RESILIENT CONNECTICUT PHASE III:

RESILIENT PORTLAND

Final Report | February 2025

Portland, Connecticut

AECOM
Delivering a better world

Acknowledgements

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EXECUTIVE SUMMARY

PROJECT OVERVIEW

The focus area of this study is located between Freestone Avenue and Waverly Avenue off Main Street in downtown Portland.

This block contains several significant community support centers, including the Portland Public Library, Waverly Senior Center and Food Bank, and the Portland Police Station. This concentration of critical public buildings is connected by parking lots and civic green spaces, including the gazebo park by the senior center, the community playground, and a parklet that focuses on the historical significance of brownstone for the town. This municipal center experiences a higher volume of use within the Town.

The topography of this block gently slopes towards a low point (elevation 92.0) adjacent to the playground and parking lot. This low area received localized flooding during heavy rain events. In the late summer of 2023, the basement of the police station and the senior center were flooded in a heavy rainstorm event, subjecting these municipal buildings to flood damage. In addition, the study area experiences extreme high heat levels in the warmer months.

AECOM analyzed current and future conditions, as summarized in Section 3 and Appendix B, that contribute to conditions that make the study area more susceptible to drainage infrastructure failures and flooding, excessive heat risk, and public accessibility challenges. With climate change projected to raise temperatures in urban environments and the anticipated increase in extreme rainfall events in the future, this study presents conceptual adaptation options that may assist with climate relief in this community and may assist in serving as a roadmap to aid other similarly affected communities throughout New England.

Portland Senior Center Food Bank raised up storage shelves on blocks to aid flooding impacts *(Aaron Flaum/Hartford Courant)*

Downtown Portland Project Area : Waverly Ave to Freestone Ave

DESIGN OBJECTIVES

The planning and conceptual design efforts focused on the project's five objectives in addressing flooding, extreme heat and social vulnerabilities. Recommendations for the implementation strategies were developed to reduce the effects of flooding and excessive heat, as well as improve accessibility for the community connecting the transit system, neighborhood, and the critical municipal facilities at the center of the study.

1 **Reduce flood impact on the critical facilities core of the Town of Portland from effects of excessive flooding and heat.**

Image of flooding in parking lot during summer 2023 storm, where the basement of the police station and the senior center were flooded

2 **Community and stakeholder priorities should drive the selection of strategies and projects.**

Image of Portland Public Library in our study area, which is one of several local groups that have helped to consult the design group on community priorities

3 **Develop plans to reduce the frequency, area and depth of flooding by reducing stormwater runoff**

Image of Portland Library roof drainage taken during first site visit

4 **Apply future projections of precipitation events by years 2050 and 2100.**

Image of catch basin analysis needed for modelling purposes, which was performed during second site visit

5 **Reduce impacts of extreme heat for the community**

Image from senior center looking towards police station, showing lack of tree canopy in existing public green space.

RECOMMENDATIONS SUMMARY

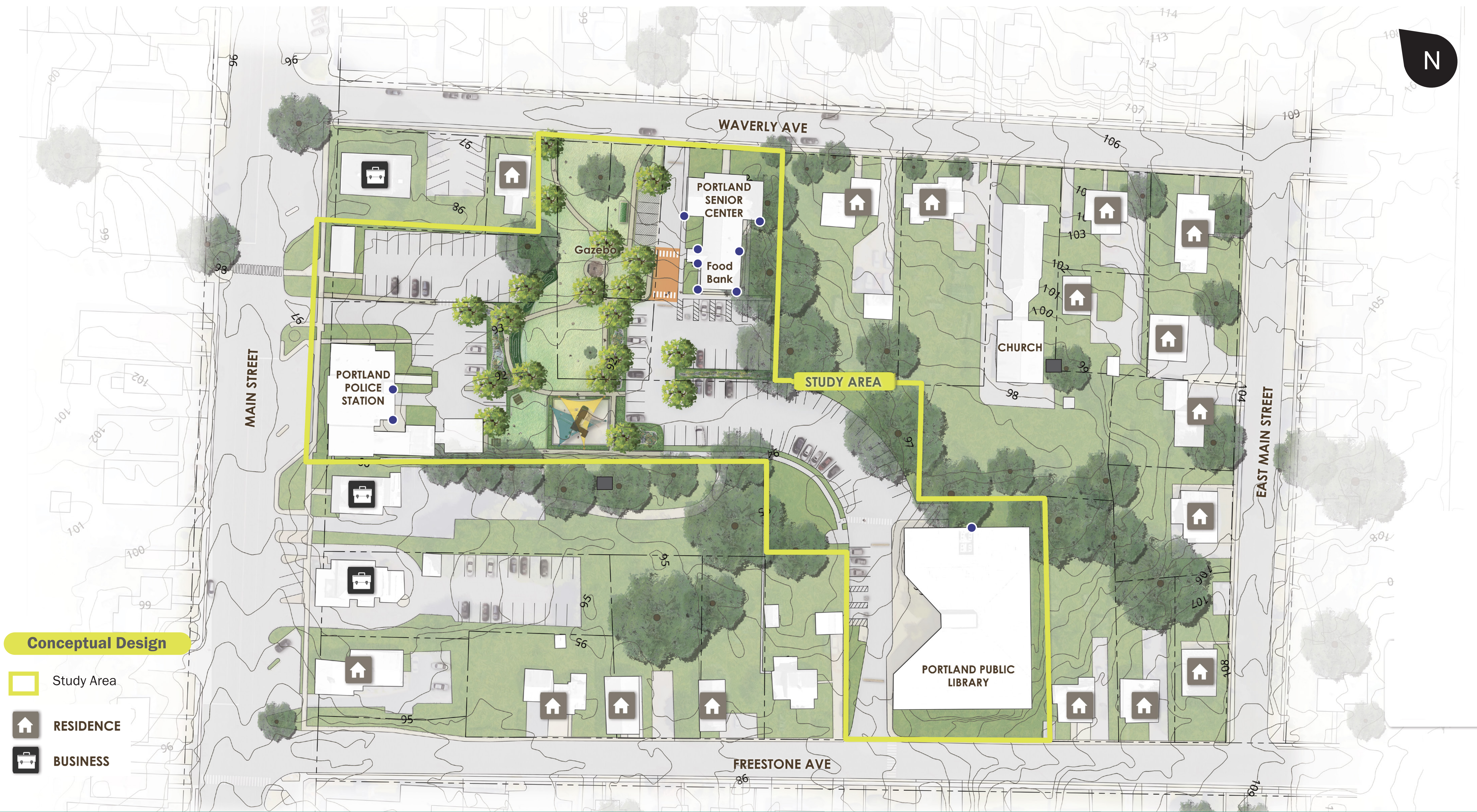
Process

Stakeholder engagement through ongoing monthly meetings with the project team and Town of Portland staff, four Advisory Committee meetings, and two Public Workshops, was a key part of developing the conceptual design priorities and alternatives that were developed for the Final Report. A Benefit Cost Analysis was developed and is summarized in **Section 4 and Appendix C**. The BCA focused on understanding options for alternatives and phasing, cost estimates, and funding opportunities. We have recommended five adaptation strategies, noted in the figure below, to address the flooding, cooling and accessibility vulnerabilities within the study area in Portland. These strategies are noted in **Section 4 'Applied Toolkit Strategies**'.

Summary

We recommend that the Town of Portland implement these strategies as shown in the Preferred Conceptual Design described in **Section 5**.

With the assistance and guidance of the Resilient Portland final report, we recommend that the Town of Portland determine whether to further the drainage system design highlighted in Alternative 1 or the expanded designs shown in Alternative 2 or Alternative 3. All three alternatives will require a further detailed study to assess the performance of the existing drainage system and right size the design elements by incorporating the recommendations from the findings. The Town should then seek and secure funding. Upon receipt of funding, we recommend that the Town undertake schematic design, refine the costs and implementation steps, and advance the project through design development, construction documentation, and implementation.



IMPLEMENTATION & ACTION PLAN

1. Seek and secure funding to further develop the design
2. Update the future conditions flood model to right size the design elements by incorporating the recommendations from the draft flood modeling findings
3. Undertake schematic design and confirm project approach with Town Leadership and the Portland community
4. Refine costs and implementation steps
5. Advance the project through design development and construction documentation
6. Develop a plan to implement the project through construction

02

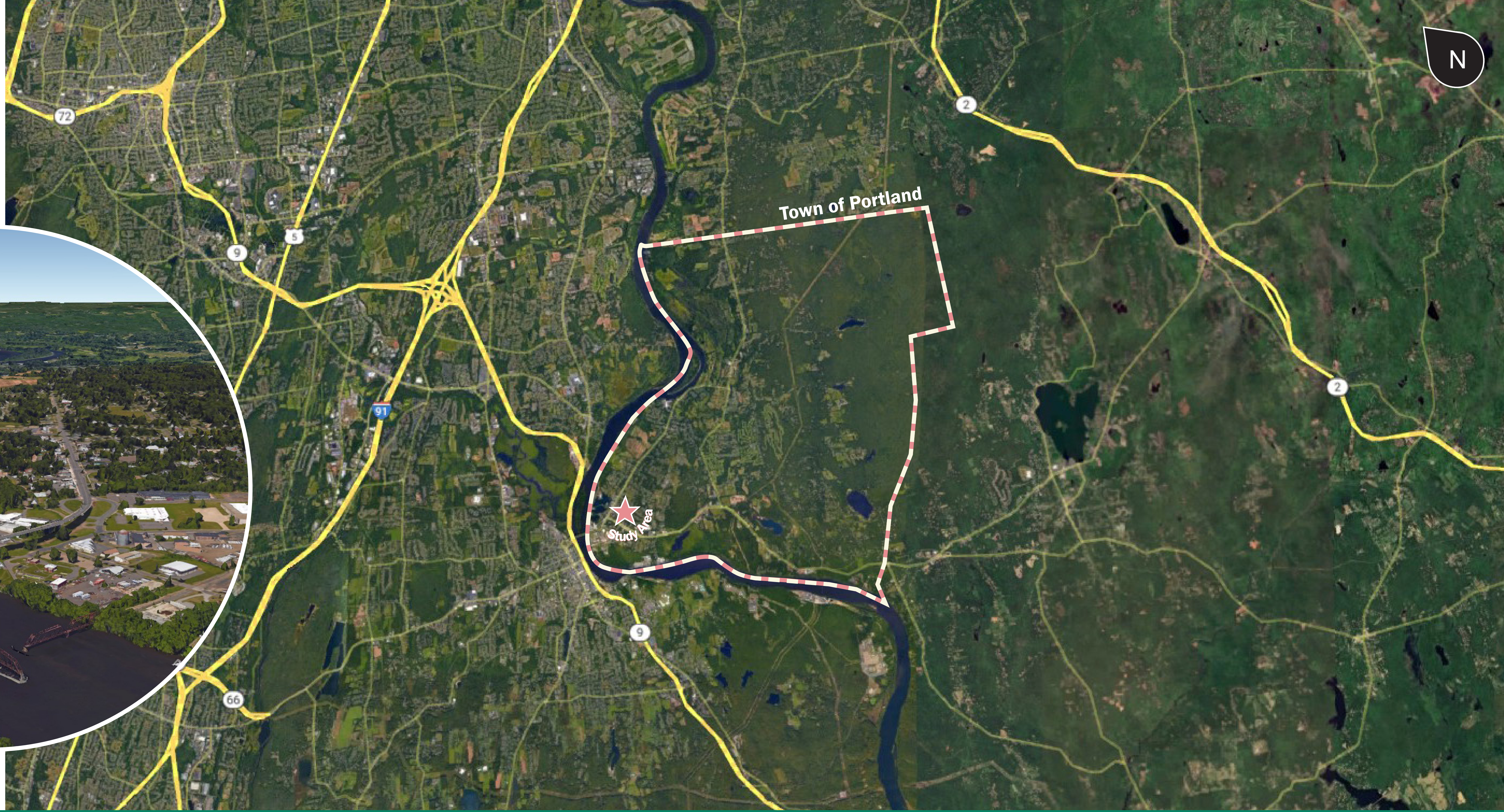
BACKGROUND & CONTEXT

TOWN OF PORTLAND, CONNECTICUT

The town of Portland is located approximately 17 miles south of Hartford along the east bank of the Connecticut River. The study area is one town block bordered by Main Street, Waverly Ave., E. Main Street and Freestone Ave., located within the Central Business District and consists of a mix of residential, business, and municipal land use.

With a population of approximately 7,000, this small town has a strong history in shipbuilding and mining brownstone from the large quarries located in the downtown. The towns' brownstone was used to construct many of the significant buildings in the major cities of the eastern United States. The quarry operation ended due to the flooding of the quarries in the 1938 hurricane.

Despite its industrial roots, Portland has shifted toward a more residential and commercial focus in recent years. The town has invested in revitalizing its downtown area, enhancing local businesses, and improving public spaces. Community initiatives have also emerged to preserve its historic architecture while promoting sustainability, such as "The Portland Clean Energy Task Force", which strives to provide the Town and its residents with options to save money and reduce harmful emissions through energy efficiency programs. Additionally, Portland's location along the Connecticut River has made it a hub for outdoor activities, attracting both residents and visitors to enjoy quarry views, hiking, and water sports.



RESILIENT PORTLAND

Resilient Portland is one of fourteen selected projects under Phase III of the Resilient Connecticut program developed by the Connecticut Institute for Resilience and Climate Adaptations (CIRCA). The partnership between CIRCA and its pilot project communities was 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. Between 2022 – 2023, Resilient Connecticut Phase II assessed regional risk and vulnerability across the RiverCOG, SECOG, and CRCOG regions of Connecticut. This assessment was done in Portland and identified several critical facilities located East of Main Street and South of Waverly Avenue within a topographic depression that commonly floods.

Phase III *(Current Phase)*

- The goal of Phase III is to solicit planning level studies to further evaluate and develop strategies to address vulnerabilities in each of the selected communities.
- Portland was selected as one of CIRCA's Phase III pilot projects based on several critical facilities in the downtown significantly impacted by heat and pluvial flooding. This area also experiences heat island impacts and could benefit from cooling corridors along pedestrian accessways from local transit.

Resilient Connecticut 2.0 Phase II

Regional Adaptation/Resilience Opportunity Areas

Name: Portland Critical Facilities
Location: Portland

Consideration	Characteristics of Area				
Flood Vulnerability	●	●	●		
Heat Vulnerability	●	●	●	●	●
Social Vulnerability	●	●	●		

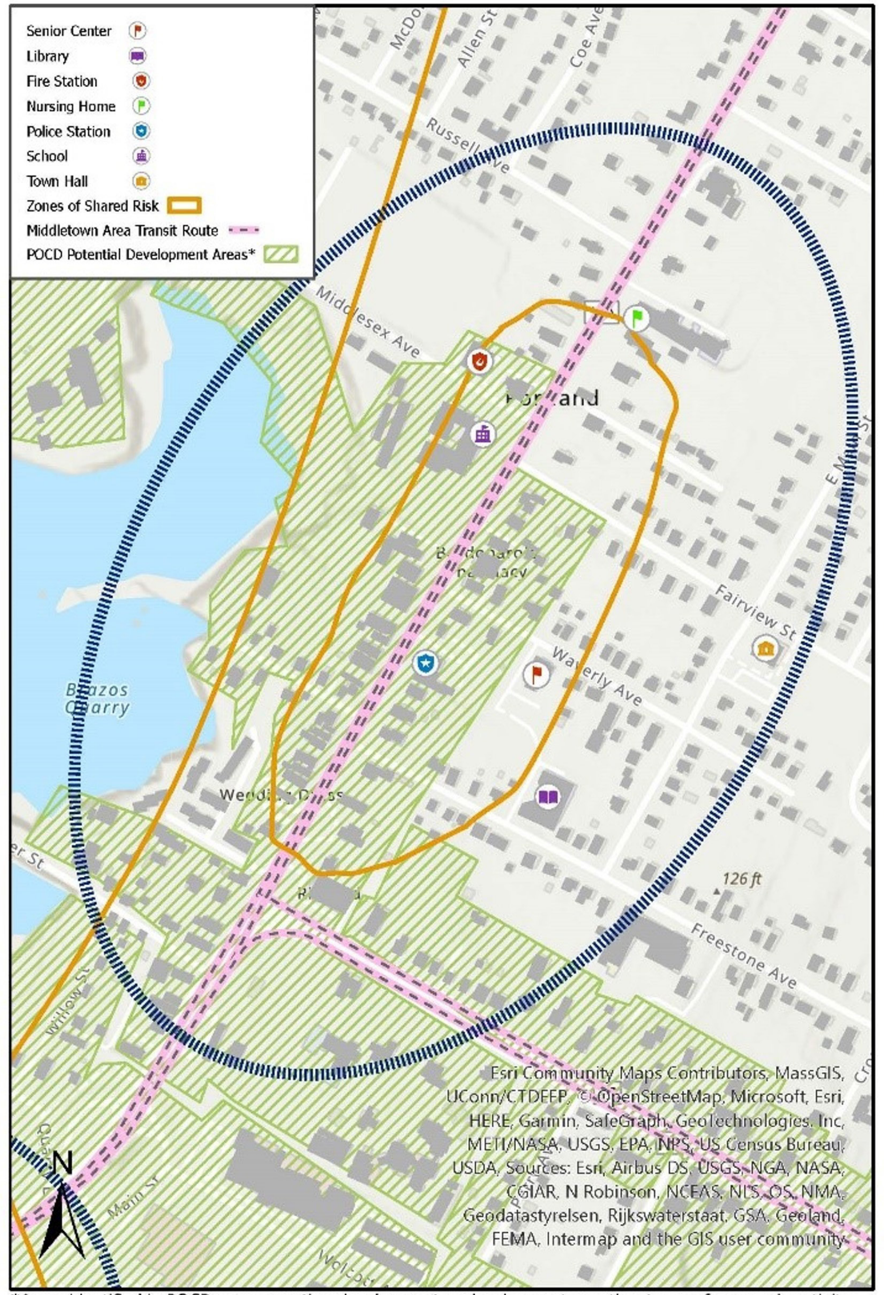
Three of Portland's critical facilities and associated parking lots -- the police department, the library, and the senior center -- experience shallow pluvial flooding after intense precipitation events. The senior center is the cooling center, warming center, and public food pantry for Portland. The area that floods is a topographic depression located on the east of Main Street and the south side of Waverly Avenue. Middletown Area Transit bus access is located on Main Street, Route 66, and High Street. Resiliency solutions for the town could have key co-benefits to advance cooling opportunities along the pedestrian accessways from transit lines to the senior center.

Portland Senior Center
Portland Police Department
Portland Public Library
Portland Town Hall

Portland Care & Rehab Center
Portland Company 1 Station
Brownstone Intermediate School

UCONN UNIVERSITY OF CONNECTICUT

CIRCA



*Areas identified in POCDs as supporting development, redevelopment, or other types of economic activity

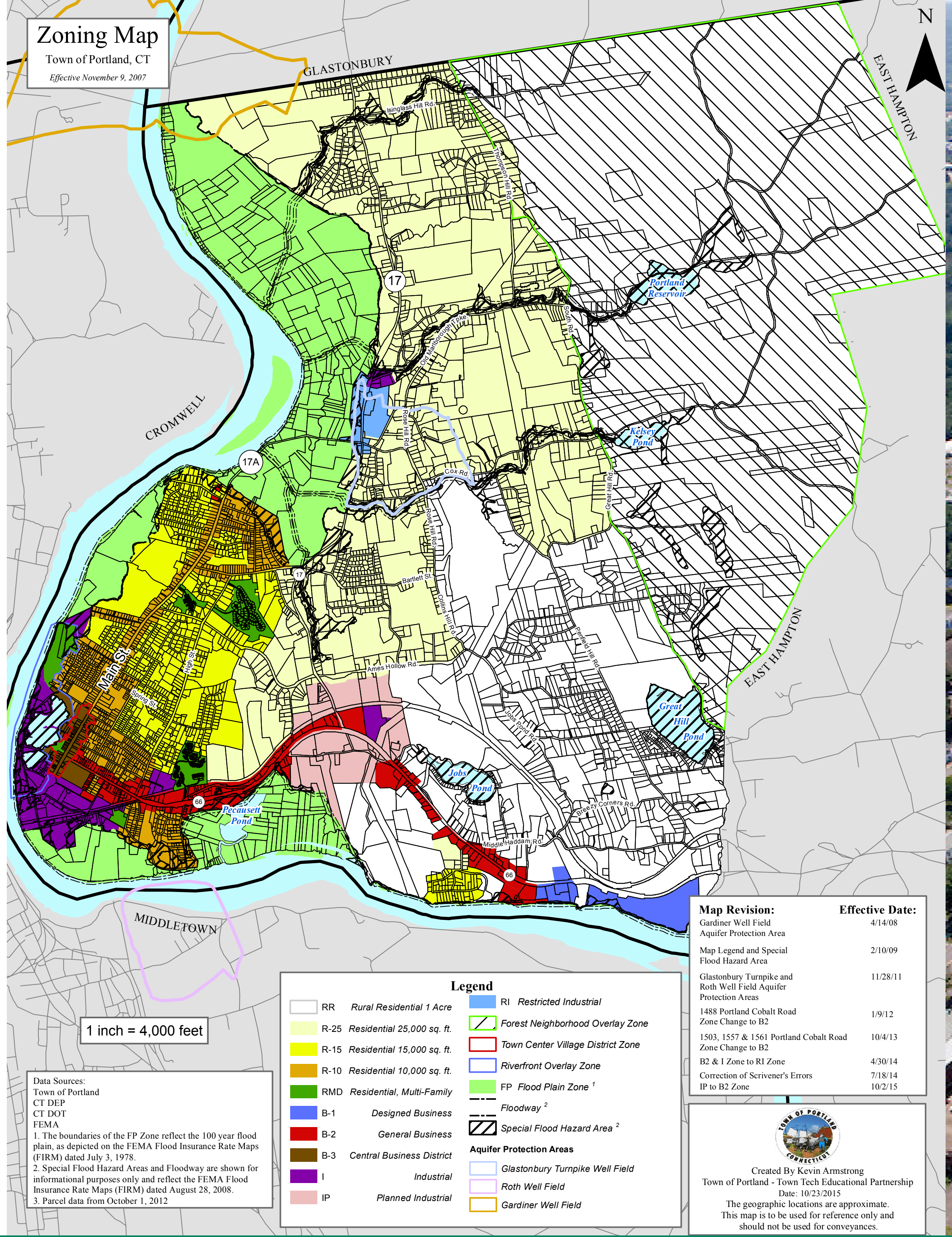
REGIONAL CHALLENGES, LAND USE & ZONING

According to the town of Portland Zoning Map, which was released in 2007, Portland is divided into fourteen landuse designations and five overlay and land protection designations. Landuse includes five residential zoning codes, three business codes, three industrial codes and five parkland and riverfront zones.

Areas of "Special Flood Hazard" are indicated on the map at the Portland Brownstone Quarry, Jobs Pond, and Great Hill Pond. In recent years residents of Jobs Pond have experienced severe flooding issues, inundating home basements and forcing many to move. NBS Connecticut reports that this previous summer nine homes had been vacated due to water damage. Despite federal funding for pump out projects ($560,000 was secured in May followed by an additional $187,000 in June), flooding is worsening throughout the region.

The focus area of this study is located partially within the "Town Center Village District Zone" and is composed of both Central Business District (B-3) and Residential, 10,000 sq ft (R-10) territories. This block, located between Freestone ave, and Waverly Ave off Main Street, is also just across the street from the Flood Hazard area indicated at the Portland Quarry, however our initial investigations have not indicated this poses additional risk.

Source: NBC Connecticut Local News, "Homes around pond in Portland still flooded; residents frustrated waiting for pumping to begin", 2024



REVIEW OF PREVIOUS TOOLS & PLANS

PORTLAND

2016-2026 Plan of Conservation and Development

IMPLEMENTATION ELEMENT

Portland Plan of Conservation and Development, 2016-2026, Implementation Element

The Implementation Element Booklet is a companion document to the “Strategic Element” of the POCD. It details the roles of “leaders” and “partners” responsible for carrying out specific policies and actions. This booklet will be updated regularly to include new items and policies and features a legend explaining the roles of “leaders” and “partners” on the back cover. It includes sections on priority issues, protecting resources, guiding development, addressing infrastructure needs, and the implementation plan. “Leaders” are those primarily responsible for executing the policies, while “partners” are other involved entities.

PORTLAND

2016-2026 Plan of Conservation and Development

STRATEGIC ELEMENT

Portland Plan of Conservation and Development, 2016-2026, Strategic Element

The Strategic Element Booklet is an updated version of the 2006 POCD, designed to guide Portland’s physical, social, and economic development over the next decade. It provides strategies to preserve the town’s character while promoting energy efficiency through adaptive reuse. The plan includes policies and action items to implement these strategies, with a focus on leveraging town policies for community revitalization and utilizing historical resources for preservation. Key initiatives include transforming the Elmcrest property into a commercial hub, improving local and state roads for better safety and accessibility, and developing the Air Line Trail and a Town Park on Route 17 to enhance recreational opportunities and protect open spaces.

The booklet is structured into three main sections. The Introduction/Executive Summary outlines the plan’s purpose, structure, and preparation strategies, along with a detailed analysis of existing conditions and zoning. The Plan Strategies section elaborates on the methods to achieve the vision, while the Conclusion/Implementation chapter covers how the plan will be executed and maintained. This comprehensive approach ensures that the plan remains relevant and effective throughout its 10-year duration, reflecting the aspirations and needs of Portland’s residents.

2021 Lower Connecticut River Valley Hazard Mitigation Plan Update

Volume 1: Planning-Area-Wide Elements

Lower Connecticut River Valley Council of Governments
145 Dennison Road Essex, CT 06426 | +1 860 581 8554 | www.rivercog.org

May 2021

Lower Connecticut River Valley Hazard Mitigation Plan, Vol 1 and Vol. 2, 2021

The Hazard Mitigation Plan describes the purpose, authority, background, and planning process for the RiverCOG region. The document outlines the importance of using long and short-term strategies to mitigate risks from natural hazards, which involves collaboration between local, state, and federal governments as mandated by the federal Disaster Mitigation Act of 2000. The plan aims to ensure sustainability and disaster resilience by integrating various local plans into a cohesive, multi-jurisdictional strategy. The 2014 updates combined previous separate regional plans, addressing both common and unique vulnerabilities across the region. The planning process included securing funding, forming committees, coordinating with stakeholders, and engaging the public to create a comprehensive risk reduction plan.

MILONE & MACBROOM RiverCOG Dewberry

Long Term Recovery and Land Use Resiliency Through Community Flood Resilience Study

Flood Susceptibility Mapping for the Lower Connecticut River Valley

June 2018

Long Term Recovery and Land Use Resiliency Through Community Flood Resilience Study

The Flooding Resilience Study discusses riverine and inland flooding as a significant natural hazard in the RiverCOG region, where numerous rivers, streams, and urban areas make floods and flash floods a frequent risk. Flooding can result from various natural events like heavy precipitation, hurricanes, and snowmelt, and is particularly problematic in densely developed town centers near water bodies. The study outlines different types of inland flooding, and details how FEMA categorizes flood zones based on their risk levels. The 2017 flood mapping study, funded by CIRCA and HUD, used logistic regression to estimate flood susceptibility based on factors such as elevation and proximity to water bodies. However, limitation in data impacted the accuracy of these models. An expanded analysis in 2020 incorporated higher resolution data, refining the flood susceptibility mapping for a better regional planning.

RiverCOG Dewberry

FUTURE DEVELOPMENT IN DOWNTOWN

The town of Portland is, located 20 minutes south of Hartford and 35 minutes north of New Haven, is a growing community strategically located between these two cities. The availability of housing throughout Connecticut is a pressing issue and Portland is building a large mixed use development close to the project area.

Brainerd Place, is a mixed-use residential apartment, retail and office development in Portland. With the tagline, “A Modern New England Town Center,” Brainerd Place will sit at the site of the old Elmcrest psychiatric Hospital, which was demolished in the summer of 2022.

The developers, Bright Ravens and DiMarco Group have begun construction of the Phase 1 of the 14.7-acre, 7-building project, which plans to include 240 apartment units, a CVS, a Starbucks, and restaurant space at the former site of Elmcrest Hospital. Portland residents are currently negotiating to lessen the proposed commercial space and increase the residential capacity to upwards of 350 units.

The Brainerd Place Plaza is located one block away from the Portland Public Library, Police Station, and town green by the Senior Center, which are within the focus area of this study. After this project is completed, Portland should expect increased local and visitor activity in community spaces throughout the downtown.

References:

“About A Modern New England Town Center.” Brainerd Place, www.brainerdplace.com/#about.

“Community Speaks Out on Development Plan.” Eye Witness News, 8 May 2024, www.wfsb.com/2024/05/09/community-speaks-out-development-plan/.

03

CURRENT & FUTURE CONDITIONS ANALYSIS

Initial Observations

Area of Extreme Heat Vulnerability

Public Realm Transit & Accessibility

Urban Tree Canopy

Flood & Drainage System Analysis

INITIAL OBSERVATIONS

1 **Lack of Shade** | Few trees or shade structures were observed within the study area

2 **Standing Water in Catch Basins** | Catch basins in the parking lot were observed with standing water.

3 **Impervious Surface** | Wide aisles and extensive asphalt within the parking lot

4 **Brownstone Historical Landmark** | Example of town's dedication to education opportunities within public spaces.

5 **Accessible Entries** | Senior center and library parking lots contain ample handicap parking spaces and accessible entry points

6 **Lacks Definition of Open Space Ownership** | Property bounds are unclear in defining public use

EXTREME HEAT VULNERABILITY

Climate Change Vulnerability Score (CCVI)

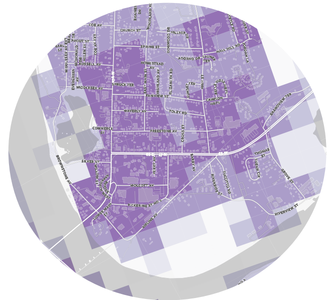
Tools developed by CIRCA were used to help identity heat impacts within the project area. One of these tools, the Climate Change Vulnerability Index (CCVI) is an index-based spatial model that identifies community vulnerability to flood and heat-related impacts of climate change. The CCVI characterizes areas based on an equation using sensitivity times exposure, divided by adaptive capacity. The combined score of the exposure, social, and adaptive capacity datums determines the overall vulnerability score.

Based on this analysis, the Main Street corridor in downtown Portland is most at risk of experiencing an extreme heat event, which directly impacts the surrounding community. In the future, Portland could designate accessible public buildings, such as the senior center and public library, as official cooling centers to assist residents who are most at risk during especially hot days.

EXPOSURE

LEAST			MOST

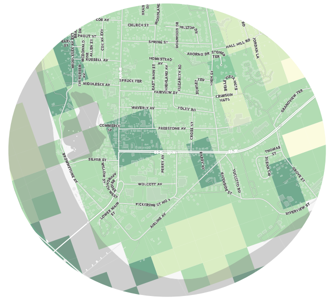
Exposure includes the change, including the magnitude and frequency of extreme events



SENSITIVITY

LEAST				MOST

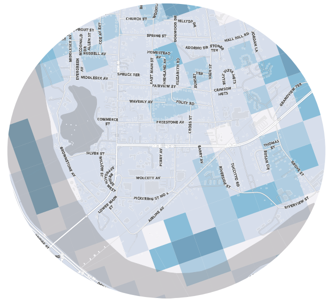
The degree to which a built, natural, or human system will be impacted by changes in climate conditions

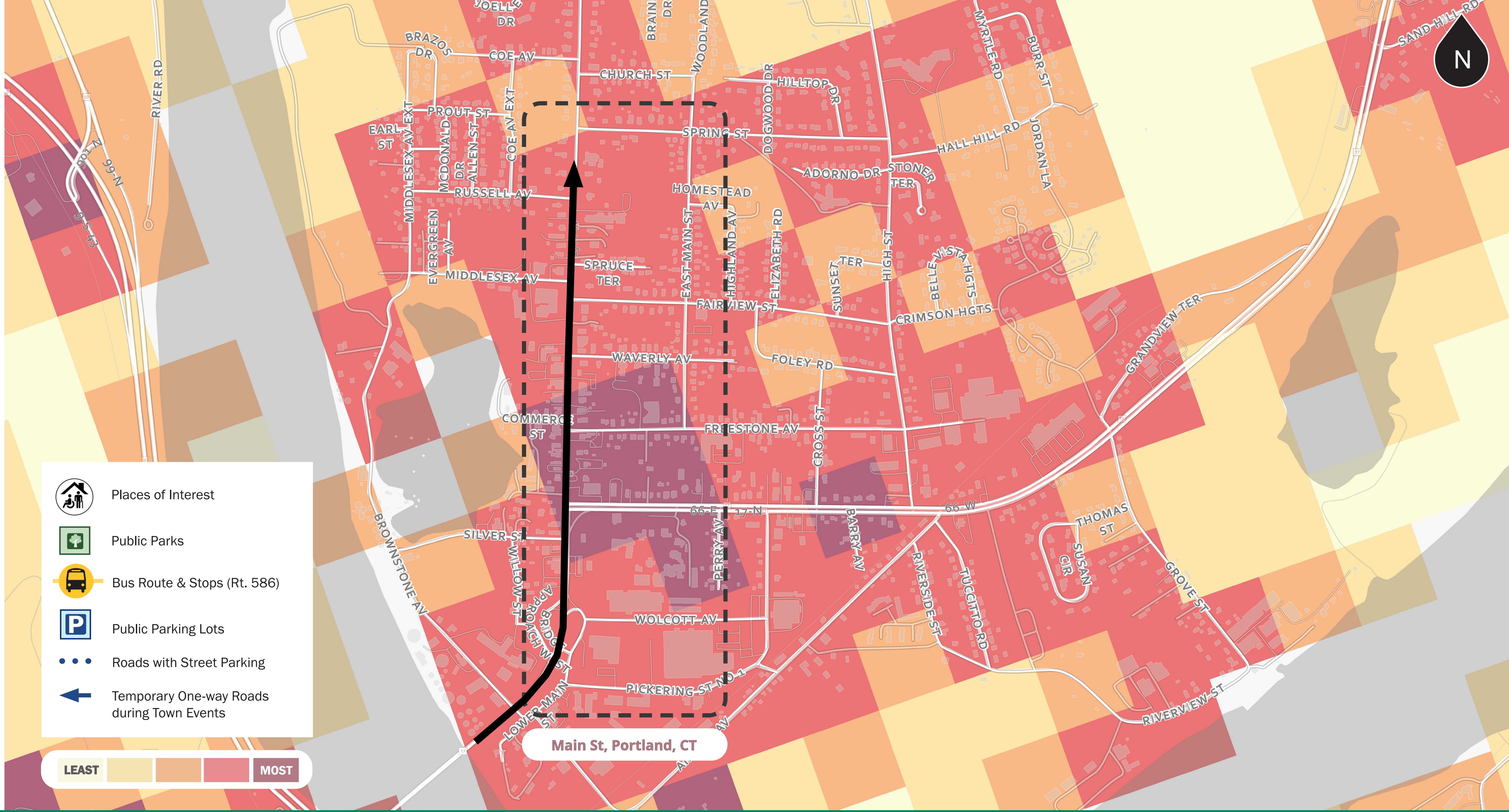


ADAPTIVE CAPACITY

LEAST				MOST

The ability of a system to adjust to changes, manage damages, take advantage of opportunities, or cope with consequences.





EXTREME HEAT VULNERABILITY

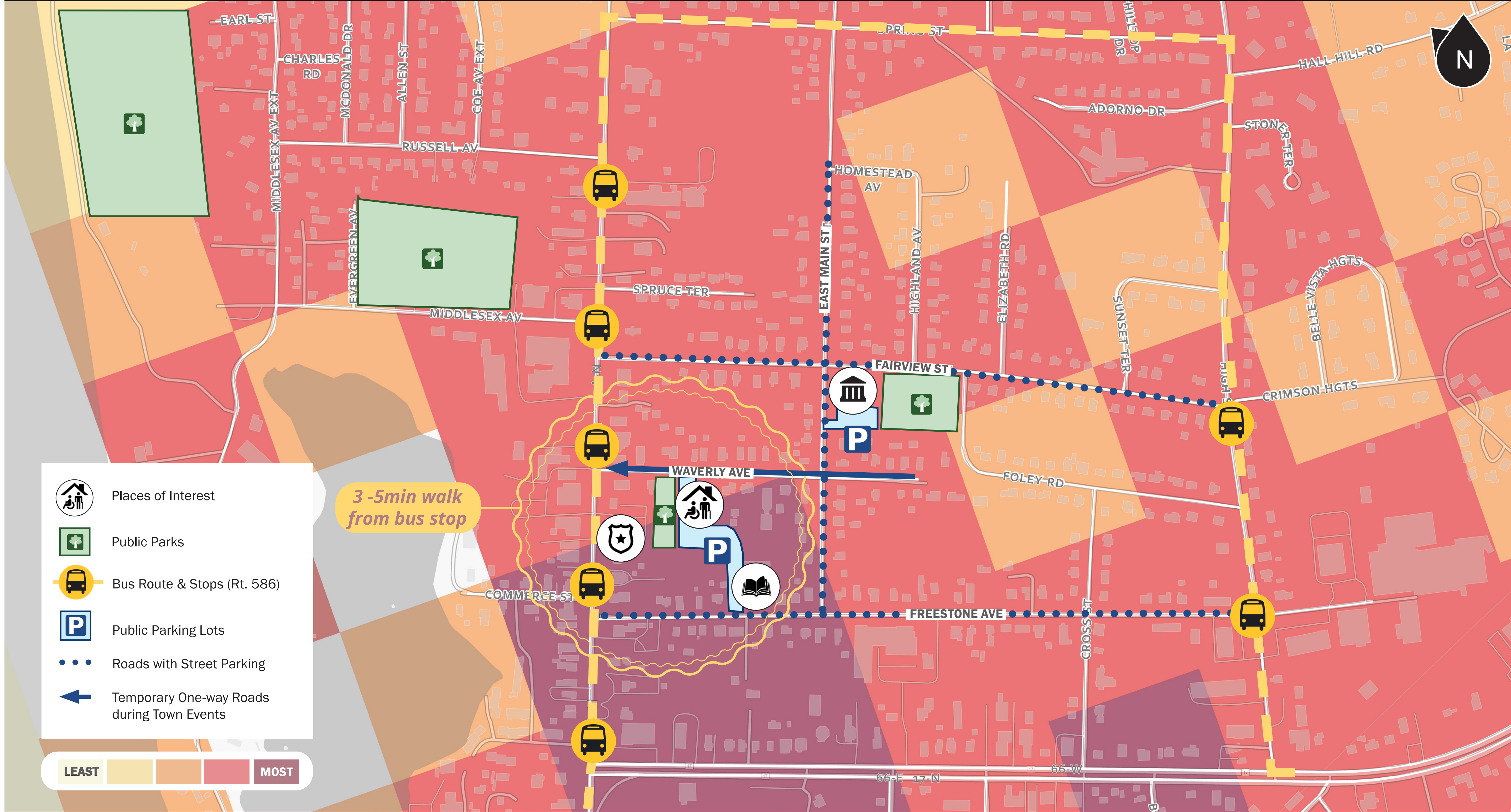
Accessibility

Portland has one major bus service, the RVT 586, which is provided by the River Valley Transit. This route loops the downtown areas and stops frequently in close proximity to our study area off Main Street, Key places of interest, such as the Senior Center and Public Library are all within 3-5 mins of the nearest stop.

Based on the first public workshop, discussions with town staff and residents, and advisory committee input, we learned that the library parking lot is highly utilized on an average day, and therefore often overbooked during popular town events and weekly activities. High traffic weekdays include Monday and Thursday, when the Senior Center opens the Portland Food Bank from 9am-noon and the Public Library hosts family reading events.

During high traffic days, residents often utilize Waverly Ave for additional parking, transforming the street into a temporary one way corridor. During Community Workshop gatherings hosted by CIRCA and AECOM, residents in attendance expressed the need for additional parking spaces in the downtown.

The green space in the center of the project area is one of the only public green spaces in the downtown. With its location adjacent to the public library and senior center and the inclusion of a much-used playground facility, this green is a key destination for the residents of the town. Accessibility and relief from extreme heat and flood conditions is critical for the continued success of this area to support the community.



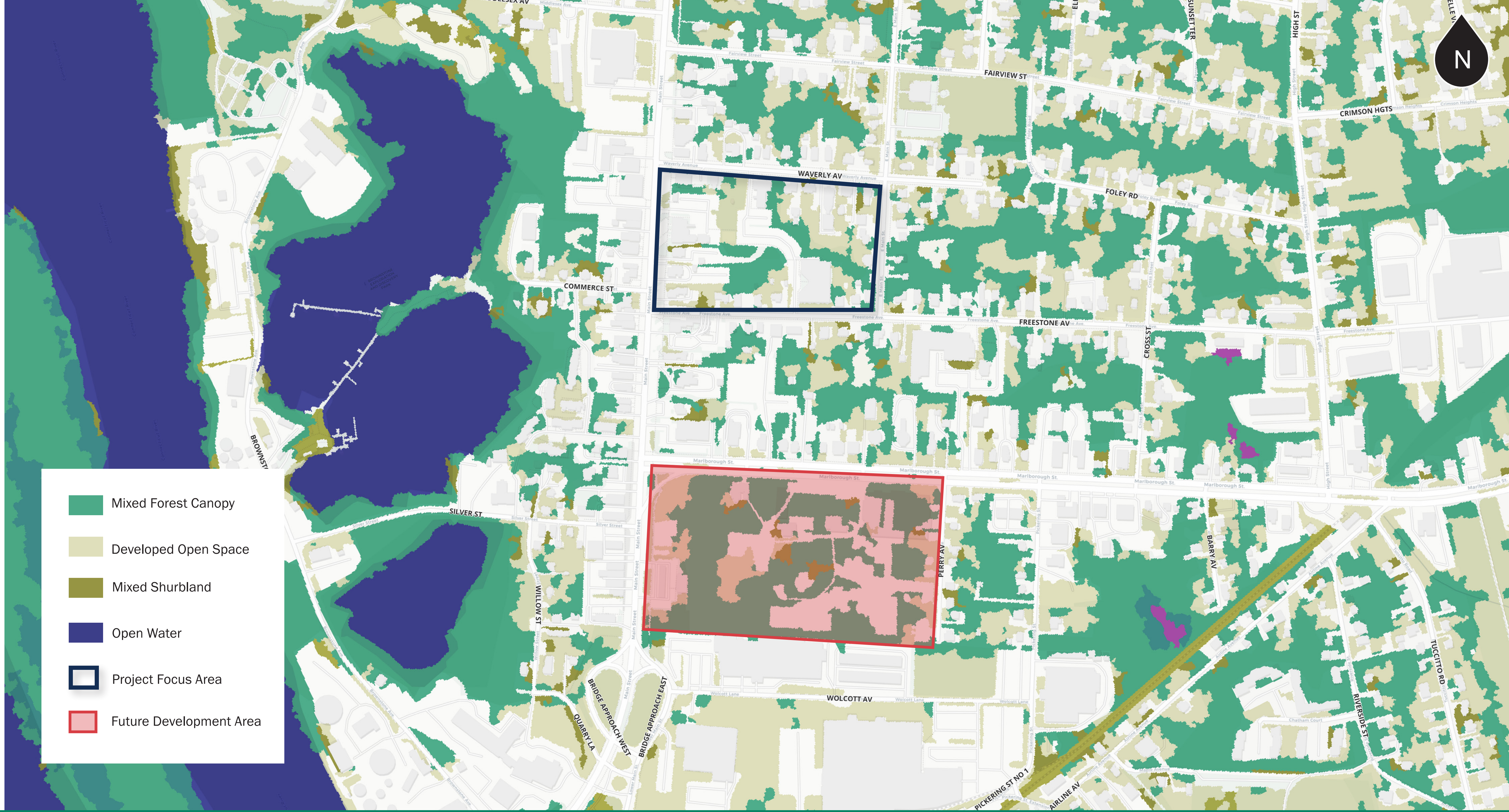
EXTREME HEAT VULNERABILITY

Urban Tree Canopy Assessment

Urban tree canopy (UTC) represents the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. This canopy provides numerous ecological, economic, and social benefits, including improving air quality, managing stormwater runoff especially in more urban areas like downtown Portland, reducing urban heat islands, and enhancing property values.

The following map shows urban canopy connectivity in the center of Portland, spanning from the quarry to High Street. This assessment reveals that downtown Portland consists mostly of developed open space with smaller patches of mixed forest canopy and mixed shurbland. Compared to other parts of the town, Main Street has significant stretches of impervious surfaces, which makes it more susceptible to heat island effects. Additionally, Brainerd Place, the mixed-residential compound currently in construction, will remove significant tree canopy from the downtown area.

Our focus area consists of several open park areas and impervious parking lots, which could benefit from additional shade trees. Residential properties and private business on the outer edge of our study area provide some shade and relief from extreme heat, however the public playground, gazebo park and parking lots in this block have a lack of shade trees creating an uncomfortable condition for the users during extreme heat conditions. As we move forward into the subsequent design phases, we will consider how we can strategically incorporate more trees into areas that are heavily utilized by the public.



FLOOD CONDITIONS VULNERABILITY

The study area contains a shared parking lot between the senior center and the library, with driveways connecting on Waverly Avenue and Freestone Avenue, as well as an adjacent parking lot behind the police station used for fleet parking. The parking lots are prone to flooding: recent observations shared by the Town of Portland from an unusually intense rain event on September 23rd, 2023, show flooding in the senior center parking area, the police station parking lot, the playground, and a portion of the town green. Some of the building basements are also prone to flooding: the senior center and police station basements also flooded during the September 23rd, 2023 rain event, causing damages. Stormwater runoff from the parking lots, the town green common space, and the playground is managed by a system of underground pipes and catch basins designed to collect and convey the runoff away from the site.

Observed Flooding Zone | *Sept. 2023*

Risk of Pipe Backflow

Direction of Runoff

Existing Stormwater Pipe Flow Direction

Existing Catch Basins & Drainage Pipes

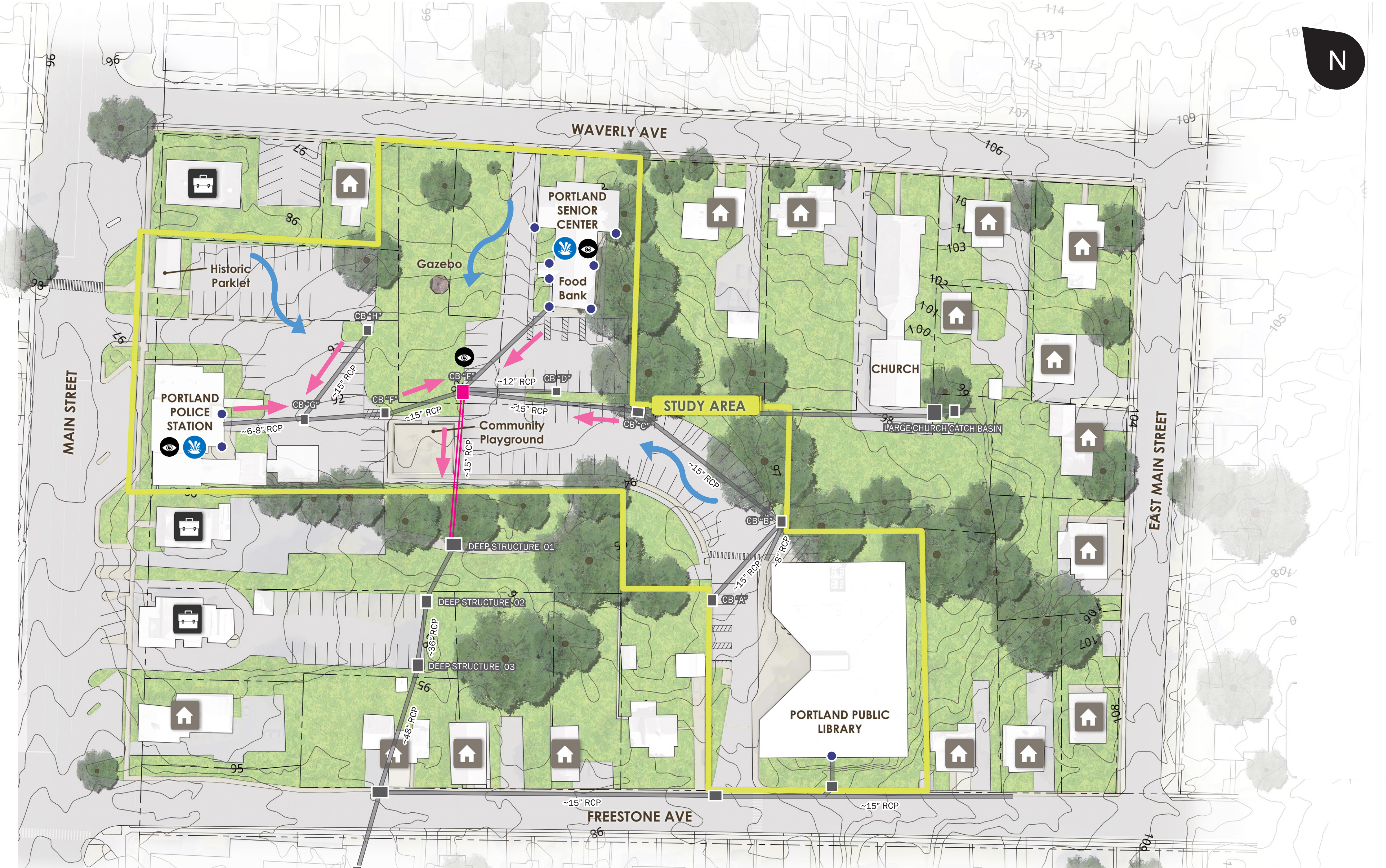
"Catch Basin E" & Undersized Outlet Pipe

Roof Downspouts

Study Area

Residence

Business



FLOOD CONDITIONS VULNERABILITY

Site Observations & Drainage Analysis

Locations of catch basins for the Town of Portland were provided by CIRCA and were referenced using GIS software for the development of a model representing the existing drainage network. Other sources of information were examined, including the existing library as-built plans, existing drainage plans, and aerial imagery, to identify locations of pipes and lawn drains. In addition, notes and assumptions shared by the Department of Public Works, as well as photos and observations from site visits, were used to understand the extent and limitations of the existing drainage system.

A walking tour of the project site was completed on February 23, 2024. Field observations about the existing drainage network were collected during two day-long site visits on May 14, 2024 (a sunny day) and May 15, 2024 (a rainy day) to confirm assumptions.

Locations of roof drains and downspouts were noted, and some assumptions were made to determine the locations of the roof drain connections to the underground existing piping system between the existing plans and site visits.

Basement drains from the police station and senior center were observed to connect to the existing drainage system at catch basins G and E, respectively. The basement drains were not modelled but they represent possible sources of backflow during severe weather events.

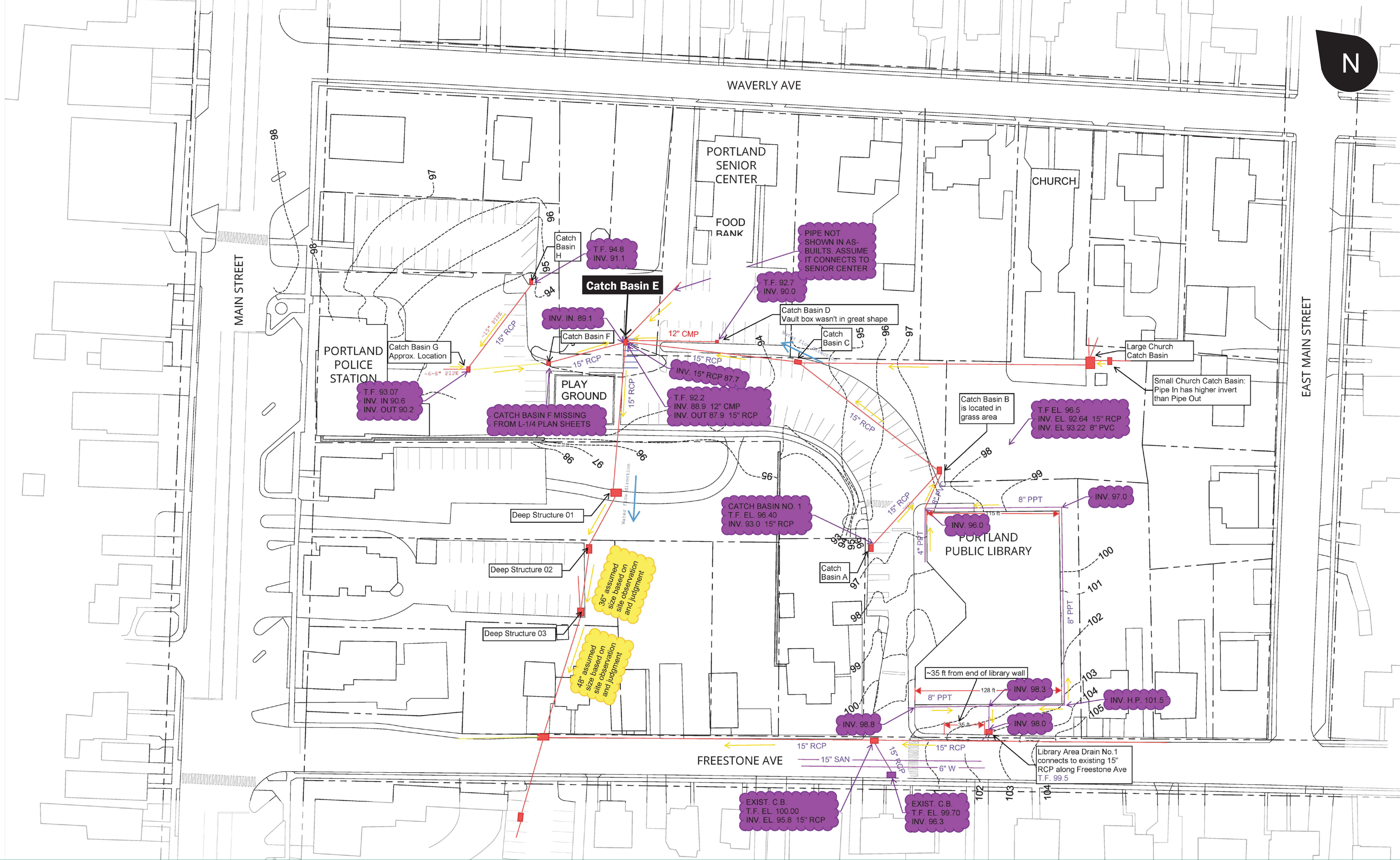
Stormwater pipes from the library parking lot, the senior center parking lot, and the police station parking lot all connect to catch basin E, which is situated at a low point adjacent to the common area and the playground. Site observations revealed additional stormwater pipes entering the piping system from the area behind a church and food pantry adjacent to the senior center. At the point of convergence, the entire piping system is connected to catch basin E by a single concrete pipe, assumed to be 15" in diameter, which extends beyond the parking lot area southward towards Freestone Avenue. The age and condition of all the pipes and catch basins vary, suggesting the system may have been built in the past and then the connections were installed afterwards a little at a time over several decades.

A series of deep catch basins connect to larger pipes which drain towards Freestone Avenue at the back of other properties next to the parking lot. These appear to connect to an existing brownstone culvert of unknown size on Freestone Avenue. Based on the existing plans, it is assumed that the network of pipes and catch basins in the parking lot behind the police station and between the senior center and library also connects to this brownstone culvert by way of the larger pipes and deeper catch basins.

RED SHAPES / LINES WERE CONFIRMED DURING SITE VISIT

PURPLE IS INFORMATION FROM AS-BUILT LIBRARY PLAN SHEETS L-1, L-2, L-4

YELLOW INFORMATION COULD NOT BE CONFIRMED BUT IS AN ASSUMPTION



FLOOD CONDITIONS VULNERABILITY

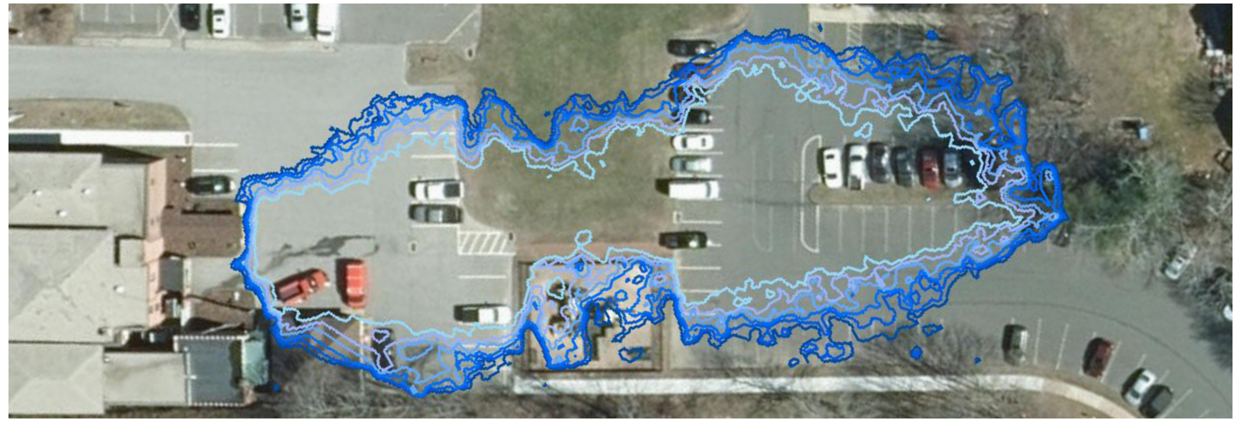
Flood Modeling Assumptions & Analysis

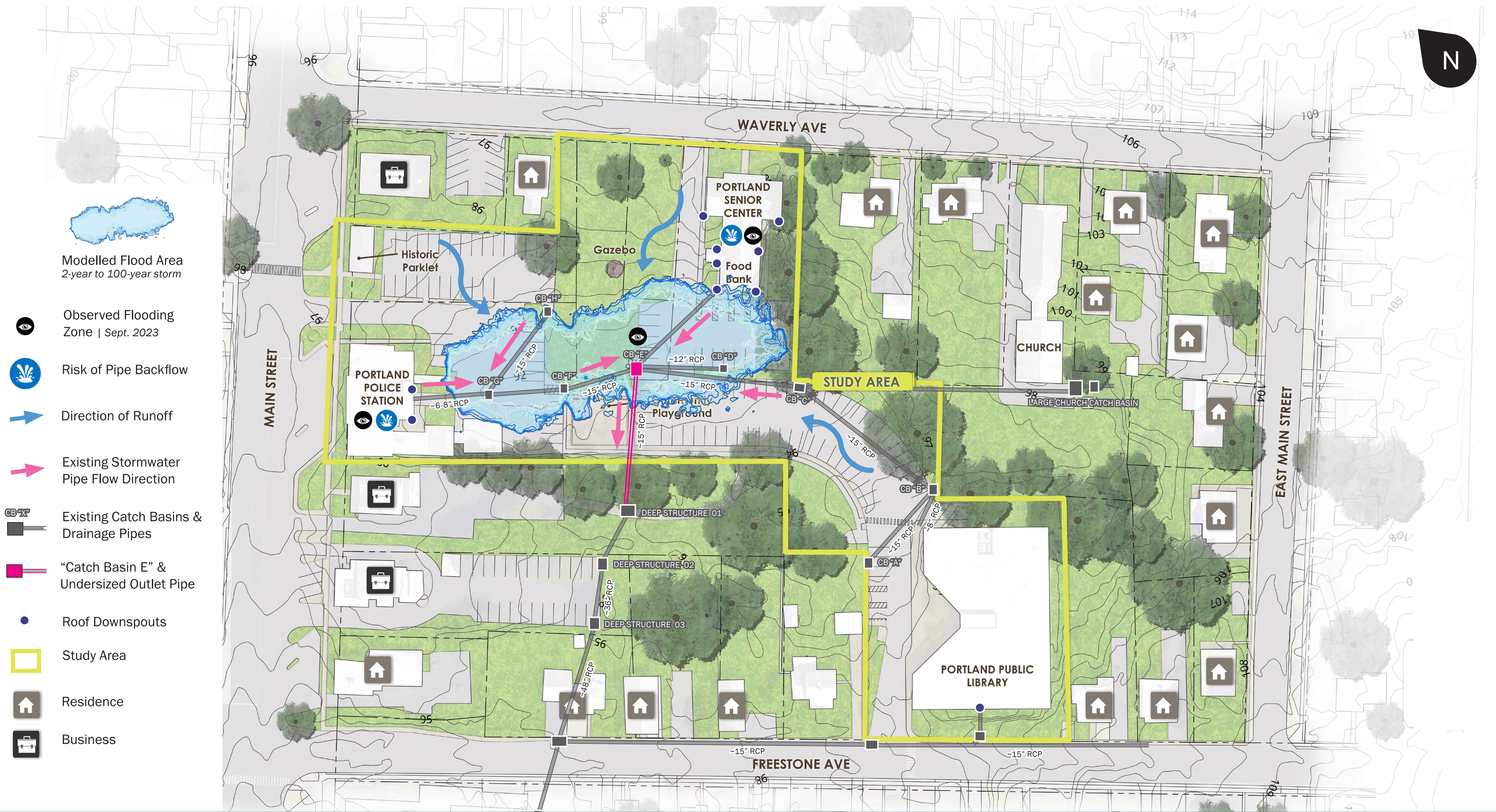
Rainfall data for the model were gathered from NOAA Atlas 14, Volume 10. The current 24-hour precipitation depths for several recurrence intervals (1-Yr, 2-Yr, 5-Yr, 10-Yr, 25-Yr, 50-Yr, and 100-Yr) were plotted into time series using the NRCS Type N10_D design storm rainfall distribution. The same distribution was used to compute time series for projected rainfall amounts in 2050 and 2080. The current rainfall, 2050 rainfall, and 2080 rainfall were all applied to the existing piping system and the model was run three times: 1) under current conditions, 2) under 2050 rainfall conditions, and 3) under 2080 rainfall conditions. In all modelling cases, low infiltration rates and a backwater condition in the pipe network were assumed to be in effect.

Initially, the design storm-based modeling approach failed to replicate observed flooding conditions. An alternative approach, based on the assumption of minimal infiltration and on historic maximum rain intensities for a subset of the same recurrence intervals (2-yr, 5-yr, and 10-yr), was then used.

Results of the modelling showed that the existing piping system reaches its capacity limits even for smaller events that have a higher likelihood of occurring in any given year under current conditions. Flooding is most likely to start at the low point near catch basin E and spread across the parking lot area and the playground, affecting the areas of the parking lot behind the police station and the senior center more severely than the areas in front of the library. Flooding of the police station basement and the food pantry in the basement of the senior center is also likely, even for smaller rain events. Expected flood depths are proportional to the size of the storm and are higher for larger storms that have a lower likelihood of occurring each year. These patterns were all exacerbated for the 2050 rainfall conditions which are projected to have more rainfall than both the current conditions and the projected 2080 rainfall conditions. For example, the 5-year rain event could have 27% more rainfall in 2050 and 22% more rainfall in 2080 as compared to current conditions. In summary, patterns of flooding that may already occur under current conditions can be expected to worsen in the 2050 condition if no changes are made to the drainage system or nearby land use.

For supplemental information on modeling methodology and sensitivity analysis please refer to **Appendix B**.





FLOOD CONDITIONS VULNERABILITY

Updating Undersized Pipes

Larger capacity pipes may aid the capture, conveyance, and attenuation of rainwater, especially during the incidents of deluges that the town has recently experienced.

Based on site observations and on initial modeling, it is recommended to increase the size of the pipe downstream of catch basin "E" (shown in pink in the diagram at right). The suggested pipe size is anticipated to be no larger than a 36" diameter concrete pipe or its equivalent. It should be noted that a smaller optimal pipe size may be justified through more detailed modeling.

As part of future stages of modeling and design, the presence/location of other existing underground utilities, as well as the expected frequency of pipe maintenance, would also need to be considered.

Inspecting and cleaning existing drainage facilities

An inspection of the existing network of catch basins and pipes should be performed. From the results of the inspection, it may be possible to identify any potential locations in the network that may be clogged with debris. If debris is found, targeted maintenance would be recommended.

Redirecting roof downspouts

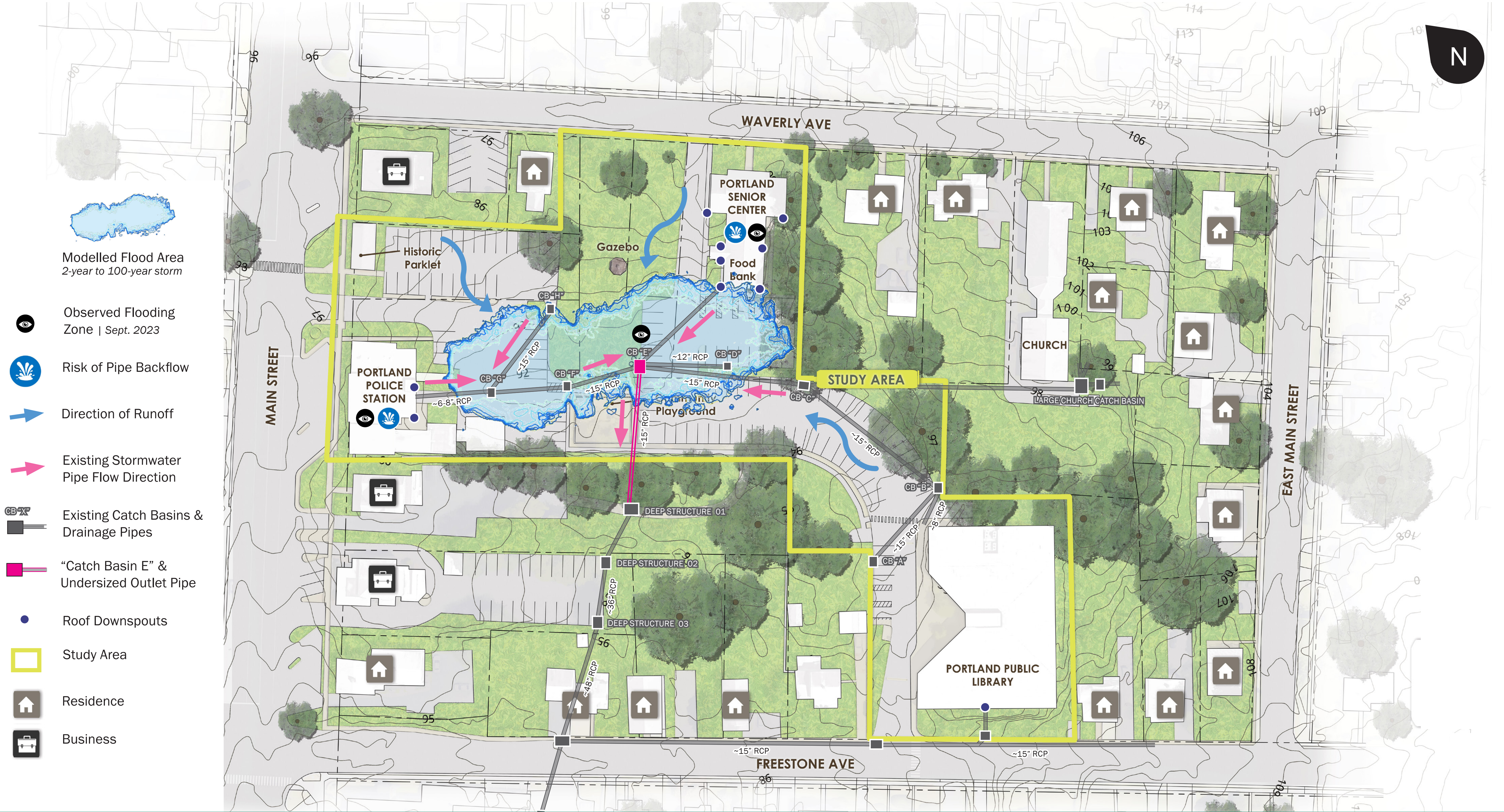
Roof downspouts were observed during site visits. Many existing roof downspouts may either connect underground or be directed to low points that are already vulnerable to flooding. It is suggested to seek opportunities to redirect roof drains away from building foundations and into proposed green stormwater infrastructure.

Flood-proofing of basements

Due to observed and modeled limitations of the existing drainage network, it can be anticipated that the basement of the Senior Center and Portland Police Station, as well as the parking lot adjoining those facilities and the Portland Public Library, will continue to be vulnerable to flooding. Some steps have already been taken to flood-proof the basements of these facilities to reduce the likelihood of repeat damages, however additional flood-proofing measures could be pursued, such as:

- Installing a backwater valve: to prevent sewage from backing up into the basement after heavy rain
- Install window well covers: to prevent heavy rainfall from seeping through basement windows
- Apply a waterproof membrane or sealant to the walls and floors: to protect against water damage
- Utilize sandbags & cement blocks to elevate storage: to protect against water damage

These actions were not included this study, however where appropriate, these measures could provide some initial flood protection while more long-term solutions are being designed and constructed.



FLOOD CONDITIONS VULNERABILITY

Flood Modeling Approach and Enhanced Modeling

The modeling process revealed some challenges. Firstly, applying a traditional design storm approach to current and future conditions was revealed to have significant limitations. Additionally, missing or incomplete data can reduce accuracy of results. Furthermore, differences between methods for estimating infiltration and peak runoff can have an out-sized impact on modeling results. For this planning-level analysis, a continuous rainfall simulation (with multi-day data from an extra-tropical system in September 2011) was performed to compare to the design storm simulations. Also, a couple different methods for estimating infiltration (Green-Ampt, NRCS) were tested out; and the Rational Method was applied as an additional method to estimate runoff to the catch basins.

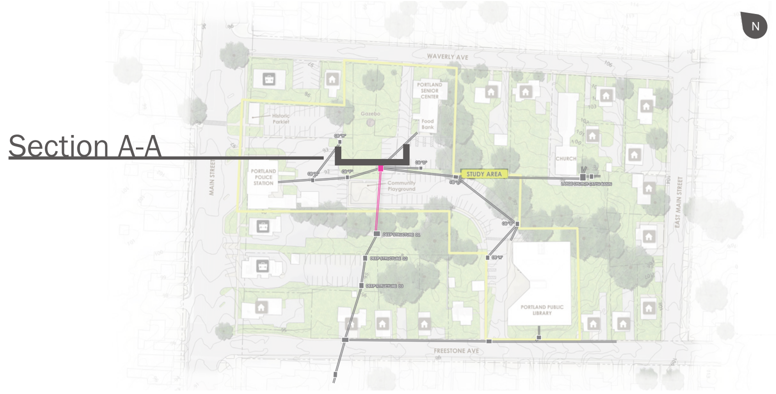
Supplemental technical flood modeling information is provided in **Appendix B**.

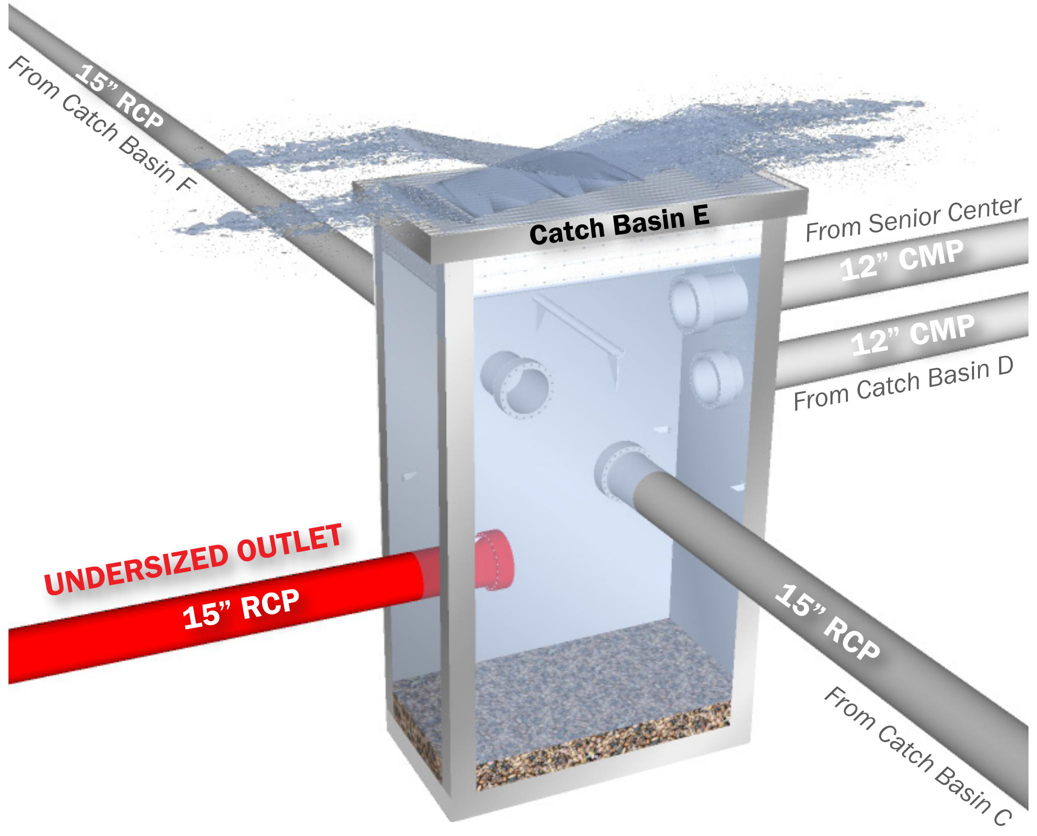
Recommendations for Enhanced Modeling

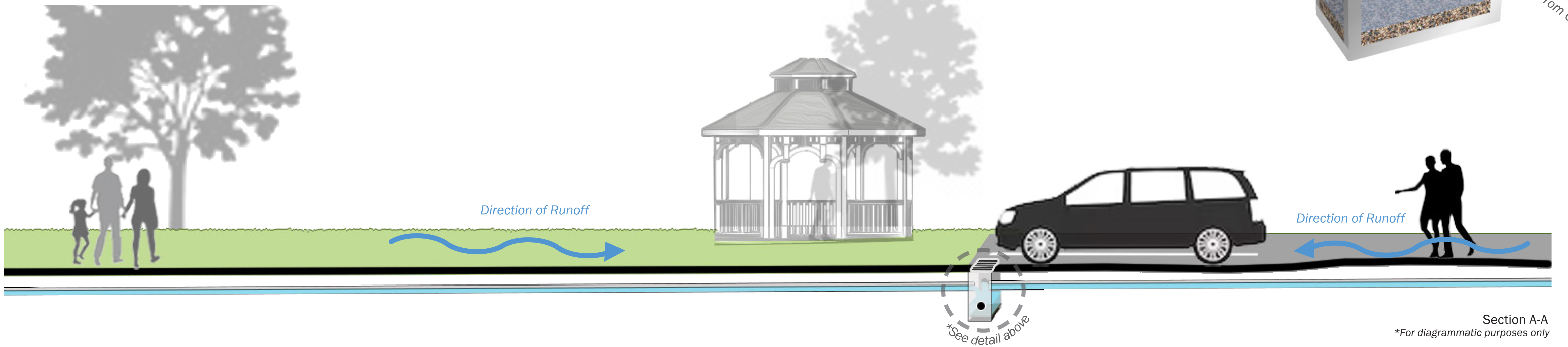
To provide a more detailed model and enhanced results, the following actions are recommended for preliminary design, with the goal of supporting the implementation of strategies described in the following sections of this report.

1. Perform soil and infiltration testing to measure hydraulic conductivity and antecedent moisture conditions, as well as confirm soil types and characteristics. The test results would be used to calibrate models and improve model accuracy.
2. Consider scenarios for short-duration, intense rain events when developing on the proposed pipe design and sizing the proposed stormwater management facilities. Work with CIRCA to determine alternative modeling approaches that incorporate short-duration, high-intensity rainfall events typical of urban cloudbursts, alongside traditional design storms.
3. Consider using continuous simulation events with hourly or sub-hourly rainfall data that is more recent than 2011, to reflect the cumulative effects of multi-day precipitation events.
4. Install a rain gauge for the town that is capable of providing rainfall measurements in sub-hourly increments, and connect it to the national network of rain gauges. Neighboring towns may indirectly benefit from this action as well.
5. Verify pipe diameters, slopes, and invert elevations, as gathered from existing plans, with detailed surveying. Use survey results to fill in any missing or incomplete data for the modeled network.

Following more detailed modeling, specific details for modifications to the existing drainage system can be made, including any potential rerouting of problematic basement drains and incorporation of stormwater management facilities described later in this report.







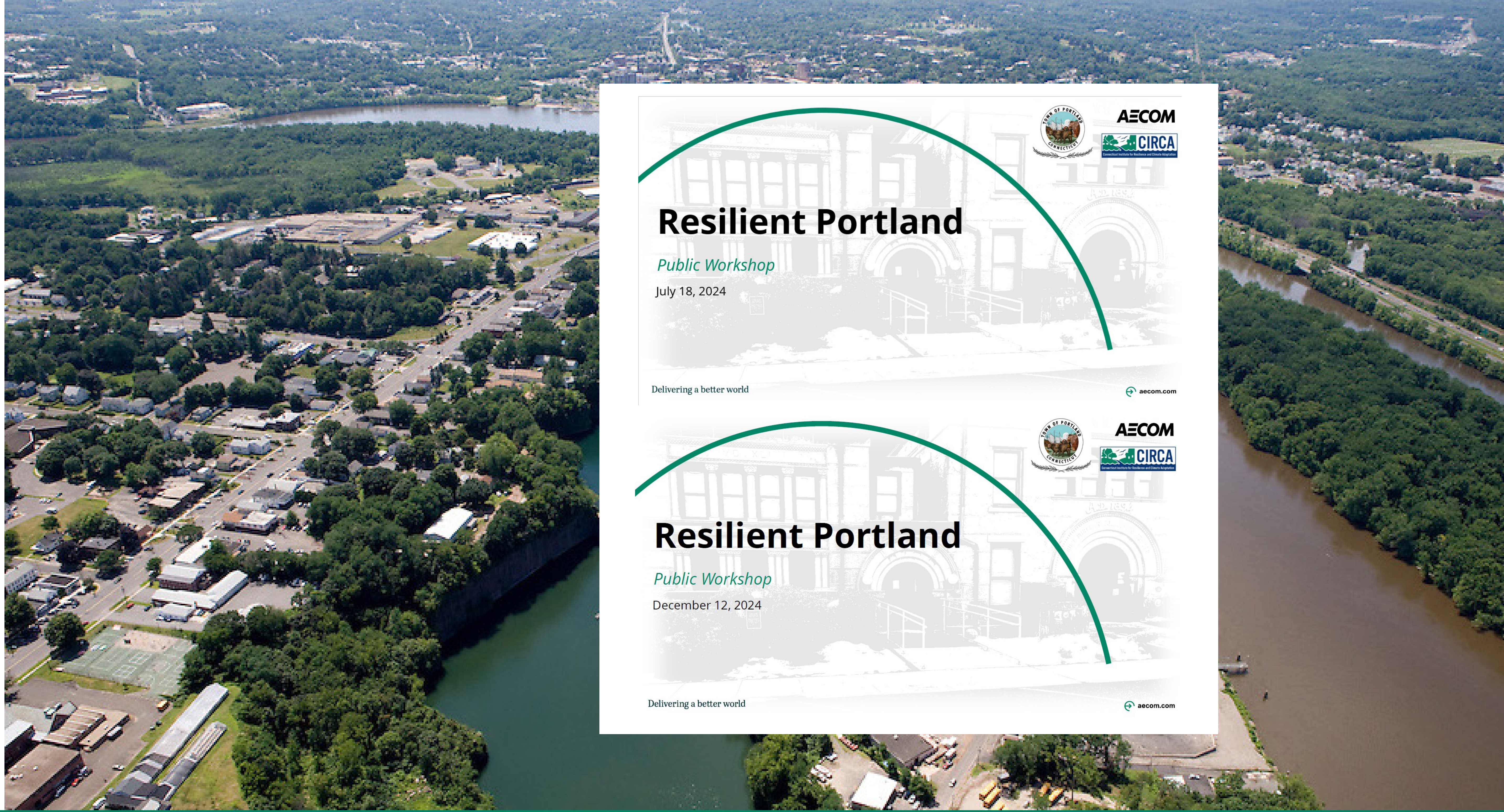
PUBLIC ENGAGEMENT

Two (2) virtual public workshops were conducted to engage the community in the planning process, soliciting feedback to hear the concerns and needs, needed to assist the planning team in establishing the priorities for concepts.

The first workshop, held in July 2024, introduced the project and presented the present-day and future flood and extreme heat conditions. Several adaptation strategies were presented to the public in the form of a “Resilient Design Toolkit”. The toolkit presented the option to reduce impervious paving, add bioretention beds to catch runoff, and add additional shade trees to the study area.

The second workshop, held in December 2024, showcased a new design scheme of the parking area and green space between the Senior Center ans Police Station with the resilient toolkit strategies applied throughout. The team presented a single rendered plan, one conceptual section, and several modeled renderings from various perspectives in the study area. Several members of the community participated in discussion, expressing the need for permeable paving choices and native plant selections to support biodiversity in the downtown.

Mary Buchanan, CIRCA Project Manager, standing behind the Portland Police Department building, where much of the flooding occurs within the Resilient Portland project limits. *(Aaron Flaum/Hartford Courant)*



04 ADAPTATION OPTIONS

Reduce impact of extreme heat

Improve neighborhood connections

Increasing capacity of stormwater system

Reduce runoff that contributes to flooding

Educate community about resiliency

RESILIENT STRATEGIES: KEY BENEFITS

Upon the completion of the flood and heat analysis and the review of the existing site conditions through site visits and stakeholder engagement, eight resilient strategies were developed to address the design objectives. Each of these strategies were incorporated within the development of the Design Alternatives.

Reduce runoff that contributes to flooding

Key Devices & Benefits:

- Add Raingardens and Bioretention beds:

  Absorbs surface water, helps to maintain groundwater, reduces the amount of untreated stormwater runoff, Increases biodiversity and helps pollinators with native plantings

- Impervious Pavement Reduction:

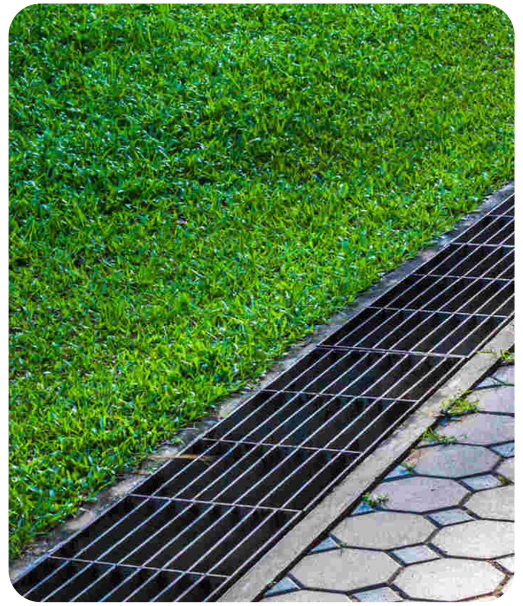
  Reduces volume of runoff from pavement into the enclosed drainage system, amounts of hydrocarbon pollution from asphalt and provides additional green open space for community enjoyment and cooling

Increase capacity of stormwater system

Key Devices & Benefits:

- Evaluate and Increase Size of Undersized Pipes:

  Prevents pooling and excessive flooding, Reduces clogs caused by debris and manages higher volumes of water

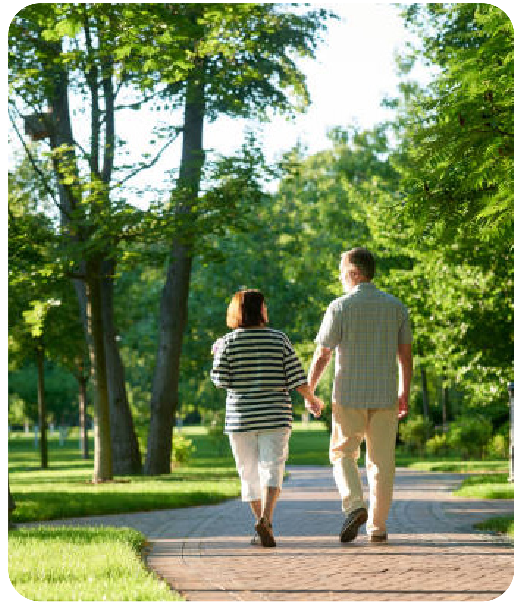


Improve neighborhood connections

Key Devices & Benefits:

- Construct Shaded Pedestrian Walkways:

  Provides accessible mode of pedestrian travel via resilient corridors for extreme heat relief.



Expand Urban Tree Canopy & Shade Structures

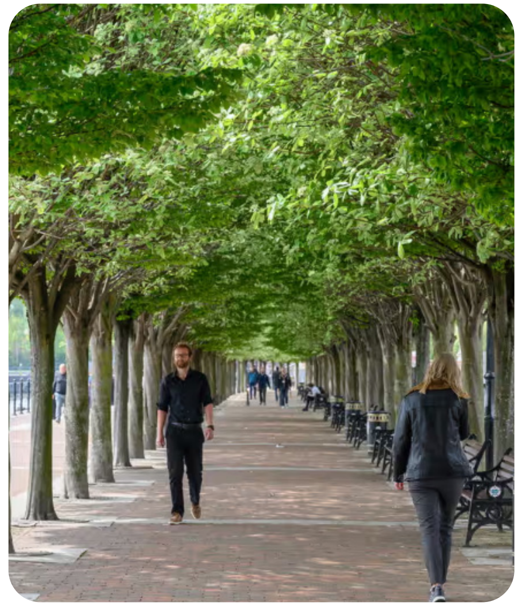
Key Devices & Benefits:

- Shade Canopy Trees:

  Provides shade for healthier community and relief from extreme heat, reduces surface temperature at Town green space adjacent to playground, improves air quality, and absorbs additional stormwater runoff

- Shade Structures:

  Provides alternative option for shade in areas that cannot accommodate trees



Signage & Community Education

Key Devices & Benefits:

- Interpretive Signage:

  Provides a deeper understanding of challenges and opportunities of resiliency within the community

- Stewardship Opportunities:

  Creates public dialogue and empowers and integrates the primary users

APPLIED TOOLKIT STRATEGIES

Increasing capacity of stormwater system

- Existing Catch Basins & Drainage Pipes
- Roof Downspouts
- Catch Basin "E" & Undersized Outlet Pipe

Updating Undersized Pipes

Based on site observations and on initial modeling, it is recommended to increase the size of the pipe downstream of catch basin "E" (shown in pink in the diagram at right). Right-sizing the outlet pipe at this key loaction is predicted to ensure the greatest improvement to the current stormwater system.

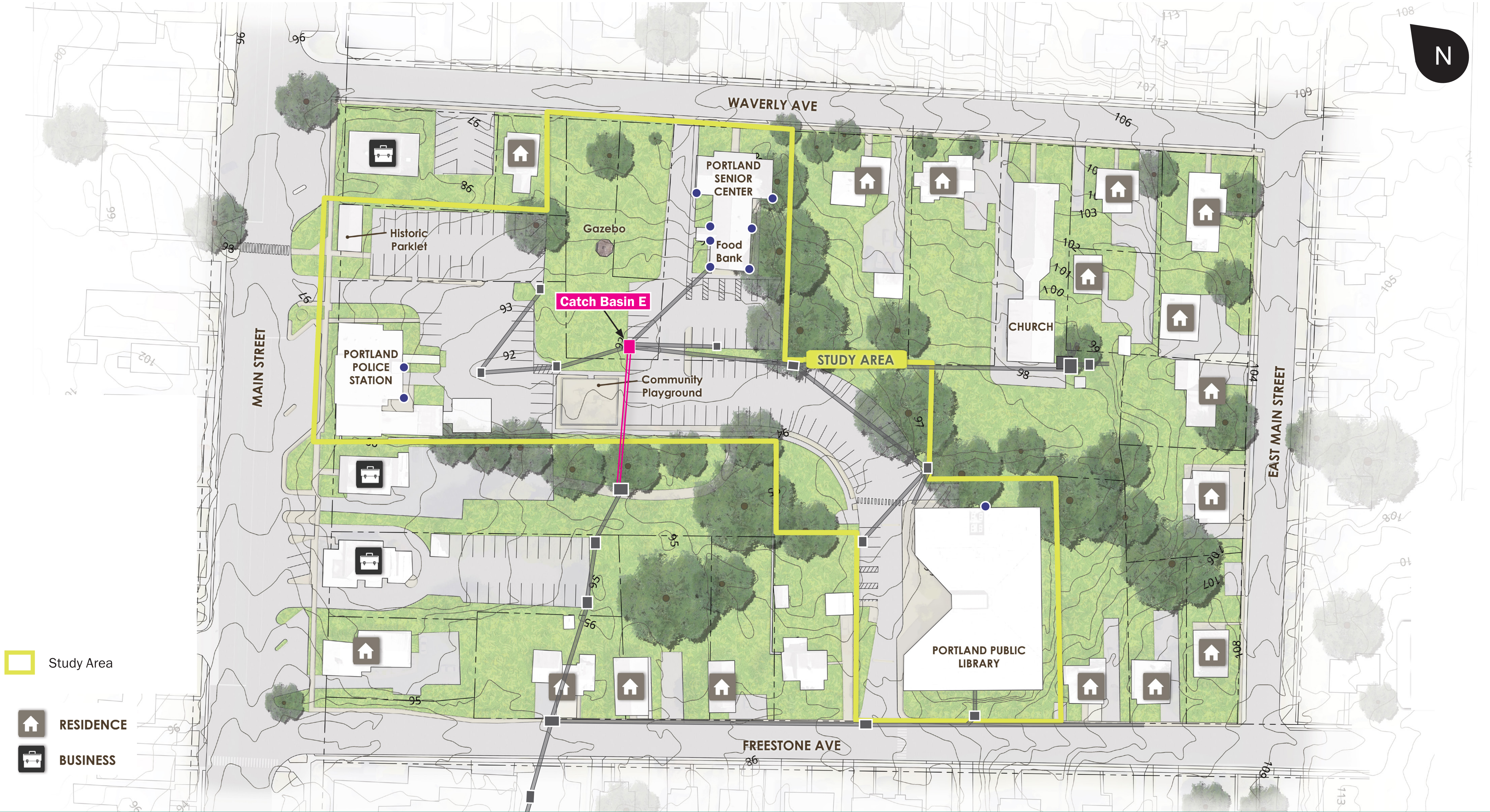
The suggested pipe size is no larger than a 36" diameter concrete pipe or its equivalent. It should be noted that a smaller optimal pipe size may be justified through more detailed modeling.

Redirecting roof downspouts

Roof downspouts were observed during site visits. Many existing roof downspouts may either connect underground or be directed to low points that are already vulnerable to flooding. It is suggested to seek opportunities to redirect roof drains away from building foundations and into proposed green stormwater infrastructure.

Flood-proofing of basements

A detailed assessment of existing and future flood-proofing of facility basements was not included in this study, however may refer to **page 44** for further explanation of flood protection strategies that could be utilized as interim prevention measures.



APPLIED TOOLKIT STRATEGIES

Reduce runoff that contributes to flooding

- New Parking Spaces
- Removed Parking Spaces
- Proposed Pervious Paving
- Proposed Added Green Space

Reduce Impervious Surface

With increasing major rainfall events, the recent incidents of flooding is evidence that the existing drainage system is not capable of conveying this higher amount of runoff. Green infrastructure and permeable paving alternatives will improve the management of rainfall events by reducing the amount of runoff and slowing the rate of flow into the underground drainage infrastructure.

120 Total Existing Parking Stalls

42 - Police Station
14 - Senior Center
64 - Public Library

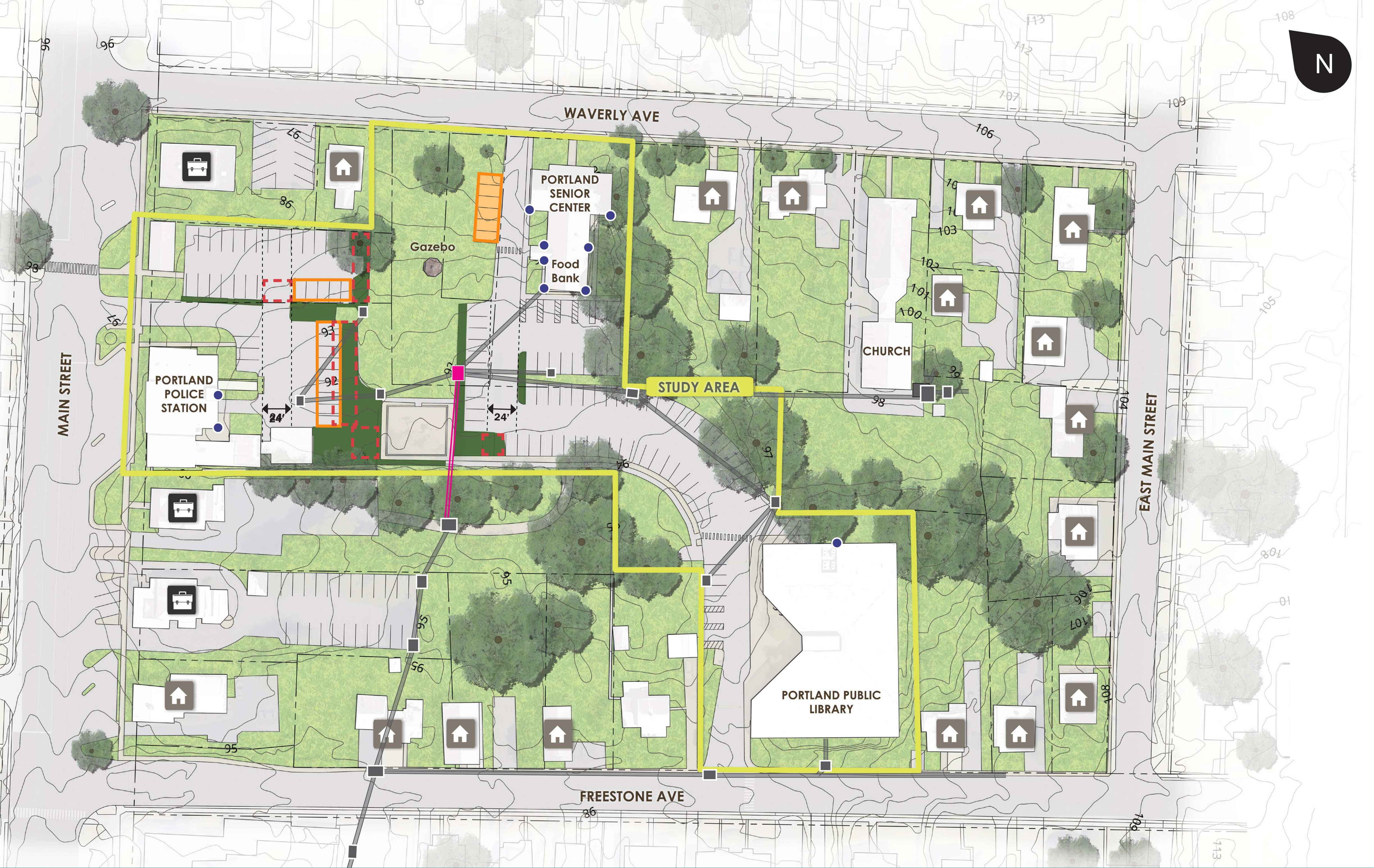
120 Total Proposed Parking Stalls

34 - Police Station
20 - Senior Center
62 - Public Library

Study Area

RESIDENCE

BUSINESS



APPLIED TOOLKIT STRATEGIES

Reduce runoff that contributes to flooding

- Proposed Berm
- Proposed Bioretention Beds
- Proposed shrub layer
- Roof Drain Rainwater Harvesting (*10-15% of Runoff Diverted to Rain Gardens*)
- Direction of Runoff

Incorporate Green Infrastructure

Sustainable drainage systems provide a method of managing stormwater that imitates the natural systems. The rainwater runoff is directed and stored at the surface to allow it to slow the rate of runoff and soak into the ground.

Rain gardens and swales are incorporated into the concept design and located at the lower elevation areas within the study site. This may provide a reduction in the amount of flow into the existing drainage system and provide storage during storm events.

Planting the rain gardens with native shrub and herbaceous plantings will support pollinators and provide an attractive natural green space, increasing biodiversity habitats and improving the air quality and cooling properties of the town of Portland's green space.

APPLIED TOOLKIT STRATEGIES

Expand Urban Tree Canopy & Shade Structures

Proposed Trees

Proposed Shade Structures

Shade Canopy Trees

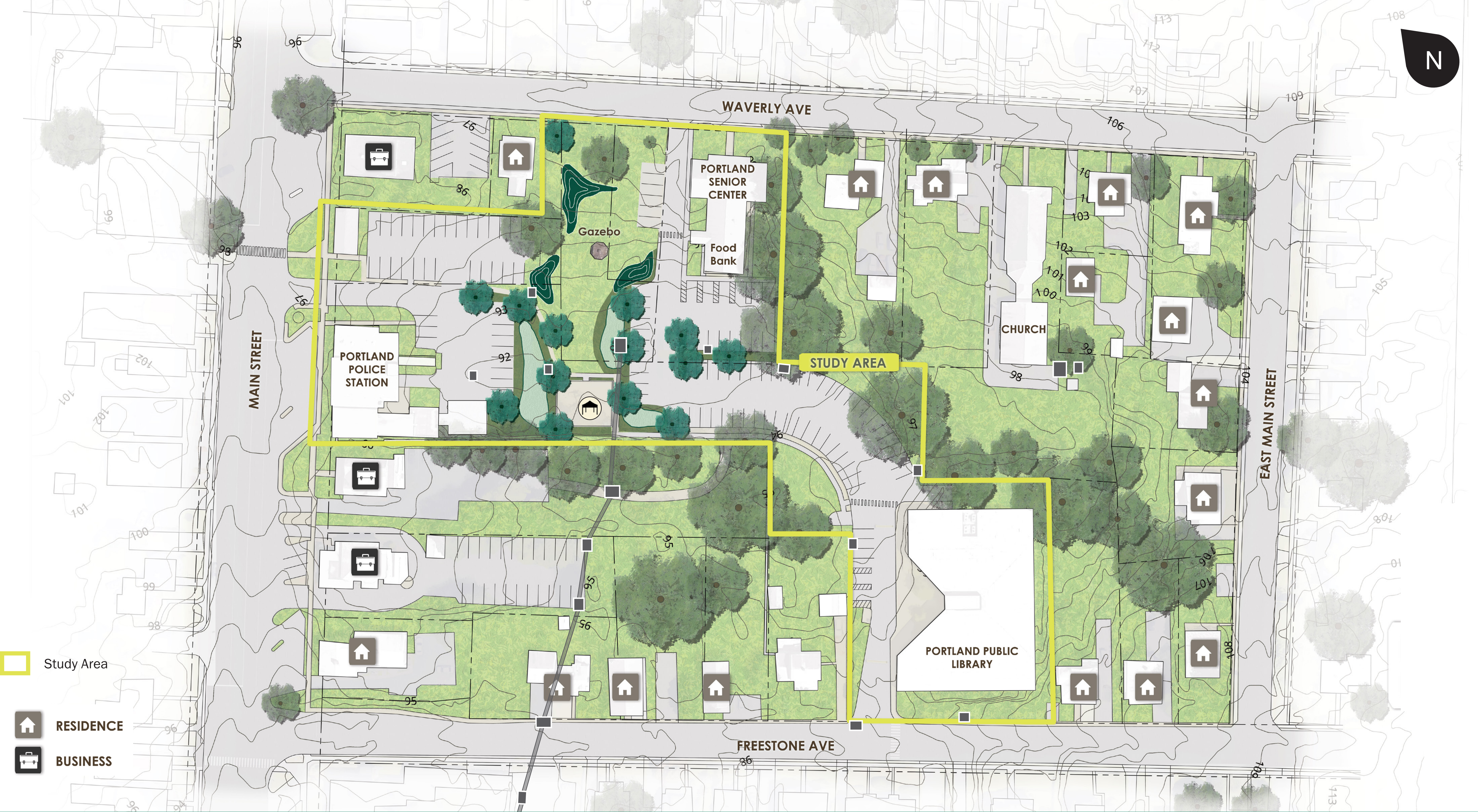
Trees play a crucial role in both reducing temperatures and managing stormwater, helping towns become more resilient to heatwaves and flooding.

Large canopy trees provide shade, reducing the amount of direct sunlight on surfaces like roads and buildings, which helps lower urban temperatures. Also, through the process of evapotranspiration, trees release moisture into the air, which cools the surrounding environment, acting like natural air conditioning. As for flood mitigation, trees help slow down rainfall and reduce the volume of stormwater that reaches the ground, minimizing flood risks by promoting groundwater recharge. Tree roots also absorb and retain rainwater, reducing surface runoff and allowing for better infiltration into the soil.

Shade Structures

Shade structures, such as canopies, pergolas, and awnings, block direct sunlight from hitting surfaces like roads, buildings, and outdoor areas, reducing temperatures in these spaces. By preventing sunlight from reaching heat-absorbing materials (like concrete or asphalt), shade structures help reduce the "urban heat island" effect, where urban areas become significantly warmer than surrounding rural areas. Additionally, shade structures provide cooler outdoor spaces for people to enjoy, reducing the risk of heat-related illnesses and offering respite during hot weather.

Shade structures may provide some flood mitigation advantages as well. By providing coverage to pavements and open areas, shade structures can help reduce the amount of rainfall that directly hits the ground, allowing for better absorption and decreasing the likelihood of flash floods or excessive ponding in impervious areas.



APPLIED TOOLKIT STRATEGIES

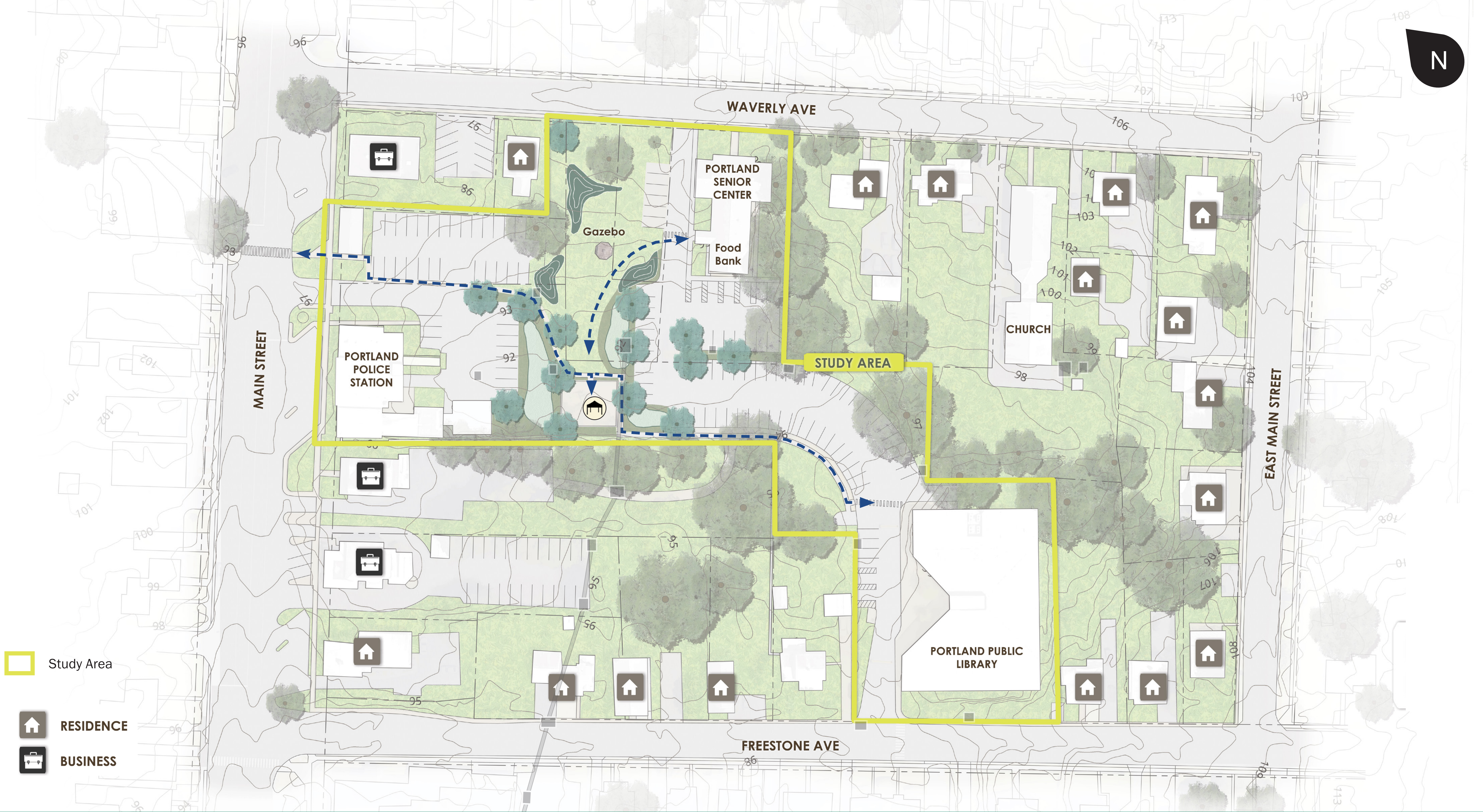
Improve neighborhood connections

Human Circulation

Enhancing Walkability & Accessibility

Improved park path networks create more accessible and interconnected green spaces, encouraging people to explore and enjoy their surroundings. This fosters a sense of community by linking parks, neighborhoods, and key destinations. Additionally, well-designed paths provide inviting routes for walking, cycling, or jogging, enhancing the aesthetic and recreational value of parks. This helps create a stronger emotional connection to public spaces and increases their use by residents.

Proposed pathways directly link recreational areas, such as the playground and picnic areas, to Main Street public transit routes and critical facilities in the downtown.



APPLIED TOOLKIT STRATEGIES

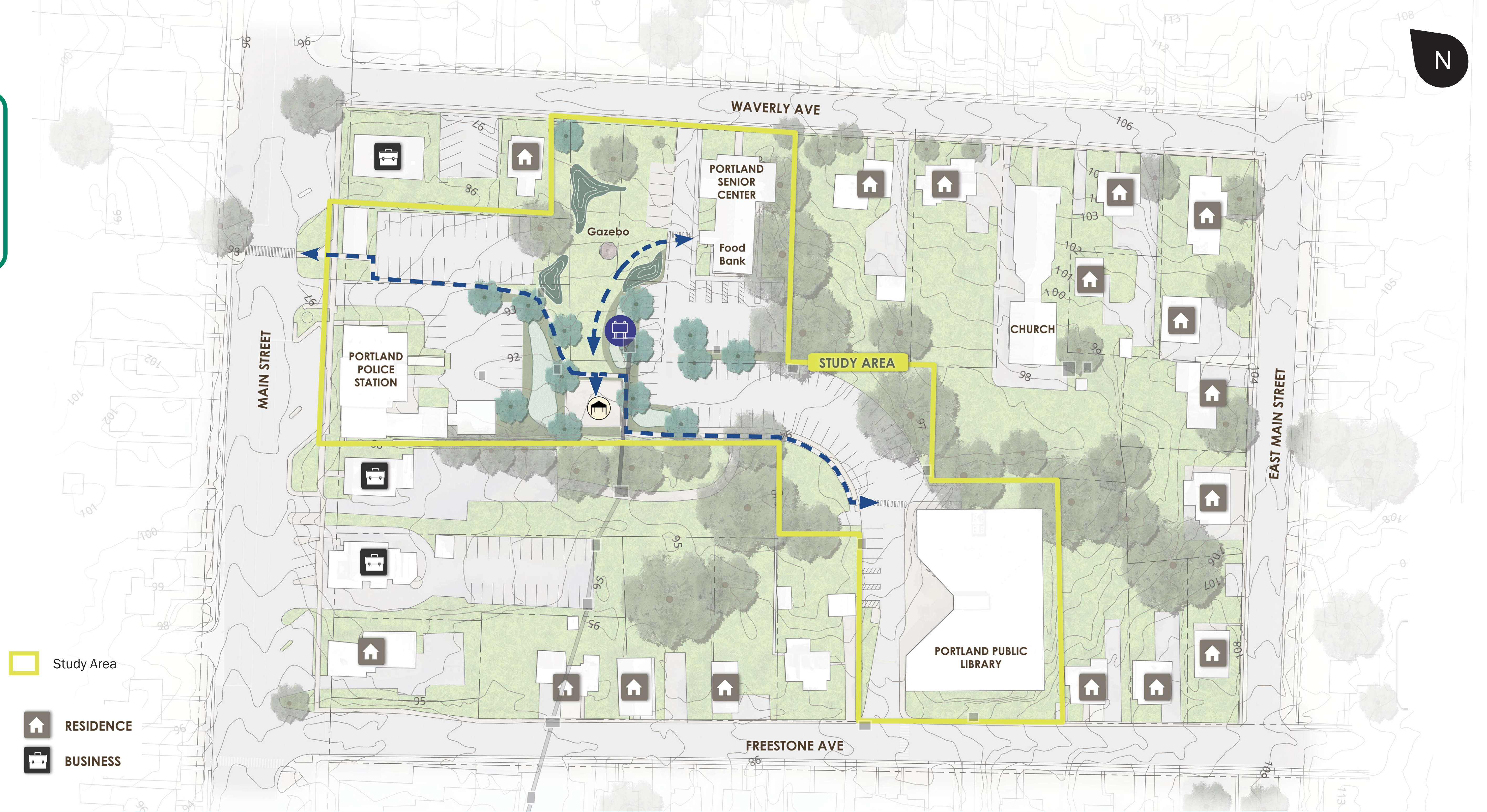
Educate community about resiliency

Interpretive Signage Suggested Location

Interpretive Signage

Interpretive signage not only raises awareness about environmental risks like heat and flooding but also enriches the public's experience of the space, fostering civic pride and a deeper connection to the place.

Signage can explain the significance of changes in the park and how local ecosystems, such as wetlands or parkland, help manage stormwater and reduce flooding by absorbing runoff and slowing water flow. Clear and informative signage can also create opportunities for learning, encouraging visitors to appreciate and take responsibility for the care of town spaces, generate public discourse and promote overall environmental awareness.



DESIGN ALTERNATIVES

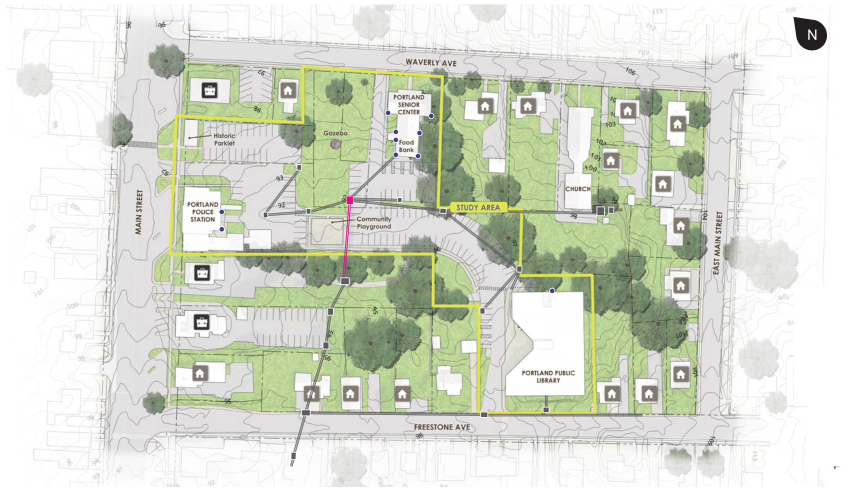
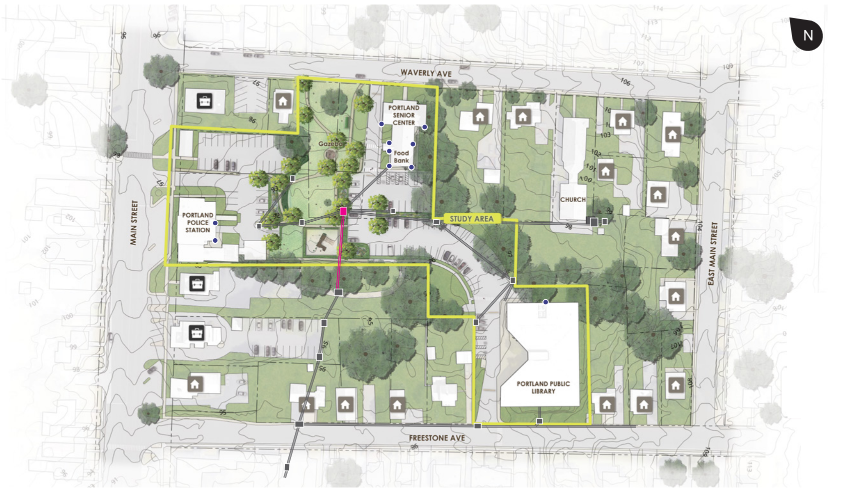
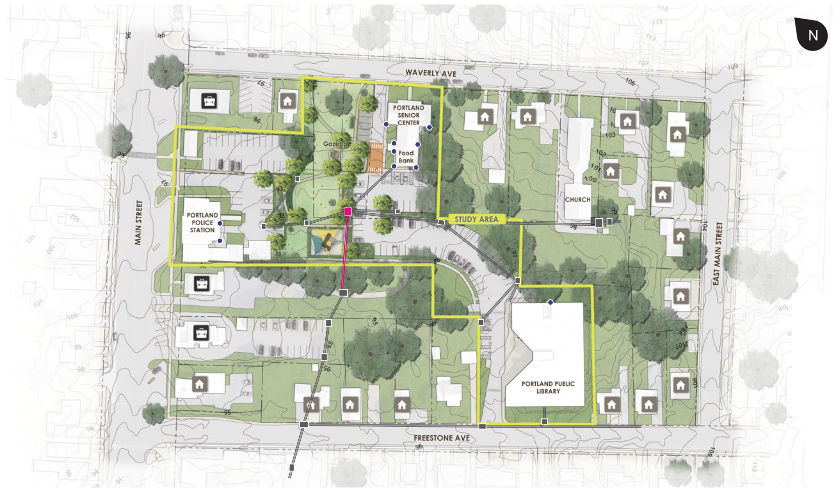
Three alternative design options were developed to address the project objectives. These alternatives incorporate the toolkit strategies to mitigate the impacts of flooding and heat, and improve community accessibility challenges.

The strategy improvements for each alternative are added to the design to provide the Town of Portland with the ability to prioritize their needs and goals for the project.

Alternative I addresses drainage system improvements to reduce flooding caused by an undersized and/or impaired existing system.

Alternative II includes additional mitigation strategies, such as reducing impervious surface area and adding green infrastructure bioswales to reduce the volume and rate of runoff during storm events. In addition, shade trees are proposed to reduce the impact of excessive heat within the study area.

Alternative III includes all design elements with the addition of pedestrian walkway connections between the project area, local transit routes and surrounding neighborhoods. This alternative also includes the additon of a shade structure at the playground. Additional parking is recommended to support the Senior Center and this parking is proposed to be constructed with pervious materials.

	Alternative I	Alternative II	Alternative III
	Drainage system improvements	Drainage system improvements Reduction of impervious surface Incorporation of green infrastructure Expand tree canopy for heat reduction	Drainage System Improvements Reduction of impervious surface Incorporation of green infrastructure Expand tree canopy for heat reduction Walkway improvements for pedestrian connections Shade structures for heat reduction Increase parking with pervious pavement
			
Actions	Replace existing 15" RCP	Replace existing 15" RCP Remove asphalt in parking lots Add lawn and plantings Incorporate rain garden and berms Plant trees throughout open park	Replace existing 15" RCP Remove asphalt in parking lots Add lawn and plantings Incorporate rain garden and berms Plant trees throughout open park Add shade structure(s) at playground and/or picnic shelter Add shaded walkway improvements for pedestrian connections Increase parking with pervious pavement
Estimated Project Cost ***For Applicable funding programs see "Funding Opportunity Matrix" in Appendix C***	$230,000	$1,220,000	$1,300,000

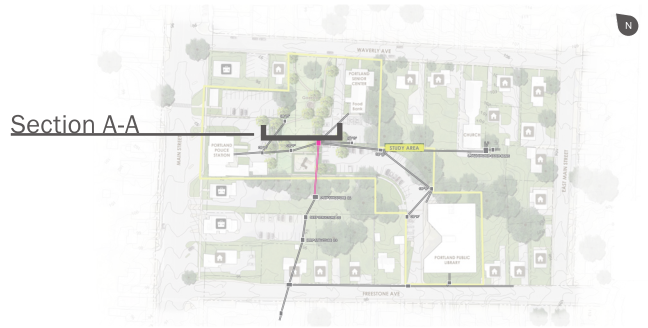
05
PREFERRED CONCEPTIONAL DESIGN

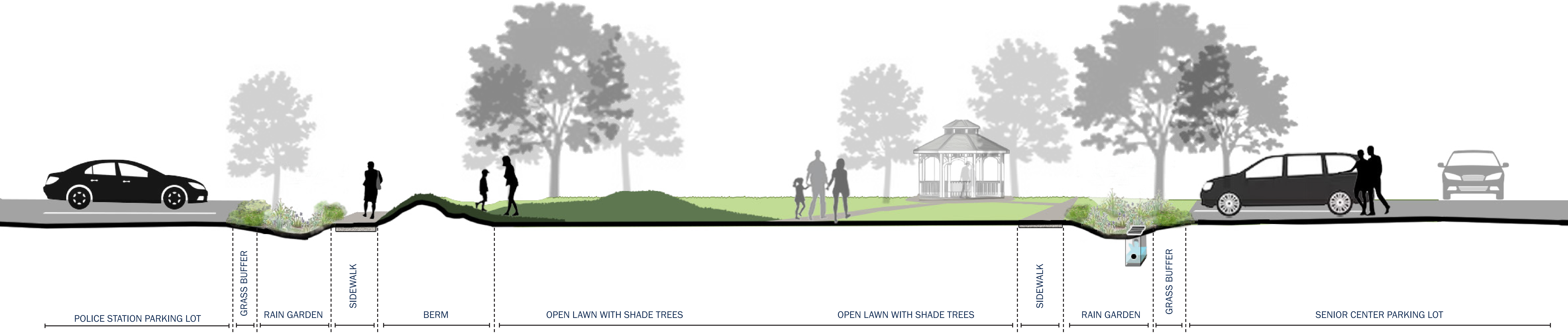
PREFERRED CONCEPTUAL DESIGN

	Design Objectives	Description
	Increase capacity of stormwater system	Update flood modeling to address undersized pipe at Catch Basin E and conduct stormwater analysis to ensure optimal pipe configuration and materials
	Reduce runoff that contributes to flooding	Provide additional strategies to manage stormwater through permeable paving, bio-retention beds, and reduction of impervious paving in parking lots
	Improve neighborhood connections	Promote walkability through shaded pedestrian connections to neighborhood and transit
	Reduce impact of extreme heat	Provide additional shade canopy trees for pedestrians in public park and playground areas, providing a healthy and safe environment for the community
	Educate community about resiliency	Incorporate interpretive signage and stewardship opportunities

PREFERRED CONCEPTUAL DESIGN SECTION

SECTION A-A: SECTION THROUGH PARKLAND AT CATCH BASIN E



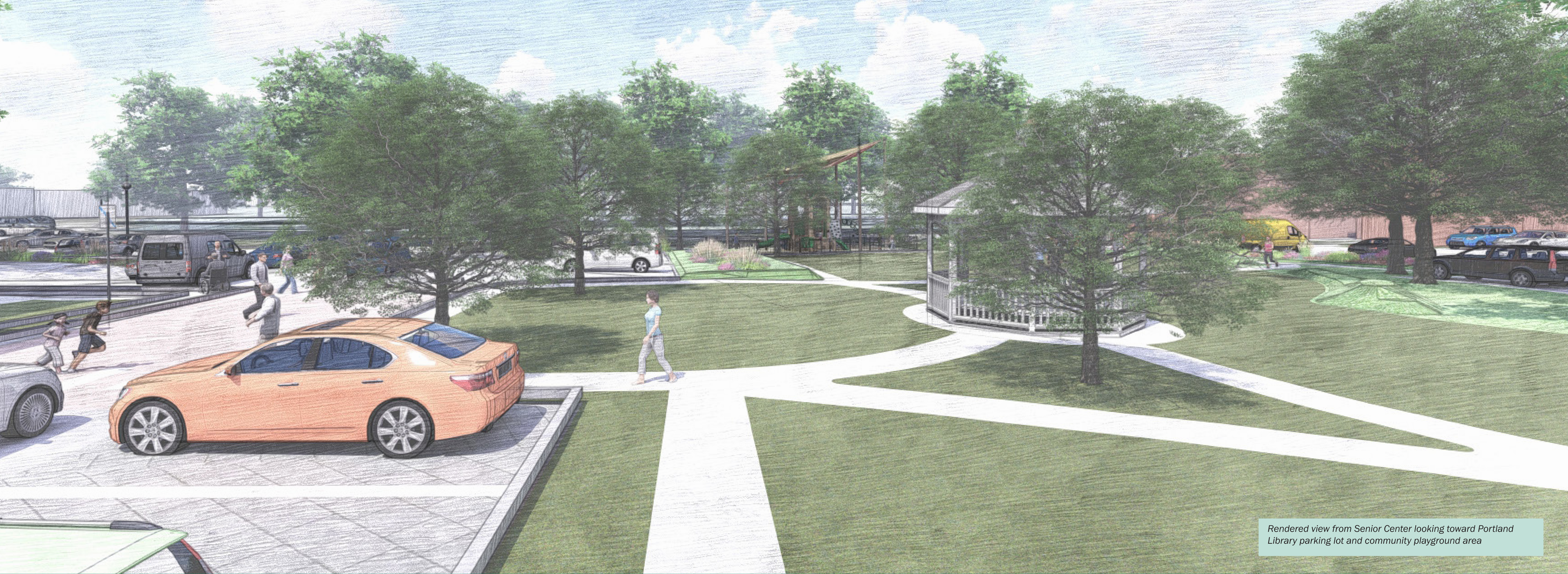


Section A-A

DESIGN RENDERING: BEFORE/AFTER

View from Senior Center looking toward Portland Police Station across public green space

Current Day View (left), Rendered Design Alternative (Right)



Rendered view from Senior Center looking toward Portland Library parking lot and community playground area

Rendered view from Police Station parking lot "Portland Fair" mural looking towards Senior Center

APPENDIX

GLOSSARY OF APPENDIX

APPENDIX A

Public Workshop Meeting Notes

Delivering a better world

PUBLIC WORKSHOP #1

Agenda

Meeting name
CIRCA Portland
Public Meeting #1

Project name
Resilient Portland

Meeting date
07/18//24, 6:30 PM

Location
Zoom

Attendees
Lorayne Black, PM *(AECOM, Landscape Architect)*
Geoffrey Morrison-Logan *(AECOM, Urban Planner)*
Ellie Peterson *(AECOM, Landscape Designer)*
Catherine Ellenburg (*AECOM, Civil Engineer)*
Mary Buchanan *(CIRCA, Resilience Planner)*
Jon Truscinski *(CIRCA, Director of Planning)*
Dan Bourret *(Town Planner)*
Margot Burns *(RiverCOG, Planner)*

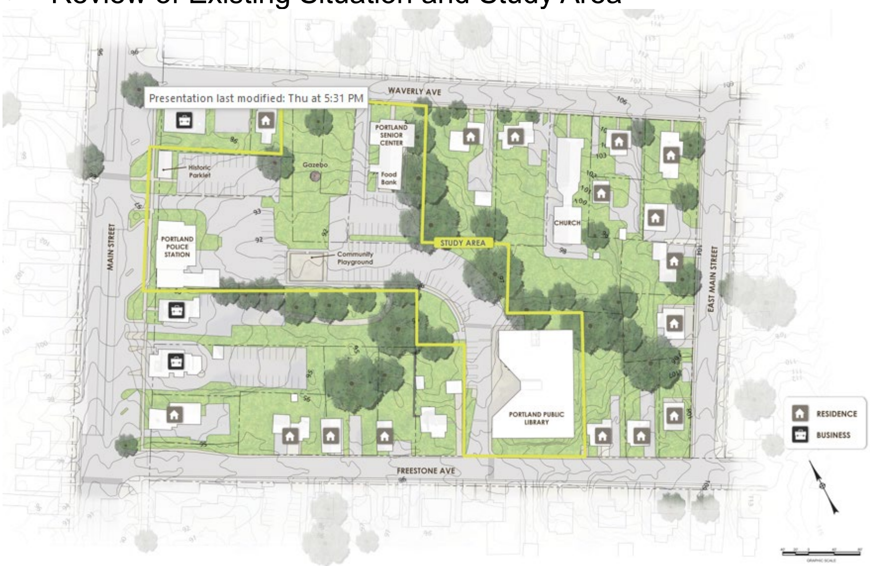
AECOM project number
60726342

Prepared by
Ellie Peterson

Meeting Agenda:

01 Welcome and Project Introduction
- Present project team
- Overview of CIRCA Mission, selection of ROARs, and the project pipeline throughout Connecticut

02 Project Overview
- Project Objectives
    i. Reduce flood impact on the critical facilities core of the Town of Portland from effects of excessive flooding and heat.
    ii. Community and stakeholder priorities should drive the selection of strategies and projects.
    iii. Develop plans to reduce the frequency, area and depth of flooding by reducing stormwater runoff
    iv. Apply future projections of precipitation events by years 2050 and 2100.
    v. Reduce impacts of extreme heat for the community
- Review of Existing Situation and Study Area



03 Heat Vulnerability & Urban Tree Canopy
- Review of urban canopy and impervious areas in study area show need for additional shade canopy

- CIRCA Heat Vulnerability Index (CCVI) demonstrates additional need for design interventions that target solutions for heat
- Analysis of public transit routes, parking areas, and accessibility for place of interest

04 Site Observations & Flood Analysis

- Site contours show that storm runoff drains towards one area within the parking lot behind the police station, creating excessive ponding
- Inlet 'E' is the junction point for all drainage in study area, which connects to an outlet pipe that is undersized for stormwater flow in system during extreme events
- Drains from buildings connect to drainage system. Ground level flooding may be caused due to lack of capacity in system

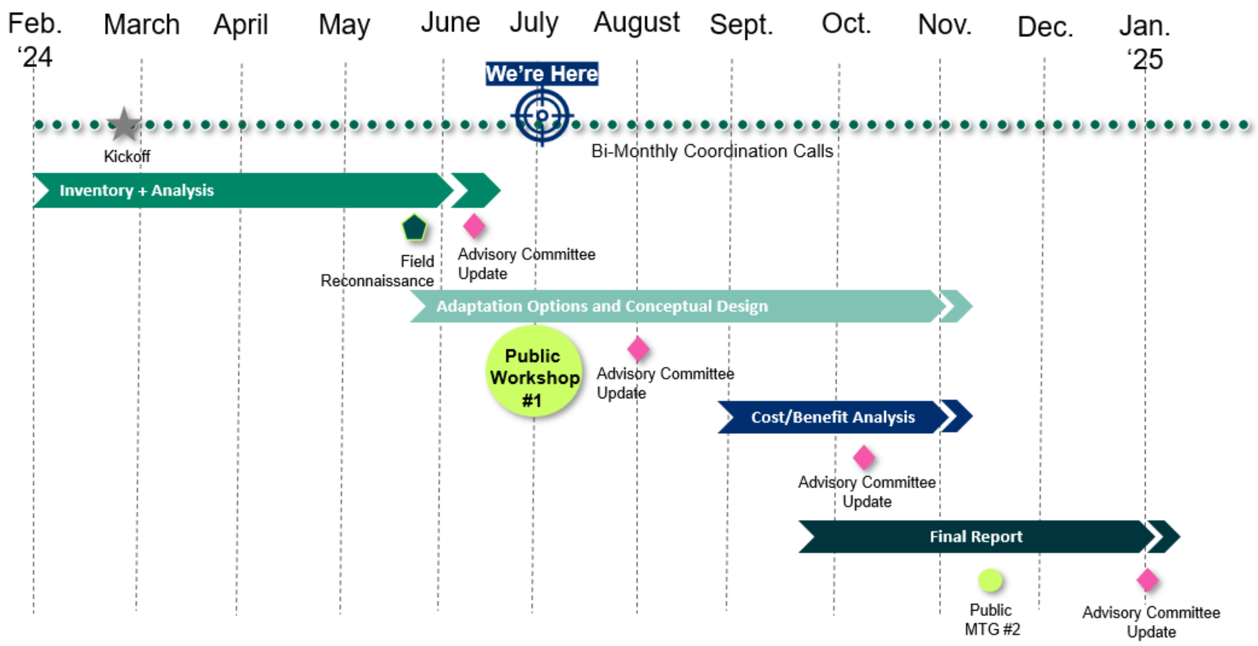
05 Resilient Strategies: Design Toolkit

- Expand Urban Tree Canopy
- Incorporate Green Infrastructure bioretention beds or "Rain Gardens"
- Reduce Impervious Paving
- Increase Pipe Capacity & Update Drainage Infrastructure
- Add Signage & Community Education tools

06 Discussion/Input from Town on Analysis and Resilient Strategies

- **Nancy Brault:**
  Comment: She agrees with filtering runoff with rain gardens and is happy with the solutions that were suggested. She is concerned about the cost of drainage infrastructure changes but feels this could be necessary.
  Question: Is there a town committee for planning process?
  Answer (Lorayne): Yes, a town advisory committee is overseeing over recommendations and offering feedback
- **Bob Ellesworth**:
  Question: What is the community use of this area?
  Answer (Dan Bourret): Public works uses this area for several events, such as an Ice cream social and petting zoo event. The library spaces and senior center also utilize this green space for family events. We would like to help make this civil park even more appealing for people to visit in the future.
  Question: Is there an evaluation of how much water is being channeled from roof drainage?
  Lorayne: Absolutely. We are considering roof runoff as well. Keep in mind, all these design recommendations will help reduce risk of flooding throughout this area.
  Question: Could we do an analysis of the current parking layout and try to improve the operations and overall capacity?
  Answer (Geoffrey/Lorayne): We understand parking is a priority and would like to optimize the availability of parking for the public with pervious alternatives to reduce flooding issues in the future
  Comment: Consider utilizing other parking areas in the downtown outside of the study area.
  Comment: Consider looking at other small downtown areas with popular central green spaces such as water feature in Glastonbury, CT and Colchester, CT.
- **Angela Hammond:**
  Question: Are we strictly limiting this to the downtown area? Could the scope be expanded to other areas?
  Answer (Dan): This is something that could be considered for the future but is far too large a scope for this project.
  Answer (Lorayne): The design toolkit that we established for this project may be useful for addressing similar issues within other areas in town in future.

Schedule



Action Items:

1. **Next Steps for AECOM**
    a. Finalize Existing and Future Conditions Analysis Task 3 Report
    b. Schedule Next Advisory Committee Meeting
    c. Develop design alternatives for study area using resilient strategies

Agenda

Meeting name
CIRCA Portland
Public Meeting #2

Project name
Resilient Portland

Meeting date
12/12/24, 6:00 PM

Location
Zoom

Attendees
Lorayne Black, PM *(AECOM, Landscape Architect)*
Geoffrey Morrison-Logan *(AECOM, Urban Planner)*
Ellie Peterson *(AECOM, Landscape Designer)*
Mary Buchanan *(CIRCA, Resilience Planner)*
Jon Truscinski *(CIRCA, Director of Planning)*
Dan Bourret *(Town Planner)*
Margot Burns *(RiverCOG, Planner)*

AECOM project number
60726342

Prepared by
Ellie Peterson

Meeting Agenda:

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  - i. Reduce flood impact on the critical facilities core of the Town of Portland from effects of excessive flooding and heat.
  - ii. Community and stakeholder priorities should drive the selection of strategies and projects.
  - iii. Develop plans to reduce the frequency, area and depth of flooding by reducing stormwater runoff
  - iv. Apply future projections of precipitation events by years 2050 and 2100.
  - v. Reduce impacts of extreme heat for the community
- Review of Existing Situation and Study Area and flood and heat analysis methodology
  - i. Key Takeaways:
    1. After our initial filed assessment of the existing drainage system and modelling of future storms, we determined that all the runoff on this block is funneling into a single catch basin located just above the community playground, referred to as "Catch Basin E".
    2. Modeling the 100-year storm event in this block confirmed that flooding would be expected to be in the same area observed during pervious severe storm events and that backflow from connected pipes would likely cause basement flooding as well

02 Adaptation Options Design Toolkit

- The following design strategies guided the final design recommendations:
    i. Increase capacity of stormwater system
    ii. Reduce runoff that contributes to flooding
    iii. Improve neighborhood connections
    iv. Reduce impact of extreme heat
    v. Educate community about resiliency

03 Design Recommendations

- Replace undersized pipe at **Catch Basin E.** Undertake additional stormwater analysis and design to right-sized pipe configuration
- Provide additional strategies to manage stormwater through **permeable paving**, **bioretention beds**, and **reduction of impervious paving**
- Promote walkability through **shaded pedestrian connections** to neighborhood and transit
- Provide **additional shade canopy trees** for heat relief for people in public park and **shade structures** in playground area, providing a healthy and safe environment for the community
- Incorporate **interpretive signage** and **stewardship opportunities**. Community crosswalk could be turned into a public art project, encouraging local engagement in park changes, while also pairing as a traffic slowly device

04 Implementation & Next Steps

- Finalize the Draft Report
- Seek and secure funding to further develop the design
- Update the future conditions flood model to right size the design elements by incorporating the recommendations from the draft flood modeling findings
- Undertake schematic design and confirm project approach with Town Leadership and the Portland community
- Refine costs and implementation steps
- Advance the project through design development and construction documentation
- Develop a plan to implement the project through construction

06 Discussion/Input from Town on Analysis and Resilient Strategies

- **Bob Ellsworth**:
  Question: Do we know where the Catch Basin E outlet pipe drains into?
  Answer (Ellie Peterson): The system drains out toward Freestone Avenue, but according to the site analysis of the stormwater system, only a small section of the outlet pipe requires replacement
  Question: Can you define permeable paving?
  Answer (Lorayne Black): Absolutely. This pavement consists of an open-graded coarse aggregate, bonded together by asphalt cement, with sufficient interconnected open spaces to make it highly permeable to

water. University of New Hampshire (UNH) has performed various studies to prove the long-term durability of this paving system as well.
Question: Could the proposed pedestrian pathways be permeable paving as well?
Answer (Lorayne/Ellie): Yes this would be recommended. Also, the parking lot reconfiguration in this scheme also offers added green space.

- **Nancy Brault** *(Wetland Commissioner for Town of Portland)***:**
  Question: Are the proposed rain gardens shown finalized in size?
  Answer (Lorayne): These drawings are purely conceptual, however in our experienced the size and depth is appropriate for this park area.
- **Sarah Elliot** *(Senior Center Director)***:**
  Question: I'm concerned about the location of the proposed senior center parking spaces because cars travel very quickly in the driveway. Is this the best location?
  Answer (Lorayne/Geoffrey/Ellie): Creating a raised crossing in this location should naturally slow traffic and make the parking lot more pedestrian friendly. People may be traveling quickly here now because the drive is fairly streamlined with no visual obstacles. Studies have shown that the addition of bump-outs are very effective to significantly slow traffic.
- **Nancy Brault** *(Wetland Commissioner for Town of Portland)***:**
  Question: Is it possible to move the Senior Center driveway off Waverly Ave to the other side of the building?
  Answer (Geoffrey): Great thought, but the property line and existing trees on that side of the building create don't allow for a wide enough corridor. Also, there is a new generator that is located on that area that could not be easily moved.
- **Chantal Foster**
  Question: Is the driveway by the senior center intended for two-way traffic?
  Answer (Geoffrey): This is an existing feature which we have not proposed changing. The driveway measures 22' wide and currently accommodates two-way traffic.
- **Bob Ellsworth**:
  Question: Could we remove the Waverly Ave driveway altogether?
- **Joan Giesemann and Elwin Guild**:
  Question: Following up on this comment, could we consider removing this driveway and creating a new drive connecting the police station to the senior center parking lot?
  Answer (Geoffrey): One thing to keep in mind about this idea is that it would cut through the existing park area however this brainstorm is great. I can see the benefit of how that could improve vehicular circulation and these ideas could be considered in future iterations of this design.
  Comment: We should consider recommending permeable paving for all future surfaces in this area.
  Comment: Trees should be mindfully selected to help with long-term maintenance of paving selections.
- **Nancy Brault** *(Wetland Commissioner for Town of Portland)***:**
  Comment: I suggest that all plantings selected in the future should be native plantings
  Answer (Lorayne): Absolutely and a focus on biodiversity as well.
- **Bob Ellsworth**:
  Question: Has someone done a study to determine the number of parking spaces needed for this area?
  Answer (Ellie): We have not done an official study; however we have received comments from representatives of the Public Library and Senior Center expressing the need for parking in this lot. One of our goals in this design process was to improve the water runoff conditions, while also maintaining the same number of parking spaces.
- **Chantal Foster**
  Question: Is it fair to say that replacing the outlet pipe at Catch Basin E will solve the drainage issue?
  Answer (Geoffrey): Right-sizing this pipe is important. We do believe this is a large contributing factor and replacing this pipe ought to be prioritized, however we put together this toolkit approach so that this key block of the downtown could perform better as a landscape overall.
  Question: Does this problem exist in other areas of Portland or did you just not look at other areas because there was no critical infrastructure?
  Answer (John Truscinski): CIRCA selects the project sites based on critical facilities or infrastructure that are especially vulnerable to flood and/or heat. This block in Portland was put on our radar because we know it is of great concern to the town of Portland and town officials can work alongside us.
  Answer (Lorayne): One of the advantages of this type of work is that the town becomes aware and has an example of the solutions that can be applied in other areas of concern
  Answer (Dan Borret): This was a targeted project from the start. The basements of the Police Station and Senior Center have flooded multiple times, and this issue is costing the town as time passes. Therefore, the town is motivated to work with CIRCA and the consultant team to remedy the problem.

- **Margot Burns**
  Comment: The state of CT is looking for projects that can be applied for at a federal level. The Cost Benefit Analysis (BCA) is an important tool to achieve this type of funding. The replacement of the undersized pipe mentioned will likely be one of the most expensive components, but it will also benefit a lot of people. So, if this improvement is emphasized in the analysis, it may raise this project above others competing in the state.
- **Bob Ellsworth**:
  Comment: It is not very appealing to walk through this area now. It would be great if we could make this area more walkable.
- **Chantal Foster**
  Comment: I would like to put in another vote for permeable paving. It would be great if the town could prioritize permeable options in this area in the future.

AECOM

APPENDIX B

Flood Model Reference Documents

Delivering a better world

Existing Conditions Model – Supplemental Information

Land Surface and Datums

Elevation contours, derived from LiDAR survey data from 2016, were gathered from the University of Connecticut Environmental Conditions Online (CTECO). The contours were used to delineate drainage areas, as well as estimate rim elevations for some catch basins when the data were not available from existing project plans. Land cover and aerial imagery were also gathered from the CTECO.

The 2016 contours from LiDAR were referenced to the North American Vertical Datum of 1988 (NAVD88). Existing library as-built plans provided by the Town of Portland did not include any notes about the vertical datum that was used for the design and construction of the library, however the plans are dated prior to 1988 and therefore it was assumed that any survey information on the plans was referenced to the older National Geodetic Vertical Datum of 1929 (NGVD29). There is a difference of approximately -1.01 ft between NAVD88 and NVGD29 in the vicinity of the Town of Portland. For example, elevation 99.0 ft (NAVD88) = 100.01 ft (NGVD29). Where applicable, any rim elevations for existing catch basins estimated from LiDAR contours were converted from NAVD88 to NGVD29.

Town of Portland Drainage Network

Spatial locations of catch basins within the Town of Portland were provided by CIRCA and were referenced using GIS software for the development of the model (**Figure 1**). These data were supplemented with information from the existing library as-built plans (**Figure 2**); existing drainage plans; aerial imagery; notes and assumptions from the Town of Portland Public Works; and photos and observations from site visits.

Figure 1: Contour data derived from 2016 LiDAR (red/orange lines) and spatially referenced catch basins (yellow dots) shown over aerial imagery for the Town of Portland.

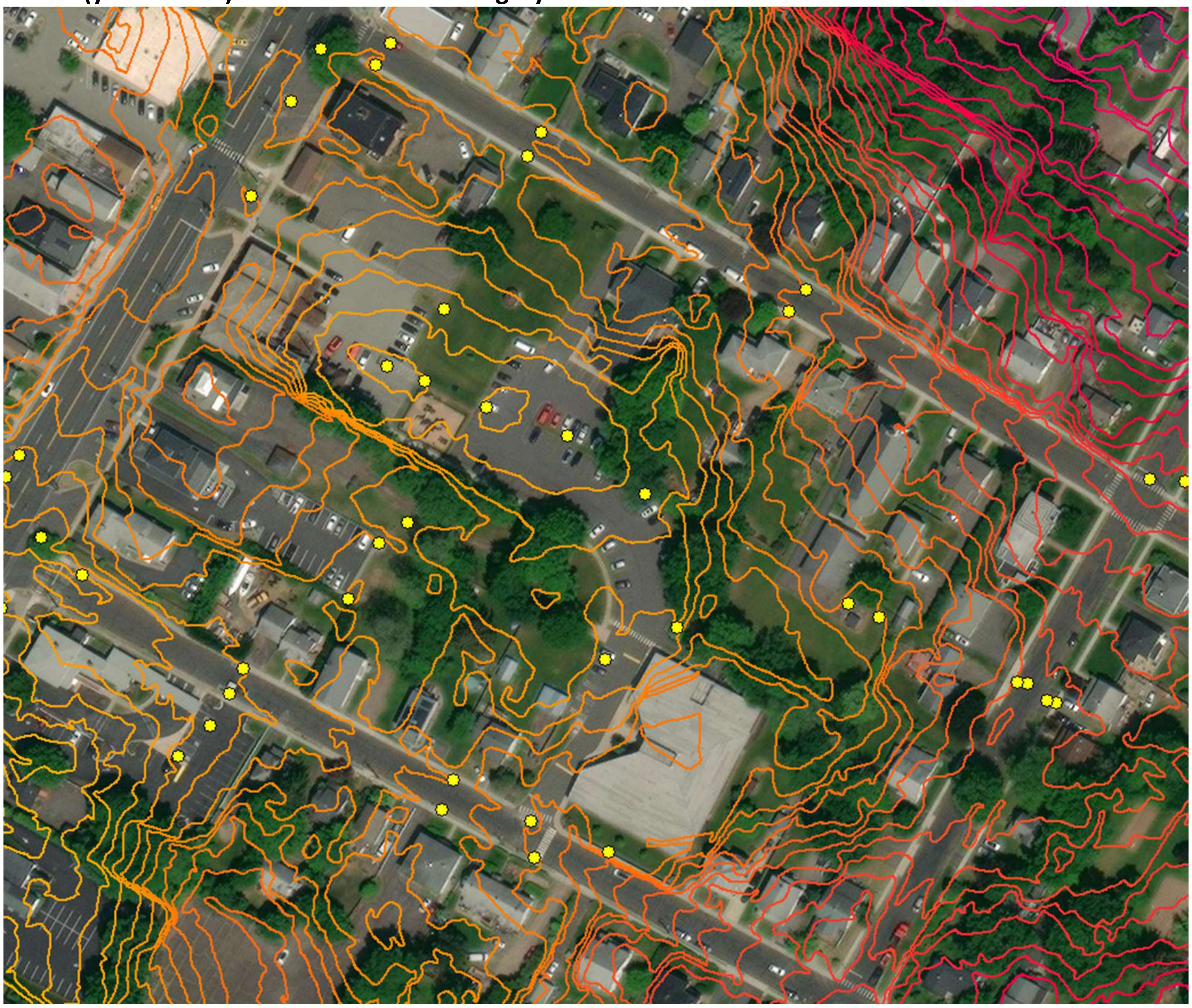
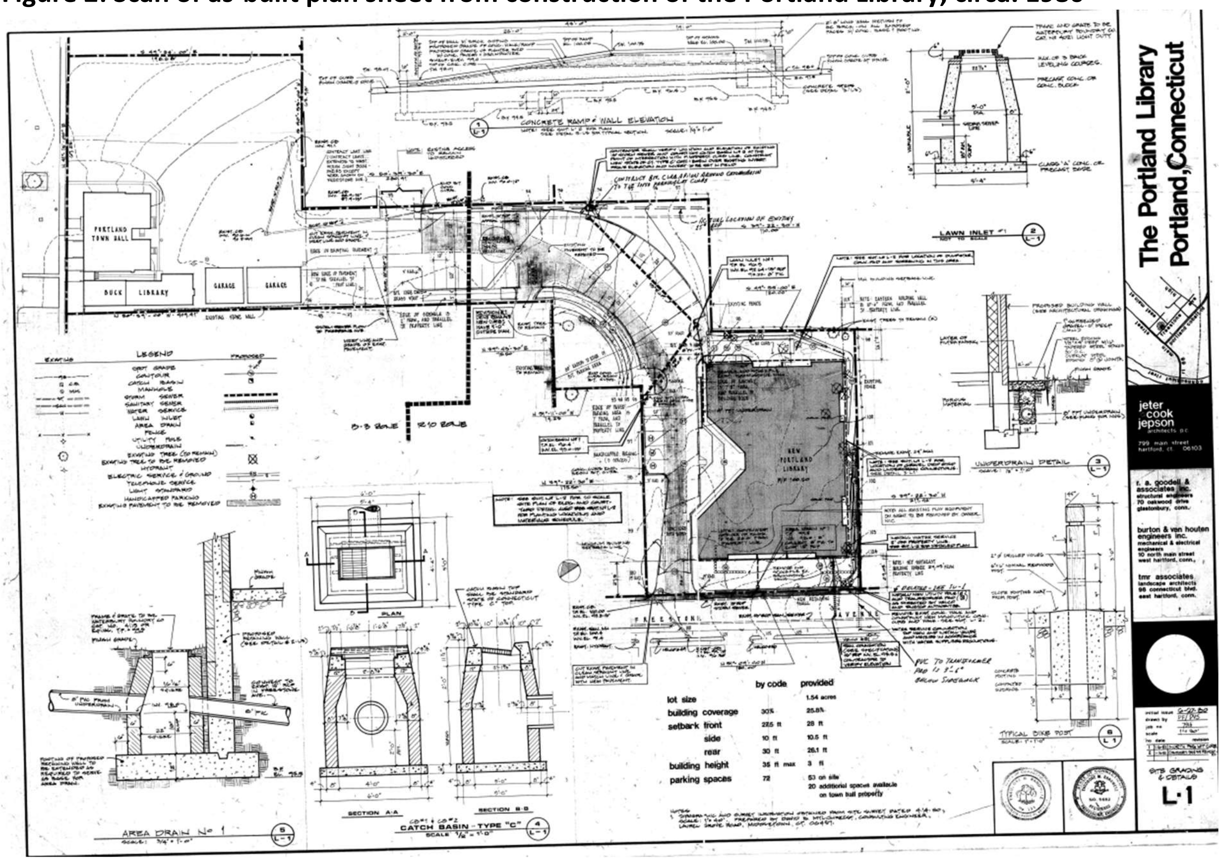
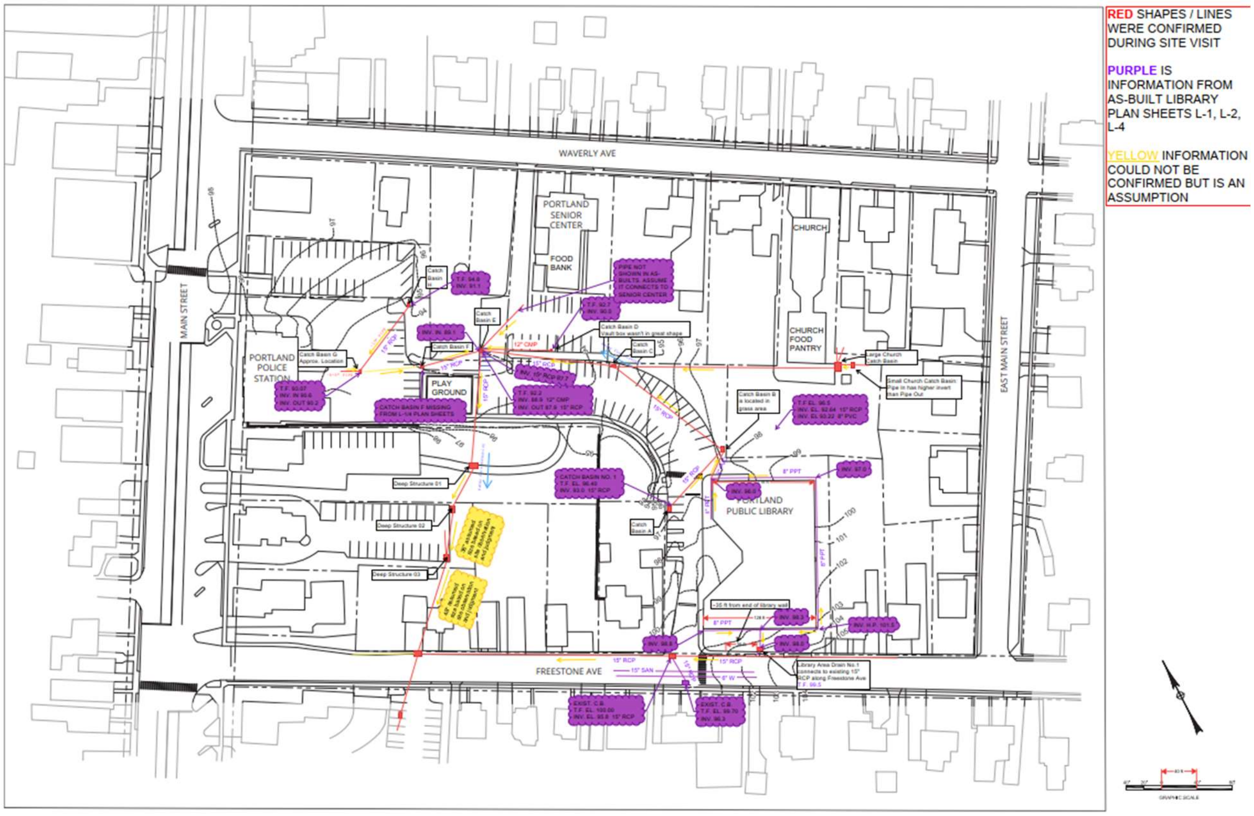


Figure 2: Scan of as-built plan sheet from construction of the Portland Library, circa. 1980



A walking tour of the project site was completed on February 23, 2024. Field data about the existing drainage network were collected during two later site visits on May 14, 2024 (a sunny day) and May 15, 2024 (a rainy day). Information from this variety of sources was synthesized to recreate, to the greatest extent possible, a representation of the existing drainage network in the project focus area, including pipes, catch basins, and lawn drains. See **Figure 3**.

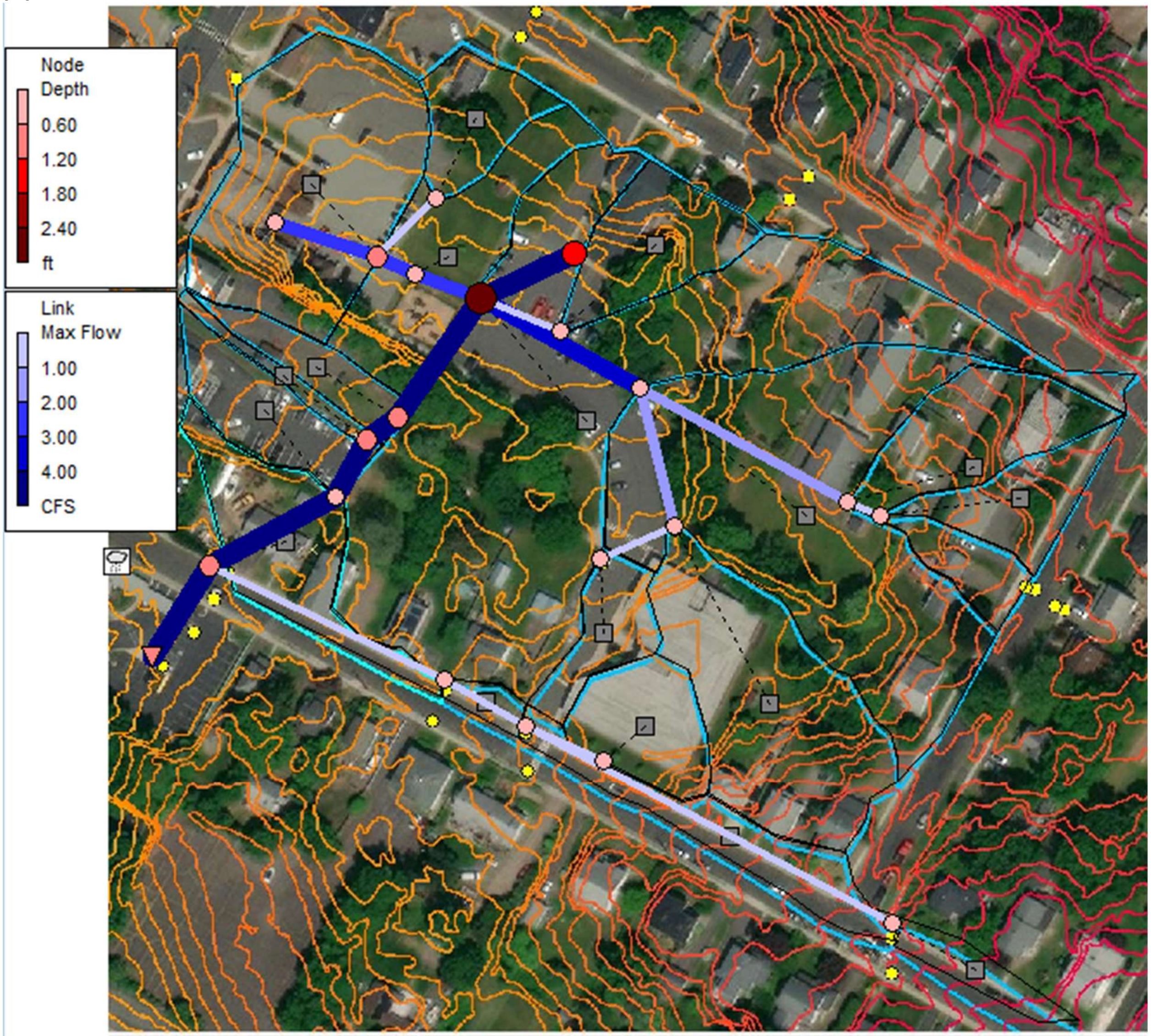
Figure 3: Representation of drainage network assembled from field notes.



Locations of roof drains and downspouts were noted in the field, and some assumptions were made about where and how they connect to the existing pipe network underground. Basement drains from the police station and senior center were observed to connect to the existing drainage system at catch basins G and E, respectively. The basement drains could not be modeled accurately, but due to their low elevations with respect to the existing drainage system inverts, they represent possible sources of backflow during severe weather events.

The limits of the modeled drainage network were chosen by setting an outfall location based on existing plans and field data. A deep catch basin on Freestone Avenue connects to an existing brownstone culvert of unknown size that is thought to drain the entire network of pipes and catch basins in the parking lot behind the police station and between the senior center and library. See **Figure 4** which depicts the modeled network.

Figure 4: Screenshot of the modeled network (with backdrop from GIS); catch basins are nodes and pipes are links in the model.



Rainfall

Time series based on a design storm were used to run the EPA SWMM model simulation. Time series for the model were computed based on rainfall data from the **NOAA Atlas 14 24-hour precipitation depths**, for several recurrence intervals (the 1-Yr, 2-Yr, 5-Yr, 10-Tr, 25-Yr, 50-Yr, and 100-Yr); and based on the **NRCS Type N10_D design storm rainfall distribution.** The rational for using these rainfall depths and distribution is based on the Connecticut Stormwater Quality Manual, Appendix G, for Stormwater Quantity Control Design Storm:

- *"In 2015, the Northeast Regional Climate Center (NRCC) developed updated NRCS rainfall distributions for the Northeast states, including Connecticut. These NRCC rainfall distributions were then replaced in 2018 for use in the NRCS WinTR-55 computer program in CT, as NRCS derived four new regional rainfall distributions (Types N10 A, B, C, and D) from the NOAA data to cover the NOAA Atlas 14, Volume 10 study area, which supersede all previous distributions.*

Connecticut NRCS recommends the use of the Type N10_D regional rainfall distribution to represent the entire state of Connecticut in WinTR-55. This or site-specific rainfall distributions can be used with the NOAA Atlas 14 estimates of 24-hour precipitation depths. The NRCS Type N10_D rainfall distribution is also recommended for use with other common rainfall runoff and stormwater design programs such as HydroCAD."

The cumulative rainfall distribution for the NRCS Type N10_D design storm was obtained from within WinTR-55 software. This design storm has a time increment of 0.1 hrs. From the cumulative rainfall distribution (**Figure 5**), the 0.1-hr incremental rainfall depths for each 24-hour precipitation event could be computed (**Figure 6**). The results of these computations were used for the time series in the EPA SWM model.

Figure 5: Cumulative Rainfall for 24-Hour Storm, Distribution NRCS Type N10 - D

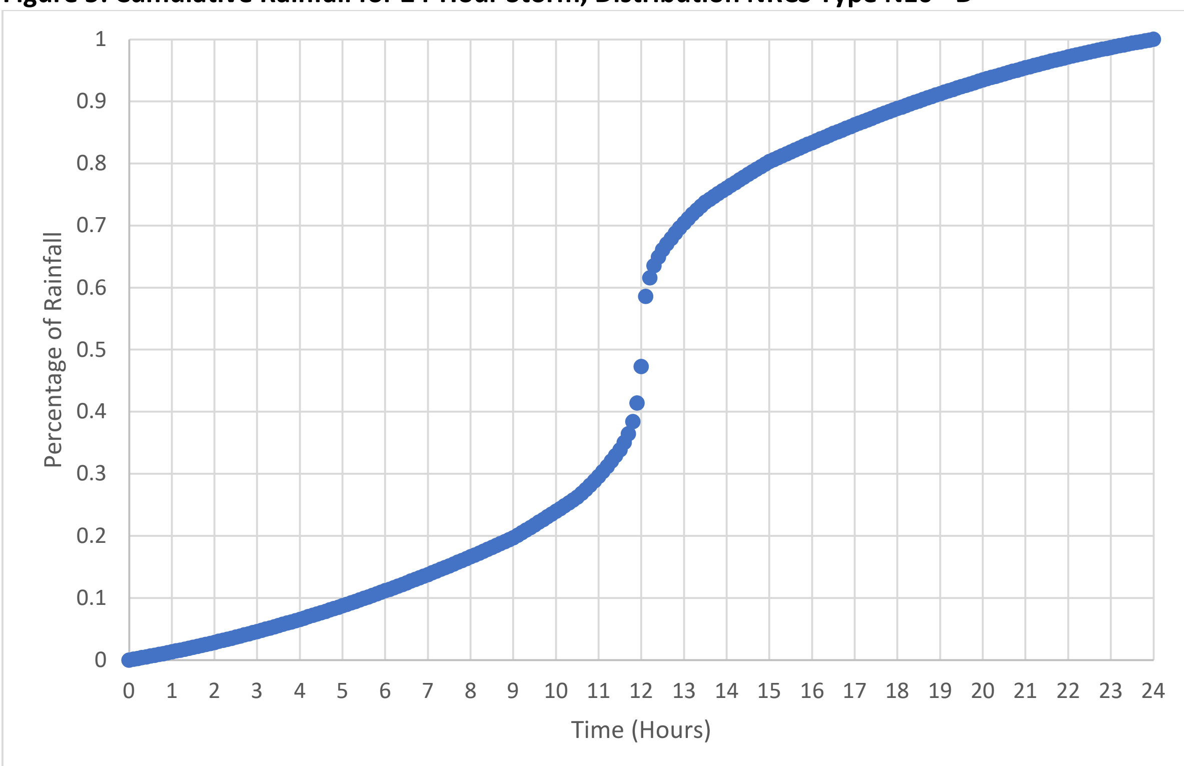
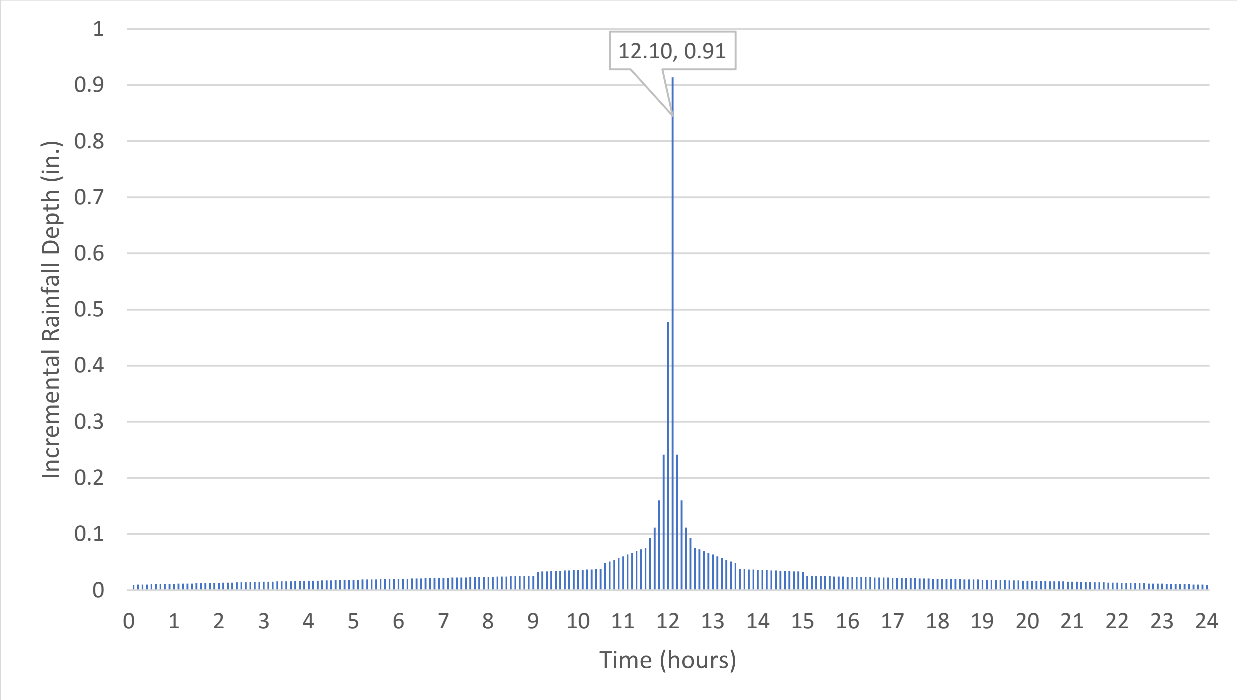


Figure 6: Incremental (0.1-hr) rainfall for NOAA Atlas 14 100-year rainfall depth and 24-Hour duration.



Infiltration and Modeling Approach

EPA SWMM can accommodate a few different approaches to infiltration modeling. The Modified Green-Ampt infiltration method was selected for this planning-level assessment. The Modified Green-Ampt method is an arithmetic model that calculates infiltration losses from the land surface based on hydraulic conductivity of the soils present at the project site. The USGS Web Soil Survey was consulted for the soil types and their respective hydraulic conductivity properties. The entire project site was found to have urban soil types with low hydraulic conductivity, leading to low infiltration capability (**Table 1**). To be conservative, the soil type with the most conservative parameters (i.e. lowest infiltration capacity) was selected and it was assumed that this soil type applied to all the modeled area.

Table 1: Soil conditions in the Town of Portland.

Soil Map Unit Symbol	Soil Map Unit Description	Saturated hydraulic conductivity (K_{SAT}), in/hr	Suction Head, inches	Initial deficit (approximate)
307	**Urban Land**	**0.06**	**8.17**	**0.154**
230B	Branford-Urban land complex, 0 - 8 % slopes	2.608	2.36	0.332
221A	Ninigret-Urban land complex, 0 - 5 % slopes	1.417	2.89	0.332

Once all inputs were established, the model was run using the Dynamic Wave routing method. One of the reasons for using this method was to permit backwater conditions in the model, in accordance with surcharge and flooding that was observed at catch basins in the parking lot.

Results

Figures 7-8 below show the modeled flow in pipes (blue shading) and on the ground surface (green line) from two different perspectives: from the senior center to the outfall on Freestone Avenue, and from the police station to the outfall. Results are presented for the 100-year storm under existing conditions and for the 100-year storm under future 2050 and 2080 conditions. There was an observed absence of any ponding in any of the modeled scenarios, which if it were present should be represented by blue shading above the ground surface. Flood depths in the modeled scenarios were all 0f t, however real-world observations and pictures showed flood depths greater than 0 ft for extreme events.

Figure 7a: Modeled pipe flow from the senior center to the outfall for the 100-year storm under existing conditions.

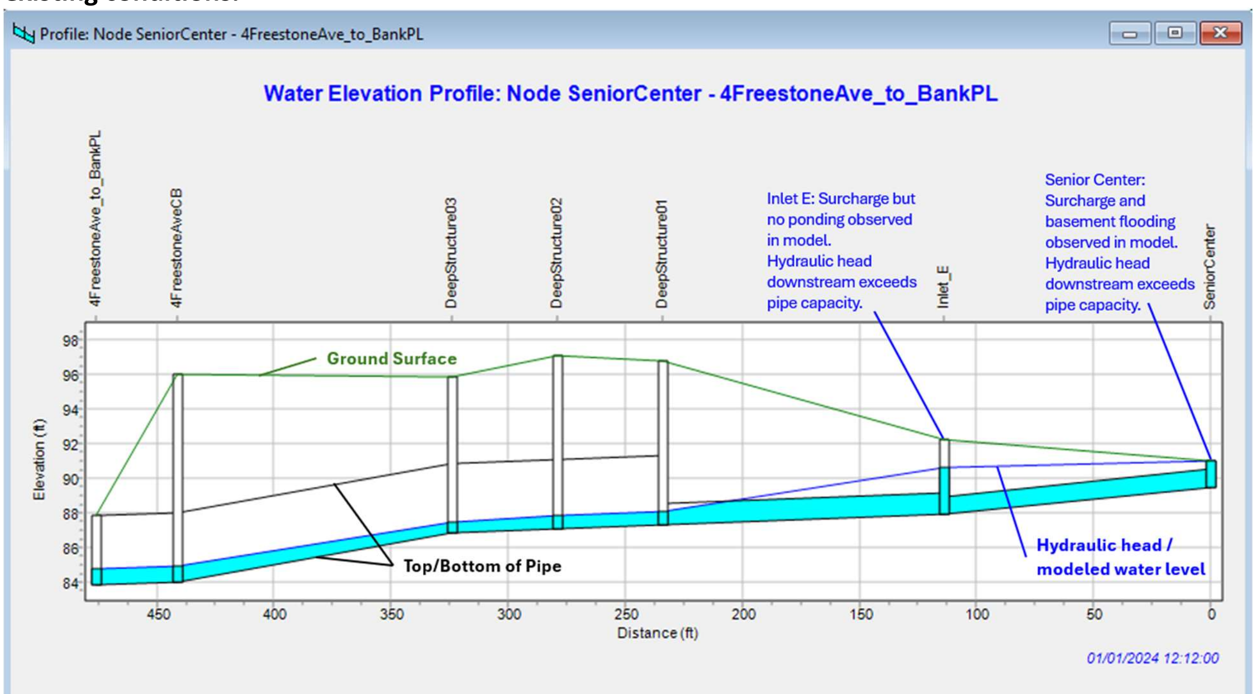


Figure 7b: Modeled pipe flow from the senior center to the outfall for the 100-year storm under future 2050 conditions.

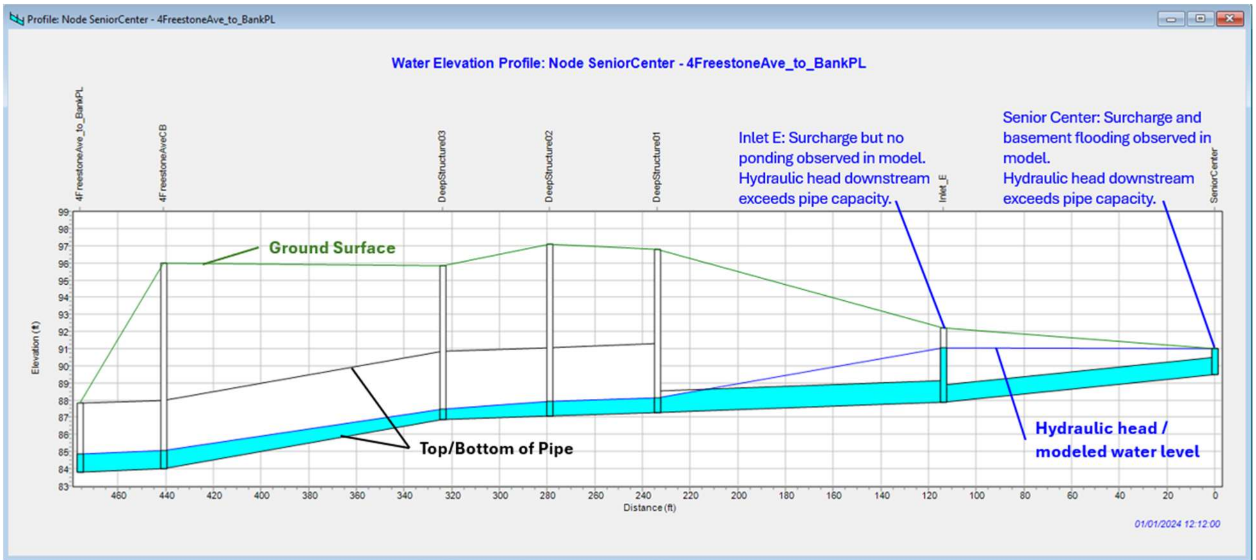


Figure 7c: Modeled pipe flow from the senior center to the outfall for the 100-year storm under future 2080 (end-of-century) conditions.

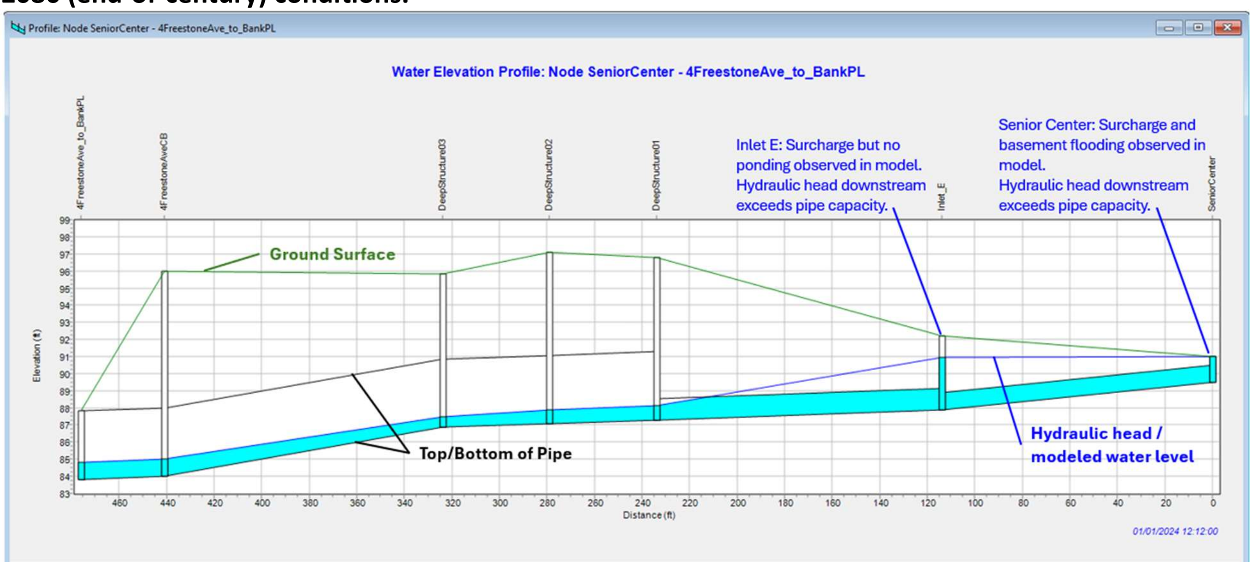


Figure 8a: Modeled pipe flow from the police station to the outfall for the 100-year storm under existing conditions.

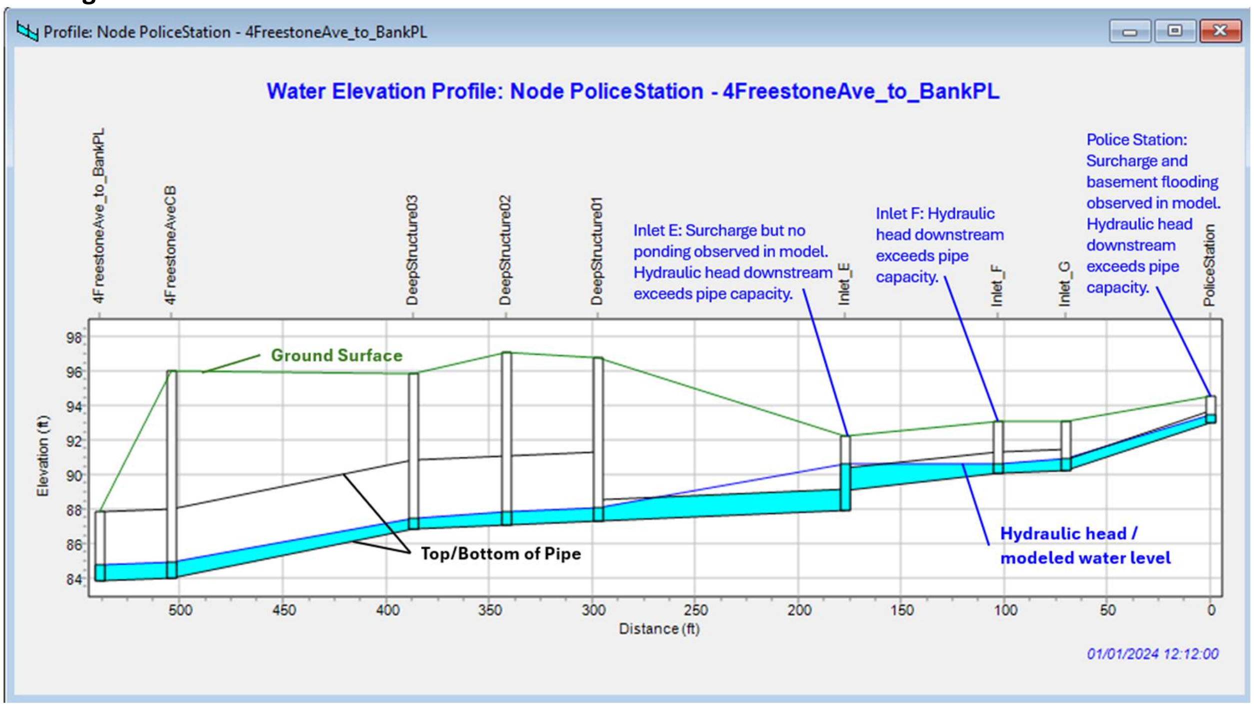


Figure 8b: Modeled pipe flow from the police station to the outfall for the 100-year storm under future 2050 conditions.

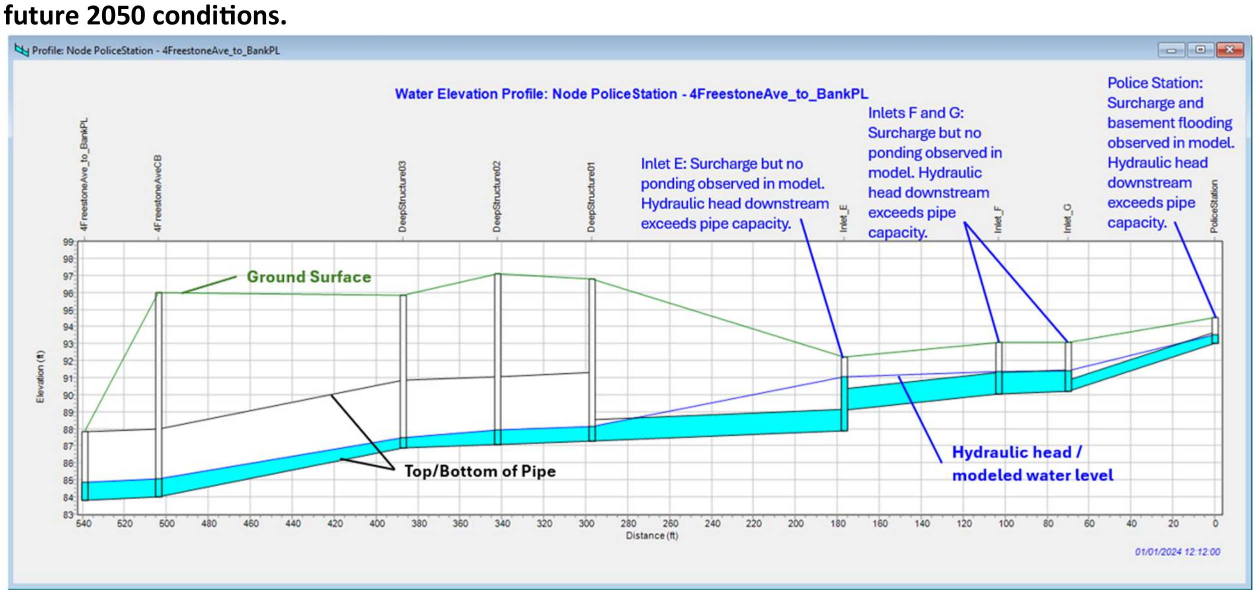
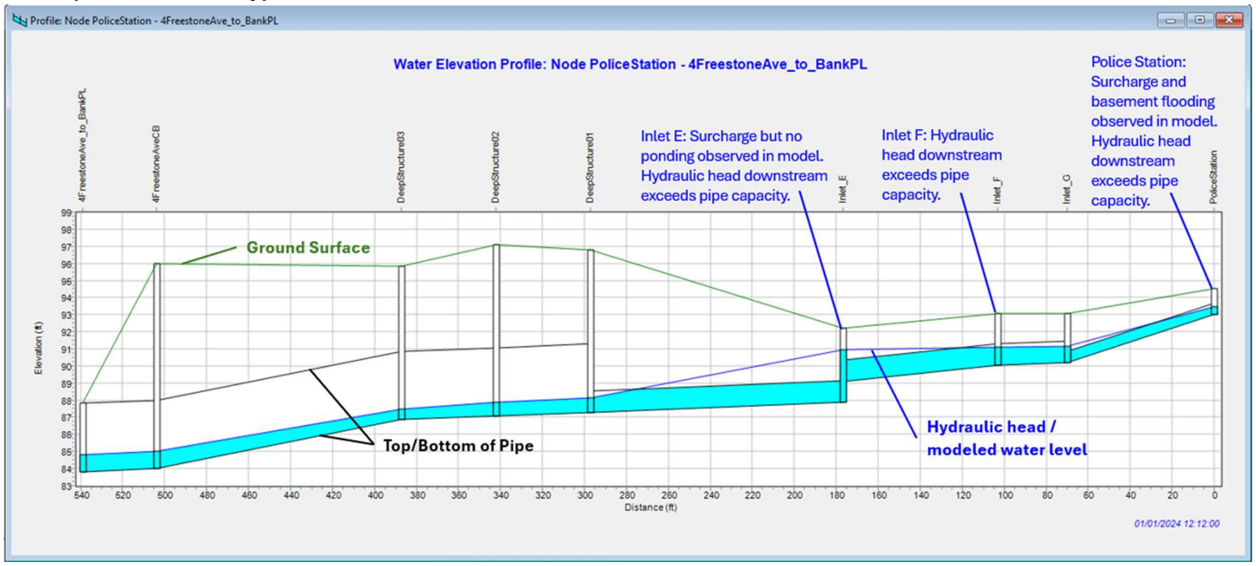


Figure 8c: Modeled pipe flow from the police station to the outfall for the 100-year storm under future 2080 (end-of-century) conditions.



Since flooding was expected in the model based on anecdotal reports following extreme events that previously occurred in town, but no surface flooding appeared in the model, another modeling approach was deployed using the Rational method. This alternative approach yielded significant flooding in the parking lot (**Figures 9a and 9b**) even for the 10-year event, a less extreme event. The two modeling approaches were considered together to make assumptions about the flooding extents which are described in the technical memorandum.

Figure 9a: Modeled pipe flow using the Rational Method from the police station to the outfall for the 10-year storm under existing conditions.

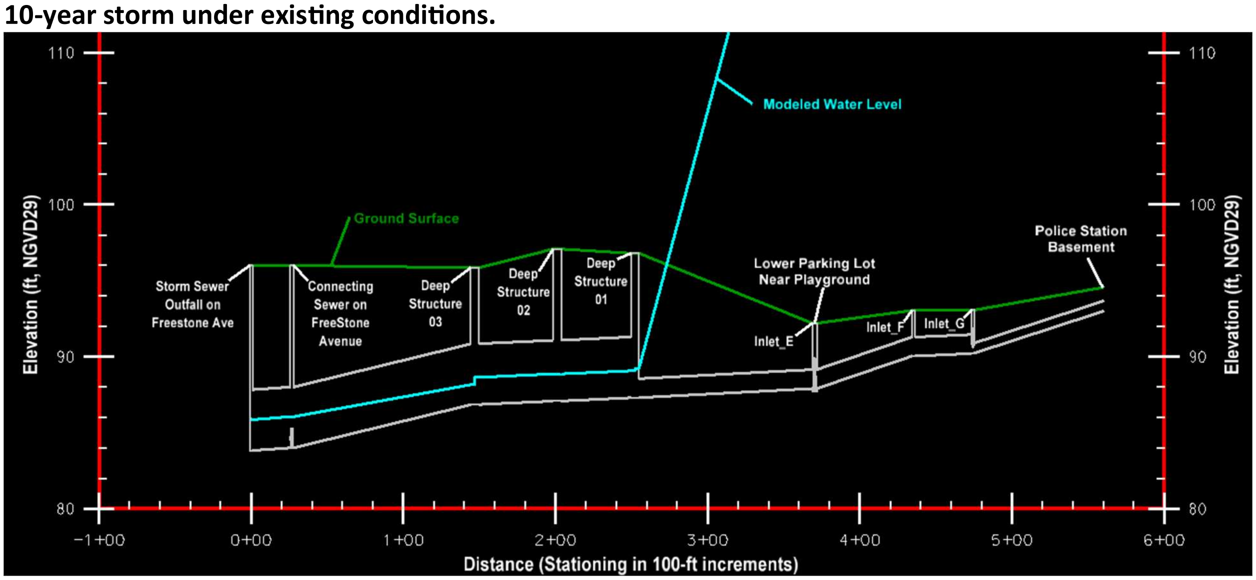
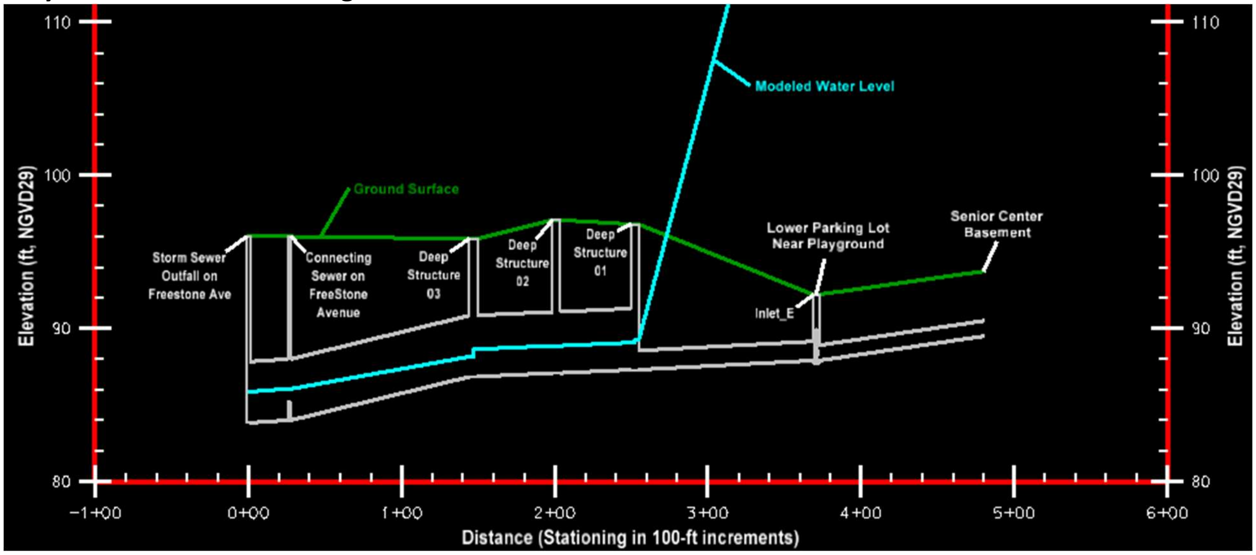


Figure 9b: Modeled pipe flow using the Rational Method from the senior center to the outfall for the 10-year storm under existing conditions.



Sensitivity Analysis

Various parameters were tested to determine what might cause the model to surcharge at catch basin E. These parameters included the pipe size for the pipe downstream of catch basin E; drainage area size; and rainfall depths and intensities, which were modeled for future conditions (**Table 2**). Rainfall conditions for the future conditions were set up using the same storm distribution as with existing. Due to other characteristics inherent to the selected modeling approach, the process of changing the rainfall conditions from existing to future 2050 or future 2080 did not produce any significant surcharge in the piping system.

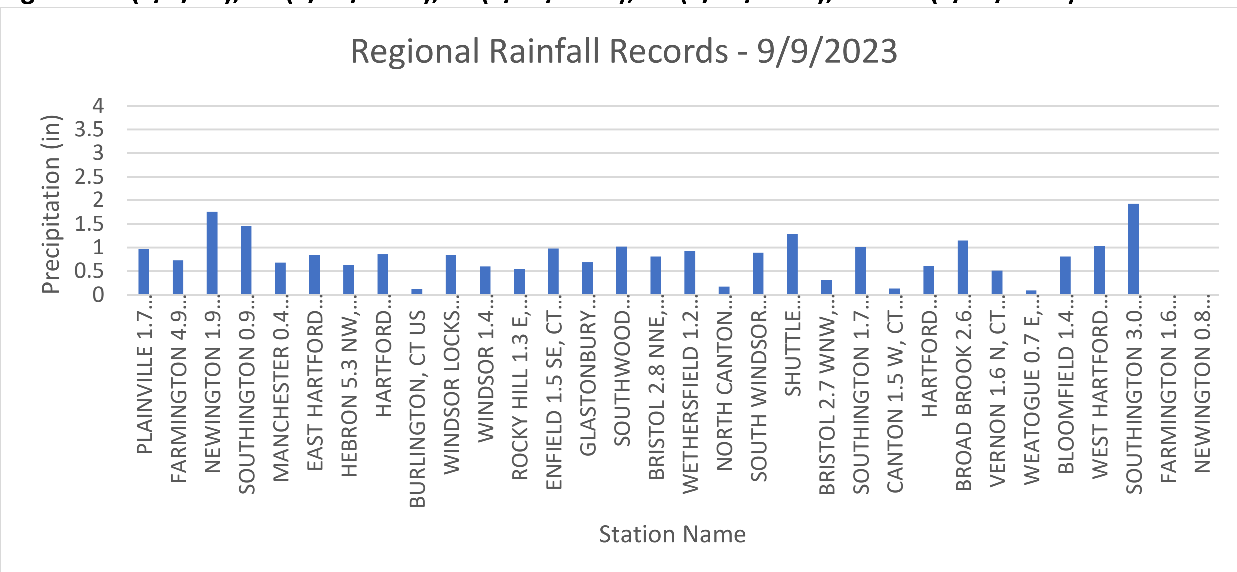
Table 2: Existing and future projected rainfall conditions.

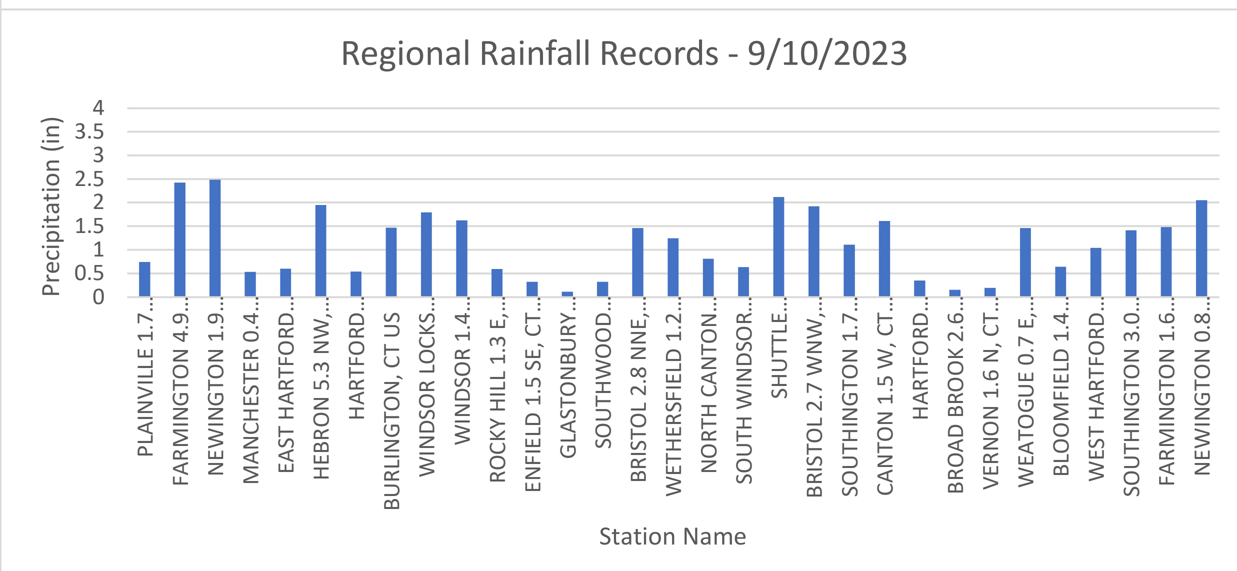
Existing	NOAA Atlas 14 Estimated Annual Rainfall Depth (in)	Design Storm Peak Rain Intensity (in/0.1 hr)	2050 Projected Scenario	2050 Annual Rainfall Depth (in)	Design Storm Peak Rain Intensity (in/0.1 hr)	2080 Projected Scenario	2080 Annual Rainfall Depth (in)	Design Storm Peak Rain Intensity (in/0.1 hr)
1-Year	2.71	0.306	1-Year	3.44	0.389	1-Year	3.31	0.373
2-Year	3.33	0.376	2-Year	4.23	0.478	2-Year	4.06	0.459
5-Year	4.33	0.489	5-Year	5.50	0.621	5-Year	5.28	0.597
10-Year	5.17	0.584	10-Year	7.70	0.870	10-Year	6.77	0.765
25-Year	6.32	0.714	20-Year	10.05	1.135	20-Year	8.60	0.971
50-Year	7.17	0.810	50-Year	12.62	1.425	50-Year	10.18	1.150
100-Year	8.09	0.914	100-Year	15.45	1.745	100-Year	12.05	1.362

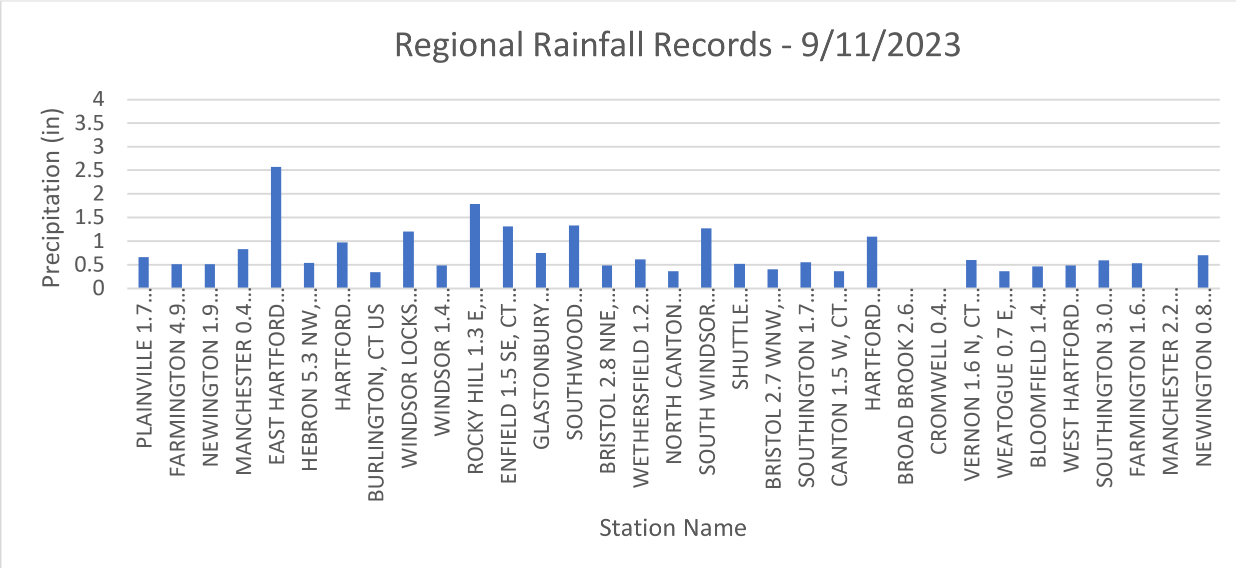
Continuous simulation

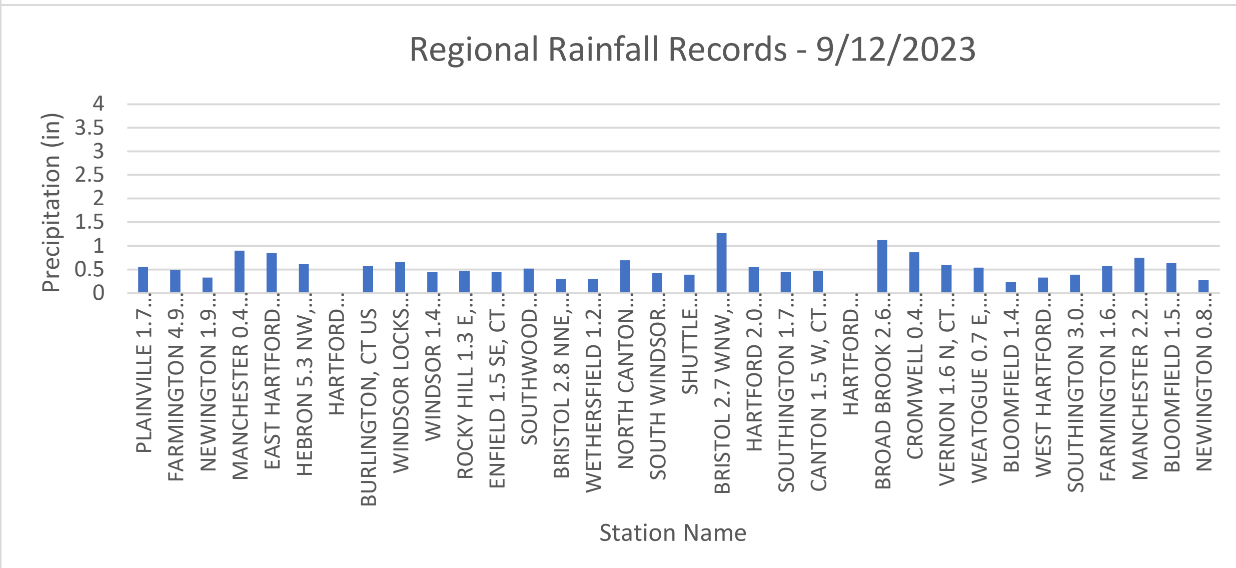
Anecdotally, it was reported that the Town of Portland experienced an unusually intense precipitation event on September 13th, 2023. Images of the flooded parking lot during this storm event were provided by the Town. The rainfall record for the month of September 2023 included several days in a row of heavy precipitation (greater than 0.5 inches and up to 2 inches or more per day) throughout the region from September 9th-12th. Rainfall on the 13th was sporadic: a few locations experienced heavy rainfall that day, while others experienced no rainfall at all. See Figures 7a-e. Since the Town of Portland does not have a gage that is connected to the national network, it could not be determined from these records just how much rain the town experienced on the 13th. However, it may be assumed that the ground was already saturated.

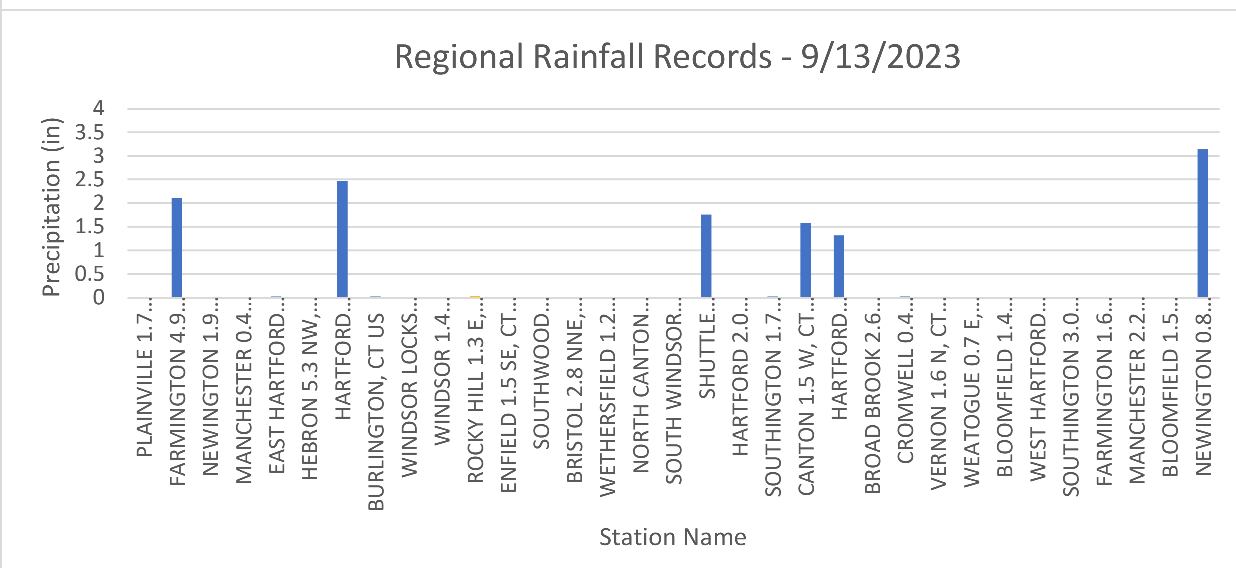
Figures 7a (9/9/23), 7b (9/10/2023), 7c (9/11/2023), 7d (9/12/2023), and 7e (9/13/2023).





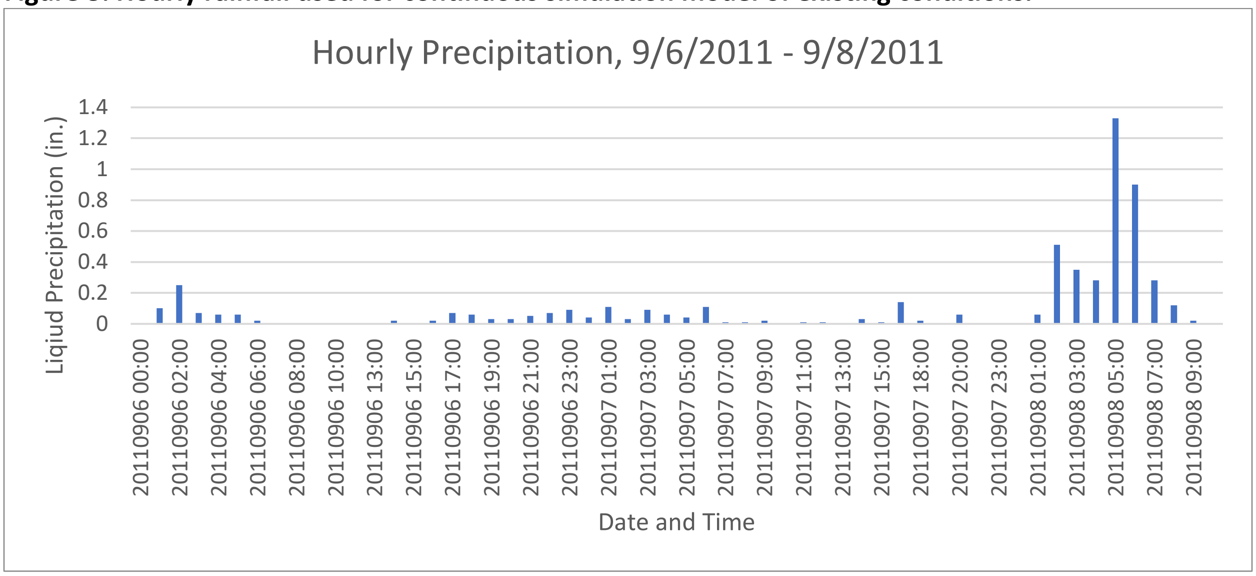

Regional Rainfall Records - 9/11/2023
Precipitation (in)
Station Name
PLAINVILLE 1.7...
FARMINGTON 4.9...
NEWINGTON 1.9...
MANCHESTER 0.4...
EAST HARTFORD...
HEBRON 5.3 NW,...
HARTFORD...
BURLINGTON, CT US
WINDSOR LOCKS...
WINDSOR 1.4...
ROCKY HILL 1.3 E,...
ENFIELD 1.5 SE, CT...
GLASTONBURY...
SOUTHWOOD...
BRISTOL 2.8 NNE,...
WETHERSFIELD 1.2...
NORTH CANTON...
SOUTH WINDSOR...
SHUTTLE...
BRISTOL 2.7 WNW...
SOUTHINGTON 1.7...
CANTON 1.5 W, CT...
HARTFORD...
BROAD BROOK 2.6...
CROMWELL 0.4...
VERNON 1.6 N, CT...
WEATOGUE 0.7 E,...
BLOOMFIELD 1.4...
WEST HARTFORD...
SOUTHINGTON 3.0...
FARMINGTON 1.6...
MANCHESTER 2.2...
NEWINGTON 0.8...


Regional Rainfall Records - 9/12/2023
Precipitation (in)
Station Name
PLAINVILLE 1.7...
FARMINGTON 4.9...
NEWINGTON 1.9...
MANCHESTER 0.4...
EAST HARTFORD...
HEBRON 5.3 NW,...
HARTFORD...
BURLINGTON, CT US
WINDSOR LOCKS...
WINDSOR 1.4...
ROCKY HILL 1.3 E,...
ENFIELD 1.5 SE, CT...
SOUTHWOOD...
BRISTOL 2.8 NNE,...
WETHERSFIELD 1.2...
NORTH CANTON...
SOUTH WINDSOR...
SHUTTLE...
BRISTOL 2.7 WNW,...
HARTFORD 2.0...
SOUTHINGTON 1.7...
CANTON 1.5 W, CT...
HARTFORD...
BROAD BROOK 2.6...
CROMWELL 0.4...
VERNON 1.6 N, CT...
WEATOGUE 0.7 E,...
BLOOMFIELD 1.4...
WEST HARTFORD...
SOUTHINGTON 3.0...
FARMINGTON 1.6...
MANCHESTER 2.2...
BLOOMFIELD 1.5...
NEWINGTON 0.8...


Regional Rainfall Records - 9/13/2023
Precipitation (in)
Station Name
PLAINVILLE 1.7...
FARMINGTON 4.9...
NEWINGTON 1.9...
MANCHESTER 0.4...
EAST HARTFORD...
HEBRON 5.3 NW,...
HARTFORD...
BURLINGTON, CT US
WINDSOR LOCKS...
WINDSOR 1.4...
ROCKY HILL 1.3 E,...
ENFIELD 1.5 SE, CT...
SOUTHWOOD...
BRISTOL 2.8 NNE,...
WETHERSFIELD 1.2...
NORTH CANTON...
SOUTH WINDSOR...
SHUTTLE...
HARTFORD 2.0...
SOUTHINGTON 1.7...
CANTON 1.5 W, CT...
HARTFORD...
BROAD BROOK 2.6...
CROMWELL 0.4...
VERNON 1.6 N, CT...
WEATOGUE 0.7 E,...
BLOOMFIELD 1.4...
WEST HARTFORD...
SOUTHINGTON 3.0...
FARMINGTON 1.6...
MANCHESTER 2.2...
BLOOMFIELD 1.5...
NEWINGTON 0.8...

EPA SWMM software has the capability of running a continuous simulation using hourly rainfall data. Hourly rainfall data for the Hartford, CT area is available through the National Centers for Environmental Information (NCEI) up through the year 2014. To mimic the watershed response to several days' worth of heavy precipitation, hourly rainfall for the month of September 2011 was collected and used to run a continuous simulation. This dataset included three days of heavy rainfall totaling over 5 inches from September 6th-8th, which coincided with the onset of remnants of a tropical storm over the region. See **Figure 8**. Results of the continuous simulation model showed higher peak flows than any produced by using a design storm. However, the model did not produce any ground-level flooding as might be expected based on anecdotal reports from similar events.

Figure 8: Hourly rainfall used for continuous simulation model of existing conditions.



MEMORANDUM

November 11, 2024

CIRCA Portland – CIRCA Team questions from e-mail dated 10/22/24

1. We'd like to follow up on the question John raised at a previous meeting about the modeling, and the differences in assumptions between the model that yielded results consistent with observed flooding and the model that didn't.

   AECOM's Responses:

   - *AECOM has provided supplemental information that describes the modeling efforts in more detail (Lorayne emailed on 10/30/24 @1:12 pm).*
   - *The main difference between the two model types is in the hydrologic approach that was selected to compute runoff. For the EPA SWMM model, current NOAA 24-hr storm precipitation frequency estimates were used to model existing rainfall conditions, and runoff from the surrounding land was computed using an infiltration-based approach (the Green-Ampt modeling method) to computer the amount of runoff that makes its way to the network of pipes and catch basins in the parking lot. Future conditions were modeled using the same approach, but the appropriate future percent increases were applied to the existing rainfall data to simulate future rainfall conditions. Using these modeling methods, the model yielded no ponding in any scenario, present or future.*
   - *A second modeling approach was set up for comparison, where the Rational method was used to model existing conditions. The Rational method assumes much higher event rainfall intensities over much shorter durations. This approach also assumes no infiltration, only some storage in the contributing drainage area. There is no practical way to apply future rainfall estimates using this method. The results of this model yielded extremely high ponding in the existing condition, such that had there been a way to apply future rainfall estimates, the effect of those future rainfall estimates on the model output would have appeared insignificant.*
   - *Our comparative analysis suggested that 1) an infiltration-based approach may significantly underestimate the amount of runoff, while 2) other methods may over-exaggerate the amount of runoff and ponding.*

2. Related to the discrepancies in the modeling results – do you feel you can say with confidence what the underlying reason for the flooding is, and that the modeling is capturing this reason? I see on the list of preferred actions that the first one is "Update

flood modeling study to address flooding source(s) and stormwater system backups." What additional questions remain to be answered with additional model updates?

AECOM's Responses:

- *Sensitivity analysis for the first modeling approach that uses the Green-Ampt method suggested that there may be one or more performance problems with the single 15" pipe that drains the junction catch basin, "Inlet E", including but not limited to the pipe being undersized; and a potential blockage in the pipe.*
- *Inverts, pipe slopes, and pipe diameters should all be confirmed through a surveyor to eliminate model uncertainties related to structural data within the pipe network.*

3. The landscape details on the concept design are looking great. Will you be able to quantify how much flood reduction will result from the proposed design?

AECOM's Response:

- *AECOM has prepared conceptual estimates of the quantity of flood reduction that will be possible with the preferred alternative.*
- *Proposed bioretention/biodetention beds in the preferred alternative could be strategically designed to capture between 30%-40% of the runoff generated by the 2-year, 24-hr storm from the interconnected parking areas and lawns between the police station, senior center, and library.*
- *Proposed pervious paved parking stalls in front of the entrance to the senior center could capture up to 98% of the runoff generated by the 2-year, 24-hr storm from the driveway entrance to the senior center. This volume reduction represents additional runoff captured before it reaches the proposed bioretention beds.*

4. I want to make sure we don't lose sight of the "Increase Pipe Capacity + Update Drainage Infrastructure" part of the toolkit. Will this element be added to the concept design?

AECOM's Response:

- *This element is considered a critical part of the suite of tools necessary for a viable concept design and will be included in the final report. Specific* *recommendations include (but are not limited to) increasing the pipe capacity that drains from "Inlet E" by upsizing the pipe.*

- *It is also recommended to evaluate the basement drains from the senior center and police station buildings in more detail than was possible for this study. Based on work completed for this study, it is believed these drains also connect to the network of pipes in the shared parking lot and are experiencing stormwater backups during heavier events. One or more basement drains may also exhibit a negative slope which would cause the drain to flow "backward".*
- *Finally, it is recommended that alternative options for the building roof drains be considered; the roof drains currently connect underground for the police station, senior center, and library.*

MEMORANDUM

November 11, 2024

CIRCA Portland – CIRCA Team questions from e-mail dated 10/31/24

1. Is there some language you can point to that explains the diference between the Dynamic Wave routing method and Rational method for the model? It's still unclear what is diferent in terms of methodology or assumptions between the two modeling approaches, and why one reproduced the documented flood conditions, while the other didn't.

   AECOM's Response:

   The Dynamic Wave Routing method is a hydraulic method used to route the flow in the pipe network that drains the parking lot. The flow in the pipe network is input from the output of the Green-Ampt hydrologic computation method.

   The Dynamic Wave routing method is desirable for this project because it can account for backups or "backwater" conditions, like those observed in the parking lot during severe weather. It can also account for flow reversal in certain cases, for instance if a pipe is believed to have a negative slope.

   The Rational Method is a hydrologic computation method like Green-Ampt, but it has very different assumptions. Green Ampt assumes that a certain portion (in this case, a substantial portion) of rainfall will never make it to the pipe network because it is absorbed through infiltration processes into the ground and "removed". Green Ampt is also dependent on the rainfall data and distribution that is selected. A 24-hr design storm distribution may have a much gentler effect on modeled flooding from runoff even during the most intense portion of the design rain event. On the other hand, the Rational method assumes no infiltration and it makes no use of typical design storm distributions like the 24-hr, 12-hr, or 6-hr. Instead, it uses a rain intensity with a (time of concentration equal to a) duration of 5-6 minutes, causing the pulse of rain to be "felt" by the modeling software all at once, like the most intense cloudbursts. For this reason, the Rational Method is often preferred for small urban watersheds with lots of impervious cover, and when used in tandem with a proper routing method, can be helpful to design stormwater pipes that have a higher factor of safety because it assumes the worst-case scenario. Unfortunately, it has its limitations and therefore may also lead to modeled flood depths that are unrealistically high.

2. Figures 9a and 9b depict modeled pipe flow under existing 10-year storm conditions using the Rational method. According to the model, where/what inlet is surcharging,

and what is the depth of flooding under the 10-year storm conditions? It appears the model is depicting significant water level above ground level, but it's not totally clear what the relationship is between the green line and the blue line and where that relationship is taking place. An accompanying site plan map that shows the location and depth of the modeled conditions would be helpful. (apologies if this is already included in the Task 3 report.)

AECOM's Response:

Figures 9a and 9b will be updated to show label for "Inlet E" at the "Lower Parking Lot Near Playground" location, to provide spatial context on the profile that is consistent with the site plan. This inlet vault represents the point where the system is surcharging excessively. The modeled water level jumps above the ground surface before it reaches this inlet because the modeled water level, or hydraulic grade line, is depicted as unrestricted by the ground surface and uncontained by the pipe. What these figures are trying to show is that the entire pipe downstream of Inlet E is flowing full and under pressure, causing the system to surcharge.

3. On page 12 under sensitivity analysis, it reads: "Due to other characteristics inherent to the selected modeling approach, the process of changing the rainfall conditions from existing to future 2050 or future 2080 did not produce any significant surcharge in the piping system." Is this saying that the future conditions are not reproducing any flooding in the parking lot in the same way that the current conditions are? If so, what are the characteristics of the selected modeling approach that is creating this result?

AECOM's Response:

Extreme flooding conditions have been observed in town, as per our interviews with the town staff. Future conditions (in either the middle- or end-of century scenario) will not only produce the same flooding conditions that are being observed now, but they will also produce more extensive flooding and more damage, if no mitigation actions are taken. The limitations of the modeling approach (overestimation of infiltration for the initial runoff calculation; design rainfall distribution data that is not suitable to represent short intense rain events), coupled with observed capacity issues in the pipe draining from Inlet E that are difficult to model, are masking the effect of increases in future rainfall.

4. The event from 2011 that was simulated seems to have not produced any flooding under either modeling approach. Is it fair to say that the type of precipitation conditions that the town has reported as being problematic and leading to flooding recently, don't appear to cause flooding under either modeling approach?

   AECOM's Response:

   The event from 2011 was modeled using the Green-Ampt approach. The rainfall data for the event from 2011 was not subject to the same limitations as the design storm data, but it was still subject to the limitations of the Green Ampt infiltration method to compute the runoff. It is likely that this event iteration overestimates the amount of runoff that was "removed" from the equation, similarly to earlier iterations that used NOAA Atlas 14 design storm data.

   It should also be noted that the rainfall data for the 2011 event has its own limitation: it was aggregated to hourly increments before being made available in the NCEI. Rainfall patterns for the actual event may have included different intensities than the hourly intensities that were reported in the aggregated version of the data. The effect of this limitation is unknown.

APPENDIX C

Benefit Cost Analysis + High Level Cost Estimate

Delivering a better world

Resilient Portland

Benefit-Cost Analysis

December 2024

Delivering a better world

Table of Contents

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Resilient Portland Benefit-Cost Analysis

This memo provides a summary of the benefit-cost analysis (BCA) completed for the Resilient Portland project, part of the Connecticut Institute for Resilience and Climate Adaptation's (CIRCA) Resilient Connecticut program. BCA is a method that determines the future risk reduction benefits of a hazard mitigation project and compares those benefits to its costs[1]. The project study area, which includes three critical facilities in Portland (the Senior Center/Food Bank, Police Station, and Public Library), is susceptible to drainage and infrastructure failures, excessive heat risk, and public accessibility challenges. This BCA evaluates the proposed resilient strategies, which include revising the parking design, updating drainage infrastructure, and incorporating green infrastructure.

Background Information

The Senior Center is the cooling center, warming center, and public food pantry for the Town of Portland. During flood events, water has entered the lower levels of the Senior Center where the food pantry and equipment are located. The Police Station serves over 9,000 people and is a 24-hour operation. Similar to the Senior Center, the basement of the Police Station, which contains cells, locker rooms, and storage of important files, has experienced damaging flood events in recent years.[2] The parking lot for these three facilities is part of a shallow topographic depression located on the east of Main Street and the south side of Waverly Avenue. Information on past damages (including impactful events in 2016 and 2023) was provided to the AECOM team to inform the BCA – including costs of flood remediation at the police station, elevator damage at the Senior Center, recurrence of the use of sandbags, and past vehicle damage.

The methodologies and economic values used in this BCA draw upon federal guidance, including publications from the U.S. Army Corps of Engineers (USACE) and the Federal Emergency Management Agency (FEMA), as well as stakeholder input as noted above. Benefits evaluated are primarily linked to stakeholders within the study area, including the Police Department, the Senior Center and the Portland community that utilizes these services. The evaluated benefits align with those of potential future funding sources, such as FEMA's Building Resilient Infrastructure and Communities (BRIC) grant which looks at criteria such as risk reduction, anticipation of climate change and other future conditions, and incorporation of nature-based solutions.

The following key concepts and assumptions apply to this BCA:

- **Static built environment:** This analysis superimposes potential future physical conditions on the existing built environment. It is likely that the built environment in the study area will undergo changes between the present year and the end of the project's useful project life. To accurately capture these dynamics, detailed information on future development plans at the building level scale are needed. This information was not available for the analysis.
- **Project useful life:** The useful life of an infrastructure project reflects the estimated amount of time that the investment will effectively provide its intended benefits. The CIRCA Portland project has been assigned a 30-year useful life, consistent with FEMA published guidance[3], though the project is expected to prove effective beyond this timeframe provided best infrastructure management (e.g., maintenance, renewal) practices are implemented.
- **Price level:** All costs have been normalized to 2024 dollars using data from the U.S. Bureau of Labor Statistics (BLS) Consumer Price Index. No cost escalation is included in this analysis.
- **Rounding:** Results presented in the tables throughout are rounded and may not sum to the presented totals due to rounding.
- **Discounting:** Discount rates are applied in a BCA to account for the social "opportunity cost" or the time value of money, allowing for a comparison of future costs and benefits in present dollars. Per economic theory, the value of future benefits is assumed to be lower than the value of present benefits. A 3.1% discount rate was used in this analysis, consistent with FEMA guidance.

[1] FEMA. (2024). *Benefit-Cost Analysis*. Accessed at https://www.fema.gov/grants/tools/benefit-cost-analysis
[2] Information provided by client.
[3] FEMA's standard value for project useful life for green infrastructure is between 25 to 35 years (i.e. urban trees is 25 years, bioretention is 35 years). The limit for minor utility mitigation projects (e.g. backflow valves) is 30 years. As such, an average of 30 years has been used for the mitigation project.

Costs

AECOM developed a high-level cost estimate for the project based on preliminary designs and conversations with the design team, prepared according to AACE Class 5 standards (-50% to +100% accuracy). The cost estimate includes the following scope:

- Removal of existing asphalt in parking lot and concrete paving
- New asphalt paving, landscaping and raingarden
- New shade cloth playground structure
- Upgrade of drainage pipeline from 15” RCP to 36” RCP
- Estimated construction start date of Q4 2025.

A summary of total project cost is displayed in Table 1.

Table 1. Total capital costs

Item	Capex (undiscounted)	Capex (discounted)
Site costs	$527,000	$499,000
Construction management costs	$286,000	$272,000
Contingency and risk	$220,000	$208,000
Design and PM	$186,000	$176,000
Total capital cost estimate	**$1,219,000**	**$1,155,000**

AECOM notes that an option for pervious asphalt was proposed and costed as an alternative to non-pervious asphalt. Owing to the very small area of this pavement and to remain conservative, the non-pervious asphalt option was used. Also of note, if just looking at a proportion of costs focused on the drainage pipe improvements, the total costs would come to an estimated ~$225,000. This was separated out to better understand the benefit-cost ratio from only this element of the project (discussed further below).

Annual operating costs were assumed to be 1% of total capital costs. A summary of estimated operating costs over the life of the project are displayed in Table 2.

Table 2: Total operating costs

Item	Opex (undiscounted)	Opex (discounted)
Total operating cost estimate	**$366,000**	**$224,000**

Benefits

The implementation of the project is anticipated to provide benefits in the form of both avoided costs from reduced flooding and added co-benefits from the green infrastructure. It was assumed that the project would provide flood mitigation benefits for up to the 50-year storm but would not protect against flooding in the 100-year storm. This may be a conservative assumption, which means the benefits may be understated. The following benefits were monetized for the BCA (see Appendix for more detail on the benefit methodology):

- **Avoided physical damages** (structural, contents and vehicles in parking lot): The project is expected to reduce flood damage in the Police Station and Senior Center and reduce flooding in the parking lot. Costs from recent events have included the costs of sandbags when a potentially large amount of rain is forecast (estimated five times per year based on stakeholder input), setting up dehumidifiers/air movers, assessing water damage and testing for asbestos, elevator maintenance, restoration of walls, floors & trim, antimicrobial application, and other remediation.

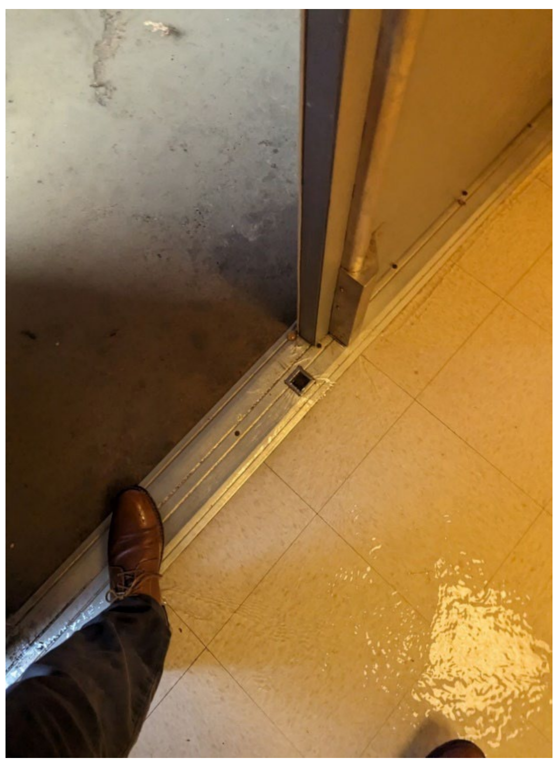
  Of note, these benefits were calculated based on flood damages from recent events and linearly interpolated based on assumed future modeled flood depths. For a 10-year event under current conditions, approximately

$30,000 in building damages was estimated. This approach may understate benefits, given that the flood depth may not have a linear correlation with damage incurred. Furthermore, the flood depths modeled at the building level are estimated. While the flood modeling extent (see figure below) barely touches the buildings, it is known that the drainage pipe is not adequate for the rain events and results in flooding in the basements (see photos below). As such, it was assumed that the depth of flooding occurring at the parking lot correlates (largely) with the depth of flooding at the building. More information on the flood depth and building damage inputs is provided in the Appendix.

Table 3. Modeled Flood Area

Notes: The above shows the modeled flood area for the 2-year to 100-year storm event.

Table 4. Senior Center Basement Flooding (September 2023)



Notes: Provided by Client.

- **Avoided critical service disruption (Police Station)**: Flooding at the Police Station and subsequent reduced police presence (due to relocation of staff) may negatively affect the population of Portland through an increase in crime. The benefit of undertaking the hazard mitigation project is the avoided loss-of-function days at the Police Station. One provider of data from the client noted flooding could lead to closure up to five days as drying units are brought in, with staff members not needing to stay on site.
- **Green infrastructure benefits**: Trees, lawn and plantings, and raingardens provide several benefits. FEMA Ecosystem Service Values for urban trees, urban open space (lawn and planting area), and bioretention (the raingardens) areas were used, which capture a range of benefits such as removal of air pollutants, reduced heat risk, carbon sequestration and avoided emissions, drought risk reduction, stormwater quality improvements, habitat and biodiversity benefits, and property value uplift.

Table 5. Avoided costs / benefits

Benefit Category	Avoided Cost / Benefit Undiscounted	Avoided Cost / Benefit Discounted
Avoided structural and contents + vehicle damage	$588,000	$355,000
Avoided critical service disruption (Police Station)	$31,000	$20,000
Bioretention	$130,000	$82,000
Urban trees	$571,000	$360,000
Urban open green space	$93,000	$59,000
Total	**$1,413,000**	**$875,000**

BCA Results

A summary of the BCA results, accounting for the total estimated present value of project costs and project benefits, as well as the net present value benefits and resulting benefit-cost ratios (BCRs), is presented in Table 6. The net present value (NPV) benefits are calculated by subtracting the present value costs from the present value benefits. The BCR is calculated by dividing the present value benefits by the present value costs. While the overall project BCR is below 1, the project may have benefits that cannot be quantified. Analysis was also undertaken for a scenario that includes the costs and benefits for upgrading the drainage pipe only (i.e., no green infrastructure or shade infrastructure) which yields a positive NPV and BCR.

Table 6. BCA results

Analysis	PV of costs	PV of benefits	NPV	BCR
Full Project	$1,379,000	$816,000	-$563,000	0.59
Drainage pipe upgrades	$255,000	$337,000	$82,000	1.32

Funding Considerations

Table 7 is a summary of some funding programs that may be applicable to the project along with some key considerations for those sources. This is not an exhaustive list but represents some of the funding options that have been discussed and are relevant to the project.

The project site is not an identified Disadvantaged Community (DAC) based on the federal Climate and Economic Justice Screening Tool (CEJST) which can limit funding opportunities. Within Connecticut, the site does not fall within an Environmental Justice Block Group (2023) as defined by the Connecticut General Statutes though the Census Block Group just across Main Street does, and some of the community served by both the Police Station and Senior Center/Food Bank are considered environmental justice communities within the state.

Of note, several sources were discussed but were not included below. With regards to FEMA's Hazard Mitigation Assistance (HMA) Programs, BRIC is included but the Flood Mitigation Assistance (FMA) funds were not – these are for projects that reduce or eliminate repetitive flood damage to buildings insured by the National Flood Insurance Program (NFIP). FEMA's Hazard Mitigation Grant Program (HMGP) also provides funding to state, local, tribal and territorial governments so they can develop hazard mitigation plans and rebuild in a way that reduces, or mitigates, future disaster losses in their communities. Funding is only available after a presidentially declared disaster with 75% Federal and 25% Non-Federal cost share. The Urban and Community Forestry Program from the US Department of Agriculture Forest Service awarded 8 projects in Connecticut in 2023, averaging $1.9 million each; the Urban and Community Forestry Program (UCF) prioritized projects in DACs using CEJST.

Table 7. Key Funding Sources

Program Name	Program Type	Agency	Program Notes	Link
Federal				
Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation Program (PROTECT)	Formula and Discretionary Funding	USDOT	"The Promoting Resilient Operations for Transformative, Efficient, and Cost- Saving Transportation (PROTECT) Discretionary Grant Program is a competitive grant program created by the Bipartisan Infrastructure Law to plan for and strengthen surface transportation to be more resilient to natural hazards, including climate change, sea level rise, flooding, extreme weather events, and other natural disasters. The Bipartisan Infrastructure Law provides over $1.4 billion over five years through this program 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."[4] In FY2022 – FY2023, USDOT awarded $830M to 80 recipients. The Naugatuck Valley Council of Governments received $1M for the Non-Coastal Connecticut Resilience Improvement Plan. For FY2024 – FY2025, $576M is available for the 4 PROTECT Grant types (Planning, Resilience Improvement, Community Resilience and Evacuation Route, At-Risk Coastal Infrastructure).[5]	Link
Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant Program	Grant	USDOT	"The USDOT Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program provides grants for surface transportation infrastructure projects with significant local or regional impact." "As of June 2024, the program has awarded more than $15 billion over sixteen rounds to local governments, Tribes, transit and port authorities, states, and other entities for capital and planning projects that will improve safety, environmental sustainability, quality of life, mobility and community connectivity, economic competitiveness, state of good repair, partnership and collaboration, and innovation."[6] For FY2025, USDOT intends to award funding through Round 1 ($1.5B dedicated to "Highly Rated Applications" and "Projects of Merit designated during the FY2024 RAISE Program) and Round 2 ($1.5B dedicated to new applications as funding becomes available under the FY2025 Appropriations Act). In FY2024, USDOT awarded funding to 3 recipients in Connecticut: • MLK Corridor Equitable Mobility Enhancement Project, Norwalk Redevelopment Agency ($14M) • Naugatuck River Greenway Trail Project, Naugatuck Valley Council of Governments ($6M) • Berlin Turnpike Corridor Planning Study, Capitol Region Council of Governments ($2M)[7]	Link
Building Resilient Infrastructure and Communities Program (BRIC)	Grant	FEMA	"Building Resilient Infrastructure and Communities (BRIC) supports states, local governments, tribes and territories as they work to reduce their hazard risk."	Link

4 FHWA, "PROTECT Discretionary Grant Program."
5 FHWA, "FY 2022 & 2023 Grant Award Recipients."
6 USDOT, "Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant Program."
7 USDOT, "RAISE FY 2025 Notice of Funding Opportunity."

			"In July 2024, FEMA announced 56 projects from the National Competition totaling $674.5 million. These projects are selected in all 10 FEMA regions and are in 22 states and the District of Columbia."[8] "Nature-based solutions are sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience. These solutions use natural features and processes to combat climate change, reduce flood risk, improve water quality, protect coastal property, restore and protect wetlands, stabilize shorelines, reduce urban heat, and add recreational space. For [FY2023], 57% of the National Competition-selected projects incorporate nature-based solutions from 16 applicants and nine FEMA regions."[9]	
State				
Climate Resilience Fund (DCRF)	Grant	CT DEEP	Through the [Department of Energy and Environmental Protection's Climate Resilience Fund (DCRF), DEEP] is providing critical planning support to local governments, nonprofits, and others seeking to advance climate resilience projects, with the goal of enabling the recipients to in turn seek federal funding for construction and implementation phases. DEEP is utilizing DCRF funds to catalyze Connecticut's resilience project pipeline and ensure our communities are competitive for federal resources, which are at historic levels as a result of the Bipartisan Infrastructure Law and the Inflation Reduction Act."[10] For FY2025, DEEP proposes 3 types of Deployment Funding – Matching Funds, Micro-Grid and Energy Resilience Funds, and Long Island Sound Study and Coastal Zone Management Funds – along with Planning and Advancement Funding. "Matching Funds: State bond funds for a portion of the non-federal cost share required for federal resilience grant applications. For example, the state may contribute a portion of the 25% of a resilience project's cost not covered by FEMA hazard mitigation assistance and grant programs. This subcategory covers federal grant programs not covered by the other two subcategories."[11]	Link
Small Town Economic Assistance Program (STEAP)	Grant	CT OPM	"Preserving the historical integrity and beauty of our small towns is vital to our economy and quality of life. The Small Town Economic Assistance Program funds economic development, community conservation and quality-of-life capital projects for localities that are ineligible to receive Urban Action bonds. This program is managed by the Office of Policy and Management and grants are administered by various state agencies."[12] In FY2024, eligible projects, such as "Recreation and Solid Waste Disposal Projects" and "Social Service-Related Projects," were selected for priority project areas, such as "Shovel-Ready Projects" and "Quality of Life and Fiscal Stability of Municipality" Improvements.[13] The Town of Portland is eligible for STEAP.	Link
CT Communities Challenge Grant Program	Grant	CT DECD	"The Department of Economic and Community Development ("DECD") is undertaking a competitive grant application process to fund multiple projects under the CT Communities Challenge Grant Program in an effort to improve livability, vibrancy, convenience, and equity of communities throughout the state. The Program is intended to potentially create approximately 3,000 new jobs. It is DECD's goal to allocate up to 50% of the funds to eligible and competitive projects in distressed municipalities."[14] Eligible projects may include "Essential Infrastructure" and "Public Space Improvements." The Town of Portland is eligible for the Communities Challenge Grant Program.	Link

8 FEMA, "Building Resilient Infrastructure and Communities."
9 FEMA, "Building Resilient Infrastructure and Communities Grant Program Fiscal Year 2023 Sub-Application and Selection Status."
10 CT DEEP, "Governor Lamont Announces $8.8 Million in State Funding to Support 21 Climate Resilience Plans and Project Development Grants."
11 CT DEEP, "Climate Resilience Fund and Climate Resiliency Revolving Loan Fund Notice of Public Meeting and Request for Information."
12 CT OPM, "2023 (FY2024) Grant Round Small Town Economic Assistance Program Guidelines."
13 Ibid.
14 CT DECD, "CT Communities Challenge Grant Program Notice of Funding Availability."

Appendix A Detailed Benefit Methodology

Avoided Physical Damages (Buildings and Vehicles)

Storm-induced flooding in the study area has resulted in damage to building structure, content, and the vehicles parked outside the buildings during flooding events. To determine direct physical damage costs, AECOM used the current and future projected rainfall condition modeling conducted for this study, damage costs and photo evidence supplied by stakeholders and DPW, and standard methodologies and guidebooks (e.g., FEMA, RSMeans).

Table 8: Avoided physical damages - key inputs

Item	Input	Source
Flood depth in building	See Table 9	Based on photos of past events and AECOM current and future projected rainfall conditions.
Structure + content damage associated with building flooding	Damage information provided by client from past events were extrapolated for other storm events under current and future conditions assuming linear correlation. Costs provided (or desktop researched based on information provided) for most recent event, assumed to correlate with a 10-year storm include: Police Station repair after 2023 flood – $25,005 Police Station sandbagging - $2,076 5x/year Senior Center elevator repairs - $4,000	Email from Ryan O'Halpin of Portland Police Department, October 2024; costs from DPW report on emergency work for water damage at the Police Station basement Information from DPW Director and from Captain Scott D. Cunningham of Portland Police Department, October 2024. Actual costs not provided; based on desktop research.
Vehicle flood depth	See Table 9	Based on client input and AECOM current and future projected rainfall conditions.
Depth damage functions (DDF) for vehicles	Damage to vehicles DDF	*Economic Guidance Memorandum, 09-04, Generic Depth-Damage Relationships for Vehicles*, USACE, 2009
Vehicles in car park	Sedan - 14 Pick-up truck - 2 Minivan - 1	This is an estimate of the number of ordinary vehicles that may be present in the car park during periods of flood. Vehicle numbers are based on Google Earth imagery. Stakeholders noted both that vehicles would be moved prior to floods, which limit officer access, and that in 2023 there was damage reported to a trunk and carpeting inside a vehicle.
Median value of vehicle types	Sedan - $27,000 Pick-up truck - $38,000 Minivan – $37,000	*Average car price*, Autolist, 2023[15]
Assumed level of protection to buildings and vehicles from project	Assumed project protects against 90% protection against flooding for 1-, 5-, 10-, 25-, 50-year storm events under current, 2050, and 2080 conditions; assume no protection for 100-year storm event	Assumed based on adaptation strategies' presumed effectiveness; no post-project implementation modeling was conducted

[15] Autolist (2023). What does the average car cost now? Accessed at https://www.autolist.com/guides/average-car-price

Table 9. Flood Depth Inputs – Existing and Future Projected Rainfall Conditions

Existing	NOAA Atlas 14 Estimated Annual Rainfall Depth (in)	Design Storm Peak Rain Intensity (in/0.1 hr)	2050 Projected Scenario	2050 Annual Rainfall Depth (in)	Design Storm Peak Rain Intensity (in/0.1 hr)	2080 Projected Scenario	2080 Annual Rainfall Depth (in)	Design Storm Peak Rain Intensity (in/0.1 hr)
1-Year	2.71	0.306	1-Year	3.44	0.389	1-Year	3.31	0.373
2-Year	3.33	0.376	2-Year	4.23	0.478	2-Year	4.06	0.459
5-Year	4.33	0.489	5-Year	5.50	0.621	5-Year	5.28	0.597
10-Year	5.17	0.584	10-Year	7.70	0.870	10-Year	6.77	0.765
25-Year	6.32	0.714	20-Year	10.05	1.135	20-Year	8.60	0.971
50-Year	7.17	0.810	50-Year	12.62	1.425	50-Year	10.18	1.150
100-Year	8.09	0.914	100-Year	15.45	1.745	100-Year	12.05	1.362

Notes: Values from AECOM modeling as presented in Table 2 of "Existing Conditions Model – Supplemental Information". 2050 depths were used for 2080; these depths were used for both vehicle and building damages. For building damages, one storm event was overwritten with different depths based on understanding of conditions today – for the 10-year event existing conditions, 2 inches was the depth used based on photographic evidence of flooding of recent events that have taken place roughly once every 7-10 years. The 20-year in 2050 and 2080 was applied as the 25-year.

Avoided Police Station Downtime

Public and essential facilities (e.g., hospitals, fire, police, emergency response, utilities) can experience service disruptions from storm-induced flooding. For this BCA, the evaluation of public and facility loss was limited to the Police Station and impacts were estimated by accounting for the expected loss of function days.

The value of avoided loss-of-function is estimated based on the serviced population and the societal benefits of maintaining that facility in the aftermath of a disaster[16]. To evaluate disruption to operations, the Portland Police Department provided assumptions about the consequences of recent flood events, including length of closure and staff relocation. Methodology from FEMA's *Standard Economic Value Methodology Report* was then used to calculate the value of avoided downtime per day.

Table 10 lists the key inputs and assumptions used to calculate the benefit of avoided police station downtime.

Table 10. Avoided police station downtime - key inputs

Item	Input	Source
Population served	9,384	*Portland town, Middlesex County, Connecticut – Profile*, United States Census Bureau, 2020[17]
Number of officers at station	12	*Police Info*, Town of Portland[18]
Numbers of officers after hazard event	0	Email from Scott Cunningham of Portland Police Department, November 2024
Expected length of downtime after flood event	5 days	Email from Scott Cunningham of Portland Police Department, November 2024
Loss-of-function calculation methodology	Various	*Benefit-Cost Analysis Sustainment and Enhancements, Standard Economic Value Methodology Report, Version 13.0,* FEMA, September 2024
Crime data	Crime statistics for Connecticut	*2019 Crime in the United States, Table 5*, United States Federal Bureau of Investigation, 2019

[16] FEMA (2019). Unit 3: The benefit-cost model. Accessed at https://www.fema.gov/sites/default/files/2020-04/fema_bca_student-manual_unit-3.pdf
[17] United States Census Bureau (2020). Portland town, Middlesex County, Connecticut – Profile. Accessed at https://data.census.gov/profile/Portland_town,_Middlesex_County,_Connecticut?g=060XX00US0900761800
[18] Town of Portland. Police Info. Accessed at https://www.portlandct.org/police-info

Green Infrastructure Benefits

Green infrastructure includes the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters [19]. Green infrastructure is a flexible solution used in urban areas to support stormwater management and hazard mitigation goals while providing other community benefits.

For this project, the green infrastructure includes tree planting, landscaping, and construction of two raingardens. FEMA provides standard values for the benefits of green infrastructure and urban open green space which have been used to monetize the value of these components in the hazard mitigation project.

The benefits captured in the urban tree estimates published by FEMA not only include stormwater volume and quality benefits, but other categories as well – including heat risk reduction.

Table 11: Green infrastructure benefits - key inputs

Item	Input	Source
Bioretention	Raingarden area – 1,428.03ft²	AECOM proposed design
	Bioretention benefit values	*FEMA Economic Benefit Values for Green Infrastructure*, July 2022, FEMA[20]
Urban trees	Number of new trees – 17 (note there was a comment an existing tree would require removal, so this was adjusted to 16)	AECOM proposed design
	Urban tree benefit values	*FEMA Economic Benefit Values for Green Infrastructure*, July 2022, FEMA[21]
Urban open green space	Lawn and planting area – 8,214.95 ft²	AECOM proposed design
	Urban open green space values	*FEMA Ecosystem Service Value Updates*, June 2022, FEMA[22]

[19] FEMA (2022). FEMA Economic Benefit Values for Green Infrastructure. Accessed at https://www.fema.gov/sites/default/files/documents/fema_economic-benefit-values-green-infrastructure.pdf
[20] Ibid
[21] Ibid
[22] FEMA (2022). FEMA Ecosystem Service Value Updates. Accessed at https://www.fema.gov/sites/default/files/documents/fema_ecosystem-service-value-updates_2022.pdf

AECOM

High Level Cost Estimate for Resilient Portland, Central Block

Portland, CT

Prepared for: Town of Portland

November 2024

Delivering a better world

Quality information

Prepared by	Checked by	Verified by	Approved by
Faith Placente	Amit Patil	John Jessie Serrano	Johannes Mueller

Revision History

Revision	Revision date	Details	Name	Position
Revision 1	Nov.11, 2024	Added Design Fees	Johannes Mueller	AVP

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Table of Contents

1. Executive Summary

This High Level Cost Estimate has been prepared pursuant to an agreement between Town of Portland, and AECOM, for the purpose of predicting costs of the work for the above referenced project.

The cost includes, but not limited to demolition works, new asphalt paving, raingarden, landscaping, shade cloth playground structure, replacement of RCP pipes, indirect cost and fees for the Resilient Portland, Central Block.

The High Level Cost Estimate presents the anticipated cost including non-pervious asphalt for parking will therefore be likely **$1,219,000.**

The anticipated cost for the Alternate pervious asphalt for parking will be likely **$1,246,000**.

2. Basis of Estimate

1) Project Scope Description:

This High Level Cost Estimate pertains to which includes, but not limited to, the following scope:

- Removal of existing asphalt in parking lot
- Removal of concrete paving
- New asphalt paving, landscaping and raingarden
- New shade cloth playground structure
- Upgrade of drainage pipe line from 15" RCP to 36" RCP
- Estimated Construction Start Date 4Q 2025

2) Methodology and Estimate Classifications (Techniques and Procedure Used)

This estimate has been prepared according to AACE (Association for the Advancement of Cost Engineering) standards for the estimate classification as indicated, and thus inherits an expected range of accuracy according to the classification.

Estimate Classification: Class 5
Similar Industry Terms for this Level of Estimate:

- Screening
- Feasibility
- Top Down
- Capacity Factored

Accuracy Range: -50% to +100%
Project Definition: 0%-5%
Expected Project Contingency: 7%-25%
Background Information Used: Few or no design perimeters. Estimate based on history data
End Use: Preliminary Project Screening, Capital Budgets, Strategic Analysis

3) Design Basis

This Cost Estimate has been prepared based on marked up preliminary design concept received in October 2024.

Conversations with members of the design team were also used in the preparation of this estimate. Any design and engineering changes and/or additions produced subsequent to these documents are not included in this estimate.

4) Planning and Pricing Basis

- The estimate is based on Q4 2024 costs likely experienced in Portland, CT. Material and equipment costs are included. Labor costs are based upon a 40-hour work week.

- Unit pricing shown within this estimate reflects AECOM's opinion of construction costs obtainable for working in Portland, CT area for this project on the date of the estimate. The intention of this estimate is to reflect fair market value for the construction of this project. It is not a prediction of low bid. Pricing is based upon competitive bidding with a minimum of 6 qualified General Contractors familiar with the conditions of working on this project. Pricing is also based on a minimum of four (4) bids for all subcontractor work. If fewer bids are received the bid results are expected to vary from the costs presented in this estimate.

- The base estimate assumes that the general contractor will be administered as competitively bid / negotiated with a selected Construction Manager / General Contractor & pre-qualified sub-contractors. The above stated below the line allowance however accommodates potential changes in procurement methodology.

5) Inclusions, Exclusions, Assumptions, and Clarifications

General Information/Notes

- No provision for overtime or accelerated schedules.
- The general contractor will have full access to the site during normal business hours.
- Assumed adequate skilled labor will be locally available.
- Our estimate includes all General Contractor and Subcontractor markups.

Clarifications / Assumptions

- We have assumed that there will be clear access to the site.

Exclusions

- This estimate only includes work under the scope narratives.
- Landscape lighting
- Phasing
- Excludes abatement.
- No contingency owner-initiated scope and program change.
- Any unforeseen conditions not stated in the above assumptions.
- Non-competitive bidding conditions.
- Sole source specifications of materials or products.
- Bids delayed beyond the projected schedule.
- Owner's contingency, other costs and fees.
- LEED design allowances.
- Cost impacts associated with restricted access to the immediate work area beyond temporary protection barriers and what is stated in the above assumptions.

6) Contingencies

- Design Contingency (10%) - This percentage is anticipated by the estimator as the relative stability of the design documents, project scope, and assumptions upon which the estimate is based are assessed. Design contingency typically accounts for costs associated with design that may not be complete enough to determine final quantities at the time of estimate preparation.

- Construction Contingency (5%) - This contingency is for unexpected cost during construction.

- Bid Contingency for Skilled Labor Shortage (10%) - This contingency is the amount of money that is added to cover potential pricing deviation from the expected skilled labor shortage.

7) Cost Estimate Mark-ups

Estimate markups are indirect costs that are expressed as a lump sum or calculated as a percentage of the subtotal of the estimated construction costs. Indirect costs are costs that are required to complete a project. Direct costs are costs that are used to run the contractor’s business. The following markups, at rates appropriate to the class of estimate, have been included in the cost estimate:

- General Conditions/General Requirements: 25%
- Escalation – 3.50%
- Contractor’s Overhead and Profit: 15%
- Bonds and Insurances: 3.75%
- Contingencies – 25%
- Design and Project Management Fees – 15%
- Project Expense / Other Direct Cost – 3%

8) Statement of Estimated Costs

AECOM has no control over the cost of labor and material, the general contractor's or any sub-contractor's method of determining prices, or competitive bidding and market conditions. This opinion of probable costs of construction is made on the basis of experience, qualifications, and best judgement of professional construction cost managers familiar with the construction industry. AECOM cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from this or subsequent cost estimates.

AECOM has no control over the quality, completeness, intricacy, constructability, or coordination of design documents, or over the amount of funds available for this project. AECOM is not responsible for design revision costs in the event that the estimate is in excess of the established budget.

AECOM's staff of professional cost managers has prepared this estimate in accordance with general accepted principles and practices. Our staff is available to discuss its contents with any interested party.

This estimate assumes that the general construction contract will be administered as a competitively bid/negotiated GMP with a selected construction manager / general contractor and prequalified subcontractors. Costs associated with a restrictive bidding market, including small business set-asides (minority, woman or veteran/service-disabled veteran owned (Except as noted) and sole-sourced contractors are not included, and can cause a significant increase to the overall cost of the project.

9) Recommendations for Cost Control

AECOM recommends that the Owner, Architect, and Engineers carefully review this entire document to ensure that it reflects their design intent. Requests for modifications of any apparent errors or omissions to these documents should be made to AECOM within ten (10) days of receipt of this estimate. Otherwise, it will be understood that the contents have been concurred and accepted. If the project is over budget, or if there are unresolved budgeting issues, alternative systems/schemes should be evaluated before proceeding further into design.

Appendix A – Cost Estimate (Non- Pervious Asphalt for Parking)

SITE WORKS COMPONENT SUMMARY

		Gross Area:	**16,150 USF**
		$/USF	$
Site Preparation & Demolition		2.12	34,190
Site Paving, Structures & Landscaping		25.02	404,014
Utilities on Site		5.47	88,330
TOTAL		**32.60**	**526,534**
General Conditions/ General Requirements	25.00%	8.15	131,634
Overtime / Shift Work (Noisy Work)			Excluded
Phasing			Excluded
Contractor's Overhead & Profit or Fee	15.00%	6.11	98,725
Escalation	3.50%	1.64	26,478
Bonds	1.75%	0.85	13,709
General Liability Insurance	2.00%	0.99	15,942
PLANNED CONSTRUCTION COST		**50.34**	**813,021**
Contingency for Development of Design	10.00%	5.03	81,302
Construction Contingency	5.00%	2.77	44,716
Bid Contingency (Skilled Labor Shortage)	10.00%	5.81	93,904
Risk Allowance			Excluded
RECOMMENDED CONSTRUCTION COST BUDGET		**63.96**	**1,032,944**
Design and Project Management Fees	15.00%		155,000
Project Expense / Other Direct Cost	3.00%		31,000
PROJECT SUMMARY (ROUNDED)		**75.48**	**1,219,000**

Item Description	*Quantity*	*Unit*	*Rate*	*Total*
Site Preparation & Building Demolition				
Site preparation	16,150	SF	0.50	8,075
Removal of existing asphalt in parking lot	7,235	SF	3.00	21,705
Removal of concrete paving	980	SF	4.50	4,410
				34,190
Site Paving, Structures & Landscaping				
Grading, allow	16,150	SF	1.60	25,840
Trees	17	EA	2,000.00	34,000
Raingarden	1,428	SF	70.00	99,960
Installation of lawn and plantings	8,215	SF	17.00	139,655
Addition of 4 ft. concrete sidewalk	3,868	SF	6.50	25,142
Additional non-pervious asphalt for parking	1,450	SF	8.00	11,600
Sub-bases, for asphalt parking	1,450	SF	5.00	7,250
Shade cloth playground structure	1	LS	42,000.00	42,000
Pavement contrast painting for accent paving at senior center crossing for speed reduction	1,189	SF	3.00	3,567
Temporary fence, allow	1	LS	15,000.00	15,000
				404,014
Utilities on Site				
Upgrade of drainage pipe line from 15” RCP to 36” RCP	112	LF	520.00	58,240
Catch basin	1	EA	5,750.00	5,750
Roof downspout	7	EA	120.00	840
Trenching, backfilling	1	LS	12,000.00	12,000
Irrigation, allow	1	LS	11,500.00	11,500
Landscape lighting				Excluded
				88,330

Appendix B – Alternate (Pervious Asphalt for Parking)

SITE WORKS COMPONENT SUMMARY (ALTERNATE)

	Gross Area:	**16,150 USF**	
		$/USF	$
Site Preparation & Demolition		2.12	34,190
Site Paving, Structures & Landscaping		25.73	415,614
Utilities on Site		5.47	88,330
TOTAL		**33.32**	**538,134**
General Conditions/ General Requirements	25.00%	8.33	134,534
Overtime / Shift Work (Noisy Work)			Excluded
Phasing			Excluded
Contractor's Overhead & Profit or Fee	15.00%	6.25	100,900
Escalation	3.50%	1.68	27,061
Bonds	1.75%	0.87	14,011
General Liability Insurance	2.00%	1.01	16,293
PLANNED CONSTRUCTION COST		**51.45**	**830,933**
Contingency for Development of Design	10.00%	5.15	83,093
Construction Contingency	5.00%	2.83	45,701
Bid Contingency (Skilled Labor Shortage)	10.00%	5.94	95,973
Risk Allowance			Excluded
RECOMMENDED BUDGET (PERVIOUS ASPHALT)		**65.37**	**1,055,700**
Design and Project Management Fees	15.00%		158,000
Project Expense / Other Direct Cost	3.00%		32,000
PROJECT SUMMARY (ROUNDED)		**77.15**	**1,246,000**

Item Description	*Quantity*	*Unit*	*Rate*	*Total*
Site Preparation & Building Demolition				
Site preparation	16,150	SF	0.50	8,075
Removal of existing asphalt in parking lot	7,235	SF	3.00	21,705
Removal of concrete paving	980	SF	4.50	4,410
				34,190
Site Paving, Structures & Landscaping				
Grading, allow	16,150	SF	1.60	25,840
Trees	17	EA	2,000.00	34,000
Raingarden	1,428	SF	70.00	99,960
Installation of lawn and plantings	8,215	SF	17.00	139,655
Addition of 4 ft. concrete sidewalk	3,868	SF	6.50	25,142
Additional pervious asphalt for parking	1,450	SF	16.00	23,200
Sub-bases, for asphalt parking	1,450	SF	5.00	7,250
Shade cloth playground structure	1	LS	42,000.00	42,000
Pavement contrast painting for accent paving at senior center crossing for speed reduction	1,189	SF	3.00	3,567
Temporary fence, allow	1	LS	15,000.00	15,000
				415,614
Utilities on Site				
Upgrade of drainage pipe line from 15” RCP to 36” RCP	112	LF	520.00	58,240
Catch basin	1	EA	5,750.00	5,750
Roof downspout	7	EA	120.00	840
Trenching, backfilling	1	LS	12,000.00	12,000
Irrigation, allow	1	LS	11,500.00	11,500
Landscape lighting				Excluded
				88,330

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