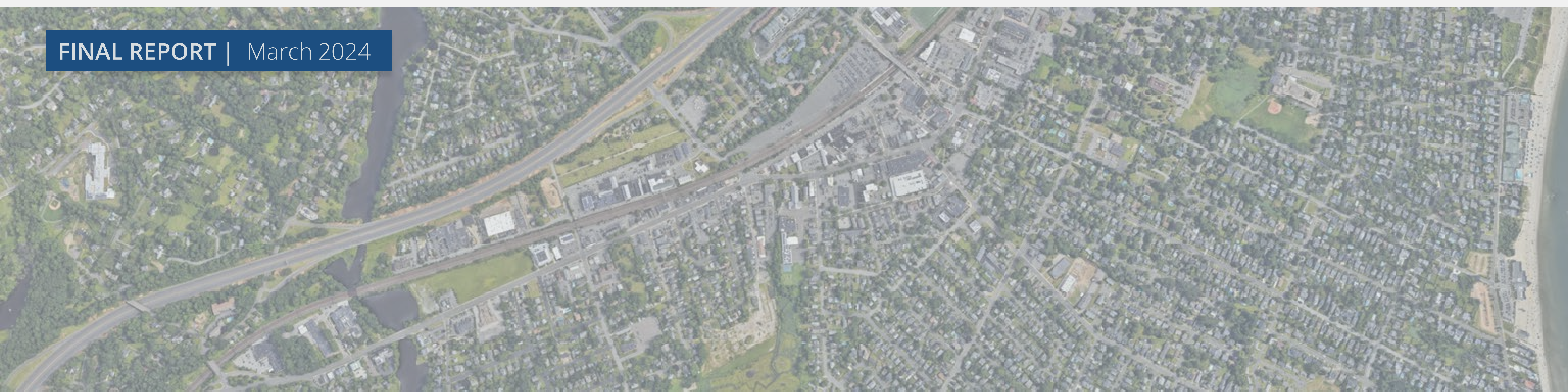
Resilient Fairfield

RESILIENT CORRIDOR ANALYSIS

FINAL REPORT | March 2024



Executive Overview

As a coastal community, Fairfield faces flooding risks from rising sea levels as well as more frequent and intense storms. Resilient Fairfield focuses on adaptive strategies to address ongoing flooding in Fairfield's downtown along several cross-streets of the Boston Post Road. This flooding is particularly problematic because the Post Road serves as a primary arterial for east/west travel and the underpasses serve as critical north/south corridors. This 'Resilient Corridor Analysis' works to harden the underpasses and connect higher flood-risk shoreline communities to those with lower flood against flooding and ensure access.

The Resilient Fairfield project area consists of Boston Post Road from North Pine Creek Road to South Benson Road, and four key underpasses at North Pine Creek Road, Mill Plain Road, Round Hill Road, and North Benson Road. Downtown Fairfield is located on slightly elevated land, surrounded by the coastal floodplain to the south, and marshlands along the Mill River and Ash Creek. The FEMA National Risk Index for these areas ranges from "Very Low Risk" to "Relatively Moderate Risk" of coastal flooding, but this ranking system does not score rainfall-induced flooding that is currently experienced flooding during heavy rain events. Climate change will exacerbate the natural hazards currently faced by the Town of Fairfield, leading to warmer and wetter winters, and hotter and drier summers that will increase storm severity and the likelihood of storm surges and intense rainfall.

A transportation network is only as strong as its weakest link, and the railroad underpasses detailed above pose a significant weakness. The flooding at these critical points is due to a combination of factors: inland overflow from tidal waters and storm surge, extreme rainfall intensity and frequency, and existing stormwater infrastructure issues all contribute to the frequent flooding of downtown Fairfield. Flooding at the underpasses and in downtown occurs intermittently throughout the year and typically occurs during severe rainfalls. The flooding leads to road closures at the underpasses and the flood depths disable cars that attempt to drive through the flood waters. Typically, the flooding only persists for short durations, during and immediately following high intensity rainfall events which overwhelm the existing drainage systems. According to the Fairfield Department of Public Works (DPW), the underpasses collectively flood around 4-6 times per year, with Round Hill Road and North Benson Road being the most frequently flooded.

Fairfield is a pilot project community for Resilient Connecticut, a multi-phase collaboration between the Connecticut Institute for Resilience and Climate Adaptation (CIRCA), state agencies, regional Councils of Governments (COGs), municipalities, and the public to better understand coastal flooding risk. Resilient Connecticut is designed to address an array of climate-related vulnerabilities, provide the communities with actionable plans, and establish a roadmap for Connecticut communities facing similar natural hazards.

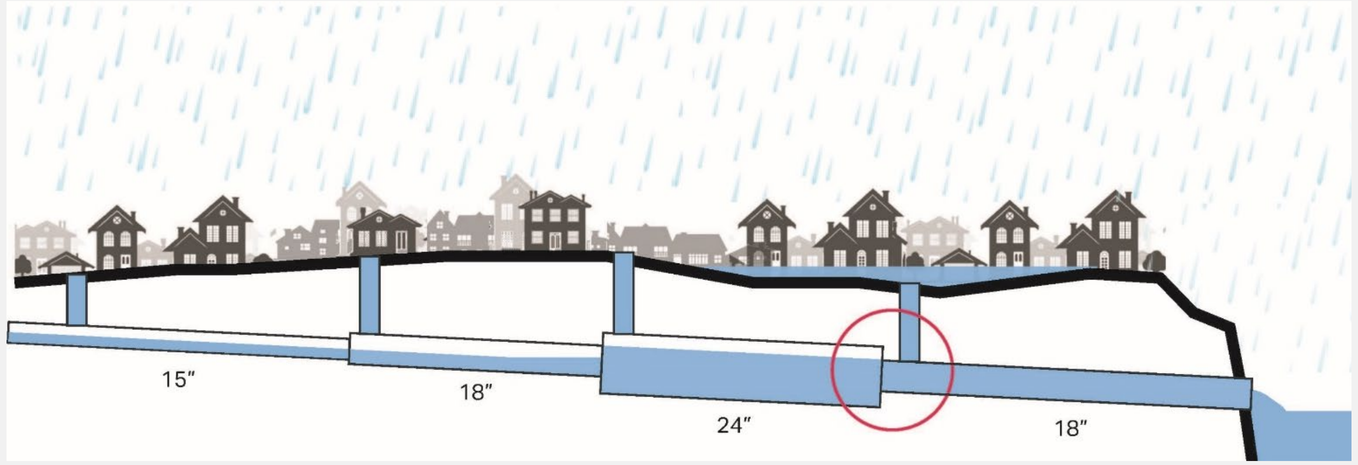
The ***Resilient Downtown Fairfield Project*** is a unique opportunity to build resilience through actionable solutions while simultaneously developing a replicable approach for addressing the many flood-prone underpasses along the Connecticut shoreline.

Over the past decade, multiple studies and reports have been commissioned to address flooding, resiliency concerns, and development in the downtown Fairfield community. These documents provided valuable insight into some of the issues at hand. A review of the existing conditions at the four underpasses and within downtown has confirmed the vulnerability echoed by the community. The underpasses currently experience flooding due to intense rain events, and the flooding can be further exacerbated when a storm system is accompanied by a storm surge, which further hinders the functionality of the existing drainage network. Of note, stormwater throughout the downtown area is collected by drainage systems which outlet to nearby waterways. The drainage systems used by the key underpasses drain to waterbodies south of the rail line, which are already taxed during an intense rain event.

The town has a system of tide gates to help mitigate inundation from storm surges. Tide gates are structures installed at the entrances of coastal waterways, that are commonly used to prevent flooding caused by high tides or storm surges by regulating the flow of water in and out. This system is primarily located along Pine Creek and Ash Creek. Pump stations are another tool to mitigate flooding, however, depending on the storm intensity and other factors such as the age and condition of the pump and appurtenances, pump stations such as those in Fairfield may not always be able to keep up with flow rates caused by extreme flooding.

Additionally, the impacts of climate change will place a greater strain on the community's existing drainage and flood control systems and increase the likelihood for underpass flooding within the study area.

Insufficient capacity is often a major issue when investigating drainage system failures. When consecutive pipes are downsized (see image) water may build up during a storm event because it is unable to flow freely to the outlet. Downsizing concerns are prevalent in Fairfield and likely play a role in the flooding of the underpasses. A modern drainage system uses increasing pipe diameters as water flows downstream to allow for aggregation along the network.



The Connecticut Stormwater Manual uses multiple criteria to define design standards for stormwater conveyance and level of impacts to adjacent areas. To meet the standard for Conveyance Protection, the system should be able to handle a 10-year event within a 24-hr period, or five inches of rain for Fairfield County. The drainage networks associated with the underpasses do not meet this standard.

The next phase of the project investigated strategies for addressing the flooding experienced at the four underpasses and within downtown Fairfield. An initial universe of options was developed encompassing three primary types of treatments: green infrastructure, flood control, and infrastructure modifications.

Green Infrastructure
A collection of natural and semi-natural systems designed to mimic the functions of natural ecosystems, providing a range of environmental, social, and economic benefits. One of the key roles of green infrastructure is stormwater mitigation, which involves managing and reducing the impacts of stormwater runoff in urban areas. Green infrastructure utilizes vegetation, soils, and other natural elements to capture, absorb, and slow down stormwater, mitigating adverse effects. Relevant examples include bio-swales, permeable pavement, detention and infiltration parks, and stormwater restoration.

Flood Control Systems
Strategies that reduce, manage, or mitigate flood conditions, including stormwater drainage systems, tide gates, pump stations, and other warning and monitoring systems. As noted in Chapter II, it is likely that some of the flooding observed at the underpasses is exacerbated by limitations of the existing flood control system. This includes undersized pipes as well as buildup of sediment and debris in the network. The function of tides gates downstream of the drainage network may also play an indirect roll in localized flooding at the underpasses, if they are not functioning as intended due to age or damage. Relevant examples include maintenance or modification of existing infrastructure, new pump stations, and installation of flood warning and monitoring systems.

Source: High Sierra Electronics. The image shows a warning system with a roadway gate.

Infrastructure Modifications
The flooding problems in Fairfield can ultimately be linked to the design of the railroad and the underpasses that are subsequently forced to dip as they cross underneath. Infrastructure modifications are often the most complex solutions, and therefore the most expensive. Relevant examples include widening the underpass, raising base elevation, constructing a new overpass, and raising the railroad elevation.

Each adaptation strategy was analyzed using the PERSISTS framework to better understand their viability moving forward. The PERSISTS framework is an assessment tool developed for Resilient Connecticut which aids in the assessment and works to balance multiple goals and priorities.

PERSISTS Framework

Permittable: Is the strategy allowable under relevant local, state. and federal regulations?

Equitable: Are the benefits of the strategy distributed equitably?

Realistic: Can the strategy be engineered and realistically funded?

Safe: Does it mitigate the target risks to people and local infrastructure?

Innovative: Does the strategy incorporate or integrate innovative thinking?

Scientific: Does the strategy reflect or improve the best available science?

Transferable: Can the strategy be applied to similar problems in other communities?

Sustainable: Is the strategy socially, economically, and ecologically aligned and supported by the public and local leadership?

After each alternative was analyzed with the PERSISTS framework, a Benefit-Cost Analysis (BCA) was performed to examine viability. The preliminary analysis was conducted using the USDOT Guidance for Discretionary Grant Programs, then, a custom model was developed to estimate the future costs and benefits for the proposed project over a 20-year analysis period. The alternatives listed below had reasonably high benefit-cost ratios, which resulted in recommendations to further investigate for possible implementation.

Green Infrastructure:
Mill Plain Road, North Benson Road

Green infrastructure (GI) retrofits to the Fairfield Rail Station parking lot are proposed as part of the strategy for Mill Plain Rd to mitigate runoff entering the drainage network. The existing parking lot is paved with asphalt and the western portion of it slopes towards Mill Plain Rd. Stormwater runoff from the parking lot enters the Mill Plain Rd drainage network under the New Haven Line. This alternative proposes a combination of permeable pavement and tree vaults to increase retention and possibly infiltration of stormwater runoff onsite, thereby reducing the total volume of stormwater entering the drainage network.

In addition, green infrastructure (GI) retrofits to the I-91 northbound on-ramp median are recommended to increase infiltration of stormwater from the highway entering the drainage system on North Benson Rd. This alternative proposes the construction of a bio-swale and/or a bio-infiltration basin to be deployed near the ramps on North Benson Rd, reducing the rate and volume of stormwater entering the existing drainage network. A bioswale could help mitigate peak flows, while a bio-infiltration basin could help promote stormwater runoff retention, storage, and infiltration from smaller, more frequent storm events.

Warning & Monitoring:
North Pine Creek Road, Mill Plain Road, Round Hill Road, North Benson Road

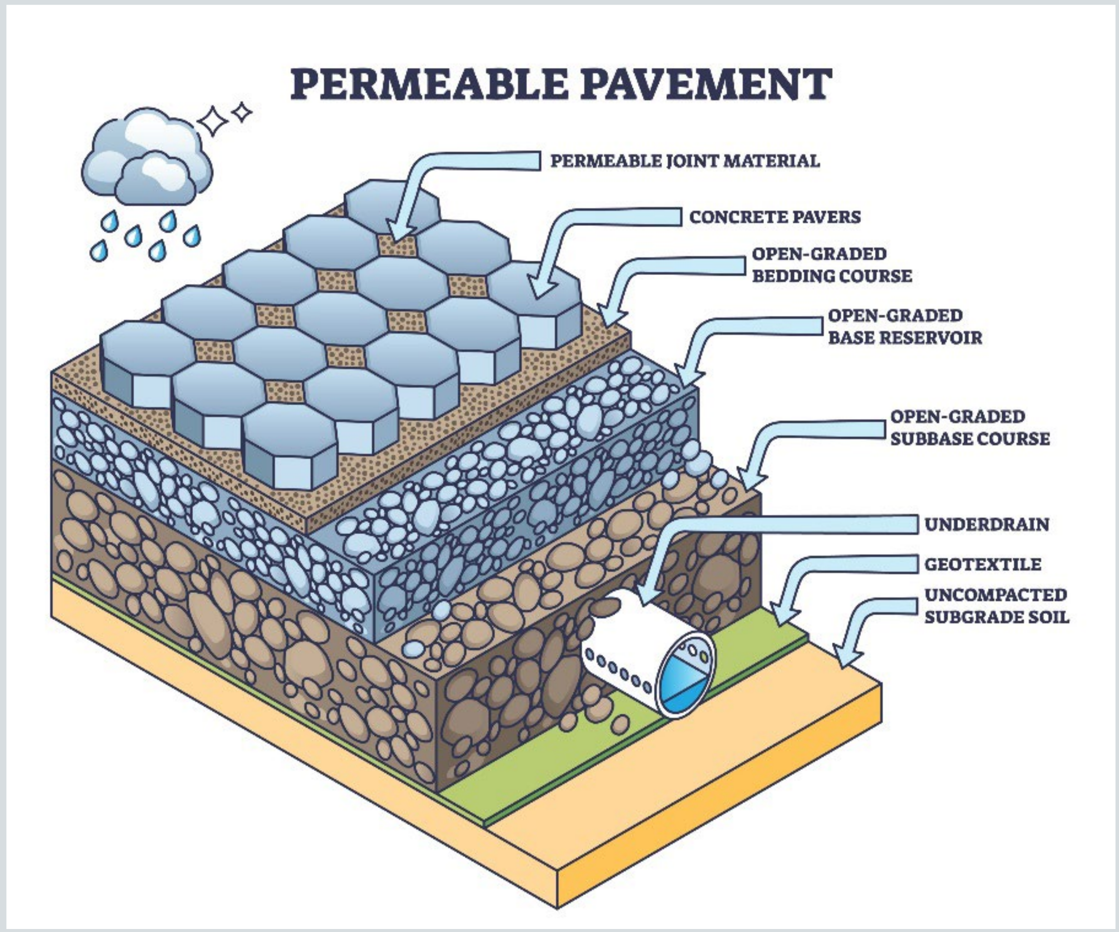
In the event of flooding at an underpass, a flooding warning system would automatically detect a flooded roadway and deploy barriers to close the road. This alternative is responsive to community concern around getting stuck at underpasses and would prevent people from attempting to cross a flooded roadway. Sensing of water can be accomplished by cameras or weight-based sensors that report water accumulation above a certain level. Once activated, the sensor triggers flashing signage and lowers a gate that physically prevents drivers from passing.

Drainage Improvements:
Mill Plain Road, Round Hill Road

Upsizing stormwater piped below the underpasses and parts of the down stream systems may help reduce localized flooding issues due to stormwater. Pipe sizes should be increased to remove constrictions in pipe runs that have been identified in the existing system. Upsizing the drainage system will increase the capacity within the pipes, which will prevent water from backing up and flowing back out of the catch basins during a storm event.

RIGHT: Permeable pavement could reduce runoff by infiltrating stormwater into the ground.

Resilient Fairfield began by examining existing conditions at the four railroad underpasses within the study area. These underpasses are critical north-south corridors which are being impacted by precipitation induced flooding from intense rain events. The flooding can be further exacerbated when a storm system is accompanied by a storm surge, which further hinders the functionality of the existing drainage network. Over the coming decades this flooding is expected to increase, driven by climate change. The investigated alternatives work, from multiple angles, to mitigate the flooding currently being experienced by the community and improve resilience for future flood events.



Definitions and Acronyms:

CIRCA: The Connecticut Institute for Resilience and Climate Adaption

CT DEEP: The State of Connecticut Department of Energy and Environmental Protection

GC3: Governor's Council on Climate Change

CLEAR: The Center for Land Use Education and Research (CLEAR)

Resilient Fairfield Chapter I:
Project Introduction

CIRCA Phase III

The partnership between the Connecticut Institute for Resilience and Climate Adaptation (CIRCA) and its pilot project communities is designed to address an array of climate-related vulnerabilities, provide the communities with actionable plans, and establish a roadmap for other Connecticut communities facing similar natural hazards. As a coastal town, Fairfield experiences storm-related coastal flooding; however, additional inland flooding occurs in the town at several low-lying underpasses and across several surface streets. The inland flooding occurs following intense rainfall and is more severe when occurring at the same time as high tides or storm surge events. This project will investigate strategies to reduce the likelihood and impacts of flooding within the study area.

Role of CIRCA + Initial Project Phases

CIRCA is a multi-disciplinary research center based on collaboration between the University of Connecticut (UConn), and the State of Connecticut Department of Energy and Environmental Protection (CT DEEP) that addresses climate action and supports research within the state. Other partners involved in research and findings include the State Agencies Fostering Resilience Working Group (SAFR), the Governor's Council on Climate Change (GC3), and the CT Department of Housing, among others.

CIRCA was founded in 2014 as a response to the impacts of severe storm damage caused by Superstorm Sandy, and the projected future storms exacerbated by climate change and rising sea levels. One of CIRCA's key goals is to not only produce high-quality research to better understand climate vulnerability at a fine-grained scale but to ensure that the best science is used by local communities for infrastructure and resilience planning.

CIRCA's key project is Resilient Connecticut, which is a multi-phase collaborative effort between CIRCA, state agencies, regional Councils of Governments (COGs), municipalities, and the public to better understand coastal flooding risk in Fairfield and New Haven Counties. Specifically, Resilient Connecticut has the following goals: 1) build capacity and promote coordination between the different levels of government that will be impacted by sea level rise and coastal flooding; 2) develop specific and implementable plans and projects; 3) use CIRCA and UConn's technical expertise to help predict flood and storm risk through modeling; and 4) contribute to a Connecticut Statewide Resilience Roadmap.

In Phase II, CIRCA used the Resilient Connecticut Planning Framework and coordinated with local governments and four regional COGs to 1) conduct public outreach among community members, and 2) assess regional risk and vulnerability for all 51 municipalities in two pilot areas of New Haven and Fairfield Counties. This project involved the creation of several interactive tools, further described below, as well as two comprehensive technical reports [Resilient Connecticut Phase II: From Regional Vulnerabilities to Resilience Opportunities, (December 2021), and the Phase II Technical Report (released in early 2022)].

Resilient Connecticut has had three phases: Phase I began in 2018 and involved creating an assessment of resilience and adaptation efforts. This was combined with public outreach to guide the creation of a Resilience Planning Framework, released in January 2020.

CIRCA created three interactive and map-based tools to better understand risk at different scales.

Social Vulnerability Index: The CIRCA team merged 30 community and social factors collected by the US Census Bureau—grouped into five main groups—into a composite Social Vulnerability Index (SVI). These factors include poverty levels, the percentage of the population without access to vehicles, and levels of the population with disabilities. Each of these may affect the adaptive capacity of the community.

Climate Change Vulnerability Index: The CIRCA team created a Climate Change Vulnerability Index (CCVI), which involved the calculation and mapping of spatial risk scores created from flood and heat vulnerability inputs, normalized by "adaptive capacities" (the SVI score).

Zones of Shared Risk: The CIRCA team created a map showing "Zones of Shared Risk," which are geographical units that share some risk from rising sea levels and greater storms. ZSRs fall into the following categories: Access; Location; Natural Protection; Proximity; and Underpass. Descriptions of ZSRs are listed below:

Access ZSRs: Risk from the inability to enter/exit an area due to flooding from sea level rise/storm surges.

Location ZSRs: Risk from the prevalence of being located within low-lying lands.

Proximity ZSRs: Risk from being located adjacent to low-lying areas.

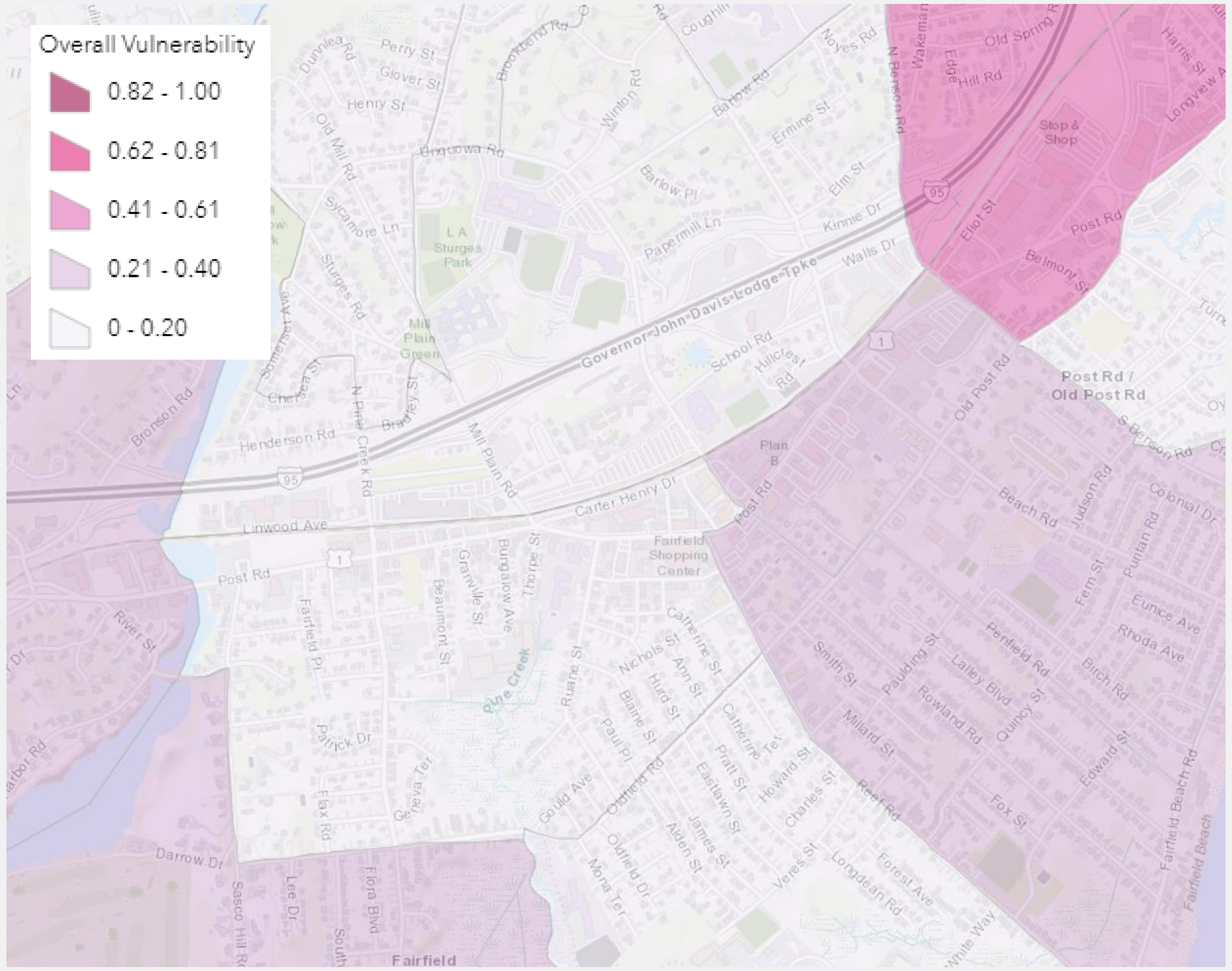
Natural Protection ZSRs: Risks to areas that provide natural flooding protection (to other areas).

Underpass ZSRs: Road underpass locations where roads often flood during heavy rainfall events.

Identifying ZSRs can support the creation of "resilient corridors" by linking more vulnerable areas to less vulnerable areas and serving as evacuation pathways. Careful analysis and thoughtful planning can help implement successful adaptation strategies to reduce the impacts of climate change, as well as increase economic development and social mobility.

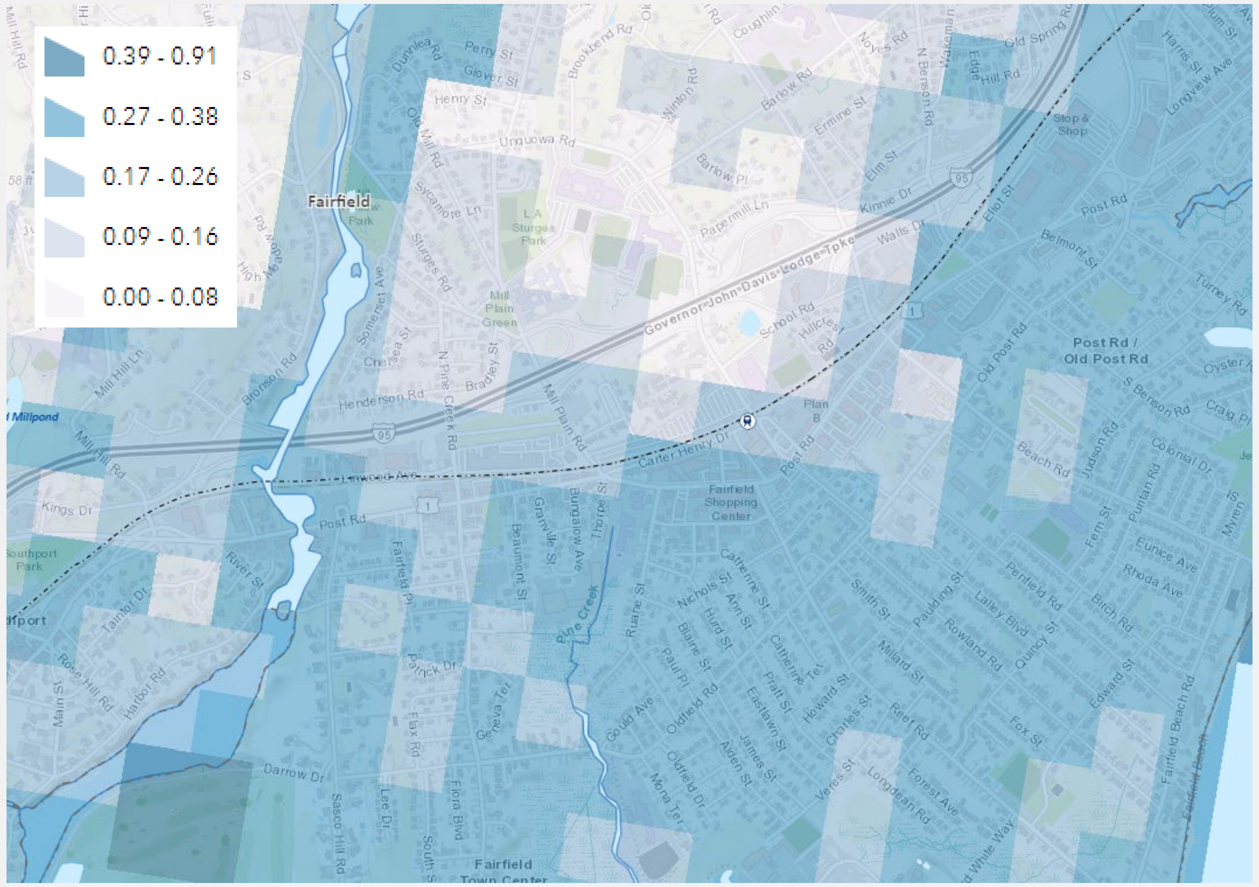
Flooding in downtown Fairfield. Source: Downtown Green Infrastructure Assessment (2018)

Social Vulnerability Index



Social vulnerability plays a key role in a community's ability to adapt to the threats of climate change. The social vulnerability within the study area is quite low and likely reflects the community's higher income levels and higher car ownership. The areas of greater vulnerability are generally concentrated towards the eastern edge of the study area.

Flood Vulnerability Index



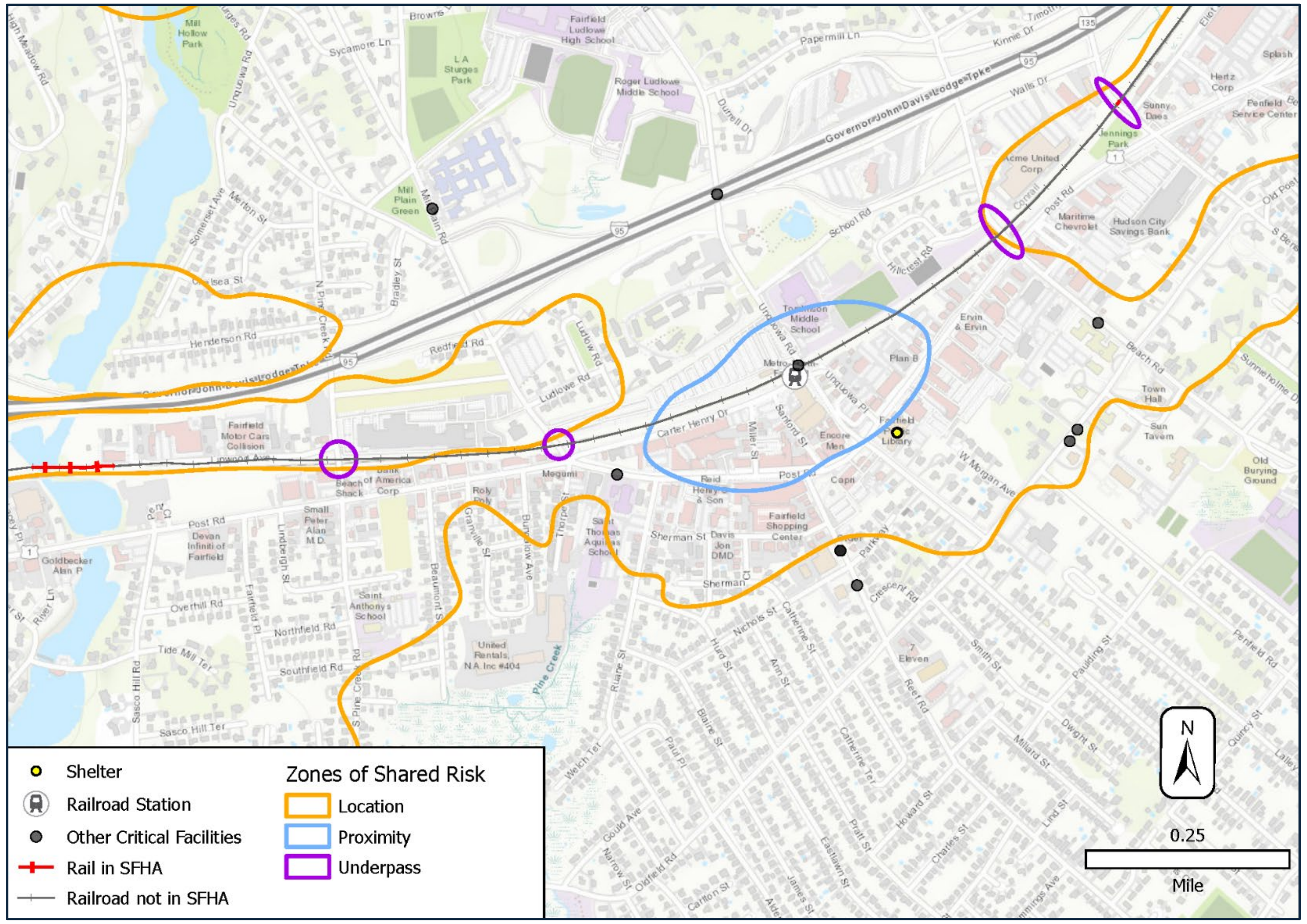
Above: Fairfield Flood Vulnerability Index. As a coastal community, Fairfield experiences higher levels of flood vulnerability due to its low elevation and proximity to Long Island Sound. The index indicates that flood vulnerability is generally highest south of the railroad and along Southport Harbor, Pine Creek, and Ash Creek. Only the underpass at North Benson Road is generally considered vulnerable to flooding from inundation associated with storm surge from the 100-yr storm event.

RIGHT: Fairfield Zones of Shared Risk Mapping. The Zones of Shared Risk assessment for downtown Fairfield indicated: 1) locational risk due to coastal flooding concerns, 2) proximity risk for the station area due to its adjacency to existing flood zones, and 3) underpass risk due to ongoing flooding at the four underpasses as key gateways between coastal and upland Fairfield. The underpass risk is the primary focus of this assessment due to their role as key connections to higher ground, particularly during flood evacuation scenarios.

Phase II of Resilient Connecticut identified zones of shared risk for the 33 municipalities in New Haven and Fairfield Counties. Through identifying zones of shared risk, CIRCA developed 63 Resilience Opportunity Areas (ROARs), across the two counties. ROARs are areas in which climate change-related flooding and rising heat risk overlap with "key regional assets"—defined as affordable housing, transportation stations or corridors, critical infrastructure, and crucial ecological systems, among others. Of the 63, 20 ROARs were further analyzed in a portfolio and Story Map broken down by the Council of Governments region.

Phase III of Resilient Connecticut involved the selection of a few communities from within the identified ROARs; and the solicitation of planning-level studies to develop and evaluate strategies that address community vulnerabilities identified in the earlier two phases. The Downtown Fairfield ROAR was selected as one of seven initial pilot projects due to the importance of the underpass connections as evacuation routes and because the type of 'basined' underpasses present in this area of Fairfield is replicated across the Connecticut shoreline. It is the hope that not only will the Resilient Fairfield pilot project develop actionable solutions to mitigate the flooding experienced in Fairfield but that the strategies proposed here will serve as a guide for other communities facing similar flooding concerns.

Zones of Shared Risk



Problem Overview and Study Area

As a coastal community, Fairfield faces flooding risks from rising sea levels as well as more frequent and intense storms. This project will develop and analyze adaptation strategies in Fairfield to increase climate resilience in the community. The analysis will in part use the PERSISTS[1] framework in conjunction with a Benefit-Cost Analysis (BCA) to understand which strategies perform best from a holistic perspective.

This project will focus on adaptive strategies to address ongoing flooding in Fairfield's downtown along Post Road. This flooding is particularly problematic because Post Road serves as a primary arterial for east/west travel; and the four underpasses act as key connections across both the New Haven Line rail tracks and I-95. In this project, downtown is defined as the area roughly between Southport Harbor/Mill River to the west and Ash Creek to the east. Downtown Fairfield is located on slightly elevated land, surrounded by the coastal floodplain to the south, and marshlands along the Mill River and Ash Creek.

The specific project area includes the following roadways and underpasses: Boston Post Road (from North Pine Creek Road to South Benson Road); and underpasses at North Pine Creek Road, Mill Plain Road, Round Hill Road, and North Benson Road. A fifth cross street at Unquowa Road was evaluated as part of a previous study (Milone & MacBroom, 2018) but is not considered here because it is an overpass and does not flood.

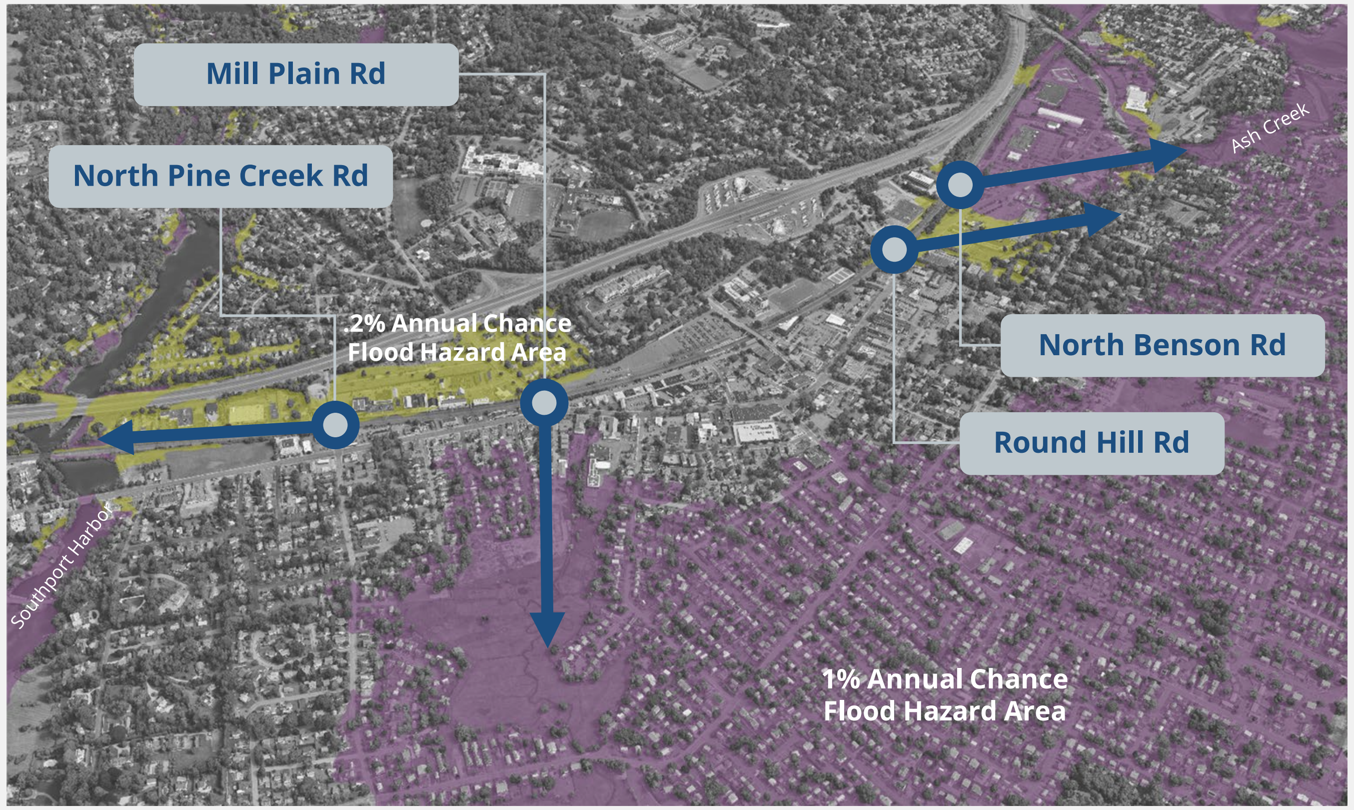
While the downtown area does not experience the same level of risk as the shoreline neighborhoods, it continues to experience flooding during heavy rain events. FEMA's National Risk Index highlights the immediate downtown area as being "Very Low Risk" and the area south of Carter Henry Drive as "Relatively Low Risk," with coastal flooding being "Relatively Moderate." However, the ranking system does not score rainfall-induced flooding. Additionally, because the data is at the census tract level, exact vulnerabilities at this scale are difficult to determine.

While the streets within the downtown area may or may not flood—depending on precipitation/storm surge severity—many roads leading to and from Downtown Fairfield are arterial or collector roads, and serve as important evacuation routes, or "resilient corridors." As a result, the entire downtown area may lose the ability to serve as a hub for evacuation to the north or provide access shelters.

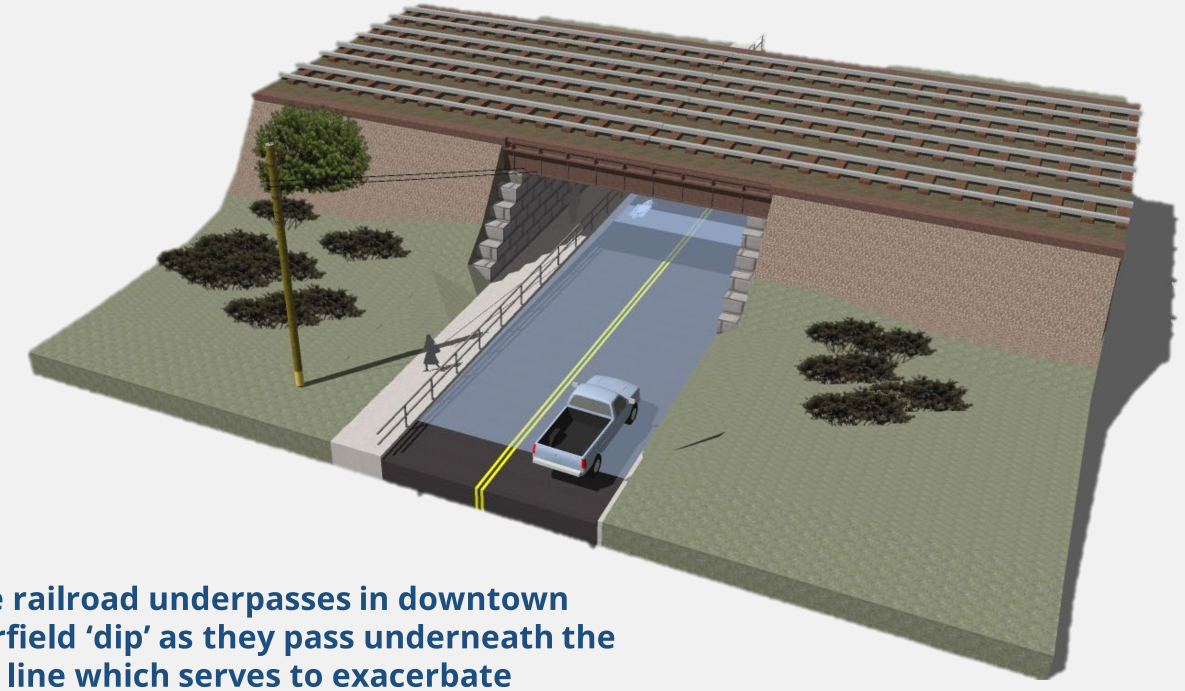
A transportation network is only as strong as its weakest link, and underpasses pose a significant weakness. Given the grade constraints for railroad operations and the dominant transport modes early in the 20th Century, underpasses were generally designed for ease of railroad use with low vertical clearances for drivers. The limited grade separation that occurred means that roadways must 'dip' to cross under the tracks. In combination with the low elevations of Fairfield generally, and proximity to Long Island Sound/tributary watercourses, these railroad underpasses present challenges from a drainage perspective across the region. The result being that these underpasses may inhibit evacuations from seaside areas to inland areas during storm events.

While multiple factors create current vulnerabilities, most of the current downtown area, along with immediately adjacent areas, are planned for increased transit-oriented development, taking advantage of the ability to access jobs in Bridgeport and New Haven (to the east), and Stamford and New York City (to the west). These new developments may offer the opportunity to further address public benefits that promote resilience through stormwater mitigation.

[1]PERSISTS is a qualitative assessment tool that helps compare the various benefits of a given adaptation strategy. More detail on PERSISTS can be found in Chapter III.



The Resilient Fairfield study area encompasses four underpasses in the downtown area between Southport Harbor and Ash Creek. Arrows reflect outfall direction.



The railroad underpasses in downtown Fairfield 'dip' as they pass underneath the rail line which serves to exacerbate drainage constraints and leads to accumulation of stormwater in the underpasses.

Previous and Ongoing Work

As a coastal town, Fairfield experiences storm-related flooding. Over the past decade, multiple studies and reports have been commissioned to address flooding, resiliency concerns, and development in the community. These documents provide valuable insight into some of the issues being faced by the community particularly as the Resilient Fairfield pilot project works to address further flooding concerns.

Summary of Relevant Studies

Fairfield Flood Mitigation Status and Plans: Report to the Board of Selectmen **(2015)**: A study commissioned by the Flood Erosion and Control Board (FECB) on inland and coastal flooding in Fairfield's "primary beach area," which was flooded during Superstorm Sandy. Specifically, the report looked at preventing and mitigating flooding in the beach area caused by the 1% annual chance or 100-year storm. The report examines completed storm mitigation measures, those in progress, and key future projects that could increase the Town's resilience.

Resiliency for Downtown Fairfield using Green Infrastructure (**Milone & MacBroom 2018):** This plan focused on the extent to which green infrastructure (GI) reduces runoff and flooding, with the goal of developing a resilience strategy for Downtown Fairfield based on GI development. Besides identifying problem areas and offering possible locations for GI, the study found the following:

- Stormwater pipes running north-south at the Unquowa Road underpass may be undersized.
- Soil/groundwater conditions are favorable for GI.
- GI will reduce peak flows and flooding volumes but will not solve the problem.
- Gi implementation would require retrofits and reconstruction.

Fairfield Plan of Conservation and Development **(2016):** This document, prepared by the Town, is the latest POCD, although it is currently being updated. The plan includes the following recommendations of relevance to this project:

- Discourage expansion of railroad parking
- Minimum development intensity (height-to-ROW width ratios).
- Review and revise evacuation and shelter plans and increase coordination among various agencies.
- Protect wetlands, shorelines and marshes from further degradation, promote ecological restoration, and pursue, whenever possible, non-structural beach erosion and flood control strategies. Establish a priority list for land acquisition to retain parcels that could aid in such preservation efforts and improve flood control in the area.

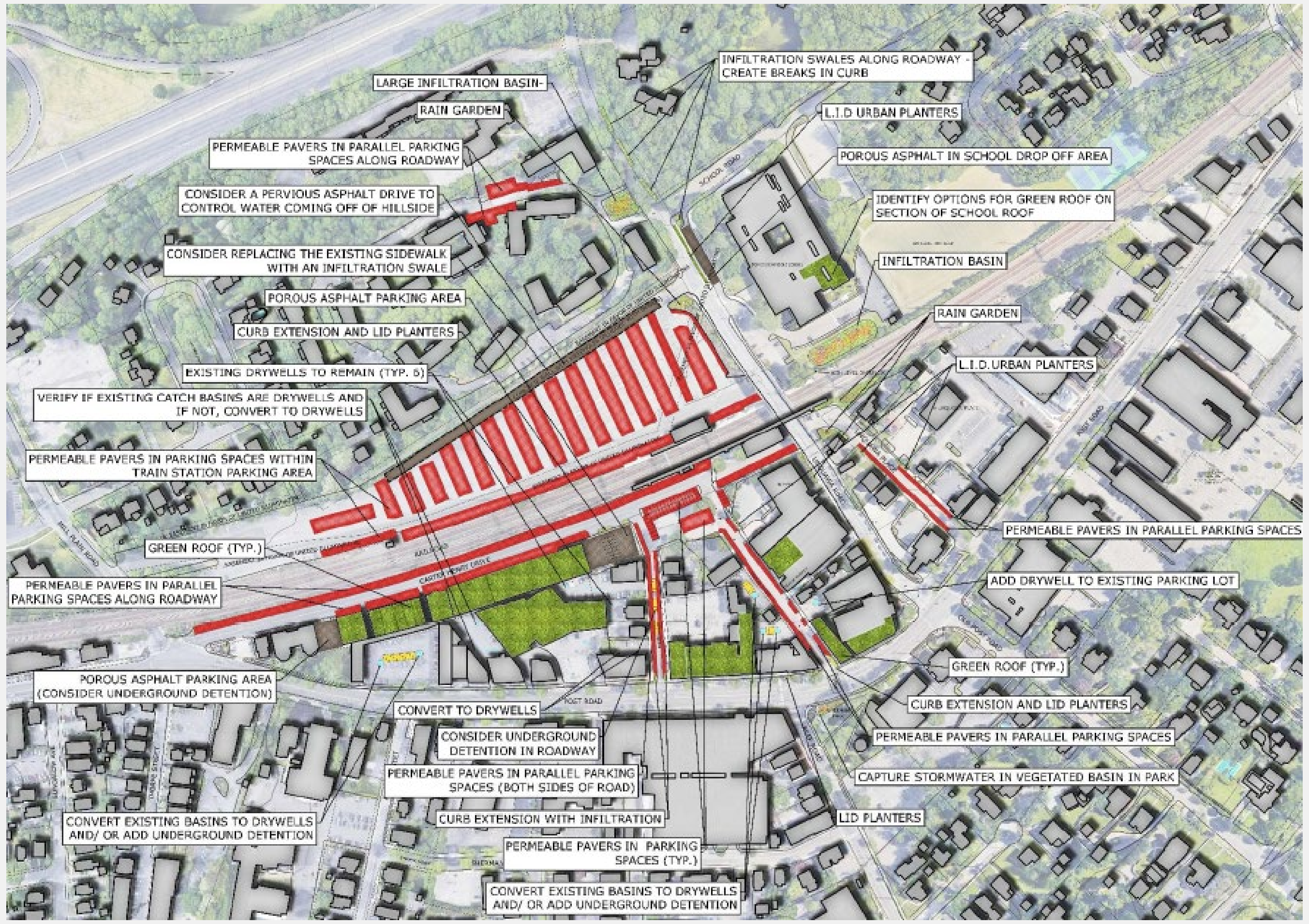
2019 Natural Hazard Mitigation Plan Update (2019): This plan, prepared for the MetroCOG region, focused on flooding risk and mitigation locations and strategies in the Greater Bridgeport Area. While having less detail than plans limited to the Town of Fairfield, the document will be helpful to ensuring that all recommendations are consistent with regional objectives.

Fairfield Storm Surge Modeling Report (2022): This study, completed by CIRCA in May 2022, described sea level rise, storm, precipitation, and wave height predictions based on the latest model inputs for the 100-year storm. The Resilient Connecticut Downtown Fairfield project will use these outputs to ensure that recommendations are responding to the latest data.

US Army Corps of Engineers Coastal Flood Risk Management Study: Fairfield and New Haven Counties, CT (2019). This study, conducted by the US Army Corps of Engineers (USACOE), created a plan that updated an early USACE effort called the Coastal Engineering Report – Fairfield Beach (2016). This plan was an effort to protect the town flood plain for a fifty + year period from anticipated flooding. ACOE evaluated multiple strategies and selected Alternate #3 as the preferred option. Alternate #3 included pump stations, tide gates, flood control easements, a pile-supported T-Wall, and a wastewater treatment plant hardening project. The selected project reported similar benefits to the other alternatives but was less expensive. However, even this alternative was estimated at $547 million, with non-federal funding requirements of 35% of the total costs.

Summary of Relevant Ongoing Work

In addition to the review of previous work completed in Fairfield, the study team is aware of additional ongoing studies. As of January 2023, the consultant team has reviewed existing plans and created a matrix of all reviewed plans, reviewed storm and precipitation modeling from CIRCA and FEMA, organized GIS information, reviewed existing drainage system info (from the Town of Fairfield), and completed maps of drainage infrastructure, storm events, and sea level rise in the study area.



Excerpt from the 2018 report *Resiliency for Downtown Fairfield using Green Infrastructure* of potential green infrastructure solutions in and around the Fairfield Train Station.

Resilient Fairfield Chapter II:

Current & Future Conditions Assessment

Existing and Future Conditions

The New Haven Line travels east-west through Fairfield. Located on a raised berm, the rail line separates coastal neighborhoods along the shoreline from the more inland community. All but one of the north/south connections (within the study area) pass underneath the railroad tracks through steel girder bridges that provide for 9′ 11″ to 11′ 6″ of clearance. These underpasses serve as critical routes to higher ground for residents south of the tracks. Stormwater is collected by a series of separated drainage systems which outlet to nearby waterways, with Round Hill Road and North Benson Road being drained by the same network.

Community Characteristics

The Town of Fairfield is located along the northern shore of the Long Island Sound. Fairfield is a community of 61,000 people with 72% of households earning more than $75,000 annually and a median income over $150,000. South of the New Haven Line and within the study area, there are approximately 8,500 residents who reflect similar demographic characteristics (income/ race/ gender) to the broader community. The community is positioned to respond well to its climate vulnerability and flooding concerns because of its community resources and active participation in climate and natural hazard planning.

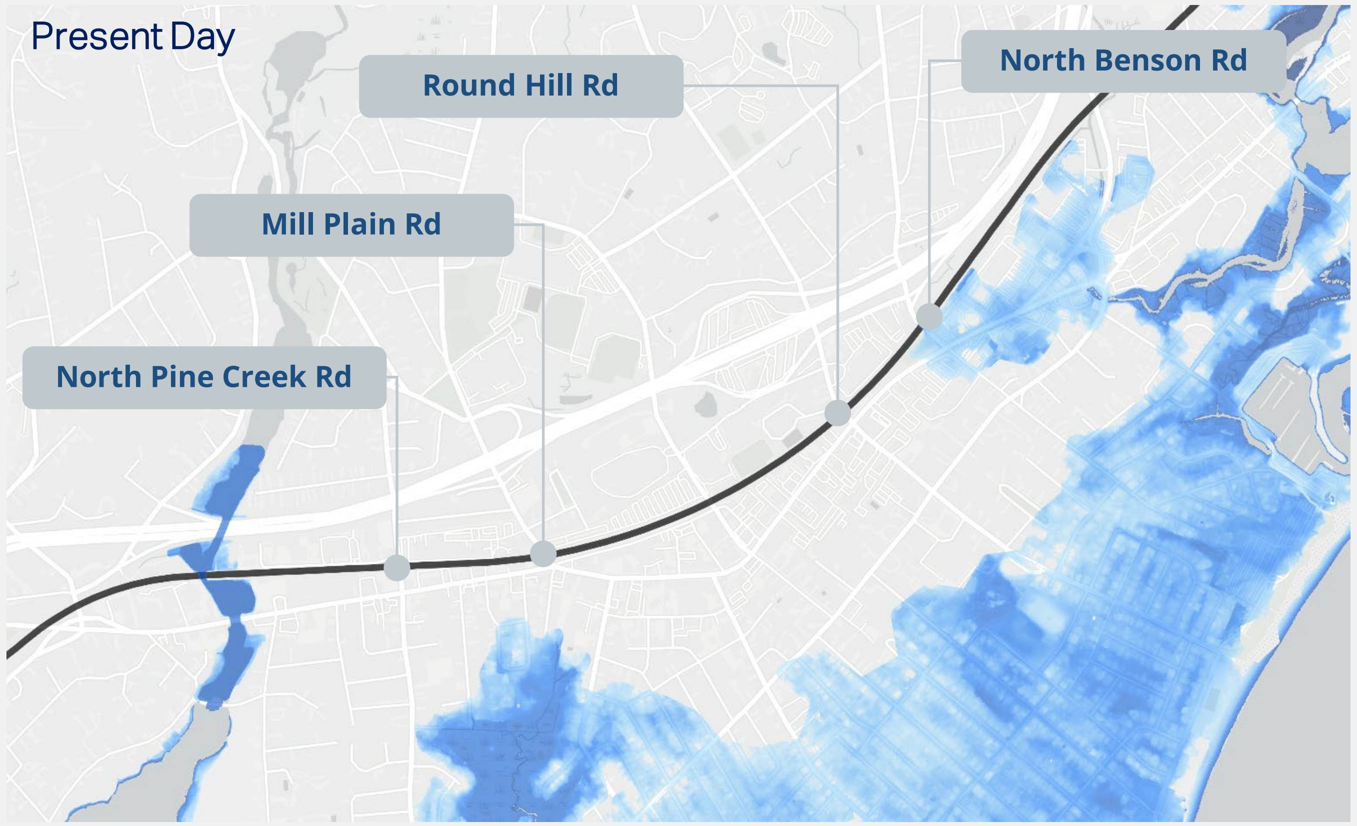
The study area encompasses significant portions of Fairfield's downtown area along Post Road which serves as a major commercial hub and local east/west corridor for the community. The Fairfield Rail Station is centered in the study area with access points on the north side of the tracks from Mill Plain Road and Unquowa Road.

The downtown area is flanked by several bodies of water to the east, south, and west. Ash Creek travels to the sound from the eastern side of the town, Pine Creek from the south (in the central study area), and Southport Harbor/Mill River is located on the western edge of the study area. These three waterways drain runoff from a significant portion of the community including the study area.

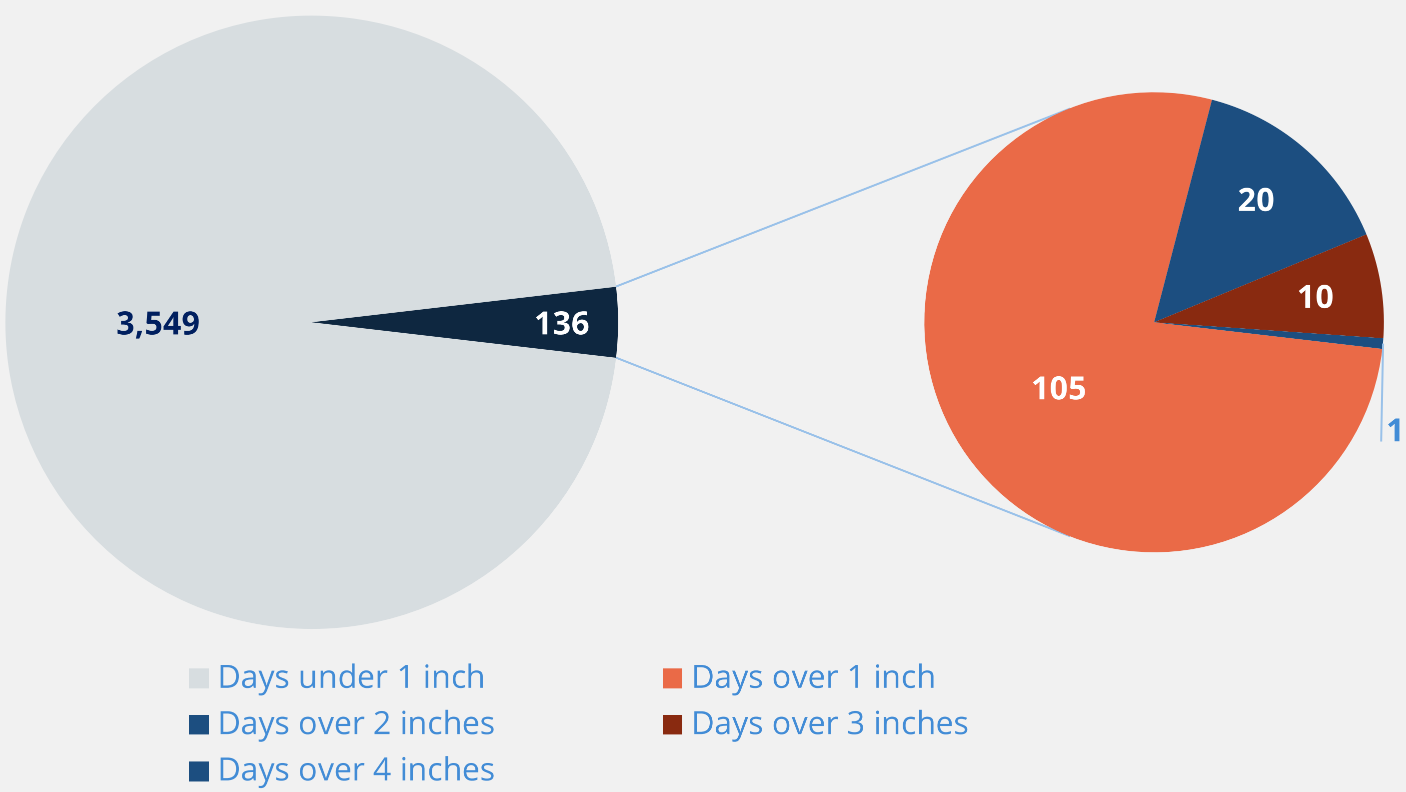
The four focus points in this study are located at the railroad underpasses. They are important means of transportation in the town and serve as the evacuation routes from areas of flood risk. Presently, only one of the critical points, North Benson Road, lies within the FEMA 100-year floodplain, but flooding at these underpasses is still a prevalent issue within the community.

The flooding at these critical points is due to a combination of factors. Inland overflow from tidal waters and storm surge, extreme rainfall intensity and frequency, and existing stormwater infrastructure issues all contribute to the frequent flooding of downtown Fairfield.

The 100-year floodplain defines the level of risk. The 100-year flood plain means there is a 1% chance of the area being flooded in any given year. Each storm event is an individual probability event, meaning that if a 100-year event happens one day, it is still possible another 100-year event can happen the next day.



Extent of flooding and flood depth for a current 100-yr storm event. Under current conditions, only the North Benson Road underpass experiences inundation from a 100-yr storm event.



Historic Pattern of Storm Surge Events

The four critical underpasses are generally located within the storm surge inundation area of a category 3 hurricane (or equivalent storm events). However, North Benson Road is closer to sea level and the Ash Creek tidal marsh is considered vulnerable to Category 1 and 2 hurricanes (or equivalent storm events). Flood risk for inundation varies significantly and is impacted by many factors, including wind speed, temperature, and location.

When a storm hits Fairfield, the surge will travel inland via the Southport Harbor, Pine Creek, and Ash Creek. Over the preceding 10-15 years, Connecticut has faced several storms (during both winter and summer) that have been accompanied by storm surges or storm surge-like conditions. Notably, this includes Hurricane Irene and Super Storm Sandy.

Historic Pattern of Rain Events

Currently, a significant portion of Fairfield south of Post Road is already within the 10-year floodplain. This means without proper storm sewer capacity or other stormwater and flood mitigation strategies, many areas in the economic hub of the community are prone to flooding. None of the critical points in this study are located within the 10-year floodplain, but they still see flooding on a regular basis. Because of this, it can be assumed that the flood problems are not necessarily caused by rainfall events alone, but a combination of rain events, storm surge, and stormwater management infrastructure concerns.

Each of the critical points are connected to the floodplain via their stormwater drainage systems, as they outfall within these areas.

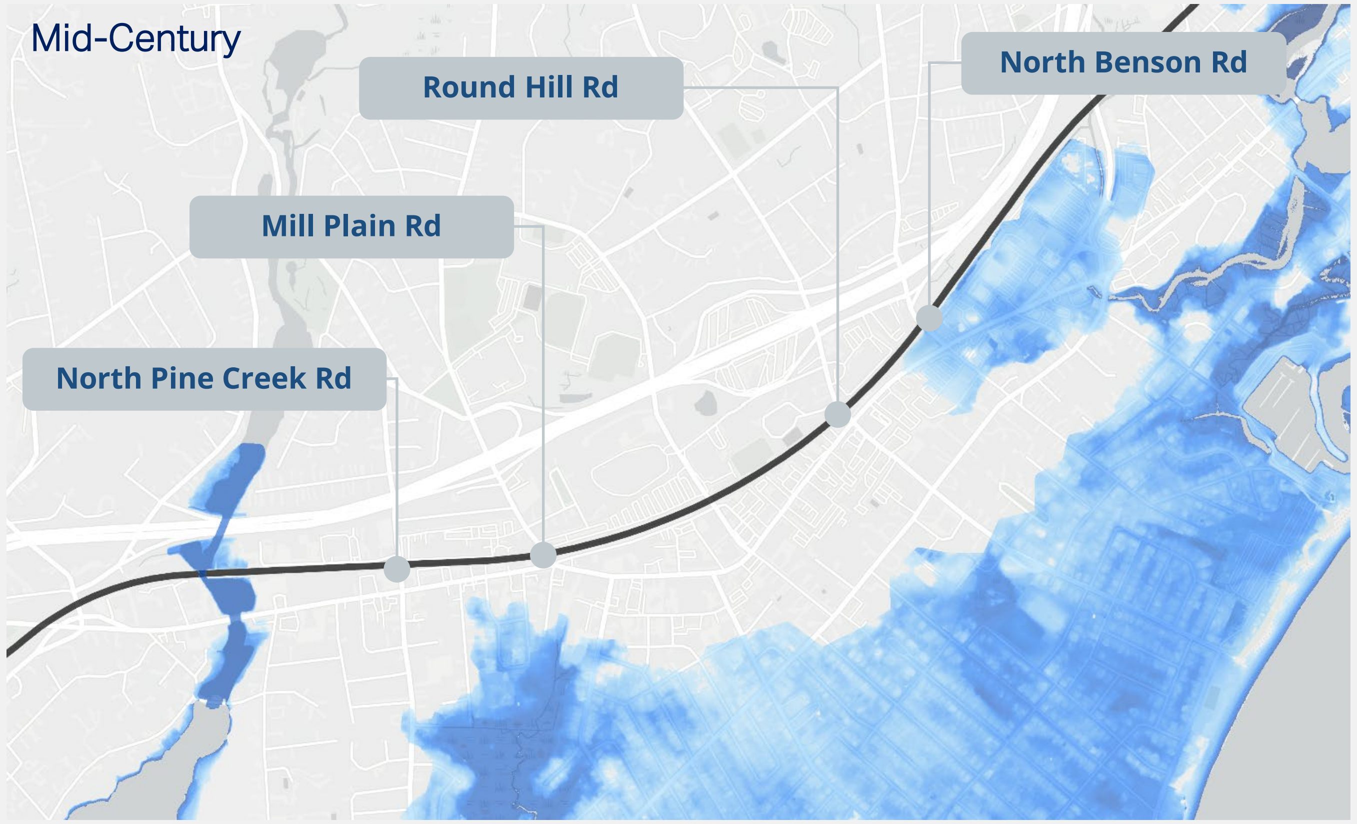
According to the available data from the University of Oregon PRISM Climate Group, the town has experienced approximately 105 days over the past 10 years where they received an excess of 1 inch of rain and 20 days with more than 2 inches of rain.

Existing Flooding

Flooding at the underpasses and in downtown occurs intermittently throughout the year and typically occurs during severe rainfalls. The flooding leads to road closures at the underpasses and the flood depths disable cars that attempt to drive through the flood waters. Typically, the flooding only persists for short durations, during and immediately following high intensity rainfall events which overwhelm the existing drainage systems.

The severity of the flood and duration can be exacerbated by coincidence with high-tides and storm surge events. According to the Fairfield Department of Public Works (DPW), the underpasses collectively flood around 4-6 times per year, with Round Hill Road and North Benson Road being the most frequently flooded. Residents also have voiced agreement in these findings for the frequency of the flooding at the four underpasses.

LEFT: Graph of 'Precipitation Days' over the preceding 10-year period (2012 to 2022) derived from the University of Oregon's PRISM Climate Group. Modeling indicated that over this time period the study area likely experienced +/- 100 days with greater than 1 inch of rain and 11 days with greater than 3 inches of rain. Anecdotal evidence from town residents also suggests that between 1 and 2 inches of rainfall is likely enough to begin causing underpass flooding.



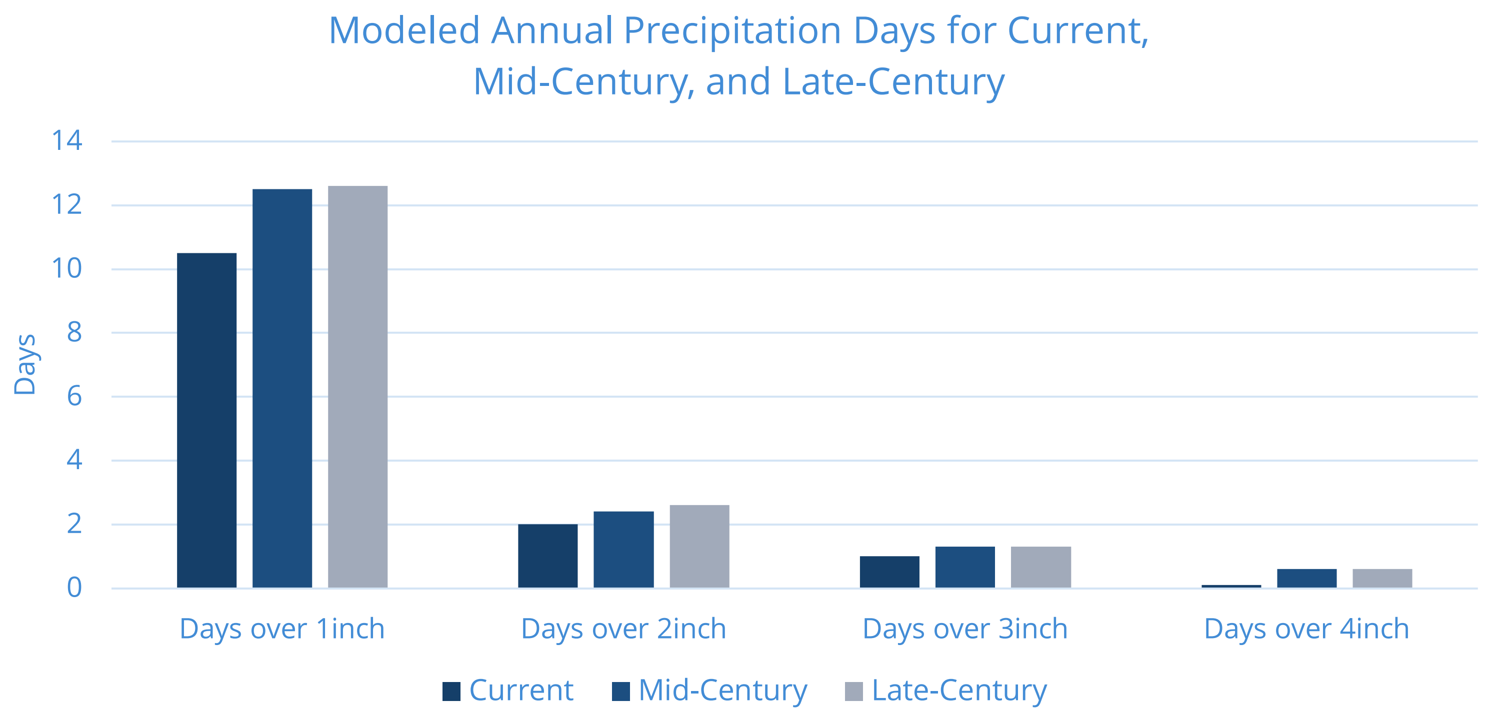
Extent of flooding and flood depth for a future 100-yr storm assuming 20 inches of sea level rise. Under this scenario, the extent of the flooding extends further inland towards the underpasses and projected flood depths have increased. This future coastal flood scenario will likely further impact the ability of the existing drainage system to handle stormwater and will induce underpass flooding at lower precipitation levels.

It is important to note that under this future scenario, evacuation to the east may be impossible due to flooding from Ash Creek cutting off Post Road and Old Post Road. Additionally, it is possible that both Post Road and Harbor Road along the western edge of the study area may also be impacted by flooding, making the underpasses (excluding North Benson Road) the only possible evacuation routes.

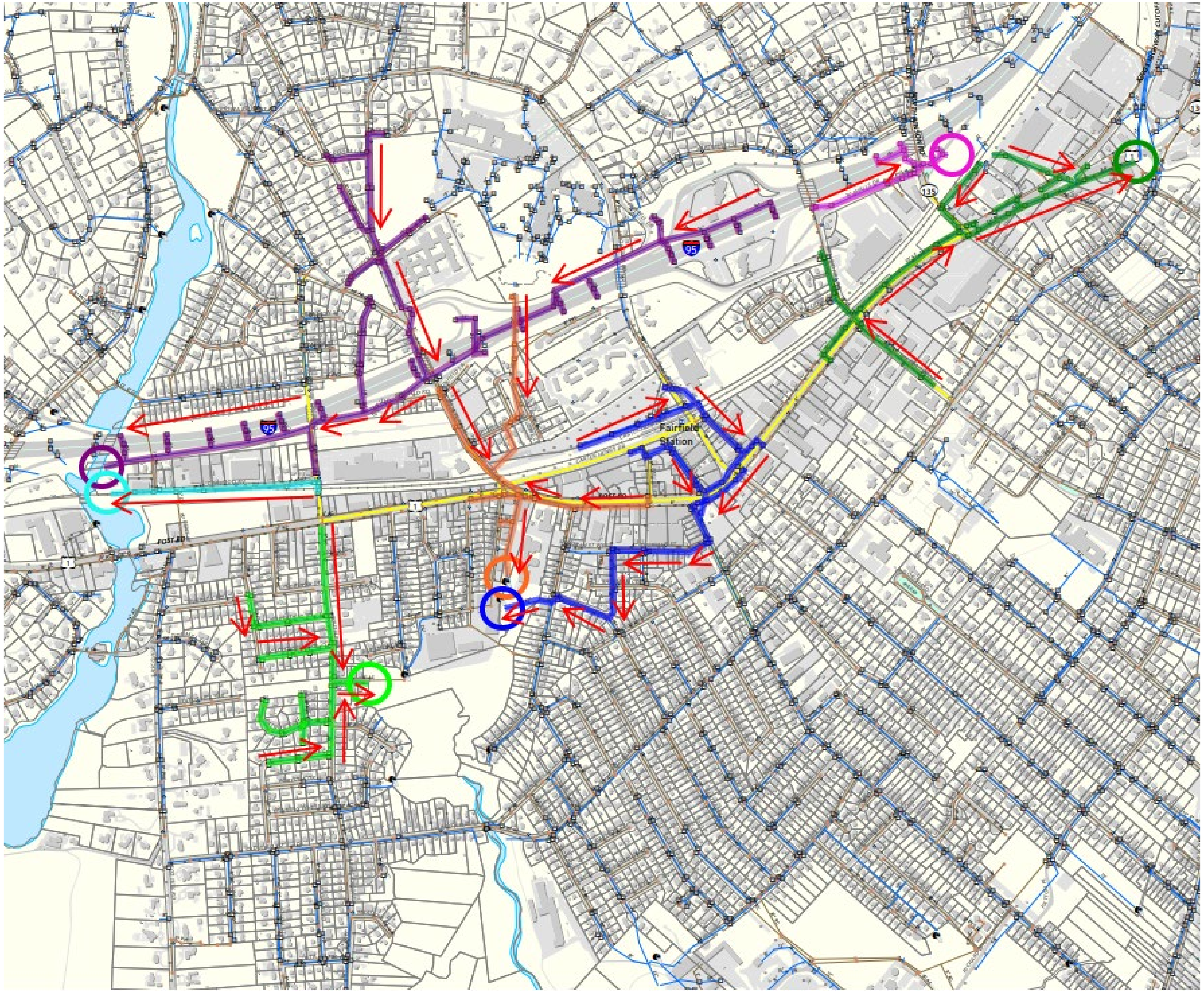
Future Flooding and Inundation

Climate change will exacerbate the natural hazards currently faced by the Town of Fairfield, leading to warmer and wetter winters, and hotter and drier summers that will increase storm severity and the likelihood of storm surges and intense rainfall.

The Connecticut Physical Climate Assessment report, published in 2019, indicates that by mid-century, average annual precipitation will increase by 8.5 percent and by 9.5 percent by late-century. Moreover, this precipitation increase will be concentrated during the winter months which could cause a 10-13.4 percent increase by mid-century and a 16.3-16.5 percent increase by late-century.



An analysis of the University of Oregon PRISM data and the Connecticut Physical Climate Assessment Report allowed for the extrapolation of increased precipitation days by mid-century and late-century. The greatest increase occurred for days over 4 inches. Over the preceding decade the study area only recorded a single day with over 4 inches of rainfall. In that same decade with a 'mid-century' precipitation increase, the study area would have received 6 days with over 4 inches of rainfall. Additionally, due to sea level rise and increased inundation, the amount of rainfall necessary to induce underpass flooding will likely decrease as high rainfall days increase.



Drainage Network

Downtown Fairfield is served by a series of underground drainage systems which utilize catch basins to capture stormwater and pipe networks to collect and move water out towards large water sources where it will eventually reach the Long Island Sound. The four underpasses within the study area are covered by three independent drainage networks:

Underpass Drainage Network and Outfall Location:

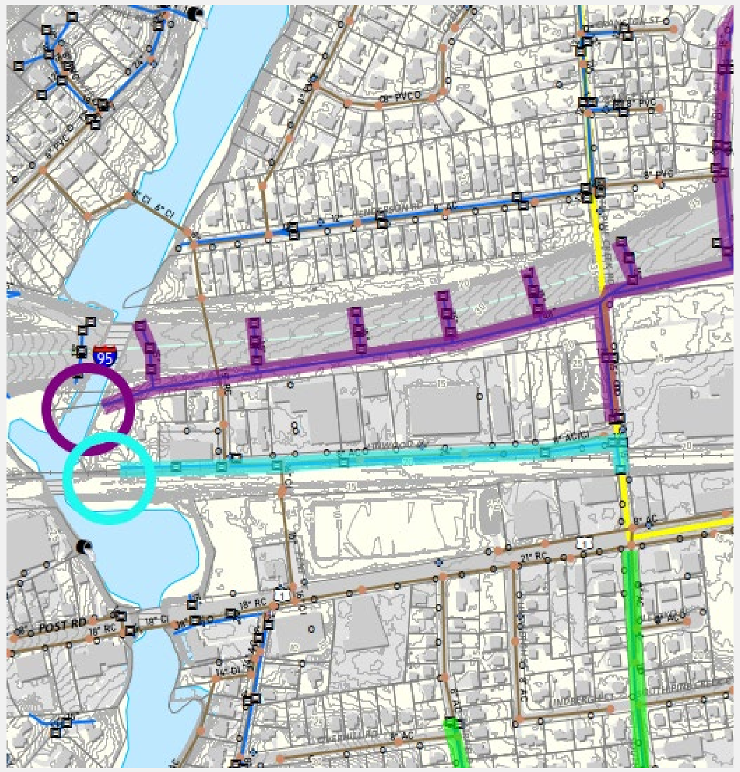
- **North Pine Creek Road:** Represented by the cyan linework, this segment only drains the underpass itself and outfalls to the west into Southport Harbor.
- **Mill Plain Road:** Represented by the orange network, this segment drains from north of the underpass and includes portions of Post Road. The network outfalls into Pine Creek.
- **Round Hill Road and N. Benson Road:** Both underpasses are drained by the same network represented in dark green. This network drains about half a mile of Post Road in addition to the underpasses and eventually outfalls to Ash Creek.

Other drainage networks service additional portions of downtown. Broadly speaking, Southport Harbor, Pine Creek, and Ash Creek drain a significant portion of Fairfield as the land slopes downwards towards the coast. Each of the four underpasses in the study area have outfalls to the surrounding waterbodies south of the rail line.

Drainage Standards: The Connecticut Stormwater Manual uses multiple criteria across multiple protection classifications to define design standards for stormwater conveyance and level of impacts to adjacent areas. The most relevant standard to the assessment is Conveyance Protection, which is intended to prevent erosive flows within internal and external drainage networks. For this classification, the system should be able to handle a 10-year event within a 24-hr period. For Fairfield County this is five inches of rain. Based on PRISM precipitation data and flooding return intervals from the town, the drainage networks associated with the underpasses do not meet this standard and do not meet a 2-year event (defined as 3.3 inches in a 24-hour period). Additionally, the design standards usually do not consider other factors, such as storm surge or future sea level rise which will inhibit the ability of the system to operate efficiently.

Underpass and Drainage Network Summaries

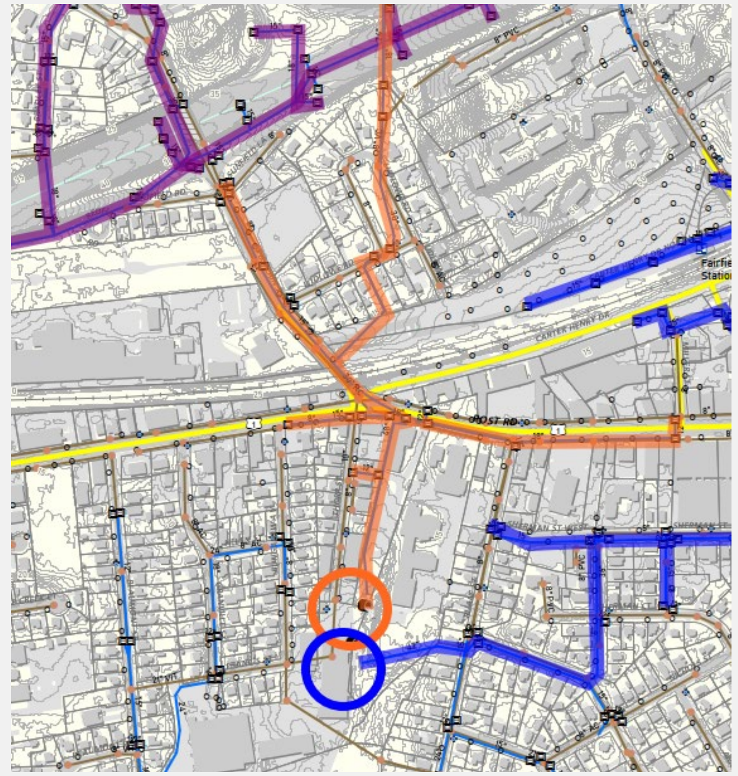
North Pine Creek Road



The catch basins that drain the underpass on North Pine Creek Road discharge to Southport Harbor. This system is unique in the downtown area in that the underpass is the most upstream part of the network with the system only draining the underpass and Linwood Ave. Through anecdotal evidence, this underpass experiences the least severe flooding of the four and likely results from the underpass being located at the top of the network. Additionally, South Pine Creek Road, north and south of the underpass is drained by additional separate systems, which prevent additional flow from entering the drainage network.

This underpass is partly within the 500-year flood zone.

Mill Plain Road

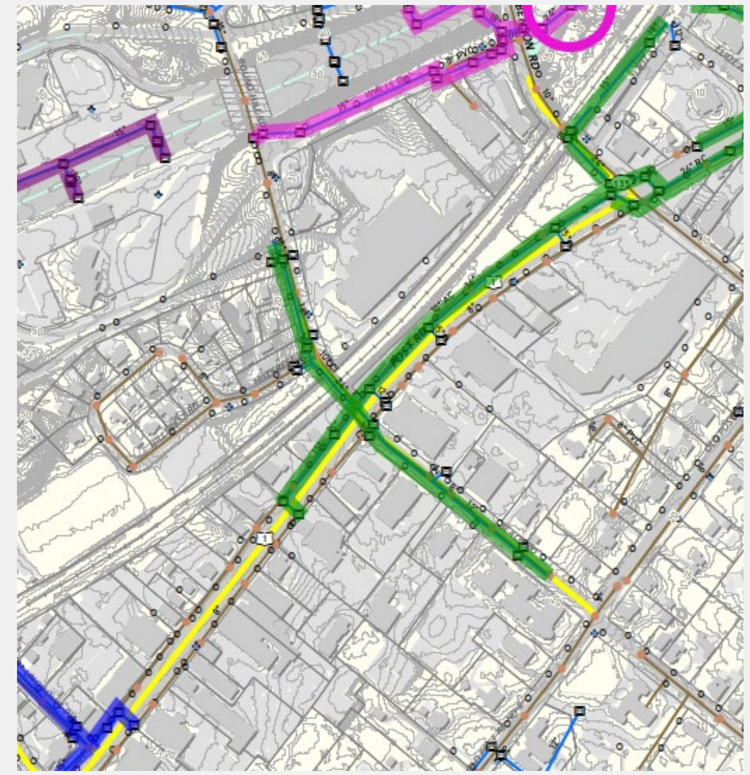


The underpass at Mill Plain Road receives a significant amount of runoff from areas north of the underpass. These areas includes: 1) a portion of the Fairfield Train Station parking lot which slopes towards Mill Plain Road, 2) Mill Plain Road from the I-95 overpass to the railroad underpass, and 3) Ludlowe Road/Court neighborhood and the sports complex of Fairfield Ludlowe High School.

This underpass area is downstream of a larger catchment area than North Pine Creek Road. The catchment areas also contains a significant amount of impervious surface. These factors likely place a greater strain on the system leading to flooding at the underpass and at the intersection of Mill Plain Road and Post Road.

This underpass is adjacent to the 500-year flood zone.

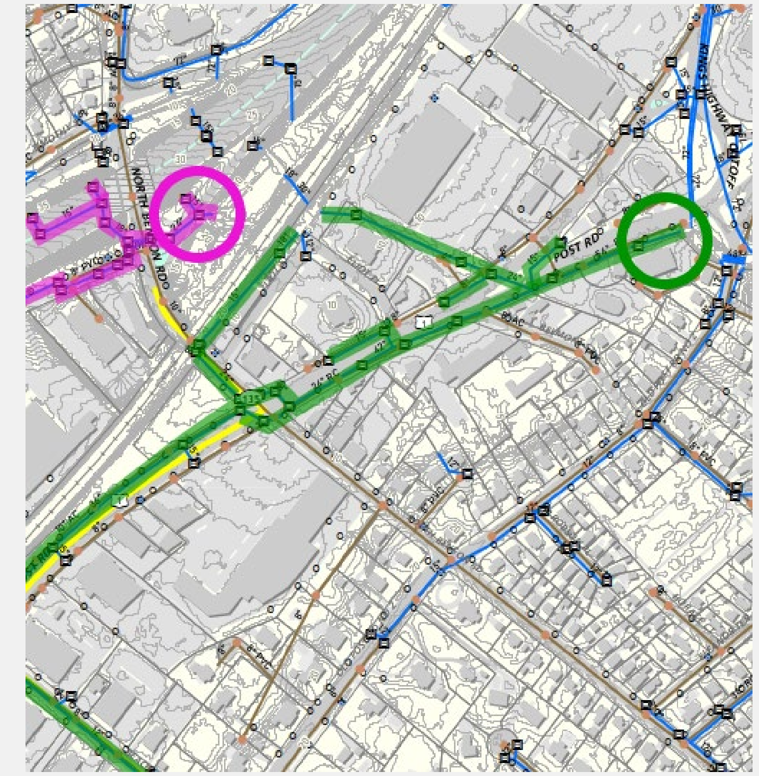
Round Hill Road



The drainage area around Round Hill Road is directed towards Ash Creek. The underpass at Round Hill Road shares a drainage network with the Benson Road underpass as well as several additional side streets.

This underpass is within the 500-year flood zone. Proximity to a flood zone contributes to increased likelihood of flooding at this location.

North Benson Road



The underpass at North Benson Road is downstream of Round Hill Road within the same drainage system. The water collected from this area is eventually discharged into Ash Creek.

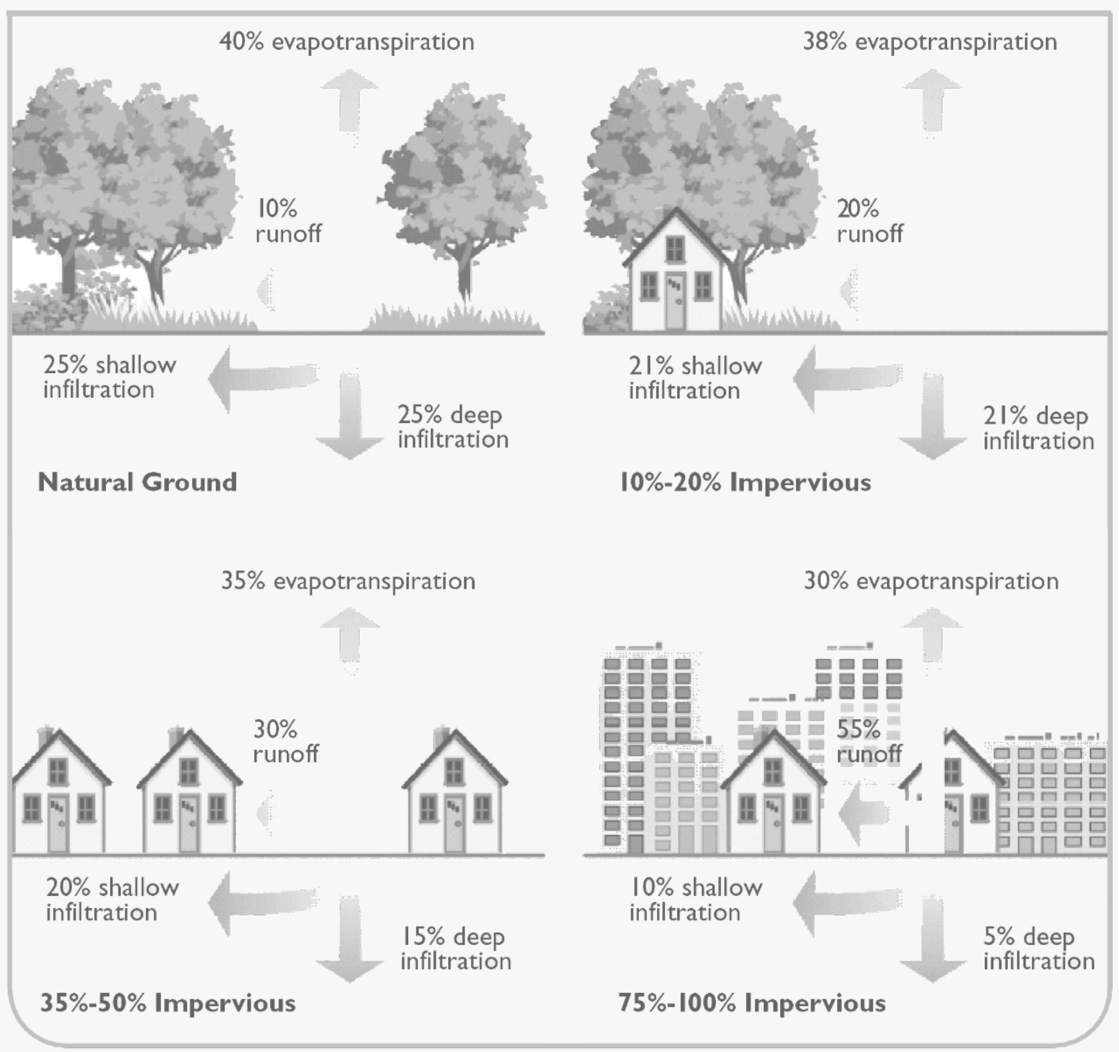
The accumulation of water from the upstream drainage network likely contributes to the severity of flooding at this location. It is also important to note that this critical point is within the FEMA 100-year flood zone.

Insufficient capacity is often a major issue when investigating drainage system failures. In this case, the stormwater drainage system is unable to handle the water being added to it during intense storm events. During an event, the drainage systems do not have enough storage area (referring to the in-network pipe volume) to transport the water to the outlet. A modern drainage system is designed to have increasing pipe diameters as water flows downstream to account for the aggregation of stormwater along the length of the network.

When pipes do not have enough capacity due to the downsizing of consecutive pipes, backwater may occur. Backwater is when water builds up within a system due to it not being able to flow freely to the outlet. This is akin to a three-lane highway merging into one lane. Traffic may start to back up, and drivers will significantly slow their speed when passing through the area, or even stop completely. And as more cars approach the merge the area of congestion moves further from the merge point. Prior reports have noted the prevalence of downsizing concerns within Fairfield, and it likely plays a role in the flooding experienced at the underpasses.

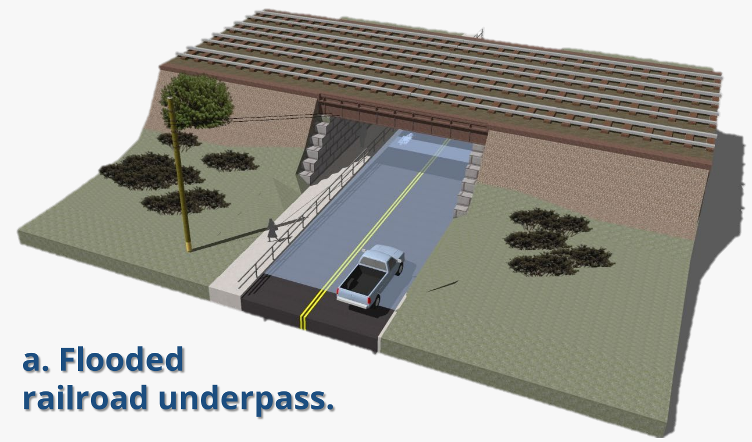
The concave nature of the underpasses due to the limited vertical clearance from the railroad operating above provides a perfect vessel for containing the excess stormwater not handled by the existing drainage networks. As stormwater flows downhill towards the underpasses, both on surface and within the drainage network, the accumulation overwhelms the network capacity and water either back flows into the concavity or accumulates there. Storm surges or covered outfall locations can further hinder the drainage system's ability to efficiently transport stormwater.

Another drainage consideration for more urban areas is the impact of impervious surface on the water cycle. As the proportion of impervious surface increases, the ability of the natural system to function properly decreases, leading to significantly increased runoff in conjunction with reduced infiltration and evapotranspiration. In a traditional hard infrastructure stormwater system, increased urbanization leads to increased runoff. It is estimated that within 1,000 ft of the underpass drainage networks +/- 35% of the land area is impervious surface.

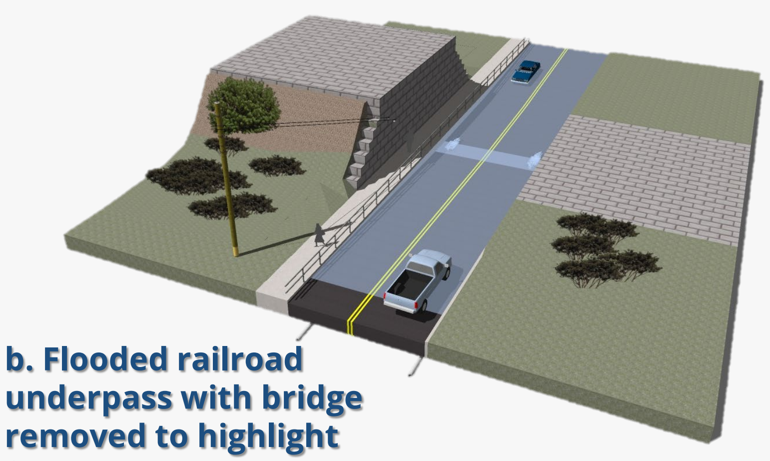


Source: Federal Interagency SRWG, 2000 through the Connecticut Storm Water Quality Manual.

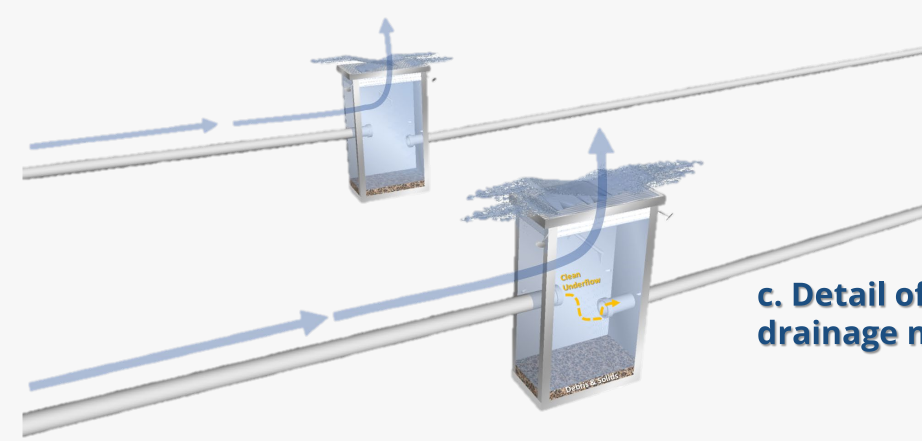
BELOW: Figure highlighting the drainage capacity concern present at the four underpasses within the Fairfield study area.



a. Flooded railroad underpass.



b. Flooded railroad underpass with bridge removed to highlight flooding.



c. Detail of overwhelmed drainage network.

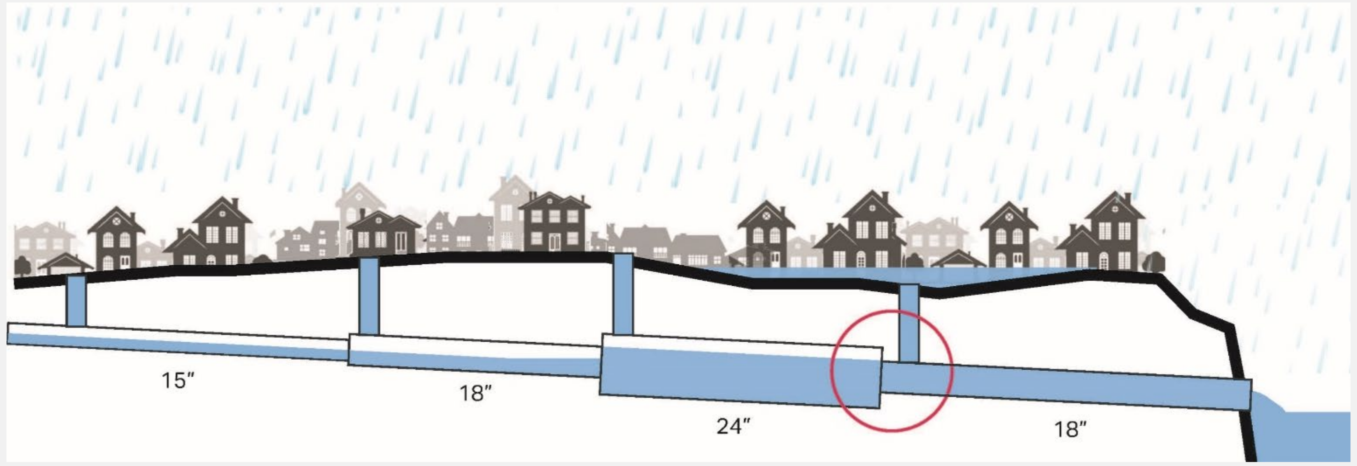
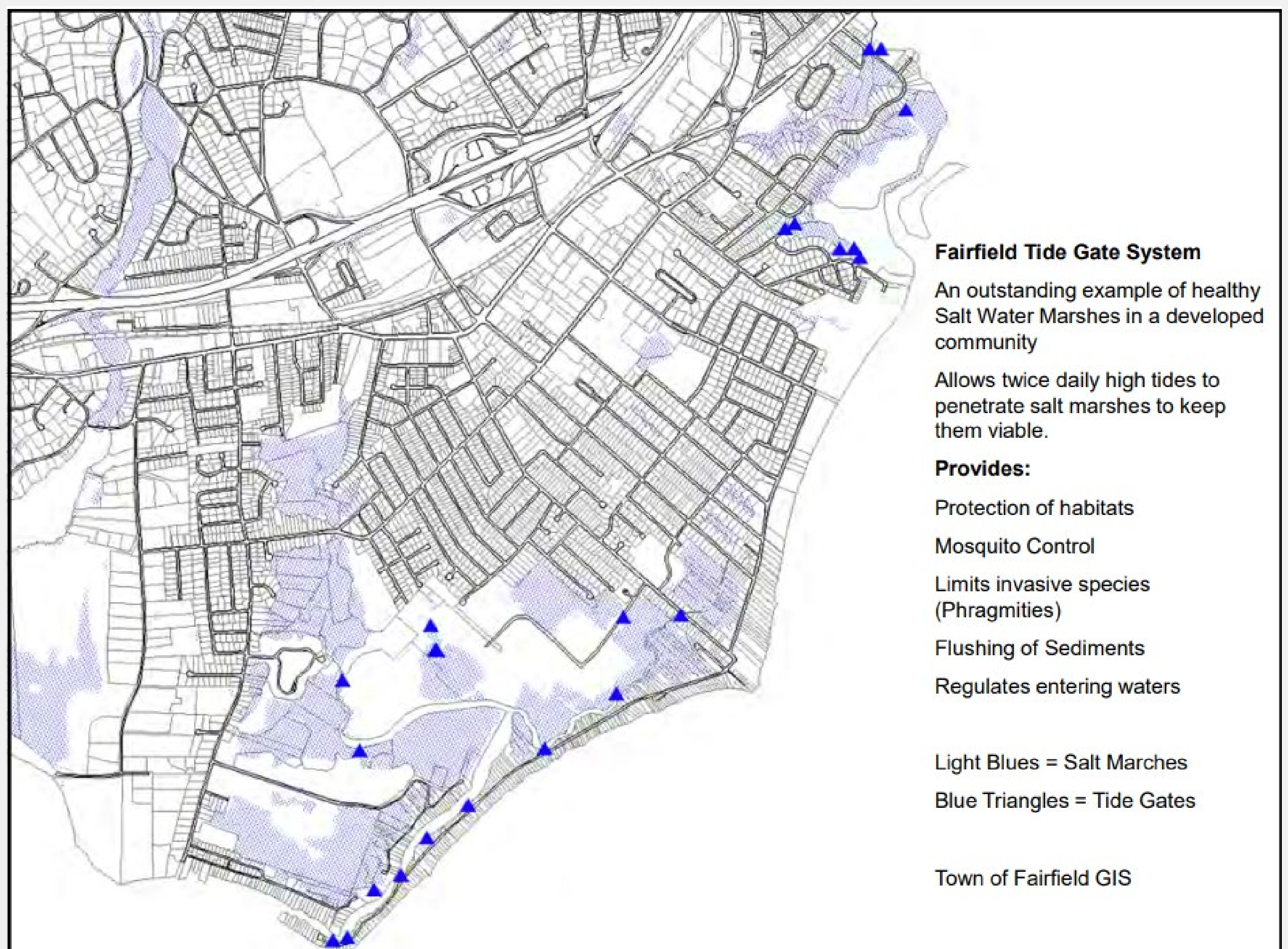


Figure highlighting the drainage network downsizing concern. In a modern drainage system, the pipe diameter is designed to incrementally increase as you get closer to the outfall location to accommodate the continually increasing stormwater volumes.



Excerpt from the Fairfield Flood and Erosion Board Flood Mitigation Plan highlighting the location of existing tide gates within the Fairfield coastal plain.

Fairfield Tide Gate System

In addition to the drainage networks described, the town has a system of tide gates to help mitigate the inundation from storm surges. The system is primarily located along Pine Creek and Ash Creek.

Tide gates are structures that are commonly used to prevent flooding caused by high tides or storm surges. They are typically installed at the entrances of coastal waterways, such as estuaries, inlets, or rivers, where the water level can rise above the surrounding land during high tide events.

The function of a tide gate is to regulate the flow of water into and out of the coastal waterway. During normal tidal conditions, the tide gate remains open, allowing water to flow freely between the coastal waterway and the surrounding ocean. However, when the water level rises above a certain threshold, such as during a storm surge or a king tide event, the tide gate can be closed to prevent the inland flooding of adjacent areas.

In the context of the inland flooding in Fairfield the tide gate network which is designed to reduce impacts from coastal may be exacerbating flooding at the underpasses by inhibiting the flow of stormwater at the equipped outfall locations. This is most likely to occur when severe rain coincides with high-tides or storm-surge-producing events which push more water up into Ash Creek and Pine Creek.

The model type and age/condition of the tide gates play a role in their functionality. Fairfield employs a combination of 'flap-only' and self-regulating tide gates. The self-regulating tide gates use a system to detect water levels and will close when the water levels reach the designated height to prevent flooding, or too much water coming inland.

Pump Stations

Pump stations play a crucial role in mitigating flood damage by removing excess water from low-lying areas or urban areas prone to flooding. The pump station functions by receiving and storing excess water during a flood event and then pumping the water out of the flood-prone area.

The pump station typically includes pumps, pipes, and an associated control system to regulate the water flow. In many cases, the control system is a tide gate. The pumps draw water from the flooded area into the pump station where it is stored in a reservoir, sump, or wet well. From there, the water is pumped through pipes or channels and released into a nearby waterway or drainage system.

Pump stations are designed to be reliable and operate continuously, even during heavy rainfall or flooding events. They are often designed with backup power sources to ensure they can function in the event of a power outage.

Pump stations are limited by the amount of flow they are designed to handle; design considerations include (but are not limited to) the type of pump, capacity and elevations of the drainage system it services, and available space. Depending on the storm intensity and other factors such as the age and condition of the pump and appurtenances, pump stations may not always be able to keep up with flow rates caused by extreme flooding.

Several pump stations currently exist in Fairfield, but the existing facilities can only do so much to mitigate the unique drivers causing localized flooding at the four underpasses. The existing pump stations are located at the WPCA plant and drain inside of the hardening of Richard White Way.

Underpass Summary Table

Underpass	Elevation of Bottom	Main Source of Flooding	Secondary Source of Flooding	Applicable Flood Zones
North Pine Creek Road	9.75	Stormwater runoff	Low slope	FEMA 0.2% (500-year) – source is Mill River
Mill Plain Road	9.67	Stormwater runoff	Low capacity to accept stormwater	FEMA 0.2% (500-year) – source is Mill River
Round Hill Road	7	Stormwater runoff	Low capacity to accept stormwater	FEMA 0.2% (500-year) – source is Ash Creek and Turney Creek
North Benson Road	6.11	Stormwater runoff	Low slope and submerged tidal outlets	FEMA 1% (SFHA) – source is Ash Creek and Turney Creek

Unlike most flooding in coastal communities, the underpasses adjacent to the Post Road corridor are vulnerable to significant flooding from stormwater runoff, which collects in the low elevations beneath the rail bridges and overwhelms the existing drainage network. The next phase of the study will work to develop solutions targeting the specific concerns and constraints at each underpass.

Existing Conditions Wrap-Up

The Resilient Downtown Fairfield Project is a unique opportunity to build resilience through actionable solutions while simultaneously developing a replicable approach for addressing the many flood-prone underpasses along the Connecticut shoreline. A review of the existing conditions at the four underpasses and within downtown has confirmed the vulnerability echoed by the community. The underpasses currently experience flooding due to intense rain events, and the flooding can be further exacerbated when a storm system is accompanied by a storm surge, which further hinders the functionality of the existing drainage network. Additionally, climate change will continue to increase the frequency with which the community experiences intense rainfall events and systems producing storm surges. By the middle of the century, Fairfield could experience 20 more days annually with 1 inch of rain or more and an additional 1.6 feet of sea level rise.

The impacts of climate change will place a greater strain on the community’s existing drainage and flood control systems and increase the likelihood for underpass flooding within the study area.

Resilient Fairfield Chapter III:

Adaptation Strategies

Alternatives Development

The next phase of the project includes investigating strategies for addressing the flooding experienced at the four underpasses and within downtown Fairfield. An initial universe of options was developed encompassing three primary types of treatments: green infrastructure, flood control, and infrastructure modifications. It is likely that multiple strategies will ultimately be recommended for each location to help reduce flooding and limit the impacts experienced by network users. The assessment of these strategies to understand their applicability to a given site and use of the PERSISTS framework will guide final recommendations. The following goals were developed, in conjunction with the public process, to help guide the development of alternatives.

Goals for Alternative Development

- Increase infiltration through reduced impervious surface
- Detain excess stormwater with green infrastructure solutions
- Improve safety for residents and other road users
- Increase drainage network capacity
- Prioritize resilient evacuation routes

PERSISTS Framework

The PERSISTS framework is an assessment tool developed during Phase I of Resilient Connecticut in conjunction with stakeholders. The framework aids in the holistic assessment of the adaptation strategies and works to balance multiple and often competing goals and priorities.

PERSISTS includes the following categories:

- **Permittable:** Is the strategy allowable under relevant local, state. and federal regulations?
- **Equitable:** Are the benefits of the strategy distributed equitably?
- **Realistic:** Can the strategy be engineered and realistically funded?
- **Safe:** Does it mitigate the target risks to people and local infrastructure?
- **Innovative:** Does the strategy incorporate or integrate innovative thinking?
- **Scientific:** Does the strategy reflect or improve the best available science?
- **Transferable:** Can the strategy be applied to similar problems in other communities?
- **Sustainable:** Is the strategy socially, economically, and ecologically aligned and supported by the public and local leadership?

Adaptation Strategies

Green Infrastructure: Green infrastructure refers to a collection of natural and semi-natural systems that are designed to mimic the functions of natural ecosystems, providing a range of environmental, social, and economic benefits. One of the key roles of green infrastructure is stormwater mitigation, which involves managing and reducing the impacts of stormwater runoff in urban areas.

During rainfall events, impervious surfaces such as roads, parking lots, and rooftops prevent water from infiltrating into the ground, leading to increased runoff. This excess stormwater can overwhelm traditional gray infrastructure, such as sewers and drainage systems, causing flooding, erosion, and water pollution. Green infrastructure, on the other hand, utilizes vegetation, soils, and other natural elements to capture, absorb, and slow down stormwater, thus mitigating these adverse effects. Some types of green infrastructure that could be beneficial to the resiliency of Fairfield are:

- Bio-Swales
- Permeable Pavement
- Detention and Infiltration Park
- Stormwater Restoration

Flood Control Systems: For the purposes of this assessment, flood control strategies include the drainage system, as well as tide gates and pump stations, and other warning and monitoring systems. As noted in Chapter II, it is likely that some of the flooding observed at the underpasses is exacerbated by limitations of the existing flood control system. This includes undersized pipes as well as buildup of sediment and debris in the network.

The function of tides gates downstream of the drainage network may also play an indirect roll in localized flooding at the underpasses. When operating normally, tide gates will control the flow of water into and out of tidal bodies of water that would otherwise be cut off from the natural flow of tides. However, if they are not functioning as intended due to age or damage, they could be less effective or could even contribute to localized flooding by preventing the outfall of stormwater. Maintenance and optimization of existing infrastructure and creation of new flood control infrastructure could help move water away from the underpasses more effectively and limit the amount of water that backs up in the system.

Some examples of adaptation improvements to flood control systems are:

- Maintenance of Existing Infrastructure
- Modifications to the Existing Pipe Network
- New Pump Stations
- Warning and Monitoring Systems

Infrastructure Modifications: Ultimately, the flooding problems in Fairfield can be linked to the design of the railroad and the subsequent underpasses that are forced to dip as they cross underneath. Possible alternatives to the existing infrastructure are:

- Widening of the Underpass
- Raising Base Elevation
- New Overpass
- Raised Railroad Elevation

Policy Changes: Impervious surface plays a significant role in the volume of stormwater that is directed towards the drainage network. Zoning policies and stormwater regulations that encourage broader use of pervious pavements and other green infrastructure solutions can help reduce the burden of stormwater runoff on the drainage network, by allowing the land to infiltrate or detain a greater portion of runoff. Periodic evaluation of these polices and regulations could reveal opportunities for improvement.

RIGHT: An applicability scoring was completed to understand what strategies could be implemented at each of the four underpasses.

Applicability Scoring

North Pine Street

Strategy	Applicability
Bio-Swales	Low
Permeable Pavement	Low
Detention and Infiltration Park	High
Stormwater Restoration	Low
Modifications to Network	Medium
New Pump Stations	Medium
Maintenance of Existing	Medium
Warning and Monitoring	High
Widening of Underpass	Low
Raising Base Elevation	Medium
New Overpass	Medium
Raised Railroad Elevation	Low

Mill Plain Road

Strategy	Applicability
Bio-Swales	Medium
Permeable Pavement	High
Detention and Infiltration Park	Low
Stormwater Restoration	High
Modifications to Network	Medium
New Pump Stations	Low
Maintenance of Existing	Medium
Warning and Monitoring	High
Widening of Underpass	Medium
Raising Base Elevation	Medium
New Overpass	Low
Raised Railroad Elevation	Low

Round Hill Road

Strategy	Applicability
Bio-Swales	Low
Permeable Pavement	Low
Detention and Infiltration Park	High
Stormwater Restoration	Low
Modifications to Network	Medium
New Pump Stations	Medium
Maintenance of Existing	Medium
Warning and Monitoring	High
Widening of Underpass	Medium
Raising Base Elevation	Low
New Overpass	Low
Raised Railroad Elevation	Low

North Benson Road

Strategy	Applicability
Bio-Swales	Medium
Permeable Pavement	Low
Detention and Infiltration Park	High
Stormwater Restoration	Low
Modifications to Network	Medium
New Pump Stations	Medium
Maintenance of Existing	Medium
Warning and Monitoring	High
Widening of Underpass	Medium
Raising Base Elevation	Low
New Overpass	Low
Raised Railroad Elevation	Low

Flood Warning Systems

Drainage network improvements and green infrastructure can dramatically improve climate resiliency for Fairfield by mitigating flooding. However, a warning in the event that flooding does occur at an underpass a flooding warning system would automatically detect a flooded roadway and deploy barriers to close the road. This alternative is responsive to community concern around getting stuck at underpasses and would prevent people from attempting to cross a flooded roadway.

These warning systems can gather and report real-time flooding data, as well as be more broadly integrated into a community's general emergency management infrastructure, allowing data to be more completely assessed and visualized by city staff.

Sensing of water can be accomplished through visual scanners/cameras or through weight-based sensors that report flooding when a certain amount of water accumulates above it. The system can be self-supporting (powered with solar panels) or can be attached to the electrical grid. Systems attached to the grid, however, can be vulnerable in major storms that cause large-scale power loss.

Once activated, the sensor will trigger some flashing signage in addition to a gate that physically prevents drivers from passing. Data can be communicated using cellular technology. The entire system—all sensors and gates—would be managed by a Base or Master Station.

Multiple companies provide similar technology, the cost estimate within this document was provided by High Sierra Electronics. A cost estimate was developed for installation of a warning system with gates and warning signage at each of the four underpasses. The estimate is approximately $900,000 for the gates and flashing signage at the four locations, the Base Station, the required software, and the installation. This figure is only an estimate but provides information about the rough investment such a system would cost in Fairfield.

Assessment of Flood Warning Systems Using PERSISTS Decision Support Criteria:

PERMITTABLE: This alternative would require minimal permitting to implement.

EQUITABLE: This alternative would improve safety for residents and has been well received by residents at public meetings.

REALISTIC: The cost, limited permitting requirements and safety benefits indicate this alternative is implementable.

SAFE: This alternative directly addresses safety by automatically closing flooded underpasses and preventing people from possibly getting stuck.

INNOVATIVE: This alternative uses advanced technology to automatically detect flooding and close the roadway.

SCIENTIFIC: This alternative does not directly address this criteria.

TRANSFERABLE: The New Haven Line extends the length of the Connecticut shoreline; many neighboring communities face similar flooding concerns at underpasses.

SUSTAINABLE: This alternative was well received during public meetings and directly responds to concerns that were voiced my members of the public.

Source: High Sierra Electronics. The top image shows a warning system with no gate, while the bottom image includes a gate.

Policy Mechanisms

Beyond the direct implementation of mitigation strategies discussed in this report (drainage improvements, green infrastructure, etc.) there are also policy measures the town could implement. In a downtown area, like Fairfield, stormwater entering the drainage networks is flowing from within the public rights of ways as well as from adjacent commercial and residential parcels. Policy mechanism would provide an avenue for the town further increase the infiltration of stormwater.

Many communities, around the country and globally, are experimenting with different policy structures to incentivize and control how property owners handle the stormwater on their properties. Included below are several examples of policy mechanisms.

Boulder, Colorado: In Boulder, Colorado, the Green Building and Green Points Program has been developed to push sustainable construction practices. The Program applies to new residential constructions, additions, and remodels over 500 square feet and incentivizes developers to adopt adaptive strategies. Through a point-based system, developers earn "Green Points" by incorporating sustainable landscaping, shading, surface water management, high-efficiency irrigation, waste management, and building rehabilitation. Projects must meet a minimum number of points across applicable categories to be permitted.

New York, New York: New York City Zoning Code focuses on specific requirements for parking lots, recognizing them as potential contributors to stormwater issues. Requiring permeable pavements and imposing stormwater management standards on larger lots, the code enforces proper grading and the inclusion of trees in designated areas. This approach not only manages stormwater but also addresses the urban heat island effect by providing shade, making the cityscape more resilient.

Buffalo, New York: Buffalo, New York implemented a Green Code Unified Development Ordinance. By emphasizing Green Infrastructure (GI) stormwater management strategies, the city prioritizes on-site water infiltration. This approach ensures that water is absorbed locally before resorting to off-site or traditional gray infrastructure solutions, thereby reducing the overall impact of stormwater runoff.

Washington, D.C.: Washington D.C., through its 2013 Rule on Stormwater Management and Soil Erosion and Sediment Control, developed a stormwater retention credit trading system. This system not only sets a high retention requirement but also provides flexibility for compliance. Projects with major land disturbing activities must adhere to a stringent retention requirement, but the city allows up to 50% retention offsite, payments-in-lieu of offsite retention, and a credit trading system. This flexibility encourages developers to go beyond the legally required limits, creating a market for stormwater credits and fostering a city-wide commitment to sustainable stormwater management.

For Fairfield, a policy system which ties permit approval for remodels or new construction to the mitigation of stormwater through onsite infiltration could help ensure that the existing drainage networks are not becoming overburdened.

Assessment of Policy Mechanism Using PERSISTS Decision Support Criteria:

PERMITTABLE: This alternative would require significant effort by the town to draft and pass new regulatory tools.

EQUITABLE: This alternative would lead to improved ecosystems service benefits by community properties that would could mitigate flooding at the four underpasses as well as more broadly in downtown Fairfield.

REALISTIC: This alternative would be considered realistic, however additional operational funding would likely be required for the administration and enforcement of the developed policy.

SAFE: This alternative would improve onsite infiltration and could contribute to onsite safety benefits as well as at the study area underpasses.

INNOVATIVE: This alternative recommends using innovative policy mechanisms to compel property owners to make certain green infrastructure and stormwater mitigation strategies when making modifications to their property.

SCIENTIFIC: This alternative recommends using a policy mechanism to help encourage the deployment of green infrastructure strategies to mitigate stormwater.

TRANSFERABLE: The New Haven Line extends the length of the Connecticut shoreline; many neighboring communities face similar flooding concerns at underpasses. Moreover, these type of policy mechanisms can apply to stormwater management concerns across the state.

SUSTAINABLE: This alternative would mitigate the flooding around private and public properties. Additionally, this alternative may provide a lower carbon footprint than a more intensive infrastructure improvement alternative.

Drainage Improvements

An alternative that may help reduce localized flooding issues from stormwater involves upsizing stormwater pipes beneath the underpasses and parts of the downstream systems. Pipe sizes should be increased to remove constrictions in pipe runs that have been identified in the existing system. Upsizing the drainage system will increase the capacity within the pipes, which will prevent water from backing up and flowing back out of the catch basins during a storm event. Based on the existing network's configuration, it is recommended to upsize the pipes within the underpasses. Increasing the number of catch basins within a drainage system could also be done to improve flow of stormwater. It is important to note that any drainage improvements would only be as successful as the maintenance regime, and all catch basins located beneath the underpasses should be properly cleaned out prior to making any system improvements.

Mill Plain Road
Currently, there are four catch basins beneath the underpass of Mill Plain Road. There is a catch basin on each side of the road at the bridge entrance and exit. There is a 30" arch pipe running along one side of the bridge footing, and it is believed that the catch basins connect to this pipe.

In addition to these four catch basins, there are nine others within the Mill Plain Road drainage network. Their maintenance and upkeep is helpful to maximize the efficiency of the system.

The outfall pipe for this system is a 48" pipe which runs parallel to Thorpe Street. From a current study that is still under review -- "Post Road (US Route 1) and Reef Road Drainage System Study" (SLR, 10/2022) -- the pipe is at almost 50% capacity without a rain event. The standing water appeared to be a result of accumulated sediment. Cleaning and maintaining this pipe is important to maximize the efficiency of the overall system.

Round Hill Road
Since the Round Hill Road system is connected to the North Benson System, these two systems are recommended to be addressed at the same time.

The underpass of Round Hill Rd is drained by two catch basins located next to the southwest abutment. There is a 24" pipe running next to the southwest abutment. It is assumed the catch basins are connected to this pipe. There are two more catch basins on either side of the road before the intersection with Post Road. it is assumed this pair of catch basins downstream of the underpass connect to the 24" pipe via a 12" pipe.

It is recommended that the upstream drainage network should be modeled to compare volumes of flow being conveyed through the underpass with the capacity of the existing system.

North Benson Road
Currently, there are double catch basins on either side of the road right before the intersection of Eliot Street and North Benson Road. The next nearest catch basin is directly before the intersection of North Benson Road and Post Road.

There is a 30"x18" arch pipe and a 24" RCP pipe that together run the length between the double catch basins at the underpass to the single catch basin before the intersection with Post Road. The 24" pipe eventually connects to the same drainage system beneath Post Road as the pipes flowing from Round Hill Road underpass.

It is unclear if the double catch basins at the underpass on North Benson Road drain to the system under Post Road, or if they drain via a 15" tile pipe to a sedimentation pond along the railroad track. Information about the existing storm drains suggests both possibilities.

Field surveys would be beneficial to confirm the drainage in this area. To be conservative, the team has assumed that the double catch basins do connect to the 24" pipe, and ultimately to the Round Hill Road drainage network.

Following surveys, it is recommended to model the drainage system to the North Benson Road underpass and compare estimated flow volumes with the capacity of the existing system.

The outfall pipe for this system is a 50"x31" arch pipe which runs parallel to Post Road towards Ash Creek. Cleaning and maintaining this pipe is important in maximizing the efficiency of the system.

Pine Creek Road
At this time, it is recommended that additional survey be conducted on the existing Pine Creek drainage system before upsizing recommendations are made. Based on existing storm sewer plans, there is a possibility that the outfall pipe is undersized, but this would need further confirmation.

Image of the 48" Mill Plain Road Outfall Pipe (Image credit: SLR, 2022)

Assessment of Drainage Improvements Using PERSISTS Decision Support Criteria:
PERMITTABLE: This alternative would require right of way acquisition to construct and implement. State and local permits will apply. Federal permits may be required depending on funding sources.

EQUITABLE: This alternative would provide substantial resilience benefits to the community while minimally impacting existing properties.

REALISTIC: This alternative is feasible and would ideally be designed so that impacts to the bridge structures can be minimized with coordination from owners/operators of the rail line. Additionally, this alternative is one of the more cost-effective options provided.

SAFE: The improvement of the drainage system would help keep evacuation routes open for residents in the area.

INNOVATIVE: This alternative addresses the flooding concern and can be coupled with other alternatives mentioned for maximum benefits.

SCIENTIFIC: This alternative would use the latest information on precipitation, climate change, and historical flooding to design systems capable of handling projected future storms.

TRANSFERABLE: The New Haven Line extends the length of the Connecticut shoreline; many neighboring communities face similar flooding concerns at railroad underpasses.

SUSTAINABLE: This alternative would benefit the flooding around private and public properties. Additionally, this alternative may provide a lower carbon footprint than a more intensive infrastructure improvement alternative. Public feedback suggests this alternative would have local support.

Study Area Overview

Possible Strategies

Green Infrastructure:
- Bio-swales
- Detention/infiltration basin parks
- Permeable pavement
- Stormwater Restoration

Flood Control:
- Modifications to existing network
- New pump stations
- Maintenance and optimization of tide gates
- Warning and monitoring systems

Infrastructure Changes:
- Widening of underpasses
- Raising base elevation
- New overpass
- Raised railroad elevation

Policy Changes:
- New impervious surface standards

North Pine Creek Road

Summary of Alternatives Considered

Strategy	Applicability	Status
Detention and Infiltration Park	High	Rejected due to proximity to river and approved site development.
Modifications to Network	Medium	Not being considered at this time.
New Pump Stations	Medium	Not Being Considered at this time
Maintenance of Existing Drainage	Medium	Being considered as a part of a universal strategy to ensure system efficiency.
Warning and Monitoring	High	Being considered as part of strategy to improve safety and data gathering at underpasses.
Raising Base Elevation	Medium	Rejected due to low existing bridge clearance.
New Overpass	Medium	Being considered as part of a long-term strategy to create redundancy for Unquowa road and having second over pass over the rail line.

North Pine Creek Road: New Overpass – Option 1

In an attempt to establish a second 'flood-proof' connection across the New Haven Line the construction of a new overpass was considered. Of the four underpasses included in the study area North Pine Creek Road provides the most favorable geometry for construction of a new overpass. Distance between the rail line and I-95 and the rail line and the Post Road were considered in determining preliminary feasibility and eliminated all but North Pine Creek Road.

North Pine Creek Road has the added advantage of being the least susceptible to inundation-based flooding. The corridor generally floods from the south and east with water moving up the drainages (Pine Creek and Ash Creek).

Flooding from this direction may block a path of egress to the north and east, including Post Road and Benson Road, forcing to people to seek a western evacuation route. Adding a second overpass in this corridor at Pine Creek Road would help to provide easier access.

It is assumed that for both alternatives, the roadway bridge structure depth is 5 feet. The required vertical clearance over the railroad is 22.5 feet while the required vertical clearance over Post Road is 16.5 feet.

For Option 1, South Pine Creek Road would rise vertically starting south of Post Road. The new overpass bridge would go over both Post Road and the railroad and make it back under I-95. The maximum grade of South Pine Creek Road is kept at or below 5%. This alternative is viable, however, it would require the acquisition of all the properties that have driveway access along South Pine Creek Road between Lindbergh Court and Post Road, including those along Pleszko Place.

North Pine Creek Road: New Overpass – Option 2

Option 2 includes an entirely new constructed road that would be located north of Post Road between Sasco Hill Road and South Pine Creek Road. It would go over the railroad and back under I-95. This alternative's maximum grade is kept at 5% or below.

Option 2 has been selected as the preferred new overpass alternative at North Pine Creek Road. This alternative would be less costly than option 1 since there would be fewer right-of-way costs. Option 1 involves raising the elevation along South Pine Creek Road, which would require the acquisition of all the properties that have driveway access along South Pine Creek Road between Lindbergh Court and Post Road, including those along Pleszko Place.

Option 2 is more viable option since it minimizes impacts to existing properties.

Assessment of a New Overpass Using PERSISTS Decision Support Criteria:
PERMITTABLE: This alternative would require substantial permitting and right of way acquisition to implement, making it possible but difficult to construct.

EQUITABLE: This alternative would provide substantial resilience benefits to the community while minimally impacting existing properties.

REALISTIC: This alternative has good engineering feasibility but would be costly to implement limiting its viability.

SAFE: The addition of a second overpass within the study area would improve evacuation opportunities for residents south of the New Haven Line.

INNOVATIVE: This alternative investigated multiple alignments to develop horizontal and vertical geometry to reduce impacts.

SCIENTIFIC: This alternative responds to projected flooding in the eastern end of the study area that would limit egress to the east in the event of coastal flooding, potentially making Unquowa Rd the only viable evacuation route. This alternative would provide a second non-floodable route.

TRANSFERABLE: The New Haven Line extends the length of the Connecticut shoreline; many communities face similar flooding concerns where a new overpass could address similar flooding concerns.

SUSTAINABLE: This alternative does not fully support the 'sustainable' criteria due to its high costs and limited public support.

Mill Plain Road

Warning and Monitoring System: Public feedback indicated that it was often difficult to know whether an underpass was flooded until reaching the underpass. A warning system will help notify drivers ahead of time that the road is not passable.

Widened Underpass and/or Raising the Base Elevation: Widening the underpass would essentially increase the volume of the 'basin' and lower depth of flooding. While it wouldn't eliminate the impacts of more severe flooding it could reduce them and prevent the need for road closures with less severe flooding. It would also provide an opportunity to add a sidewalk on the west side of the road and widen the sidewalk on the east.

Permeable Pavement: Approximately half of the Fairfield Train Station parking lot slopes towards Mill Plain Road. It is likely that some of the runoff is accumulating in the catch basins at the underpass. Pervious or porous pavements could reduce runoff by infiltrating storm water directly into the ground.

Storm Water Restoration: Marshes are very good at absorbing stormwater runoff and dampening storm surges. However, over time these natural systems maybe affected by land development and may require intervention to restore their ecological function. This nature-based solution may improve the capacity of the system to naturally store stormwater.

Maintenance of Existing: Routine cleaning of the existing drainage network could help mitigate localized flooding from smaller rain events temporarily, until a better solution can be implemented.

Summary of Alternatives Considered

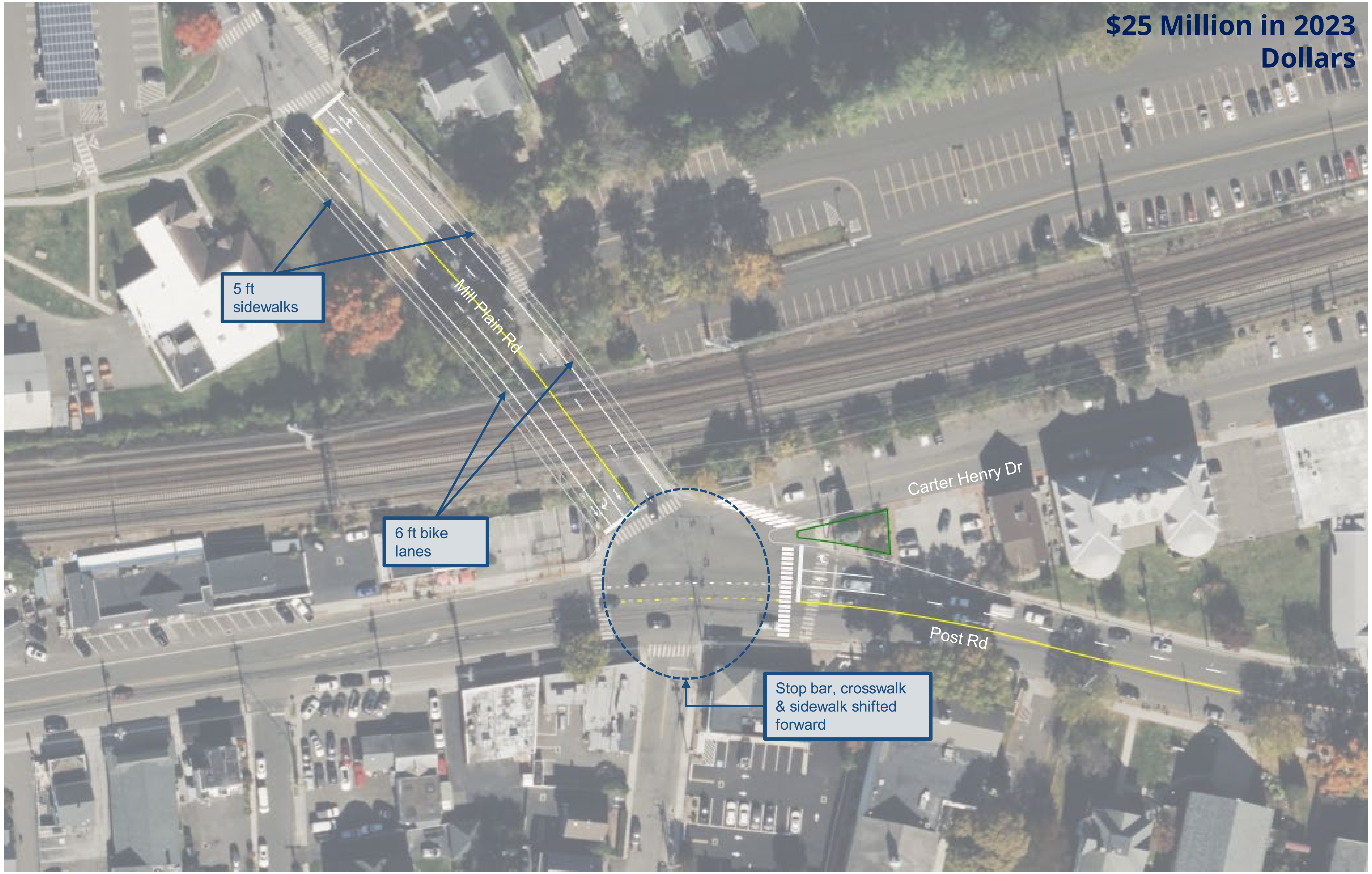
Strategy	Applicability	Status
Bio-Swales	Medium	Being considered in the form of dry tree wells.
Permeable Pavement	High	Being considered to increase infiltration and reduce runoff from station parking.
Stormwater Restoration	High	Not being considered at this time.
Modifications to Network	Medium	Being considered as part of a universal strategy to upsize system capacity.
Maintenance of Existing Drainage	Medium	Being considered as part of a universal strategy to ensure system efficiency.
Warning and Monitoring	High	Being considered as part of a strategy to improve safety and data gathering at underpasses.
Widening of Underpass	Medium	Being considered as part of a strategy to improve flood resilience and multi-modal connectivity
Raising Base Elevation	Medium	Rejected due to low existing bridge clearance.

Mill Plain Road - Widened Underpass

The underpass at Mill Plain Road experiences a high frequency of flooding due to inland overflow from high intensity rainfall events, as well as inadequate stormwater infrastructure. In addition to egress concerns caused by the flooding, the underpass is also narrow and affords limited bike and pedestrian amenities. This corridor connects between downtown Fairfield and the middle and high school campuses to the north.

Widening the underpass would work to improve the safety of the corridor by including sidewalks and bike lanes on both sides of Mill Plain Road. It would be the intent that the improved bike and pedestrian facilities would be extended on either side of the underpass to the area at Fairfield Ludlowe High School. On Post Road, the stop bar, crosswalk, and sidewalk will be shifted forward as well.

The widened underpass will also work to mitigate flood impacts by creating a larger surface area for the stormwater to accumulate, reducing the likelihood of road closures. While this alternative won't eliminate the impacts of more severe flooding, it will help alleviate some of the flooding that occurs and would provide significant co-benefits by also improving the bike and pedestrian accommodations between downtown and the middle and high school campuses.



Mill Plain Road - Widened Underpass

Assessment of a Widened Underpass at Mill Plain Road Using PERSISTS Decision Support Criteria:
PERMITTABLE: This alternative would require significant coordination between state agencies and rail operators.

EQUITABLE: This alternative would provide significant resilient corridor benefits through enhancing bike and pedestrian connectivity in addition to its flood mitigation potential.

REALISTIC: This alternative presents some engineering and staging challenges given its impacts to an active rail corridor.

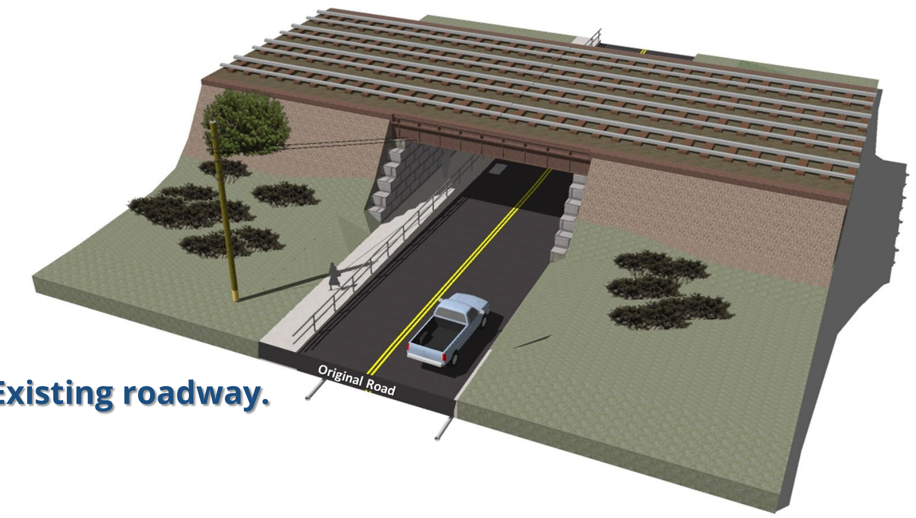
SAFE: The alternative would significantly improve the safety of the corridor for cyclists and pedestrian moving through the area.

INNOVATIVE: This alternative addresses the flooding concern from a new direction and focuses on alternative modes and views the road flooding mitigation as a secondary concern.

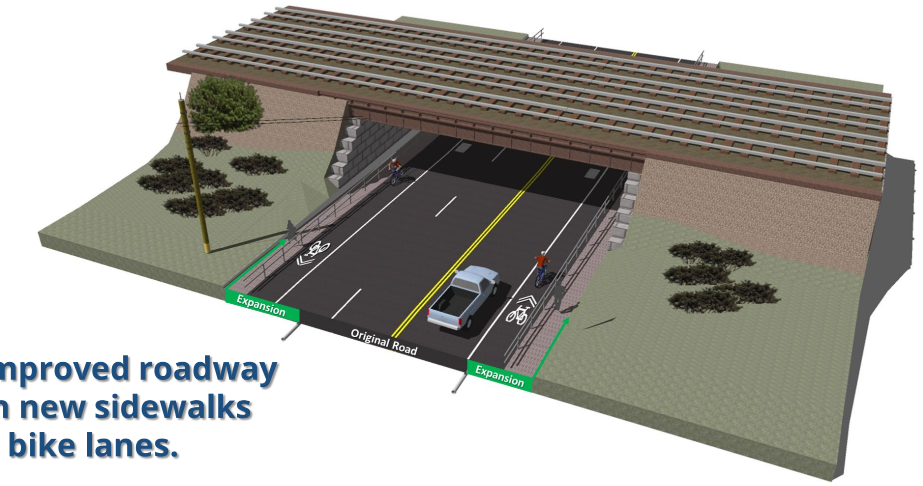
SCIENTIFIC: This alternative responds to the 'resilient corridor' focus of CIRCA by improving safety for multimodal users.

TRANSFERABLE: The New Haven Line extends the length of the Connecticut shoreline; many communities face similar flooding concerns and underperforming bike and pedestrian networks.

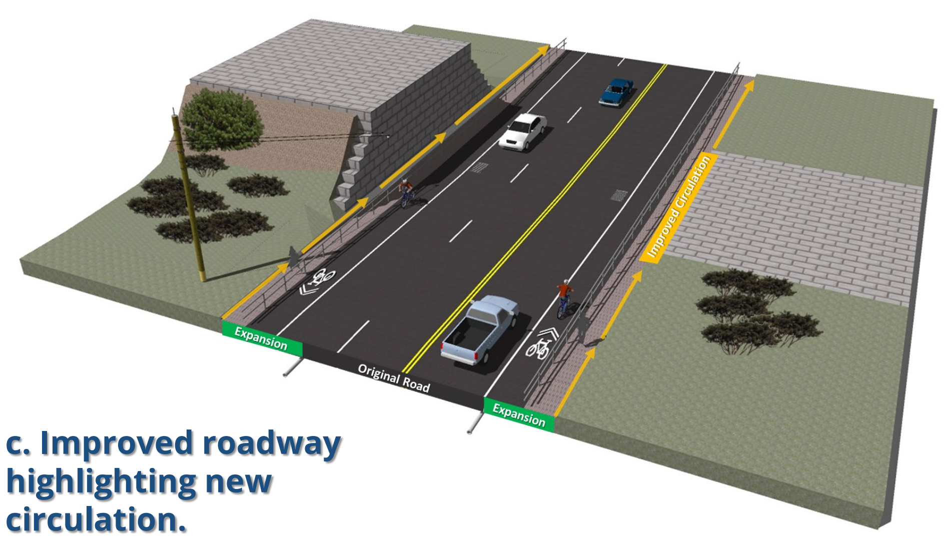
SUSTAINABLE: There has been public support for alternative pedestrian/bicycle facilities. It is considered sustainable since it benefits the surrounding environment and society.



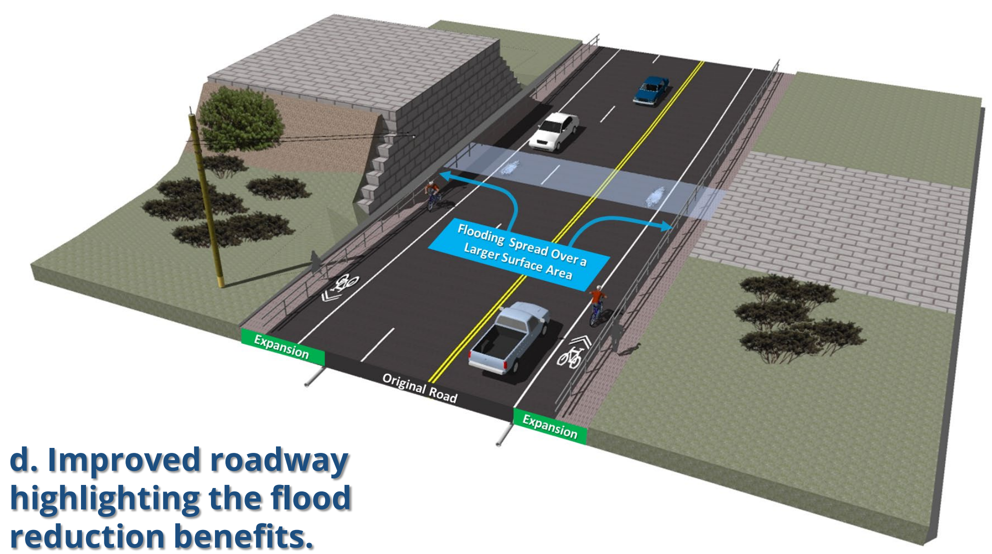
a. Existing roadway.



b. Improved roadway with new sidewalks and bike lanes.



c. Improved roadway highlighting new circulation.



d. Improved roadway highlighting the flood reduction benefits.

Mill Plain Rd – Green Infrastructure Options

Green infrastructure (GI) retrofits to the Fairfield Rail Station parking lot are proposed as part of the strategy for Mill Plain Rd to mitigate runoff entering the drainage network. The existing parking lot is paved with asphalt and the western portion of it slopes towards Mill Plain Rd. Stormwater runoff from the parking lot enters the Mill Plain Rd drainage network under the New Haven Line. This alternative proposes a combination of pervious pavement and tree vaults to increase retention and possibly infiltration of stormwater runoff onsite, thereby reducing the total volume of stormwater entering the drainage network.

The successful implementation of these green stormwater retrofits would depend on early coordination with owners, operators, and users of the rail station parking lot. Options for temporary parking could help to bolster community support for the project especially during construction. Long-term maintenance after construction will be necessary to ensure the devices continue to function properly. Through this alternative there is the possibility for shared benefits to both the railroad owners/operators and the Town of Fairfield.

Additional soils and geotechnical investigation will be necessary to determine the infiltration capacity of the existing subsurface; establish a survey of existing underground utilities; and the health of existing trees as an indicator of potential for successful tree vaults.

Use of stormwater tree trenches in Phila., PA

Maintenance of a type of permeable parking surface in Philadelphia, PA

Suggested layout option: solid dots indicate possible tree vaults, and dashed lines indicate a possible location for permeable pavement. Layout is dependent on subsurface investigation.

Assessment of Green Infrastructure Alternatives Using PERSISTS Decision Support Criteria:

PERMITTABLE: The location's distance from FEMA flood zones is favorable due to reduced likelihood of coastal flooding. State and local permits may apply. Federal permits may be required depending on project funding.

EQUITABLE: This alternative would distribute benefits between the rail station parking lot and to drivers using Mill Plain Rd. Community engagement will be essential during construction.

REALISTIC: A moderate cost is expected for design and construction due to the location. The cost of maintenance must also be considered.

SAFE: Mill Plain Rd is a coastal evacuation route. The alternative has the potential to improve safety at the nearby underpass by reducing the severity of localized stormwater flooding from runoff.

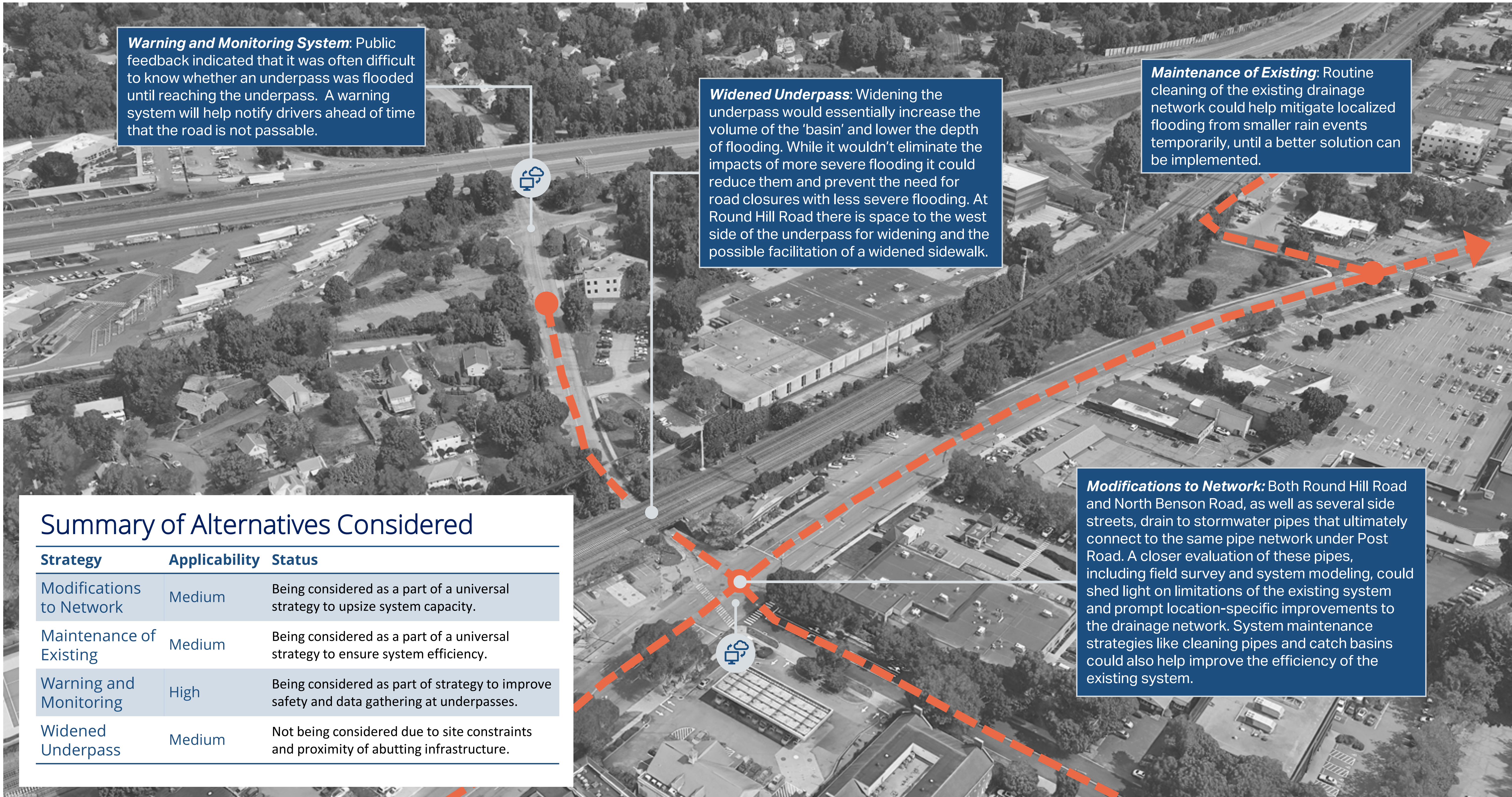
INNOVATIVE: This alternative would leverage nature-based stormwater solutions. It can be combined with other alternatives for maximum benefit to safety.

SCIENTIFIC: This alternative responds to best available climate science.

TRANSFERRABLE: Due to the highly visible location along a major commuter rail line, the alternative has the potential to extend beyond the local community by benefiting all users of the rail station.

SUSTAINABLE: Strategic use of tree vaults could help offset emissions through carbon sequestration over the lifetime of the alternative. The trees and stormwater retention/infiltration devices would provide ecosystem services and improve ecological function.

Round Hill Road



Summary of Alternatives Considered

Strategy	Applicability	Status
Modifications to Network	Medium	Being considered as a part of a universal strategy to upsize system capacity.
Maintenance of Existing	Medium	Being considered as a part of a universal strategy to ensure system efficiency.
Warning and Monitoring	High	Being considered as part of strategy to improve safety and data gathering at underpasses.
Widened Underpass	Medium	Not being considered due to site constraints and proximity of abutting infrastructure.

North Benson Road

Summary of Alternatives Considered

Strategy	Applicability	Status
Bioswales	Medium	Being considered increase infiltration of storm water flowing from the I-95 NB on ramp.
Detention and Infiltration Park	High	
Modifications to Network	Medium	Being considered as a part of a universal strategy to upsize system capacity.
Maintenance of Existing	Medium	Being considered to ensure system efficiency.
Warning and Monitoring	High	Being considered to improve safety and data gathering at underpasses.
Widening the Underpass	Medium	Being considered as part of a strategy to improve flood resilience and multi-modal connectivity

North Benson Road - Widened Underpass

The underpass at North Benson Road experiences the most severe flooding of the four underpasses in the study area and is the only underpass at risk from storm surge/inundation-based flooding (from Ash Creek). The underpass currently does not provide dedicated pedestrian or bicycle facilities, with a narrow sidewalk terminating at either end of the bridge. Benson Road serves as a critical north-south corridor between Fairfield University to the north and downtown Fairfield to the south; adding pedestrian and bicycle accommodations would improve safety for many road users.

Under this alternative the underpass would be widened to accommodate sidewalks and bike lanes. These improvements would lay the groundwork for better connectivity to Fairfield University. The new underpass configuration, including the sidewalks and bike lanes, would be similar to those depicted for Mill Plain Road.

The widened underpass will also work to mitigate flood impacts by creating a larger surface area for the stormwater to accumulate, reducing the likelihood of road closures. While this won't eliminate the impacts of more severe flooding, it will help alleviate some of the flooding that occurs and would provide significant co-benefits by also improving the bike and pedestrian accommodations between downtown and the middle and high school campuses.

PERSISTS Framework:

PERMITTABLE: This alternative would require significant coordination between state agencies and rail operators.

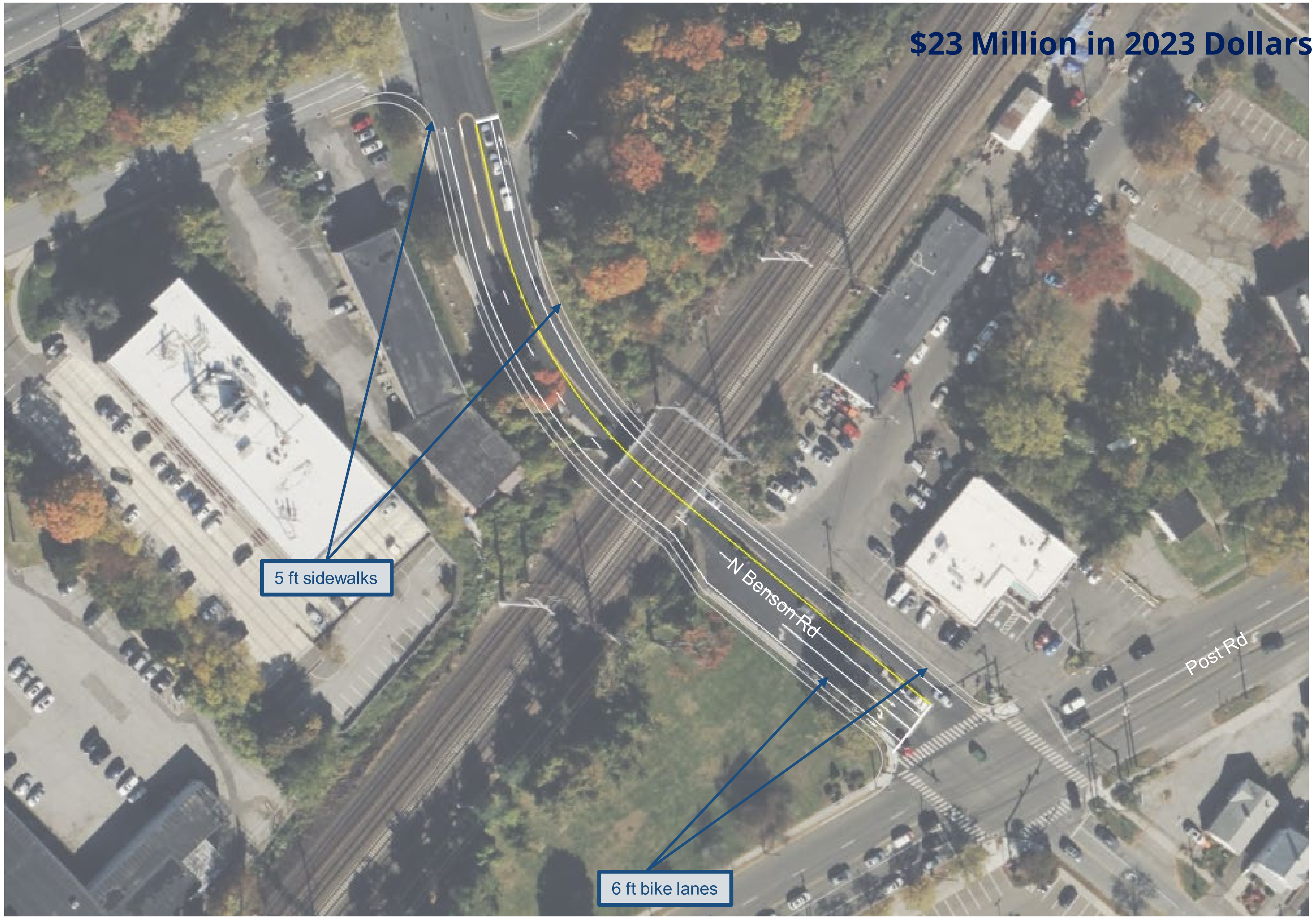
EQUITABLE: This alternative would provide significant resilience benefits through its bike and pedestrian enhancements in addition to its flood mitigation potential.

REALISTIC: This alternative presents some engineering and staging challenges given its potential impacts to an active rail corridor.

SAFE: The alternative would significantly improve the safety of the corridor for cyclists and pedestrian moving through the area.

INNOVATIVE: This alternative addresses the flooding concern from a new direction and focuses on alternative modes of travel with the road flooding mitigation as a secondary concern.

SCIENTIFIC: This alternative responds to projected flooding in the eastern end of the study area that could limit evacuation to the east, potentially making Unquowa Rd the only viable evacuation route. This alternative would provide a second non-floodable route.



SCIENTIFIC: This alternative responds to projected flooding in the eastern end of the study area that could limit evacuation to the east, potentially making Unquowa Rd the only viable evacuation route. This alternative would provide a second non-floodable route.

TRANSFERABLE: The New Haven Line extends the length of the Connecticut shoreline; many communities face similar flooding concerns and underperforming bike and pedestrian networks.

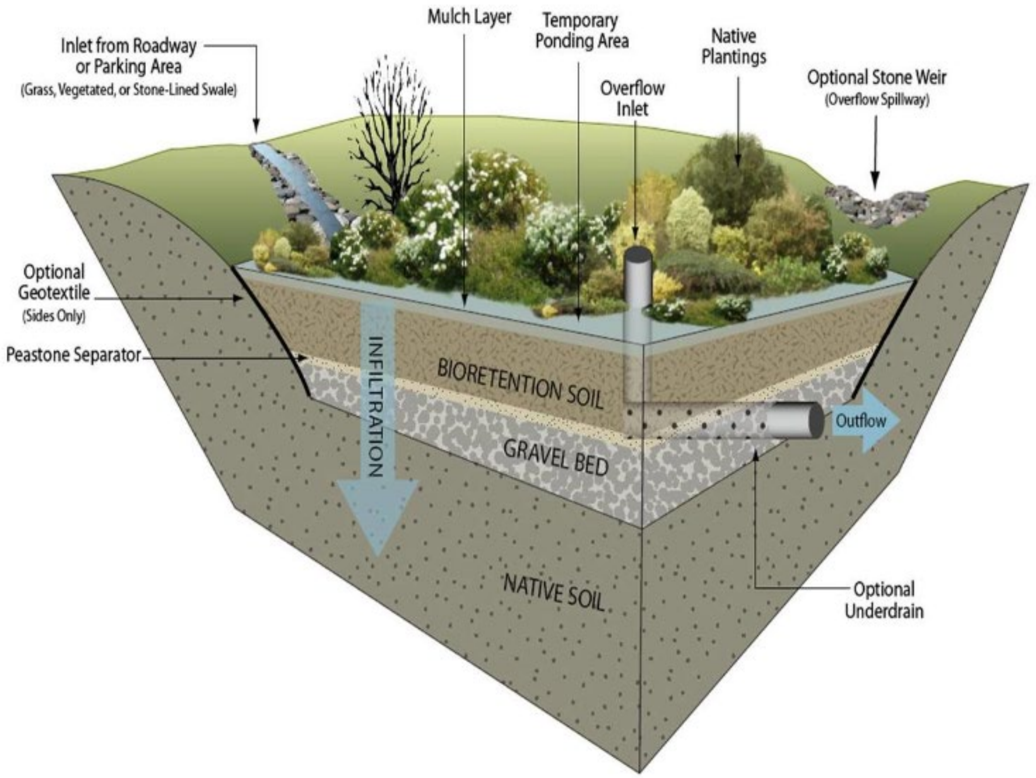
SUSTAINABLE: For this alternative, there has been public support for pedestrian/bicycle facilities. It is considered sustainable since it benefits the surrounding environment and society.

North Benson Rd - Green Infrastructure Options

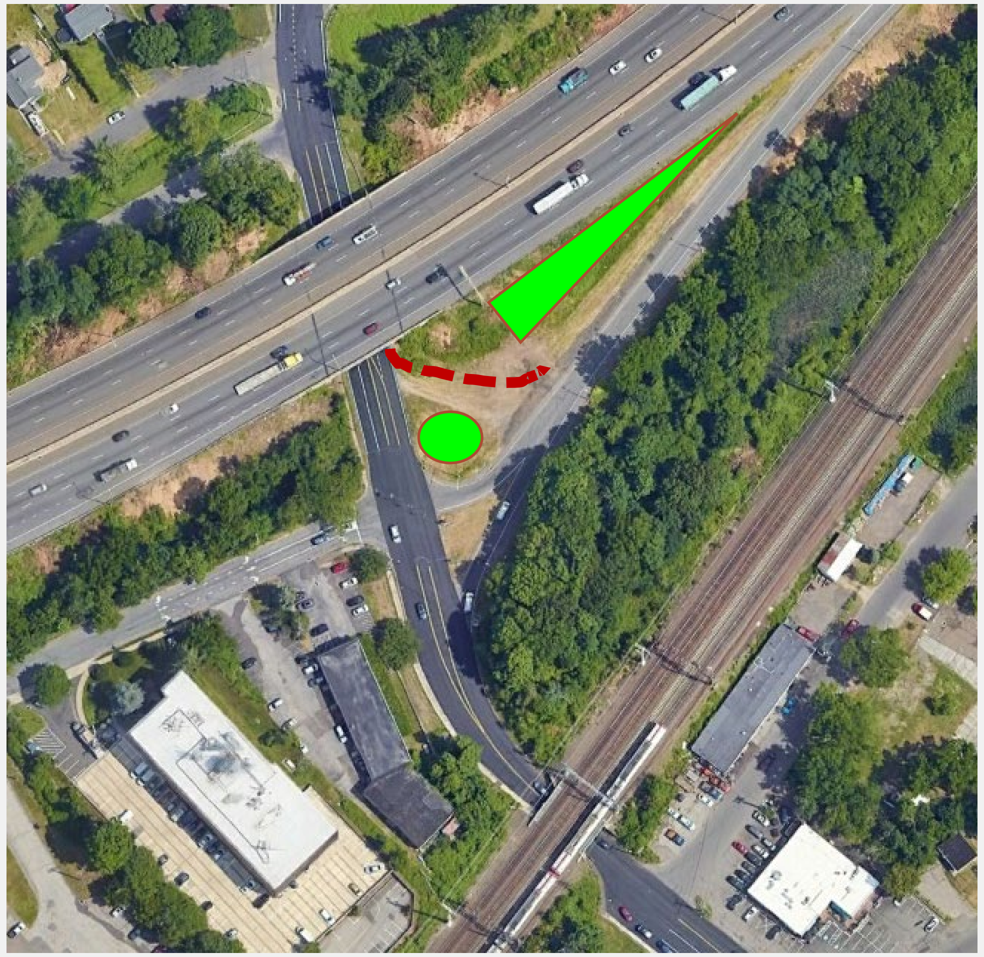
Green infrastructure (GI) retrofits to the I-91 northbound on-ramp median are recommended to increase infiltration of stormwater from the highway entering the drainage system on North Benson Rd. This alternative proposes the construction of a bioswale and a bio-infiltration basin near the ramps on North Benson Rd, reducing the rate and volume of stormwater entering the existing drainage network. A bioswale could help mitigate peak flows, while a bio-infiltration basin could help promote stormwater runoff retention, storage, and infiltration from smaller, more frequent storm events. This alternative, like other GI alternatives, will not address major flood hazard events or flooding from coastal storm surge.

The successful implementation of these green stormwater devices would depend on early coordination with owners and operators of the land adjacent to the highway. Highway ramp access would need to be maintained during construction. Long-term maintenance of the GI devices following construction would be necessary to ensure the devices continue to function as designed. There is an opportunity through this alternative for collaboration and shared benefits to both the highway owners/operators and the Town of Fairfield.

Some technical considerations for this alternative include the infiltration capacity of the existing soils adjacent to the highway; the stability of the sloping highway embankment; and the presence or absence of existing subsurface utilities (including but not limited to buried communication lines and stormwater pipes). A pathway for maintenance vehicles to access the site could help facilitate effective and routine landscaping maintenance in a way needed to support the devices' long-term functionality.



Suggested layout option: green circle indicates a possible basin location, and triangle indicates a possible location for a bioswale. The red dashed line indicates a possible pathway for maintenance access. The final layout would ultimately depend on the results of subsurface field investigation.



Assessment of Green Infrastructure Alternatives Using PERSISTS Decision Support Criteria:

PERMITTABLE: The location's distance from FEMA flood zones makes it more favorable than others (for example, Jennings Park). State and local permits will apply. Federal permits may be required.

EQUITABLE: This alternative would provide the most benefit to drivers using North Benson Rd and to commercial business owners on or near Benson Rd.

REALISTIC: A low cost for design and construction is expected compared to other types of alternatives.

SAFE: Benson Rd is a coastal evacuation route. The alternative may improve safety at the nearby underpass by reducing the severity of localized stormwater flooding from runoff.

INNOVATIVE: This alternative would leverage nature-based stormwater solutions and can be combined with other alternatives for maximum benefit.

SCIENTIFIC: This alternative could utilize the latest precipitation and climate data in planning and design.

TRANSFERRABLE: Surface GI stormwater treatments may be implemented in a variety of locations within and outside of the Town of Fairfield after considering site suitability.

SUSTAINABLE: Construction and materials would be associated with a carbon emissions footprint, however vegetation plantings in the devices could help offset some of these emissions through carbon sequestration, provide ecosystem services, and improve ecological function.

Benefit-Cost Analysis

The preliminary benefit-cost analysis was conducted using the USDOT Benefit-Cost Analysis (BCA) Guidance for Discretionary Grant Programs as a guide for preferred methods and monetized values. The parameters of the benefits analysis follow the protocols set by the Office of Management and Budget (OMB) Circular A-94 as well as the recommended benefit quantification methods by the USDOT. Generally, standard factors and values accepted by Federal agencies were used for the benefits calculations except in cases where more project-specific values or prices were available. As more data becomes available it can be added to the analysis to provide a more accurate estimation.

A custom model was developed to estimate the future costs and benefits for the proposed project over a 20-year analysis period, with benefits starting in 2026. The benefits and costs are expressed in constant 2024 dollars, which avoids forecasting future inflation and escalating future values for benefits and costs. The gross domestic product chained price index from the OMB and deflators from guidance were used to adjust cost estimates or price values into 2024-dollar terms. The use of constant dollar values requires the use of a real discount rate for discounting to the present value. Projects expecting to use Federal funding are required to use a 7 percent discount rate. All benefits and costs were discounted to a 2024 base year.

The BCA includes five benefit categories – residual value, vehicle damages avoided, delays avoided, emergency response delays avoided, and amenities. The conditions without the project or the "baseline" are flooding six times a year for approximately four hours. By mid-century this increases to ten times a year for six hours. There is also assumed to be one vehicle lost to damages from flooding each year, and this increases to two vehicles by mid-century.

Delay times were estimated for each road based on their AADT and detour routes. To estimate emergency response delays, methodology provided by FEMA was followed and focused on the population served by the Fairfield Fire Department located on the opposite side of the railroad.

Each alternative was assumed to fully eliminate detours and vehicle damages in the case of a flood event. This was done to simplify analysis, its likely that not all alternatives will eliminate all flooding impacts. Additionally, benefits related to improved connectivity and multi modal access were not considered by this quantitative analysis but are qualitatively reflected in the results and recommendations section.

The tables to the right and on the following page summarize the benefit cost assessment for the four underpasses.

North Pine Creek Road

Strategy	BCA Ratio	Next Steps
Flood Warning System	2.5	Recommended for implementation and for the town to seek grant funding mechanisms, even without flood mitigation, benefits significantly exceed costs.
New Overpass	0.2	Not recommended to be pursued at this time due to the high cost. The town should reconsider if future flooding outpaces current modeling.

Mill Plain Road

Strategy	BCA Ratio	Next Steps
Flood Warning System	2.1	Recommended for implementation and for the town to seek grant funding mechanisms, even without flood mitigation, benefits significantly exceed costs.
Widened Underpass	0.2	Not recommended to be pursued at this time due to the high cost. The town should reconsider if future flooding outpaces current modeling.
Green Infrastructure Options	1.9	Recommended for further investigation. The town should consider conducting a site feasibility study to complete a geologic survey.
Drainage Improvements	1.3	Recommended for further investigation, consider combining work with Unquawa Road area drainage project.

Round Hill Road

Strategy	BCA Ratio	Next Steps
Flood Warning System	2.3	Recommended for implementation and for the town to seek grant funding mechanisms, even without flood mitigation, benefits significantly exceed costs.
Drainage Improvements	2.0	Recommended for further investigation, would be completed in conjunction with the North Benson Road improvements since they are a combined network.

North Benson Road

Strategy	BCA Ratio	Next Steps
Flood Warning System	2.5	Recommended for implementation and for the town to seek grant funding mechanisms, even without flood mitigation, benefits significantly exceed costs.
Widened Underpass	0.2	Not recommended to be pursued at this time due to the high cost. The town should reconsider if future flooding outpaces current modeling.
Green Infrastructure Options	2.8	Recommended for further investigation to determine feasibility.

Resilient Fairfield Chapter IV:

Results and Recommendations

Resilient Fairfield began by examining existing conditions at the four railroad underpasses within the study area. These underpasses are critical north-south corridors which are being impacted by precipitation induced flooding from intense rain events. The flooding can be further exacerbated when a storm system is accompanied by a storm surge, which further hinders the functionality of the existing drainage network. Over the coming decades this flooding is expected to increase, driven by climate change. By middle of the century, Fairfield could experience 20 more days annually with 1 inch of rain or more and an additional 1.6 feet of sea level rise. The investigated alternatives work, from multiple angles, to mitigate the flooding currently being experienced by the community and ensure improved resilience towards future flood events.

Goals for Alternative Development

Increase infiltration through reduced impervious surface	Detain excess stormwater with green infrastructure solutions	Improve safety for residents and other road users	Increase drainage network capacity	Prioritize resilient evacuation routes

Strategies By Location:

North Pine Creek Road:

- Warning and monitoring system
- New overpass

Mill Plain Road:

- Warning and monitoring system
- Widened Underpass
- Green Infrastructure
- Drainage Improvements

Round Hill Road

- Warning and monitoring system
- Drainage Improvements

North Benson Road

- Warning and monitoring system
- Widened Underpass
- Green Infrastructure
- Drainage Improvements

Key Takeaways

Flood Warning Systems— Flood Warning Systems, ideally including gates that physically impede drivers from driving through flooded underpasses, have significant potential to keep the community safe and limit property damage. Strategic investment in such systems at these four underpasses would help Fairfield staff to assess how such systems could be integrated into the existing emergency management system before wider adoption citywide or regionally.

Policy Changes—Though infrastructure recommendations are crucial, policy shifts also should play an important role in taking the pressure off the infrastructure. For example, while wider stormwater pipes or widening an underpass may be required, policy can ensure that new developments include a sufficient quantity and type of Green Infrastructure, which absorbs a greater quantity of water before the water enters pipes and the wider network. Examples of Green Infrastructure include bio-swales; permeable pavements; and detention and infiltration parks.

Positive policy changes can also take the form of updated stormwater drainage standards that would allow Fairfield to withstand the more intense storms and storm surges of the coming century.

Other Key Points

1. Existing station parking at Fairfield Station offers a greater opportunity for green infrastructure than along North Benson Road (at Jennings Park specifically).
2. The North Pine Creek Road overpass is technically complicated, may require land, and would be expensive. It is less likely to be successfully completed.
3. Widened underpasses, such as the widened underpass proposed at North Benson Road, Round Hill Road, and Mill Plain Road, offer the potential to improve bicycle and pedestrian facilities in an uncomfortable location. In this way, these are as much transportation projects as flood protection projects.

Next Steps

This document has outlined some potential projects to mitigate the flooding experienced in Fairfield's downtown. A clear next step is reviewing the identified alternatives for potential discretionary grant funding. The following page outlines some potential grant funding sources that identified alternatives would be eligible for.

Funding Opportunities

As noted, recommendations include three primary measures to address and prepare for flooding at the four underpass locations: green infrastructure, flood control and infrastructure modifications. Alternatives such as flood warning systems, drainage improvements and overpass modifications are included among those measures. Implementation of the recommendations will require further planning and design prior to construction, all of which are expected to result in significant expenditures.

Absent direct local funding, the community will need to consider alternative funding sources from various state and federal formula and discretionary grant programs. Some of these programs may be obvious – CTDOT roadway and bridge funds from state appropriations and FHWA formula funding programs, or CTDEEP's Climate Resilience Fund. However, there are numerous grant opportunities from USDOT, USEPA and the US Army Corps of Engineers that target solutions to the issues identified in this Resilient Fairfield report.

In addition, the EPA Green Infrastructure Federal Collaborative has compiled a comprehensive table of funding resources available to states and local communities. Fairfield should consider applying for these funds directly or in partnership with CTDEEP or CTDOT.

Two programs representative of the aforementioned grant opportunities are highlighted below.

Building Resilient Infrastructure and Communities
Federal Emergency Management Agency
Building Resilient Infrastructure and Communities (BRIC) supports states, local communities, tribes and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. The program's guiding principles are supporting communities through capability and capacity building; encouraging and enabling innovation; promoting partnerships; enabling large infrastructure projects; maintaining flexibility; and providing consistency.

Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation
Federal Highway Administration
The vision of the Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Discretionary Grant Program is to fund projects that address the climate crisis by improving the resilience of the surface transportation system, including highways, public transportation, ports, and intercity passenger rail. Projects selected under this program should be grounded in the best available scientific understanding of climate change risks, impacts, and vulnerabilities. They should support the continued operation or rapid recovery of crucial local, regional, or national surface transportation facilities. Furthermore, selected projects should utilize innovative and collaborative approaches to risk reduction, including the use of natural infrastructure, which is explicitly eligible under the program. Also called nature-based solutions, these strategies include conservation, restoration, or construction of riparian and streambed treatments, marshes, wetlands, native vegetation, stormwater bioswales, breakwaters, reefs, dunes, and shade trees. They reduce flood risks, erosion, wave damage, and heat impacts while also creating habitat, filtering pollutants, and providing recreational benefits. Projects in the PROTECT Discretionary Grant Program have the potential to demonstrate innovation and best practices that State and local governments in other parts of the country can consider replicating.

BELOW: Excerpt from Green Infrastructure Federal Collaborative's table of funding resources.

Green Infrastructure Federal Collaborative

Navigating Federal Funding for Green Infrastructure and Nature-Based Solutions

AGENCY	PROGRAM	PLANNING & DESIGN	IMPLEMENTATION OR CONSTRUCTION	OPERATIONS & MAINTENANCE	MONITORING
EDA	American Rescue Plan Program: Economic Adjustment Assistance Funds	YES	YES	NO	NO
EDA	Public Works and Economic Adjustment Assistance Funds	YES	YES	NO	NO
EPA	Clean Water State Revolving Fund (CWSRF)[1]	YES	YES	NO	NO
EPA	Environmental Justice Collaborative Problem-Solving Cooperative Agreement Program	YES	YES	NO	YES

Source: https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities

Underpass Summary Table

Underpass	Elevation of Bottom	Main Source of Flooding	Secondary Source of Flooding	Applicable Flood Zones
North Pine Creek Road	9.75	Stormwater runoff	Low slope	FEMA 0.2% (500-year) – source is Mill River
Mill Plain Road	9.67	Stormwater runoff	Low capacity to accept stormwater	FEMA 0.2% (500-year) – source is Mill River
Round Hill Road	7	Stormwater runoff	Low capacity to accept stormwater	FEMA 0.2% (500-year) – source is Ash Creek and Turney Creek
North Benson Road	6.11	Stormwater runoff	Low slope and submerged tidal outlets	FEMA 1% (SFHA) – source is Ash Creek and Turney Creek

Unlike most flooding in coastal communities, the underpasses adjacent to the Post Road corridor are vulnerable to significant flooding from stormwater runoff, which collects in the low elevations beneath the rail bridges and overwhelms the existing drainage network. The next phase of the study will work to develop solutions targeting the specific concerns and constraints at each underpass.

Existing Conditions Wrap-Up

The Resilient Downtown Fairfield Project is a unique opportunity to build resilience through actionable solutions while simultaneously developing a replicable approach for addressing the many flood-prone underpasses along the Connecticut shoreline. A review of the existing conditions at the four underpasses and within downtown has confirmed the vulnerability echoed by the community. The underpasses currently experience flooding due to intense rain events, and the flooding can be further exacerbated when a storm system is accompanied by a storm surge, which further hinders the functionality of the existing drainage network. Additionally, climate change will continue to increase the frequency with which the community experiences intense rainfall events and systems producing storm surges. By the middle of the century, Fairfield could experience 20 more days annually with 1 inch of rain or more and an additional 1.6 feet of sea level rise.

The impacts of climate change will place a greater strain on the community's existing drainage and flood control systems and increase the likelihood for underpass flooding within the study area.

Next Steps

The next phase of the project will work to develop strategies for combatting the flooding concerns highlighted by this investigation. A portfolio of options that addresses the existing drainage and flood control systems, incorporates green infrastructure strategies, and looks at ways underpass infrastructure can be modified to reduce their flooding potential, will be developed.

In addition to adaptive strategies, the next phase will investigate monitoring and warning systems. The existing conditions process uncovered a major data gap in the reporting of previous incidents of underpass flooding. To better predict when flooding may occur and better understand their return frequency, accurate recording of flood dates and depths will be critical.

The initial portfolio of options will be vetted through a public process and benefit cost analysis. This will help develop an understanding of which of the options are preferred by the community and provide the greatest level of protection against future flooding.