESTAURANT. BUILDING COVERS ALMOST ENTIRE LOT.	0	0.06
15423	1474 POST ROAD	E & F ASSOCIATES, LLC C/O ABCO LTD	BRICK COMMERCIAL BUILDING. WITH MODEST PARKING LOT.	5000	0.32
15424	1494 POST ROAD	H, J, R & H REALTY	COMMERCIAL COMPLEX. BUILDING COVERS ENTIRE LOT		0.14
15425	1508 POST ROAD	MERCURIO BROTHERS,INC.ET ALS	STORES/OFFICE BUILDING WITH PAVED PARKING LOT	16000	0.59
15426	1520 POST ROAD	MERCURIO BROS INC & MERCURIO DOMENIC & J	RESTAURANT. BUILDING COVERS ALMOST ENTIRE LOT.	1200	0.12
15427	1530 POST ROAD	DM ACQUISITIONS, LLC	STORE. BUILDING COVERS WHOLE LOT	0	0.12
15429	54 MILLER STREET	DOMBROSKI PROPERTIES,INC.	SMALL OFFICE BUILDING WITH PAVED PARKING LOT. SOME VEGETATION AND LANDSCAPING AROUND BUILDING AND PARKING LOT	4300	0.13
15430	69 SANFORD STREET	SANFORD STREET,LLC	STORES/OFFICE BUILDING WITH PARKING LOT	7500	0.25
15431	59 SANFORD STREET	SANFORD KAP, LLC	RESTAURANT WITH SMALL PARKING LOT.	5500	0.17
15432	55 MILLER STREET	POLLACK WESTFAIR ASSOCIATES LIMITED PART	RESTAURANT WITH SMALL PARKING LOT	7500	0.26
15433	33 MILLER STREET	33 MILLER STREET LLC	SMALL RESIDENTIAL STYLE OFFICE BULDING WITH SMALL PARKING LOT	2500	0.13

PID	ADDRESS	OWNNAME	DESCRIPTION	PAVED AREA	PARCEL SIZE
15434	23 MILLER STREET	MILLER STREET INVESTMENTS LLC	SMALL RESIDENTIAL STYLE OFFICE BULDING WITH SMALL PARKING LOT	1800	0.1
15435	1552 POST ROAD	1552 REALTY PARTNERS	RESTAURANT/OTHER COMMERCIAL USE WITH SMALL PARKING LOT	5400	0.19
15436	1560 POST ROAD	GRASSO REALTY INC	STORES/APARTMENTS WITH SMALL PARKING LOT	2700	0.12
15437	1568 POST ROAD	POLLACK WESTFAIR ASSOCIATES LIMITED PART	LARGE PLAZA WITH LARGE PARKING LOT. BUILDING COVERS 2/3 OF LOT AREA	23000	1.1
15438	1596 POST ROAD	JORDANOPOULOS ELEFTHERIOS & LITSA (SV)	STORE WITH SMALL PARKING LOT	4600	0.18
15439	1610 POST ROAD	1610 POST ROAD, LLC C/O JOHN KARAGEORGE	STORES WITH LARGE PARKING LOT	15000	0.35
15440	1630 POST ROAD	ROSS YVONNE	STORES WITH NO PARKING LOT. BUILDING OCCUPIES VIRTUALLY ENTIRE LOT AREA.	0	0.07
15441	1636 POST ROAD	KARAVITIS DEMETRIOS	STORES WITH NO PARKING LOT. BUILDING OCCUPIES VIRTUALLY ENTIRE LOT AREA.	0	0.1
15442	1700 POST ROAD	HERITAGE SQUARE,LLC C/O PYRAMID REAL EST	LARGE PLAZA WITH LARGE PARKING LOT	30000	1.25
15452	1720 POST ROAD	1720 POST ROAD LLC	PROFESSIONAL BUILDING WITH SMALL PARKING LOT AND SMALL GRASSY AREA	3000	0.3
15470	1710 POST ROAD	FAIRFIELD TOWN OF	VACANT GRASSY LOT, NO STRUCTURE	0	0.25
15471	1740 POST ROAD	INWOOD EQUITY FAIRFIELD, LLC C/O ONYX MA	RESTAURANT WITH SMALL PARKING LOT. PARKING LOT HAS SOME GARDENS/LANDSCAPING	2000	0.16
15472	101 SANFORD STREET	FAIRFIELD TOWN OF	PARKING LOT. SMALL VEGETATED ISLAND ON EAST SIDE	9000	0.21
15473	100 SANFORD STREET	STATE OF CONNECTICUT C/ODEPT OF TRANSPOR	PARKING AREA AND TRAIN STATION RIGHT OF WAY. SOME SMALL GRASSY ISLANDS ALONG EDGES.	4000	0.12
15481	165 UNQUOWA ROAD	FAIRFIELD TOWN OF	TRAIN STATION/TRAIN TRACK RIGHT OF WAY. (EXTENDS BEYOND PROJECT AREA) INCLUDES CARTER HENRY DRIVE	200000	13.6
15482	200 UNQUOWA ROAD	FAIRFIELD TOWN OF	FAIRFIELD MIDDLE SCHOOL. PARCEL ROUGHLY 50% IMPERVIOUS SURFACE.	40000	9
15483	190 HILLCREST ROAD	MANATCH REBECCA & JUSTIN (SV)	PRIVATE RESIDENCE- WOODED LOT	500	0.35
15484	182 HILLCREST ROAD	ESSIG BRAD & SARAH (SV)	PRIVATE RESIDENCE- WOODED LOT	1000	0.48
15485	176 HILLCREST ROAD	ARMISTEAD STACIE BRANSON & TIMOTHY R G (	PRIVATE RESIDENCE- WOODED LOT	1000	0.18
15502	230 UNQUOWA ROAD	FAIRFIELD TOWN OF	MOSTLY VACANT WOODED LOT WITH SMALL OUTBUILDING	0	0.3
15503	155 UNQUOWA ROAD	FAIRFIELD TOWN OF	PORTION OF PARKING LOT WITH 2 DOZEN SPACES AND A GRASSY MEDIAN	14600	0.34
15504	195 UNQUOWA ROAD	FAIRFIELD TOWN OF	TRAIN STATION PARKING LOT. SOME GRASSY MEDIAN ON NORTHERN FRINGE	225600	5.18
21682	107 ROUND HILL ROAD	FAIRFIELD TOWN OF	SCHOOL PARKING AND VACANT LAND	40000	2
106756	140-220 CARTER HENRY DRIVE	Station Square	COMMERCIAL WITH PARKING LOT	9200	0.9
106909	46 MILLER STREET	Miller Street	COMMERCIAL WITH SMALL PARKING LOT	1500	0.1