Preliminary Engineering Report Holmes Street Seawall – Innovative Design for Climate Resilience

Stonington, CT
April 2023
Revised June 2023
Prepared by Weston & Sampson
For the Town of Stonington

Sponsored by a grant from the Connecticut Institute for Resilience and Climate Adaptation (CIRCA). CIRCA is a partnership between the University of Connecticut and the State of Connecticut Department of Energy and Environmental Protection. More information can be found at: www.circa.uconn.edu

Sponsored by a grant from the Connecticut Institute for Resilience and Climate Adaptation.

The Connecticut Institute for Resilience and Climate Adaptation (CIRCA) is a partnership between the University of Connecticut and the State of Connecticut Department of Energy and Environmental Protection. CIRCA's mission is to increase the resilience and sustainability of vulnerable communities along Connecticut's coast and inland waterways to the growing impacts of climate change on the natural, built, and human environment.

More information about CIRCA can be found at circa.uconn.edu.

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

\\wse03.local\WSE\Projects\CT\Stonington CT\ENG23-0002 Holmes St Seawall\5.0 Design Report\2 Homes Rpt text_Draft_client.docx

EXECUTIVE SUMMARY

Holmes Street serves as an important collector road within Historic Downtown Mystic connecting local businesses, homes, and points of interest. An approximately 500-foot-long section of Holmes Street from the intersection with Bay Street and extending southwest past the intersections with Frazier Street is supported by a seawall along the western shore of the Mystic River. The existing seawall is in poor condition due to the age of the structure and scour due to rise in the water level and severe weather events.

The Town of Stonington was awarded a Connecticut Institute for Resilience & Climate Adaptation (CIRCA) grant to identify sustainable and resilient solutions to repair or replace the seawall. The solutions proposed are specific to the project location, but the results from this study are intended to be transferable to other communities facing similar climate challenges from increasing storm surge and sea level rise.

Weston & Sampson was selected as the technical consultant to perform this study, which included evaluating existing conditions through site visits, survey, subsurface explorations, and structural evaluations; assessing coastal flood risk and resilience alternatives; preparing preliminary engineering alternatives with cost estimates; and recommending next steps to refine alternatives and advance through construction.

Downtown Mystic is subject to current and future flood risk, and Holmes Street has flooded in the past under storm events. Flooding extends beyond the limits of the Holmes Street Seawall, which means that solutions proposed for this site will not be independently effective in mitigating flood risk. The resilience considerations for the site emphasize reducing the consequences from flood events (both to the infrastructure as well as community), adaptability of the solution, potential for creating social and economic value, and environmental benefits. Weston & Sampson developed several preliminary resilience concepts that can be integrated with structural alternatives for repairing or replacing the wall. The concepts are not mutually exclusive and may be combined as final design advances.

Three structural alternatives were developed based on the results of this study:

1. rehabilitation of the existing seawall by installing sheet piling
2. complete wall replacement with soldier pile and lagging wall
3. complete wall replacement with conventional cast-in-place concrete retaining wall.

Each of these alternatives will need to be designed and constructed to be scour resistant and can be integrated with larger regional resilience initiatives, including policy and physical measures. An opinion of probable cost associated with each structural alternative was presented, as well as next steps to advance design, permitting, and construction.

1.0 INTRODUCTION

Holmes Street serves as an important collector road within Historic Downtown Mystic, connecting local businesses, homes, and points of interest. The site's location relative to surrounding physical features is shown in *Figure 1 – Locus Map*. An approximately 500-foot-long section of Holmes Street from the intersection with Bay Street and extending southwest past the intersections with Frazier Street is supported by a seawall along the western shore of the Mystic River, as shown in *Figure 2 – Site Plan*.

Despite retrofits, upgrades, and regular maintenance by the Town, the soils supporting the seawall have been eroding due to rise in the water level and severe weather events. The Town is seeking to rehabilitate the existing seawall to maintain this vital connector road. The project needs to consider the short and long-term implications of alternative solutions in conjunction with considering the impacts of climate change, constructability, and permitting.

This report presents the results of Weston & Sampson's preliminary design for repairs to the Holmes Street Seawall in Stonington, Connecticut including innovative design considerations for climate resilience.

1.1 Site Description

Section 1.1 Text Here Holmes Street is a two-way roadway with the seawall and sidewalk on the northwestern side and a guardrail on the southeastern side.

The upper portion of the existing seawall is primarily constructed of mortared angular cobbles where the exposed face has been dressed to a flat surface except for the northeast end of the wall which is constructed of mortared stone blocks. A single span bridge below Holmes Street connects Mystic River to an inland tidal cove. Photos of the seawall are included in *Appendix A.*

Elevations are summarized in *Table 1*. The mudline of the Mystic River adjacent to the seawall is at about El. -2. Existing ground surface elevations referenced herein are based on a topographic survey performed by CLA Engineers, Inc. in January 2023. Elevations are in feet and reference the North American Vertical Datum of 1988 (NAVD88).

Table 1. Existing Site Elevations

Approximate Location	Elevation	
	Center of Road	Top of Seawall
Southwestern End	3.6	6.4
Above Bridge	5.1	9.3
Northeastern End	4.1	6.5

The Mystic River is a tidal water body connected to Mystic Harbor and thereby to Long Island Sound. Tidal fluctuations are typically around 3 vertical feet. The closest active NOAA tide gauge is in New London, CT (Station ID: 8461490), which is approximately 7 lineal miles from the site. During Hurricane Sandy in 2012, the New London gauge registered high tide at approximately El. 6.1. The highest tide reported since was approximately El. (December 2022).

1.2 Scope

Our scope included a field reconnaissance, preparation of a topographic and bathymetric survey base plan, geotechnical exploration program, structural evaluation of existing seawall conditions, coastal flood resiliency assessment, preliminary engineering assessment and alternative analysis, and recommended next steps.

The recommendations in this report are based on our understanding of the site conditions as described herein. Our recommendations are subject to the Limitations provided in *Section 6* of this report. Additional information on the use of this report and its limitations is provided in the document "Important Information about this Geotechnical Engineering Report" by Geoprofessional Business Association (GBA), enclosed as *Appendix E.*

2.0 SUBSURFACE EXPLORATION PROGRAM

2.1 Geologic Setting

Based on the "Surficial Geologic Map of the Mystic Quadrangle, Connecticut, New York, and Rhode Island" prepared by J. E. Upson in 1971, mapped surficial geology conditions at the site include outwash deposits of moderately well sorted silt, sand, and gravel underlying fill.

The "Bedrock Geologic Map of the Old Mystic and part of the Mystic Quadrangles, Connecticut, New York, and Rhode Island" indicates that the bedrock underlying the site is a orange-pink to light gray, fined to medium grained gneiss of the Sterling Plutonic Group.

2.2 Subsurface Explorations

2.2.1 General

Subsurface conditions were explored by advancing three borings (B-1, B-2, and B-3/B-3A) and excavating three test pits (TP-1 through TP-3) between November 21 and 22, 2022. Approximate exploration locations are shown in *Figure 2 – Site Plan*. Weston & Sampson geotechnical engineering staff monitored the exploration activities in the field and prepared logs for each exploration. Boring and test pit logs are included in *Appendices B* and *C*, respectively.

2.2.2 Borings

The borings were completed by New England Boring Contactors of Glastonbury, CT. Standard penetration tests (SPTs) were conducted in each boring by driving a split spoon sampler with an automatic hammer in general accordance with ASTM D1586. Boring B-3 was terminated at 12 feet and continued as B-3A. The borings were advanced to depths between 32 and 35 feet below the road surface. Additional details are provided on the boring logs and the Guide to Subsurface Exploration Logs included in *Appendix B*.

Following completion of drilling, the borings were backfilled with cuttings and the surface patched with asphalt cold patch.

2.2.3 Test Pits

The test pits were excavated by the Town Department of Public Works to depths of up to about 7 feet below the sidewalk using a backhoe equipped with a 2-foot-wide toothed bucket and a maximum vertical reach of approximately 15 feet. The purpose of the test pits was to observe the condition of the foundation supporting the seawall. Following completion of excavation, the test pits were backfilled with the excavated material and the surface restored with concrete or bituminous pavement. Additional details are provided on the test pit logs included in *Appendix C*

2.3 Subsurface Conditions

2.3.1 Soil Conditions

The native soil encountered in the borings was generally consistent with the mapped surficial geology. The conditions encountered in our borings and test pits are described below, in general order of their occurrence with depth. The general Unified Soil Classification System (USCS) designation for each stratum is included in the descriptions below in parentheses.

The subsurface description is based on a limited number of explorations. Variations may occur and should be expected between exploration locations. The strata boundaries shown in our logs are based on our interpretations and the actual transition may be gradual. Refer to the boring and test pit logs for detailed descriptions of the soil samples collected.

Surficial Materials: The borings were advanced within the roadway and encountered about 5 to 6 inches of asphaltic concrete (AC) pavement at the ground surface. The tests pits were excavated directly adjacent to the seawall through a 4 to 5-inch-thick concrete sidewalk.

Fill: Fill was encountered below the surface materials in each of the borings and test pits. The fill was generally described as dark brown to brown, dense to very dense SAND and GRAVEL with few to little silt (SP-SM, SM, GP-GM). The deeper fill contained occasional debris (ash, pavement, and brick). Numerous cobbles were observed in the test pit excavations. TP-2 terminated in the fill at about 2.7 feet. The fill extended to about 3.5 feet below the ground surface (BGS) in TP-1 and TP-3.

As fill material containing debris has been identified during this geotechnical evaluation, environmental review should be considered to evaluate potential premiums, liabilities, or regulatory requirements which may result from soil management during construction.

Organic Deposits*:* Organic material was encountered within the sand in B-1; below the fill in B-2 and B-3, and within the sand in B-3A. The organic deposits were generally described as organic fines with some sand and little gravel (OL) and varied in consistency from soft to very stiff. In B-3 it was described as peat (PT). In B-1 the organic deposit was encountered within the sand between about 7 and 13.5 feet BGS. In B-2 the organic deposits extended to about 9.5 feet BGS, and in B-3/3A the organic deposit below the fill extended to about 5.7 feet BGS and within the sand between about 15 and 18.5 feet BGS.

Sand*:* Native SAND was encountered below the fill TP-1, TP-3, and B-1, and below the organic deposits in B-2 and B-3/B-3A. The SAND was generally brown or gray, medium dense, fine to coarse sand with trace to little fine gravel and trace to little silt (SP-SM, SP, SM, SW-SM). The sand extended to the bottom of these explorations at depths ranging from 4.7 to 35 feet.

2.3.2 Groundwater

The site is along the shore of the Mystic River which is a tidal water body. In the vicinity of the site, the tide generally fluctuates by about 2.5 feet. Groundwater levels are anticipated to match the water level in the river and will fluctuate with season, tide cycles, variations in precipitation, construction in the area, and other factors.

3.0 EXISTING SEAWALL

3.1 General

The seawall consists of stone masonry which is about 24-inches-wide at the top and widens to about 33 to 36 inches approximately 4 feet below the top of wall. At the northeastern end of the seawall, near the intersection with Bay Street, the last approximately 32 feet of stone masonry wall was constructed out of a different stone masonry and looks to be either an addition or repair to the original stone masonry construction. The seawall has an approximately 1-inch-thick cast-in-place concrete cap. The upper approximately four feet of seawall consists of mortared stone masonry while the remaining lower section was dry stacked masonry stone. These condistions are illustrated on *Figure 5 – Roadway Cross Sections.*

The seawall had 8 stone masonry pilasters located at various locations along the seawall. The stone pilaster measured 3 feet by x 3 feet with 3.3-foot x 3.3-foot concrete caps. There were several drainage components that penetrate through the seawall and utility poles are located directly adjacent to the seawall in the Mystic River. The height of the seawall was measured from the sidewalk (rearface of the seawall) and found to vary from 27 inches to 42 inches along the seawall length in a sepintain shape.

A single span bridge is located at the approximate center of the seawall. Repairs were made to the bridge circa 1999 which included grouting of voids in the existing seawall proximate to the bridge. The culvert headwalls are supported on spread footings as illustrated on *Figure 5*. A copy of the design drawings are included in *Appendix D.*

3.2 Evaluation

The stone masonry joints are in fair condition with minor locations of missing mortar between the stones of various depths. Throughout the inspection, masonry hammers were used to strike the stone, masonry cap, mortar and concrete to assess hollow regions at the cap and wall. Various locations of the concrete cap sounded hollow and observed concrete spalling and cracks were noted throughout the concrete cap. The front face of the seawall, at or below the varying tide waterline, was observed to have missing and shifted stones at various locations. The lower portion of the wall also does not have mortared joints. There was some undermining along the front face (water side) of the wall at various locations. Large voids were observed between the foundation stones in TP-2.

Based on the conditions observed, the overall structural condition of the seawall is fair and requires rehabilitation to prevent issues from developing further. Based on the inspection, it appears that the seawall was constructed and/or reconstructed in multiple sections. The water side of the lower section of the wall needs to be repaired by reinstalling and/or chinking the existing stone masonry to help stabalize the existing wall. The concrete cap is also an issue with the concretre spalling and concrete deterioration. The seawall height at the sidewalk side does not meet current code standards requirements for pedestrian safety. The seawall height will need to be extended up to 15 inches to meet current AASHTO and CTDOT safety standards of 42 inches.

4.0 COASTAL FLOOD RESILIENCY ASSESSMENT

4.1 General

Holmes Street was flooded during Hurricane Sandy in 2012 and the seawall is experiencing erosion as a result of more frequent extreme weather events and sea level rise. Holmes Street is one of only two roads leading to the historic downtown Mystic area. Holmes Street is subject to current and future coastal flood risk. Combinations of coastal resilience strategies seek to reduce the flood risk in the conceptual design alternatives considered.

4.2 Present Flood Risks

4.2.1 Tidal Fluctuations

Tidal fluctuations are typically around 3 vertical feet based on the current (1983-2001) National Tidal Datum Epoch (NTDE) for the closest active NOAA tide gauge (New London, CT, Station ID: 8461490), which is approximately 7 lineal miles from the site.[1] *Image 1* illustrates the tidal fluctuations at this tide gauge.

- Mean Higher High Water (MHHW): The average of the higher high-water height of each tidal day observed over the NTDE.
- Mean High Water (MHW): The average of all the high-water heights observed over the NTDE.
- Mean Tide Level (MTL): The arithmetic means of mean high water and mean low water.
- Mean Low Water (MLW): The average of all the low water heights observed over the NTDE.
- Mean Lower Low Water (MLLW): The average of the lower low water height of each tidal day observed over the NTDE.

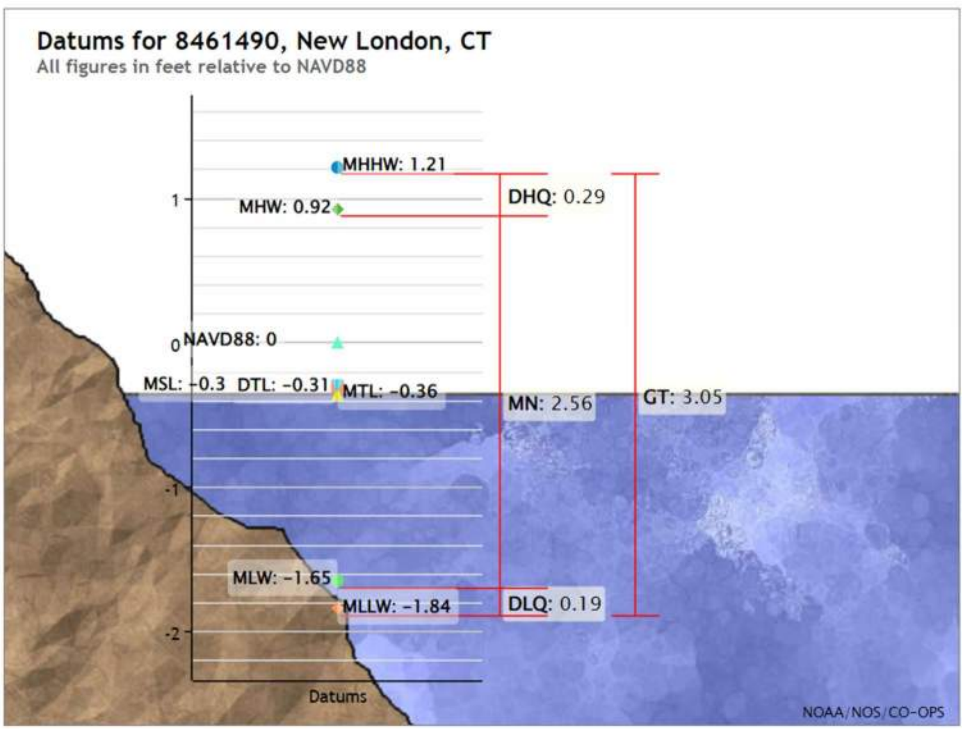
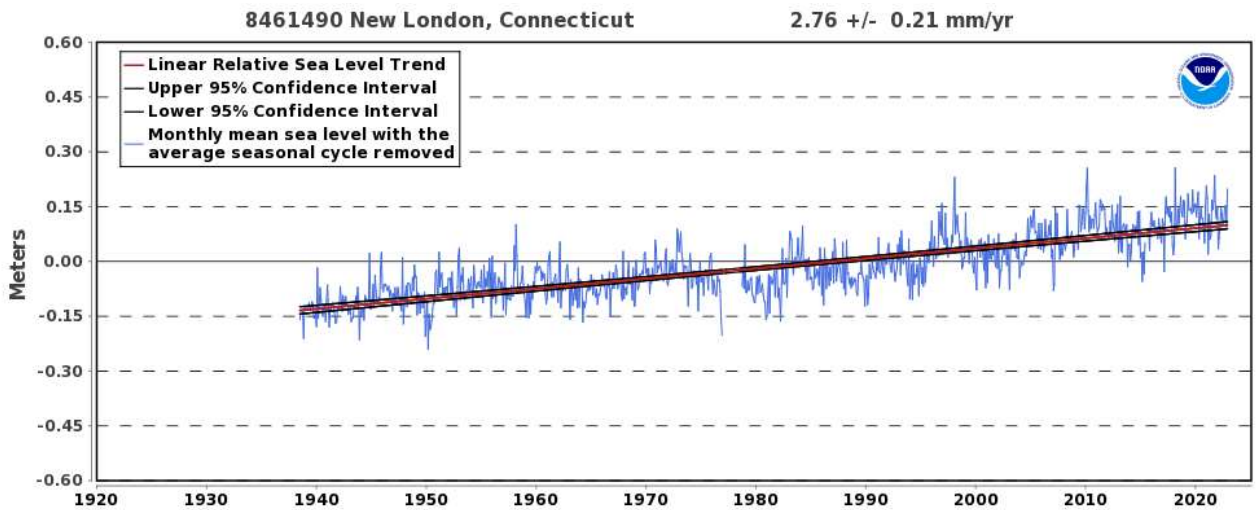


Image 1. Tidal Datums for New London, CT Station relative to NAVD88 Datum (NOAA)

[1] NOAA Tides & Currents Webpage: https://tidesandcurrents.noaa.gov/datums.html?datum=NAVD88&units=0&epoch=0&id=8461490&name=New+London&state=CT

The NTDE sets the mean sea level (MSL) and represents measurements of 19 years (between 1983 and 2001), which removes periodic variations in water level due to the astronomical cycles and aperiodic variations due to meteorological forcing of the ocean. (Sea Level Rise in CT, CIRCA, Donnell, 2019).

Based on recorded tidal fluctuations since 2002, the monthly average MHHW has been about El. 1.48 and the monthly average MLLW has been about El. -1.55. This indicates a roughly 0.28 foot increase from the NTDE, which reflects measurements between 1983-2001. This is slightly greater than the NOAA recorded relative sea level trend of 2.76 +/- 0.21 mm/year (equating to ~0.2 feet over past 21 years) as shown *Image 2* below.



The plot shows monthly mean sea levels relative to the most recent Mean Sea Level (MSL) datum established by NOAA Center for Operational Oceanographic Products and Services (CO-OPS). The trends show a change of roughly 0.91 feet increase in MSL in the past century.

Image 2. Relative Sea Level Trend for Station 8461490 New London, CT (NOAA)

The average highest monthly tide since 2002 has been at approximately El. 2.63. The average lowest monthly tide since 2002 has been at approximately El. -2.51. During Hurricane Sandy in 2012, the New London gauge registered high tide at approximately El. 6.1. The highest tide reported since then was approximately El. 4.6 (December 2022).

4.2.2 FEMA Flood Rate Insurance Maps

The FEMA Flood Insurance Rate Map (FIRM) for the site is included as *Figure 3* and was last updated in August of 2013. The FIRM indicates that site exists within FEMA Zone AE with a base flood elevation of El. 11.[2] Zone AE is classified as a Special Flood Hazard Area, which is an area

> The 1% annual-chance flood refers to a 1-in-100 chance (or 1% chance) each year of being flooded. The combination of sea level rise and the expected increase in frequency and intensity of storms due to climate change may result in a higher likelihood of flood waters exceeding the current existing base flood elevation in any given year.

[2] FEMA references the North American Vertical Datum of 1988 (NAVD88).

inundated by 1% annual-chance flooding and in which base flood elevations have been determined, as indicated on the FIRM.

4.2.3 USACE Hurricane Flood Maps

The US Army Corps of Engineers (USACE) created Sea, Lake, and Overland Surge from Hurricanes (SLOSH) maps for each Connecticut coastal community. The SLOSH flood map for Stonington, CT is included in *Figure 4*. The site is located within the CAT 1 Zone, which represents "winds of 74 to 95 miles per hour". Damage primarily to shrubbery, trees, foliage, and mobile homes. No real wind damage to other structures. Some damage to poorly constructed signs. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings" based on the Saffir/Simpson hurricane damage scale.

4.2.4 Summary of Current Flood Risk

Holmes street is currently at risk of flooding during extreme storm events, such as Hurricane Sandy in 2012, as well as more frequent storms that result in tides flanking the seawall. The seawall is currently at risk of overtopping during the 1% annual chance flood or during a CAT 1 hurricane or greater. Based on the existing profile of the roadway and seawall and FEMA FIRM (El. 11), the flood depths presented in *Table 2* have a current 1% annual likelihood of occurring. Flood depth is defined as the thickness of flood waters from the water surface to the top of the referenced hard surface.

Table 2. Current 100-yr Storm Flood Depths at Holmes Street Seawall

Approximate Location	Flood Depth (feet)	
	Center of Road	Top of Seawall
Southwestern End	7.4	4.6
Above Bridge	5.9	1.7
Northeastern End	6.9	4.5

4.3 Future Coastal Flood Risk

4.3.1 Sea Level Rise Scenario

The State of Connecticut has adopted a uniform recommended sea level rise scenario. Public Act 18-82, otherwise known as Senate Bill No. 7 "AN ACT CONCERNING CLIMATE CHANGE PLANNING AND RESILIENCY," was signed into law by the Governor in 2018 and charged the Department of Energy and Environmental Protection (CTDEEP) to publish the state's sea level rise scenario. The Connecticut Institute for Resilience & Climate Adaptation (CIRCA) recommended a sea level rise (SLR) scenario of 0.5 m (1 foot 8 inches) higher than the national tidal datum in Long Island Sound by 2050 for the state[3]. This scenario was adopted by CTDEEP and is intended to guide communities in preparing for climate change.

[3] https://portal.ct.gov/DEEP/Coastal-Resources/Coastal-Hazards/Sea-Level-Rise

4.3.2 Tidal Projections

For planning purposes, projected tidal datums were estimated by applying this SLR scenario (20 inches or 1.69 feet) to the NTDE for the New London Station, as shown in *Table 3*.

Table 3. Tidal Projections

Tidal Datums	MHHW	MHW	MSL	MLW	MLLW
Present (NTDE 1983-2001)	1.21	0.92	-0.30	-1.65	-1.84
2050 (+1.69 feet of SLR to NTDE)	2.90	2.61	1.39	0.04	-0.15

This indicates the current mean sea level (MSL) is similar to what we can expect for typical low water heights in the future.

4.3.3 Sea Level Rise and Storm Surge Projections

The report titled, "Town of Stonington Coastal Resilience Plan," dated August 2017 provides an overview of current and future coastal flood risk, vulnerable community assets, and potential resilience solutions. Within that report, the Mystic neighborhood was identified as one of the most vulnerable to sea level rise and storm surge. Holmes Street was not directly studied as an asset through the plan, but *Image 3* illustrates the annual probability of flooding under current, 2030 (0.55 feet of SLR), and 2050 (1.69 feet of SLR) for the site.

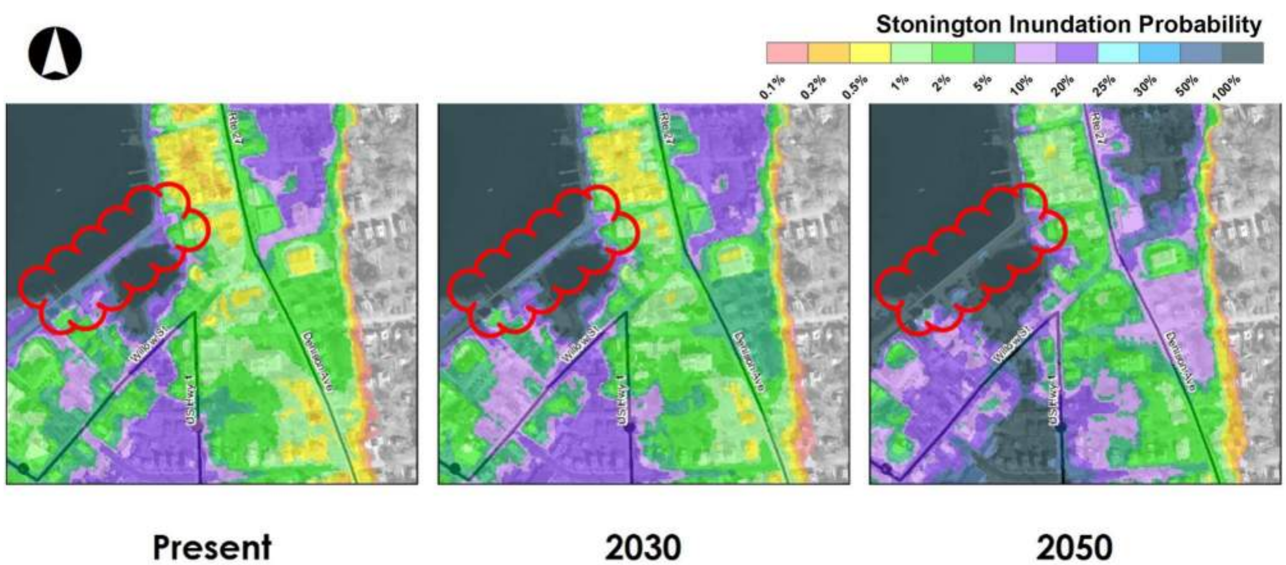


Image 3. Annual Probability of Flooding Maps – Snapshot of Holmes Street – taken from 2017 Town of Stonington Coastal Resilience Plan (Stonington, CT Website)[4]

Projected water surface elevations were not published in the 2017 Town of Stonington Coastal Resilience Plan. For planning purposes, future flood elevation was estimated using the FEMA 100-year

[4] https://www.stonington-ct.gov/planning-department/pages/stonington-ct-resiliency-plan

elevation provided in the FIRM and adding the SLR scenario (20 inches). This results in a future estimated water level of El. 12.7 for the 2050, 100-year storm event without accounting for wave action and/or freeboard.

Based on the existing profile of the roadway and seawall and estimated future water level based on El. 12.7 (2050, 100-yr Storm Event), the flood depths presented in *Table 4* have a 1% annual likelihood of occurring with 20 inches of SLR.

Table 4. Projected 100-yr Storm Flood Depths at Holmes Street Seawall

Approximate Location	Flood Depth (feet)	
	Center of Road	Top of Seawall
Southwestern End	9.1	6.3
Above Bridge	7.6	3.4
Northeastern End	8.6	6.2

This indicates that the projected depth of water on Holmes Street during the 100-year flood event with 20 inches of SLR will be 7.6 feet to 9.1 feet based on the existing roadway profile.

Flood maps were also available through the CIRCA Connecticut Shoreline online Sea Level Rise viewer, which provided scenarios for the 10-year and the 100-year Flood Events with and without 20 inches of SLR as shown in *Image 4*.

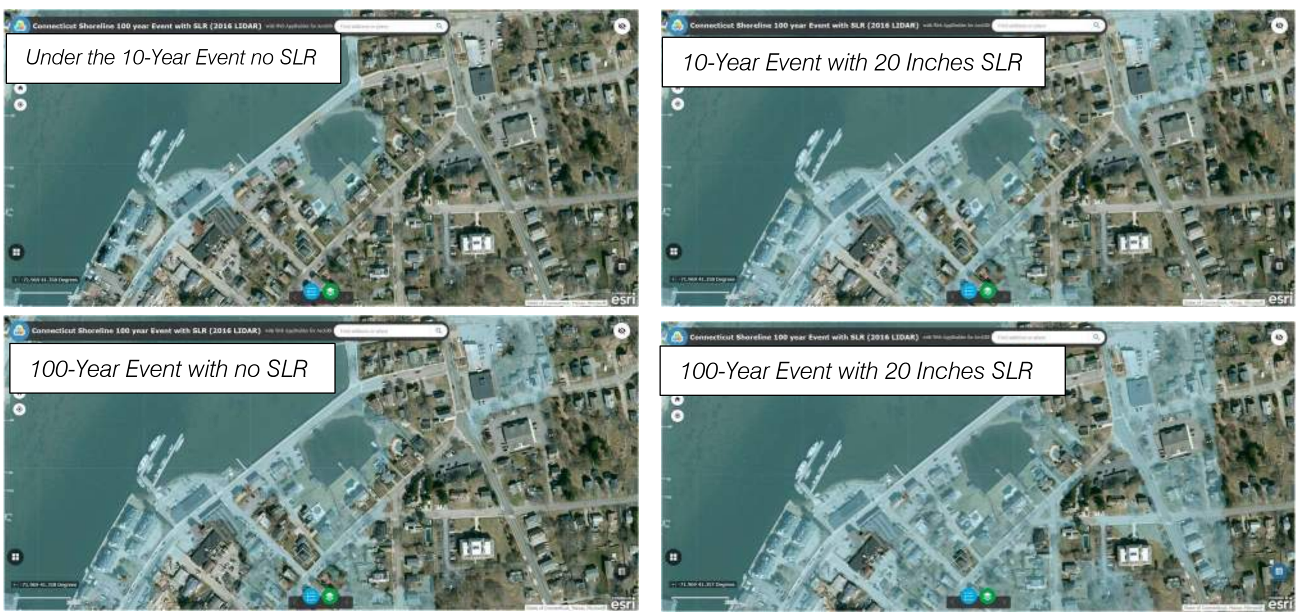


Image 4. Inundated Areas (Shown in Blue) (CIRCA SLR Viewer)[5]

These maps indicate that the current 100-year flood event is similar to the 10-year flood event with 20 inches of SLR. In other words, over the next 30 years, the 100-year flood event will be ten times more likely to occur on an annual basis.

[5] https//lisicos.uconn.edu/SLR/

4.3.4 Summary of Future Flood Risk

The likelihood of extreme weather events resulting in seawall flanking and/or overtopping and Holmes Street flooding increases with sea level rise. The surrounding shoreline to the northeast and southwest of the project area is similarly inundated in present and future scenarios. Based on regional flood maps that support the 2017 report findings that Downtown Mystic is one of the most vulnerable neighborhoods to SLR, the site is potentially vulnerable to other off-site flood pathways that inundate adjacent areas of Downtown Mystic, in addition to pathways directly from the abutting Mystic River

4.4 Integrating Climate Resilience into Design Alternatives

Given the current and future likelihood of flooding, flood depths, and extent of flooding beyond the limits of the project site, improvements for the Holmes St. seawall will likely not be able to provide flood reduction benefits for the community without additional coordinated regional interventions.

The 2017 report included several conceptual alternatives for consideration to reduce flooding for Downtown Mystic. In the absence of a formal plan or strategy in place, the climate resilient strategies for this section (500 linear feet) of seawall focus on reducing flood risk, increasing the ability to recover quickly after flood events, and additional qualitative evaluation criteria to support design alternatives along with the technical assessments.

4.4.1 Overview of Climate Resilience Strategies

Flood resilience includes reducing risk as well as increasing the ability to bounce back after extreme events. Nature-based solutions mimic natural processes—which typically can respond and recover from extreme events better—and offer diverse benefits that make them attractive resilience solutions.

There are a variety of solutions to increase climate resilience, ranging from physical solutions to operational/administrative policies. Effective adaptation is often a combination of the following general strategies:

> Flood risk is the product of the probability of flooding and the associated damages/ consequences. Consequences may be directly quantifiable (such as repair costs), have indirect costs (such as reduced economic activity), and/or public health impacts (such as loss of life, reduced emergency service capabilities, or environmental releases). Methods to lower risk include reducing the likelihood of flooding, flood damage, or both.

- Policy: Administrative, operational, and/or maintenance actions performed by the Town of Stonington to prepare for, respond to, and recover from climate change impacts.
    - Example actions: Plan for increased maintenance along Holmes Street; install "Turn Around, Don't Drown" signage on the roadway; install educational signage about the resilient design components of the project at the site; and/or notify residents of impending flood risk through emergency communications.

- Retreat: Relocate outside the mapped flood extents and/or elevate above flood waters. [6]
    - Example actions: Raise roadway above the future projected flood elevation; redirect traffic; and/or relocate Holmes Street out of the floodplain (with the exception of road closure, likely unfeasible).
- Accommodate: Engineered and/or nature-based solutions to embrace flooding (tidal, storm surge, and/or stormwater) and reduce the impact to vulnerable infrastructure, properties, and residents.
    - Example actions: Design roadway to recover quickly from flood events, including supportive drainage infrastructure; and/or reduce wave action by designing revetments or living shoreline to reduce run-up/overtopping.
- Protect: Engineered solutions to prevent flooding from impacting vulnerable infrastructure, properties, and residents.

  Example actions: Install temporary flood barriers along Holmes Street; raise height of seawall to act as a flood barrier; and/or install tide gates on the bridge near the center of Holmes Street

These strategies are illustrated on *Image 5* on the next page.

[6] Elevate is sometimes considered an "accommodate" strategy for house retrofits, because it allows the water to flow underneath the property. Given that the site is a seawall and roadway, elevating the roadway could technically done as a bridge (accommodating flow underneath) or by raising structures and filling (creating a barrier of protection). In either case the roadway has retreated above the projected water elevation, which reduces flood risk by reducing likelihood of flooding.

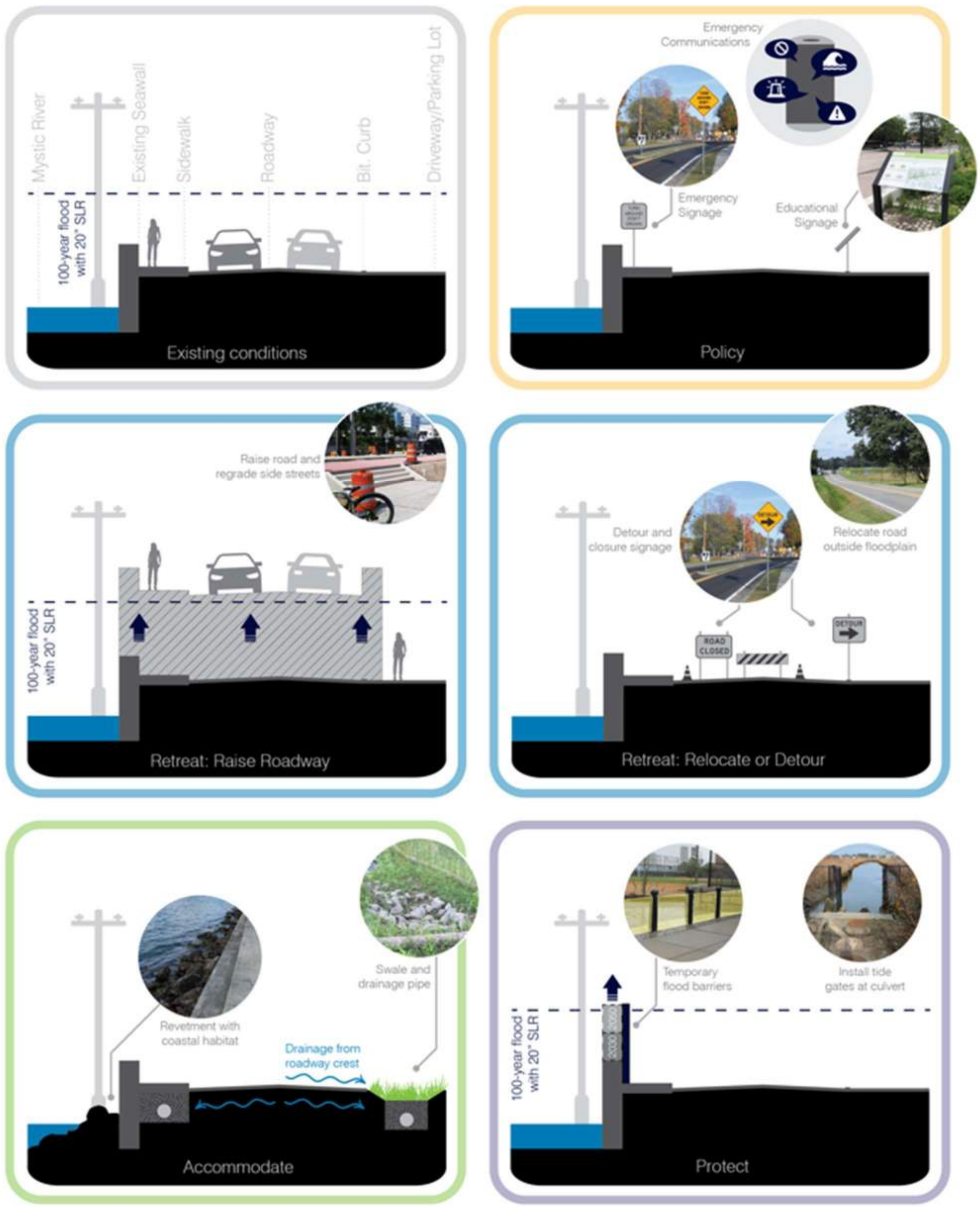


Image 5. Menu of Solutions to Increase Climate Resilience

4.4.2 Preliminary Qualitative Considerations for Climate Resilience Strategies

In addition to the geotechnical and structural technical assessments provided in this report, there are several other qualitative criteria that may influence alternative selection. The following preliminary considerations reflect the qualitative criteria that may be used to discuss alternatives/concepts with regulators, the public, and other decision-makers, but do not represent a comprehensive list of all possible decision-making criteria.

Effectiveness: Potential risk reduction from proposed alternative, either through reducing likelihood or consequence of flooding. This may reflect reducing sea level rise/storm surge flooding, extreme precipitation flooding, and/or coastal erosion.

Adaptability: Potential for incremental implementation of the solution to adapt to SLR over time. This may reflect designing the structure to increase in height, to accommodate tide gate retrofits, or incorporate natural solutions along the waterfront over time. Some alternatives may be more flexible rather than fixed.

Value Creation: Potential benefits or negative impacts to the public realm, including the neighborhood and individual properties, by the proposed alternative. This may reflect creating value by improving quality of life through design decisions and/or impacting accessibility of the roadway.

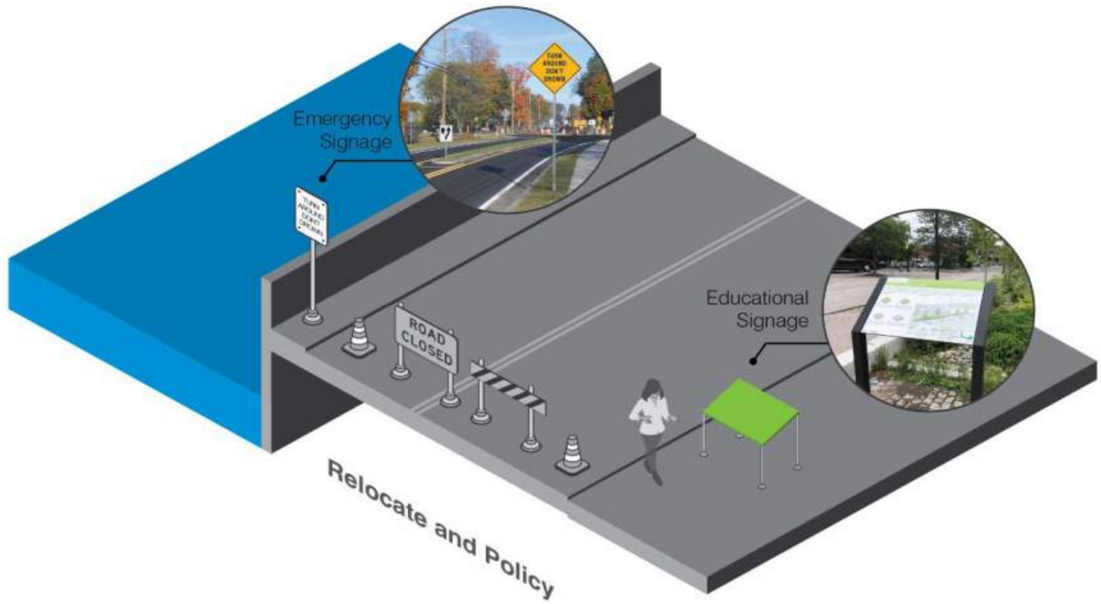
Environmental: Potential opportunities to improve ecological conditions of the area through the proposed alternative. This may reflect restoring natural habitats or integrating nature-based solutions, such as living shorelines, into the design. This criterion may also influence feasibility of the project being approved by regulators and/or funding opportunities.

4.4.3 Preliminary Climate Resilience Opportunities for Holmes Street Seawall Repair/Replacement

The likelihood of extreme weather events resulting in Holmes Street overtopping increases with sea level rise. The opportunities provided below were informed by the current and future flood risk findings, existing site conditions, and information reviewed and cited in this report. There is no opportunity to demonstrate independent effectiveness in mitigating flood risk without larger regional interventions.

Four opportunities, labeled A through D, were developed to consider in conjunction with the seawall redesign. Each opportunity is presented with a schematic diagram illustrating the concept, preliminary discussion, and opinions on the qualitative evaluation criteria. These concepts are not exhaustive or mutually exclusive. Opportunities may be implemented in tandem or at different points in time to increase benefits and coordinate with other regional initiatives.

A Redirect traffic away from Holmes St. during extreme weather events and when tides are predicted to exceed El. 4.



Holmes Street is an important collector road within Historic Downtown Mystic connecting local businesses, homes, and points of interest. Permanent relocation to an area that is not within mapped flood extents is likely unfeasible based on the extent of flooding within the Downtown Mystic neighborhood. Temporary redirection of traffic and road closures based on a threshold tide condition may increase public health and safety.

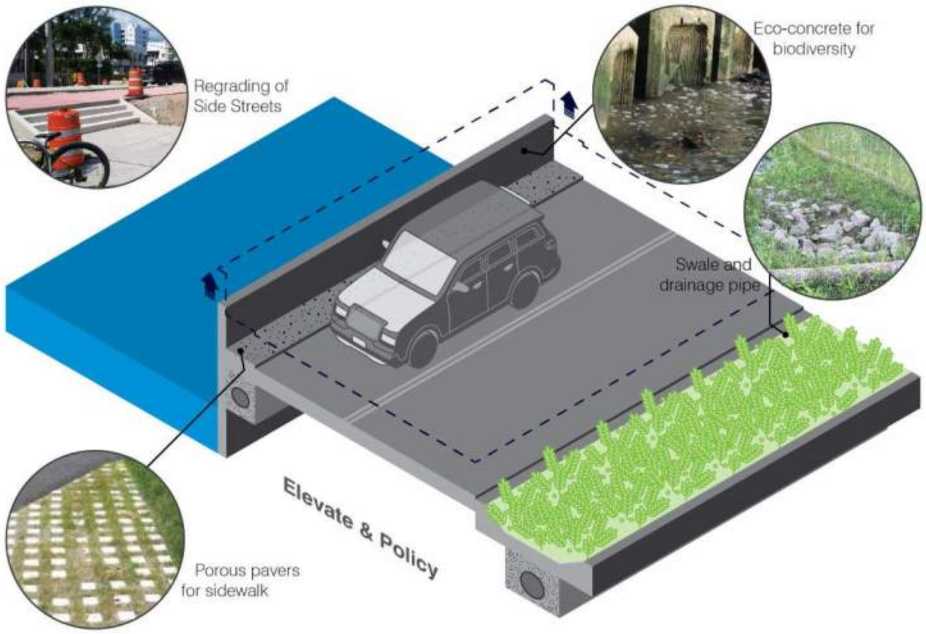
While this strategy won't reduce flood risk for the roadway or seawall, it may reduce the risk of vehicles and/or pedestrians being impacted by flooding through this section of roadway.

This strategy can evolve over time based on the frequency of flooding and learn from experience. For example, redirected traffic routes are flexible to adapt based on patterns.

This strategy may create new traffic patterns that have additional benefits and impacts for the community. Local businesses that are accessed via Holmes St. may be upset by road closures that impact accessibility.

This strategy may result in increased vehicle miles traveled, which if fossil fueled—could have a slight increase in carbon emissions. It also may reduce the likelihood of vehicles being flooded and fuel being leached into coastal waters.

B Raise the seawall and roadway to the maximum extent possible (based on surrounding conditions) and design for future elevation.



The only known underground utilities below Holmes St. between the intersections of Frazier St. and Bay St. are drainage structures. Vehicle access to # 22 and #40 Holmes Street is from this stretch of Holmes Street. The intersection of Holmes St. and Frazier St. is approximately El. 3.9, and the intersection at Bay St. is approximately El. 4.3. Based on surrounding grades and connecting driveways, it may not be technically feasible to raise the roadway and corresponding seawall significantly without requiring substantial regrading of side streets to maintain accessibility (including ADA).

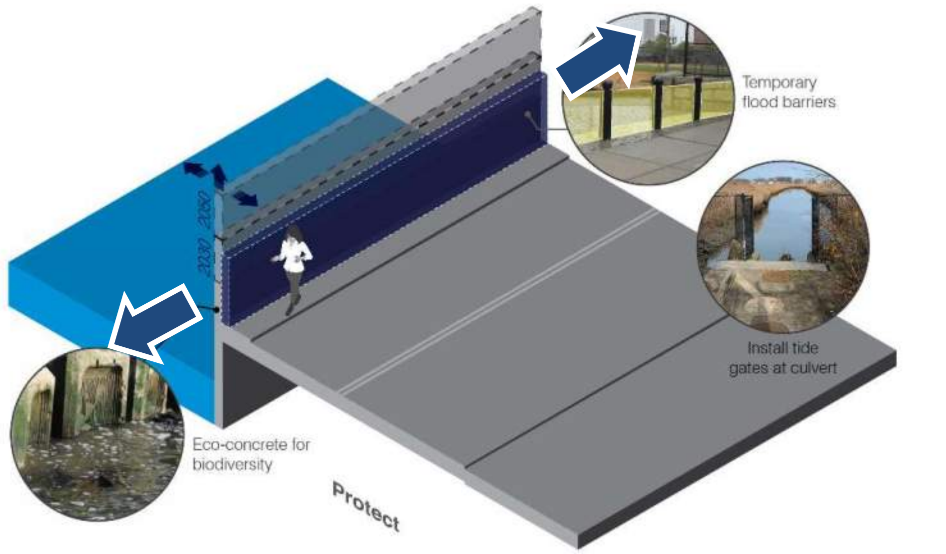
This strategy may reduce the likelihood of nuisance flooding (high tides) on the roadway. Additional modeling is needed to assess the impact of stormwater runoff as a result of grade changes.

Roadway raising of less than 6 inches may be feasible via an adaptive paving strategy, but typically roadway raising is a fixed strategy. This is because of impacted adjacent infrastructure (roads/utilities) as well as properties. The seawall and roadway could be planned to be raised in the future with larger regional efforts to prevent flooding of downtown Mystic (see protect below).

There are opportunities to improve pedestrian and bicycle traffic through this strategy, but design should seek to minimize impacts to driveways, abutting properties, and intersections.

The seawall could be designed using materials that allow biodiversity and/or carbon storage. The seawall could also be textured to promote habitat. In raising the roadway, there are opportunities to integrate green infrastructure solutions (such as porous pavement for sidewalks or bioswales) to treat stormwater runoff.

C Install a barrier along the top of the seawall (or increase seawall height).



A new seawall could be designed and installed with a higher top elevation than existing permanent or temporary barriers. The target increased height would be ~ 6.3 feet at the ends and ~3.4 feet in the center. This does not account for freeboard or wave action, which may result in higher elevations. A tide gate would be necessary to prevent water from passing through the seawall via the culvert, thus flooding the roadway from behind.

This strategy won't reduce the likelihood of flooding on the roadway due to flanking of the seawall. Additional modeling is needed to assess effectiveness of tide gate (adaptive plan) and stormwater discharge to evaluate inland flood risk.

The seawall design can be planned to be adaptive in the following ways:

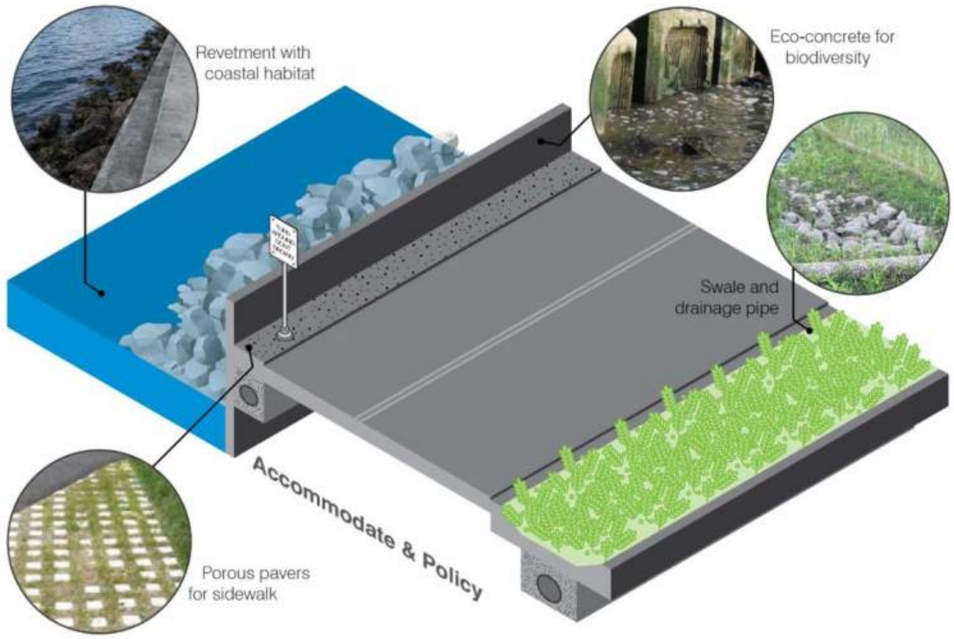
- Increase height incrementally (permanent or temporary).
- Connections at the end of the seawall for other barriers to tie into.
- Retrofit a tide gate to the culvert.

This first adaptation measure may serve as a tie-in for adjacent efforts in the future that combined with larger regional efforts may reduce flood risk.

This strategy, once fully implemented, may obstruct view of the river, which is likely to be objected to from the local community. Temporary barriers would block views when deployed, but would also require operational capacity to maintain, deploy, and retract.

The seawall could be designed using materials that allow biodiversity and/or carbon storage. The seawall could also be textured to promote habitat. This strategy, once fully implemented, may impact the existing ecosystem since flow of water through the culvert would be controlled. If there are species that pass through the culvert, their travel may be impended due to gate operations.

D Design the seawall and roadway to reduce wave heights, erosion, and recover quickly from flood events.



The redesign of the seawall should account for frequent inundation. Roadway grading may be designed to improve drainage after a flood event. Some opportunities to reduce the impact of frequent coastal flooding include designing for overtopping, sloping a revetment in front of the seawall, and/or designing the top of the seawall to redirect some of the reflected water and waves away from the wall.

This strategy won't reduce the likelihood of flooding, but it may reduce the consequences to the infrastructure because of flooding, which lowers the risk. Note: wave action and erosion potential were not modeled through this project, but the site is not within a velocity zone based on available information.

The maintenance/response component of this strategy is more flexible than the engineered components. The Town may include a planned inspection schedule to observe performance of the wall and roadway over time.

This strategy will likely not have a significant impact on value creation other than reducing the duration of time the roadway is flooded after a storm. The environmental improvements may improve the streetscape and encourage more pedestrian traffic during fair weather times.

Increased surface roughness is likely to dissipate wave energy as well as improve coastal habitat. The seawall could be designed using materials that allow biodiversity and/or carbon storage. If a revetment is part of the design, it may be able to be designed to enhance habitat for marine life and vegetation (shapes, textures, spacing between rocks). There are opportunities to integrate green infrastructure solutions (such as bioswales) to improve drainage.

4.4.4 Recommended Next Steps for Advancing Resilience Considerations

Technical Assessments

Additional engineering analyses and assessments are recommended to advance the feasibility of these opportunities, including but not limited to the following:

- *Integrated coastal and inland modeling*: the opening through the seawall at the bridge discharges stormwater into the Mystic River. The ability to discharge stormwater under existing conditions may be impacted by climate change, as well as proposed alternatives.

- *Potential adverse impacts*: the design will likely need to demonstrate that the rehabilitation or replacement of the seawall does not have adverse impacts on the community or environment to obtain a USACE general permit. This will likely include evaluating potential for wave refraction/deflection and may include stormwater and habitat assessments.

- *Wetland delineation and habitat assessment*: evaluating the existing coastal habitat (including marine life and vegetation) was not included within the scope of work. It is likely that the potential impact and/or proposed benefit to coastal habitat will need to be evaluated to obtain a USACE general permit.

- *Traffic study*: the roadway may be impassable more frequently as a result of flooding. The Town may want to identify existing traffic patterns and plan for detours in advance of extreme weather events.

Stakeholder Feedback

These concepts have been prepared without community feedback to inform the qualitative considerations. They can be shared with the public to help refine design decisions, inform priorities, as well as support plans for regional interventions.

Funding Opportunities

The ability to obtain funding will be a key component for next steps in implementing a preferred alternative. There are several existing available private, local, state, and federal grant programs. The following opinions are preliminary based on our experience with similar grants.

- *Emergency Management Performance Grant*: This FEMA-funded grant may be an opportunity to support the policy alternatives related to preparing, responding to, and recovering from flooding along Holmes Street. There are certain eligibility requirements that municipalities must meet for funds.

- *Long Island Sound Futures Fund:* This NFWF funded program may be an opportunity for funding improvements if the benefit to the coastal habitat can be demonstrated in design. This grant will fund "Planning that sets-the-stage for implementation of habitat restoration projects including: 1) community engagement, planning and prioritization; 2) feasibility, suitability or alternatives analyses; 3) site assessment and conceptual design; and 4) final design and permits."[7] These design/planning projects range from $50k to $500k with a 25% match requirement. The application period ended May 10, 2023.

- *STEAP Grant*: This program is funded by the State Bond Commission and can only be used for capital projects. STEAP funds cannot be used for design, studies, planning and/or engineering. Municipal match is not required, but preference is given to those that make at least a 20% match. The limit for funds is $500k for a fiscal year. The grant period is currently closed.

- *Mitigation Grants*: The Hazard Mitigation Assistance (HMA) grant programs through FEMA require a FEMA-approved Hazard Mitigation Plan. To fund a project through these programs, it must directly reduce the vulnerabilities identified in the risk assessment. Stand-alone mitigation activity must solve a problem independently or constitute a functional portion of a solution to be eligible. It is unlikely that a project framed as a "flood risk reduction" activity would be eligible, but it may be possible to pursue a "retrofit" activity. The HMA Program and Policy Guide was updated in March 2023.

- *Pre-Disaster Mitigation (PDM) Grant Program*: This program is now separate from the HMA grant program and is authorized by Section 203 of the Stafford Act. "Mitigation projects must solve a problem independently or constitute a functional portion of a long-term solution for which there is assurance that the project as a whole will be completed or there is a reasonable plan and available funding for completion."[8] Given that current and future flooding extend beyond the limit of work for this project and there is no formal regional intervention plan in place, it is unlikely that this project would be eligible.

[7] https://www.nfwf.org/programs/long-island-sound-futures-fund/long-island-sound-futures-fund-2023-request-proposals
[8] FY2023 PDM Grant Program NOFO, page 11.

5.0 PRELIMINARY RECOMMENDATIONS FOR SEAWALL

5.1 General

This project is focused on the approximately 500-foot-long section of seawall supporting Holmes Street adjacent to the Mystic River. As discussed above, the flooding potential in this area extends beyond the limits of this seawall. Therefore, this structure cannot be retrofitted to provide independent flood protection and the recommendations are focused on reducing the risk to the structure and public during flood events and reducing the recovery time after a flood. However, when developing alternatives for rehabilitation or replacement of the seawall, we considered options that would be adaptable for inclusion in potential future regional flood protection initiatives while being protective of the seawall and roadway without increasing adverse effects to adjacent areas.

5.2 Structural and Geotechnical Design Alternatives

Weston & Samson looked at three alternatives to improve the structural and geotechnical stability of the seawall and increase the resiliency of the structure.

The alternatives include rehabilitation of the existing seawall by installing sheet piling, complete wall replacement with soldier pile and lagging wall, or complete wall replacement with conventional cast-in-place concrete retaining wall. Each of these alternatives will need to be designed and constructed to be scour resistant. Selection and implementation of these alternatives need to consider the presence of existing fill and organic materials which are not suitable bearing materials and are susceptible to settlement due to increases in the vertical loads.

5.2.1 Alternative 1: Rehabilitation of the Existing Seawall

The existing seawall could be rehabilitated by installing steel sheet piling in front of the wall as shown on *Figure 6 – Sheet Pile Support of Existing Seawall*. The sheet piles will reduce/eliminate the scour potential and corresponding undermining of the foundation. The gap between the sheet piles and existing seawall will be filled with scour resistant material such as large stone, flowable fill, or concrete. Subsequently, voids between the dry stacked foundation stones can be filled with flowable fill or cement grout. The missing stones from the upper portion of the wall can be replaced. The installation of the sheet piling, repairs and concrete placement can be performed from back of the wall which will require only temporary closure of the existing sidewalk and one-lane of roadway. The traffic will be maintained with one-lane alternating traffic during the construction working hours then at the end of the workday the roadway and sidewalk will be reopened daily.

Obstructions such as revetment in the river adjacent to the seawall and inclusions in the fill such as concrete fragments, building debris or boulders may present challenges to installation of sheet piles. A pilot sheet pile driving program by a contractor with a typical pile driving rig and typical sheet pile sections may be used to further explore this option.

As noted above, the existing concrete cap along the top of the seawall is in poor condition. To meet current AASHTO and CTDOT pedestrian safety standards, we recommend increasing the height of the seawall by a minimum of 15 inches. This can be done by either increasing the wall height with additional stone masonry or concrete, or by adding a bridge rail system to the top of wall with a new thin concrete cap on top of the existing masonry.

It is anticipated that implementation of this alternative will be the least disruptive to vehicle and pedestrian traffic, least disruptive to the river front since coffer dams and deep excavations are not necessary. Conversely, this alternative has the shortest life span and will require more maintenance than the following alternatives.

As noted above, improvements to the seawall will not reduce the impact of flooding to the area since it can be flanked on both ends. The Town may consider this alternative to improve the condition of the seawall as regional flood mitigation measures are developed.

5.2.2 Alternative 2: Reconstruction of Seawall using Soldier Pile and Lagging Wall

The existing seawall could be removed and replaced with a Soldier Pile and Lagging wall supporting the roadway fill as shown on *Figure 7 – Soldier Pile and Lagging Wall Sketch*. Galvanized steel H-piles, typically spaced between 8 to 10 feet, would be set into drilled shafts extending into suitable bearing material sufficiently below the scour depth to provide structural support of the roadway embankment. Drilled micropiles (DMP's) with a tighter soldier pile spacing may be an alternative to the drilled shafts, particularly if obstructions are present.

Precast concrete lagging panels will be placed between the steel piles from the top of the concrete caisson up to approximate existing finished grade. The panels would extend below the scour depth. Engineered fill will be placed behind the wall to support a cast-in-place moment slab to carry the sidewalk and support the roadway. Pedestrian fall protection can be provided either by extending the soldier pile and lagging, parapet on the moment slab, or a bridge rail system up to a minimum of 42 inches from the top of sidewalk.

It is anticipated that implementation of this alternative will be moderately disruptive to vehicle and pedestrian traffic. Temporary shoring which also provides water control, such as interlocking steel sheet piles, would be necessary within the Mystic River and within the existing roadway such that installation of the lagging and placement of backfill can be completed in the dry. This alternative would provide a long-term replacement of the seawall.

5.2.3 Alternative 3: Reconstruction of Seawall with Concrete Retaining Wall

The existing seawall could be removed and replaced with a cast-in-place concrete cantilever retaining wall as shown on *Figure 8 – Concrete Retaining Wall Sketch*. Construction of the retaining will require a large excavation to construct the of footing on suitable bearing material below scour elevations. Alternatively, the concrete retaining wall could be supported on deep foundations extending below the scour depth to reduce the depth of the excavation. The retaining will include either a bridge rail system or the top of wall will extend 42 inches higher than the top of sidewalk.

It is anticipated that implementation of this alternative will be moderately disruptive to vehicle and pedestrian traffic or a full road closure with a detour (this option would reduce construction time). This construction will require temporary shoring and water handling during construction similar to Alternative 2. This alternative would provide a long-term replacement of the seawall.

5.3 Incorporating Climate Resilience

The preliminary climate resilience opportunities described in Section 4 were integrated with the structural and geotechnical design alternatives described above to reflect resilience recommendations for the existing seawall and a new seawall.

5.3.1 Climate Resilience Recommendations for Alternative 1: Rehabilitation of the Existing Seawall

The integration of preliminary climate resilience concepts with the proposed structural and geotechnical design Alternative 1 is illustrated on *Figure 9 – Incorporating Resiliency with Support of Existing Seawall.* This illustration includes the following climate resilience targets and associated design features:

Climate Resilience Target	Design Features Include
• Reduce the risk to the existing seawall • Accommodate flood waters (both coastal and stormwater) to reduce the duration of flooding on the roadway • Incorporate natural and nature-based solutions where possible	• Coastal revetment that protects the wall from erosion and enhances bio-diversity • Green infrastructure as part of interior drainage in the roadway that reduces recovery time after flood events.

This approach reflects considerations related to the preliminary climate resilience opportunities: A) Redirect traffic away from Holmes St. during extreme weather events and when tides are predicted to exceed El. 4. and D) Design the seawall and roadway to reduce wave heights, erosion, and recover quickly from flood events.

5.3.2 Climate Resilience Recommendations for Alternatives 2 & 3: Reconstruction of Seawall (Solider Pile & Lagging or Concrete Retaining Wall)

The integration of preliminary climate resilience concepts with the proposed structural and geotechnical design Alternatives 2 and 3 are illustrated on *Figure 10 – Incorporating Resiliency with Reconstruction of the Seawall.* This illustration includes the following climate resilience targets and associated design features:

Climate Resilience Target	Design Features Include

• Rebuild the seawall so that it can increase in height in the future • Raise the seawall, sidewalk, and roadway to the maximum extent possible from existing conditions to reduce frequency of flooding • Accommodate flood waters (both coastal and stormwater) to reduce the duration of flooding on the roadway • Incorporate natural and nature-based solutions where possible	• Bio-enhanced concrete with increased surface complexity/roughness to encourage coastal habitat and reduce wave action. • Coastal revetment that protects the new wall and increases bio-diversity • Green infrastructure as part of interior drainage in the roadway that reduces recovery time after flood events. • Elements at top of seawall that can adapt in future up to target flood elevation for regional protection

This approach reflects considerations related to the preliminary climate resilience opportunities: A) Redirect traffic away from Holmes St. during extreme weather events and when tides are predicted to exceed El. 4.; B) Raise the seawall and roadway to the maximum extent possible (based on surrounding conditions) and design for future elevation; and D) Design the seawall and roadway to reduce wave heights, erosion, and recover quickly from flood events.

5.4 Permitting Considerations

Based on the location of this project, the anticipated work, our preliminary assessment, experience with other projects in this area, and correspondence with CTDEEP we anticipate permitting for the proposed seawall rehabilitation will likely include the following:

- If the existing seawall is repaired, including raising the height by up to 12 inches:
    - United States Army Corps of Engineers (USACE) Pre-Construction Notification (PCN), which also includes CTDEEP Land & Water Resources Division Form L for CT submitted to CTDEEP and USACE.
    - CTDEEP Certificate of Permission (COP)
- If the exiting seawall is replaced:
    - USACE Individual Permit submitted to CTDEEP and USACE
    - A CTDEEP Land & Water Resources Division Form C Structures, Dredging and Fill (SDF) permit may be required depending on the construction methodology and the impacts to surrounding coast resources.
    - If a SDF permit is required, a CTDEEP 401 water quality certificate will also be required.
- For either approach (repair or replacement):

- Local Inland Wetlands & Watercourses Activity Application submitted to the Stonington, CT Inland Wetlands & Watercourses Commission
- Town of Stonington Coastal Area Management (CAM) permit
- Town of Stonington Special Use Permit

5.5 Preliminary Cost Estimate

We have prepared an engineer's estimate of probable cost for design and construction of the three alternatives described above. These estimates are based upon our recent experience on other similar projects. The estimates assume that the project will be constructed in 2024 and include a 20% contingency. Costs are highly dependent on timing of construction, global supply chain issues, and market climate at the time of bidding.

Table 5. Engineer's Estimate of Probable Cost	
Alternative 1: Rehabilitation of the Existing Seawall	$2,750,000
Alternative 2: Reconstruction of Seawall using Soldier Pile and Lagging Wall	$3,600,000
Alternative 3: Reconstruction of Seawall using Conventional Cast-in-Place Concrete Retaining Wall	$4,200,000

5.6 Next Steps

Following selection of an alternative by the Town, there are several items that will need to be further developed during detailed design. These items may include, but not be limited to:

- Performing additional subsurface explorations to further assess the soil and bedrock conditions at the site and configuration of the existing seawall foundations at other locations. directly measure the soil friction angle, cyclic resistance ratio (CRR), and small-strain shear wave velocities.
- Assessing the potential impacts of climate change on the performance of the bridge and ability for stormwater to outflow from the inland pond to the Mystic River. The mudline below the center of the bridge is at about El. -2 based on the survey. As sea levels rise, the ability of the stormwater within the inland pond to drain to the ocean will be reduced as the coastal waters are higher.
- Assess retrofitting the bridge with a tide gate to prevent coastal flooding from flow below the bridge into the pond. The design of future improvements to the bridge should consider the present and future tidal datums to reduce risk of unintended consequences of stormwater flooding.

- Determining the level of permitting effort required for the selected alternative.
- Collecting additional data, as needed, to satisfy permitting requirements.
- During preliminary design phase, have pre-permitting review meetings with Town of Stonington Land Use, CTDEEP, and USACE.

6.0 LIMITATIONS

6.1 Observation of Construction

Satisfactory earthwork and foundation performance depends to a large degree on the quality of construction. The actual subsurface conditions encountered during construction may vary from those encountered in the subsurface investigations and may require revisions to the recommendations provided in this report. Recognition of changed conditions often requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated. In addition, sufficient monitoring of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications.

The recommendations in this report are preliminary as actual subsurface conditions may differ from those interpreted based on our subsurface explorations. In order for our recommendations to be considered final, we must be retained to observe the actual subsurface conditions encountered during construction. Our observations will allow us to interpret the actual conditions present during construction and adapt our recommendations if needed.

6.2 Variations of Subsurface Conditions and Use of Report

We have prepared this report for use by the Town of Stonington and members of the design and construction team for the subject project and site, only. The data and report can be used for estimating purposes, but our report, conclusions, and interpretations should not be construed as a warranty of the subsurface conditions and are not applicable to other sites.

Explorations indicate conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect subsurface conditions that may exist between exploration locations. If subsurface conditions differing from those described are noted during the course of excavation and construction, reevaluation will be necessary.

Site development plans and design details were not finalized at the time this report was prepared. The recommendations presented should be revisited and revised as the project design advances. If design changes are made, we should be retained to review our conclusions and recommendations and provide a written evaluation or modification. Additional geotechnical engineering analyses and explorations may be necessary.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, expressed or implied, are given. For additional information on the use of this report, please refer to the document titled "Important Information about This Geotechnical-Engineering Report" included in *Appendix E*.

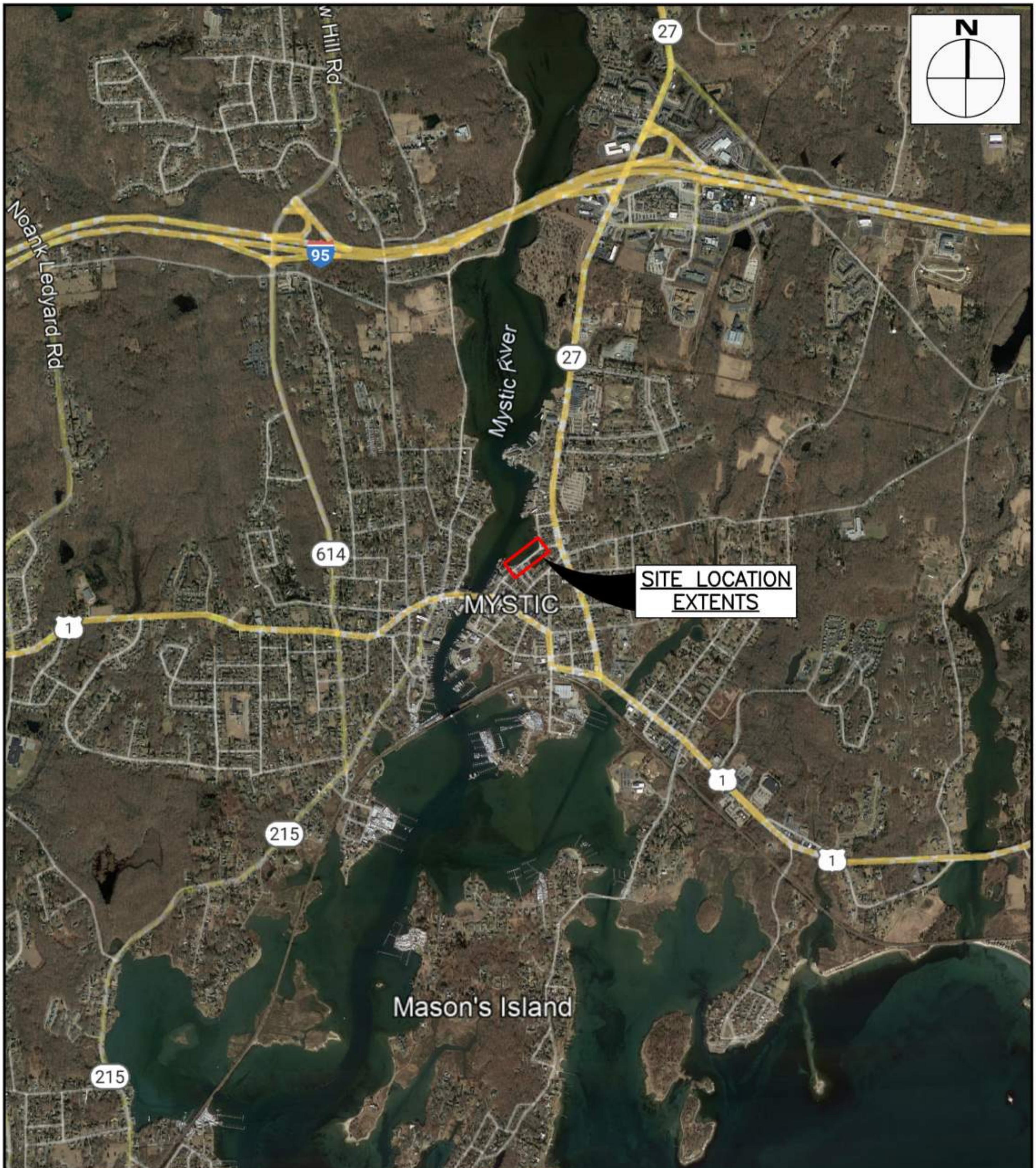
6.3 Climate Change Projections and Use of Report

The climate data, projections, and coastal flood maps referenced in this report are based on available published literature available for the Town of Stonington and State of Connecticut at this time. The climate projections provided by others and underlying assumptions and uncertainties have not been independently reviewed by the project team. The limitations provided in the cited literature by others also apply to this technical report.

Actual climate conditions will vary and may be more or less extreme than the projections and estimated elevations and flood depths summarized in this report. The recommended SLR projection and tidal datums may change based on future updates by others. The project did not evaluate other climate change impacts, such as changes to rainfall, heat, groundwater, species migration, etc. The risk to the site may be influenced by joint probability events that were not evaluated in this study.

The information and conclusions presented within this report are not intended as final opinions and should continue to be vetted with experts in the field, with updated climate projections, and with regulatory requirements. Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the generally accepted practices in this area at the time this report was prepared. No warranty, expressed or implied, is given.

FIGURES



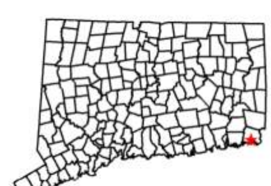
Weston & Sampson

FIGURE 1
LOCUS MAP

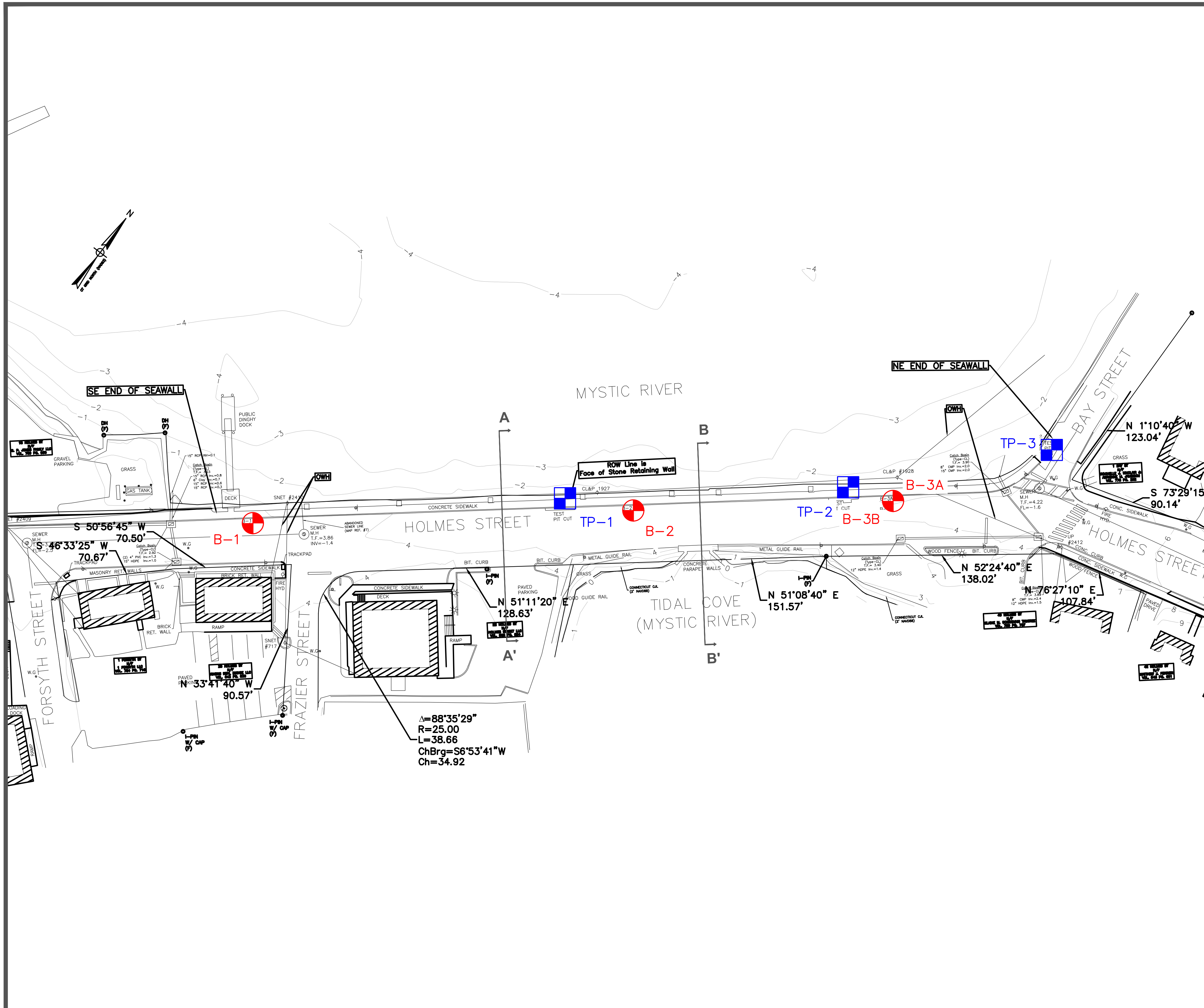
HOLMES STREET SEAWALL
STONINGTON, CONNECTICUT
NEW LONDON COUNTY

GOOGLE EARTH, LANDSET COPERNICUS
CIRCA FEBRUARY 2020

SCALE IN FEET
0 2000 4000



\\wse03.local\WSE\Projects\CT\Stonington CT\ENG23-0002 Holmes St Seawall\3.1 Geotech\3.0 CAD\Locus Map_2023.02.14.dwg



Weston & Sampson

Weston & Sampson Engineers, Inc.
55 Walkers Brook Drive, Suite 100
Reading, MA 01867
978.532.1900 800.SAMPSON
www.westonandsampson.com

NOTES

1. THIS PLAN WAS PREPARED USING A JANUARY 12, 2023 DRAWING TITLED, "EXISTING CONDITIONS SURVEY" PREPARED BY CLA ENGINEERS, INC.
2. EXPLORATION LOCATIONS SHOWN ARE BASED ON SURVEYOR MEASUREMENTS CONDUCTED BY CLA ENGINEERS, INC. IN JANUARY 2023.
3. BORINGS WERE COMPLETED BY NEW ENGLAND BORING CONTRACTORS, INC. OF GLASTONBURY, CONNECTICUT AND OBSERVED BY WESTON & SAMPSON ENGINEERS ON NOVEMBER 21 THROUGH 23, 2022.
4. TEST PITS WERE COMPLETED BY THE TOWN OF STONINGTON AND OBSERVED BY WESTON & SAMPSON ENGINEERS ON NOVEMBER 22, 2022.

LEGEND

B-# DESIGNATION AND APPROXIMATE LOCATION OF BORING

TP-# DESIGNATION AND APPROXIMATE LOCATION OF BORING

GRAPHIC SCALE

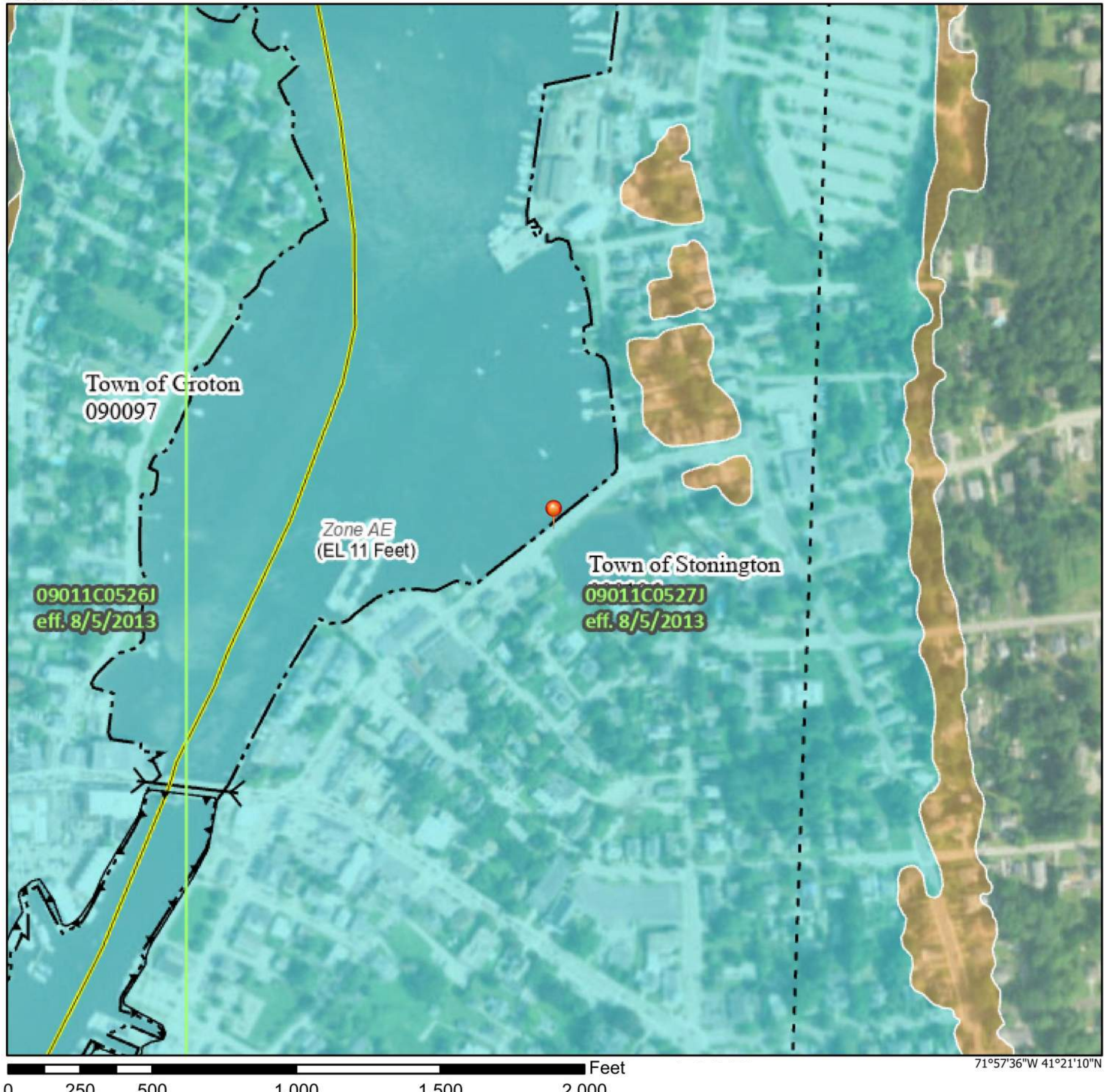
60 30 0 60 120

SCALE: 1"=60'

ORIENTATION	TITLE
	SITE PLAN
	PROJECT
	HOLMES STREET SEAWALL INNOVATIVE DESIGN FOR CLIMATE RESILIENCE HOLMES STREET STONINGTON, CONNECTICUT 06355

DATE	2/2023	FIGURE
DRWN BY	NMK	FIGURE 2
CHKD BY	JACM	
PRJ. NO.	ENG23-0002	
REV. NO.	-	

71°58'14"W 41°21'37"N



71°57'36"W 41°21'10"N

Weston & Sampson

Weston & Sampson Engineers, Inc.
55 Walkers Brook Drive, Suite 100
Reading, MA 01867
978.532.1900 800.SAMPSON
www.westonandsampson.com

LEGEND

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) *Zone A, V, A99*
		With BFE or Depth *Zone AE, AO, AH, VE, AR*
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
		Future Conditions 1% Annual Chance Flood Hazard *Zone X*
		Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
		Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard *Zone X*
		Effective LOMRs
		Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES	B 20.2 / 17.5	Cross Sections with 1% Annual Chance Water Surface Elevation
	8	Coastal Transect
	513	Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

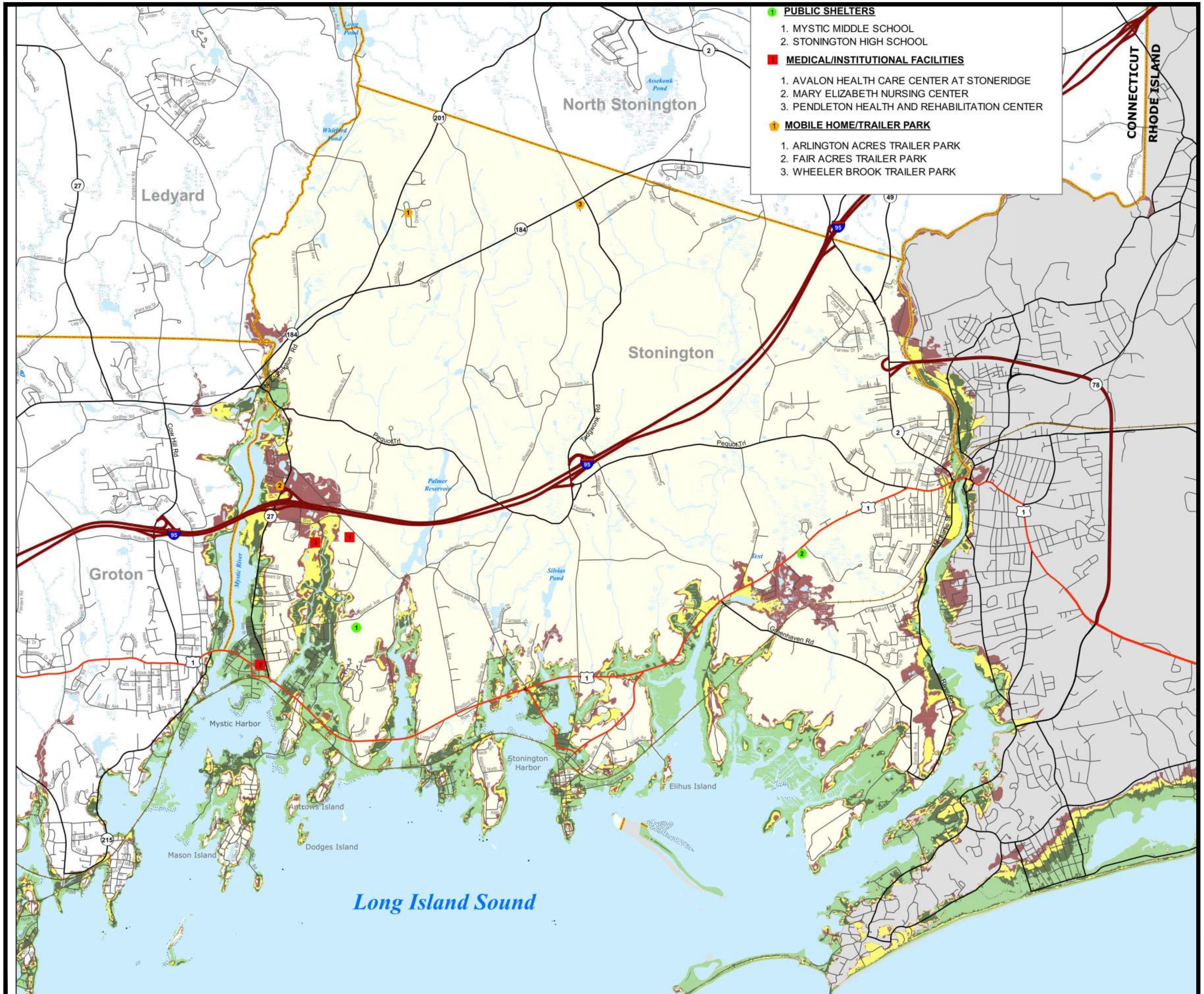
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 2/23/2023 at 3:42 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

ORIENTATION	TITLE
N	FEMA FIRM
	PROJECT
	HOLMES STREET SEAWALL STONINGTON, CONNECTICUT NEW LONDON COUNTY

DATE	04/2023	FIGURE
DRWN BY	VS	FIGURE 3
CHKD BY	JM	
PRJ. NO.	ENG23-0002	
REV. NO.	-	



Weston & Sampson

Weston & Sampson Engineers, Inc.
55 Walkers Brook Drive, Suite 100
Reading, MA 01867
978.532.1900 800.SAMPSON
www.westonandsampson.com

NOTES

Hurricane surge elevations were determined by the National Hurricane Center using the NY3 and PV2 SLOSH model basins, and assumed peak hurricane surge arriving at mean high water.

The hurricane surge inundation areas shown on this map depict the inundation that can be expected to result from a worst case combination of hurricane landfall location, forward speed, and direction for each hurricane category.

The source of basemap transportation features such as roads and railroads is Tele Atlas 2008. The source of other basemap features is the Connecticut DEEP.

The primary ground elevation data source was LiDAR data created by Terrapoint LLC for FEMA. That data was supplemented where needed by ground surface LiDAR data created by Terrapoint LLC for the State of Connecticut. The vertical accuracy of all LiDAR data is approximately +/- 1 foot, and the horizontal accuracy is approximately +/- 3 feet.

The horizontal projection of this map is Connecticut State Plane NAD83 feet. All elevation data was referenced to the NAVD88 vertical datum.

LEGEND

Hurricane Surge Inundation
- Category 1
- Category 2
- Category 3
- Category 4

Transportation
- Interstate Highway
- US Highways
- State/Local Highways
- Local Road
- Railroad
- Airport

Political
- Town Boundary
- State Boundary

Facility Location Key
- Public Shelter
- Medical/Institutional Facility
- Mobile Home/Trailer Park

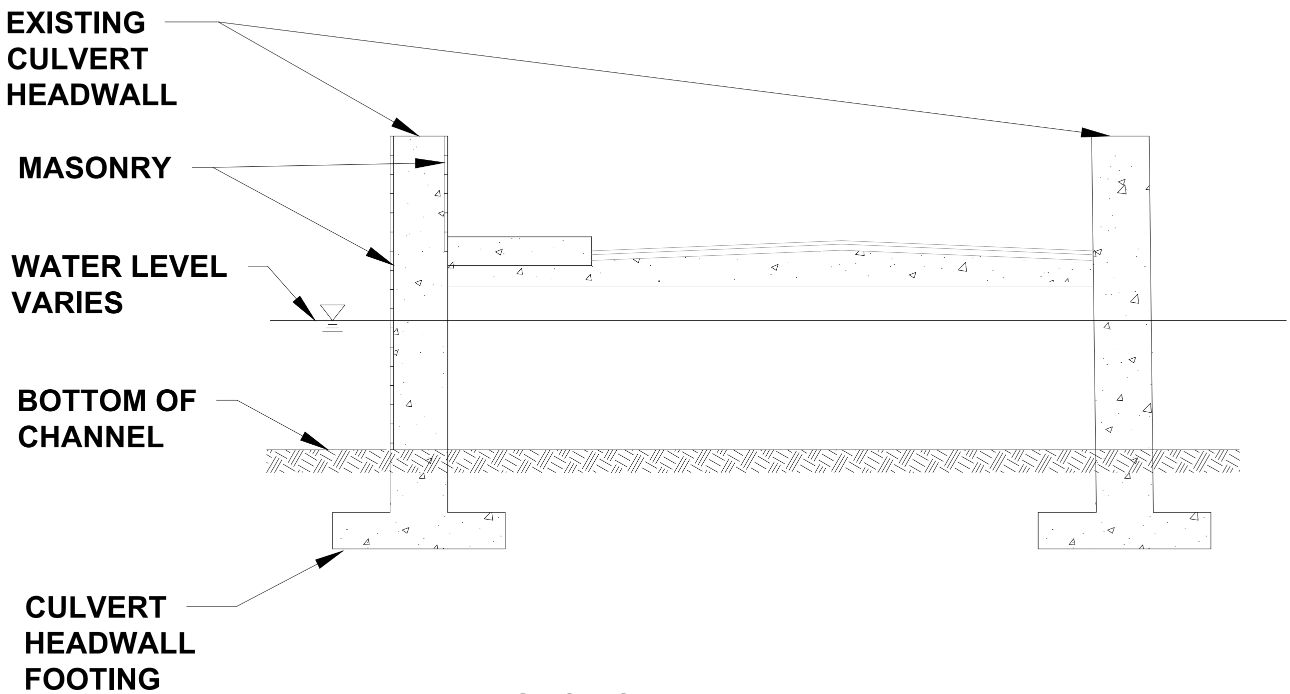
Hydrographic Features
- Water
- Intermittent Water
- Flats
- Rocks
- Inundated Area
- Marsh
- Cranberry Bog
- Dam
- Fish Hatchery
- Aqueduct
- Sewage Pond
- Water Tank

Surge flooding generated by Category 3 & 4 hurricanes can overtop the height of the Pawcatuck Hurricane Local Protection Project. Although hurricanes of this nature are considered rare events, their occurrence is possible.

US Army Corps of Engineers New England District FEMA

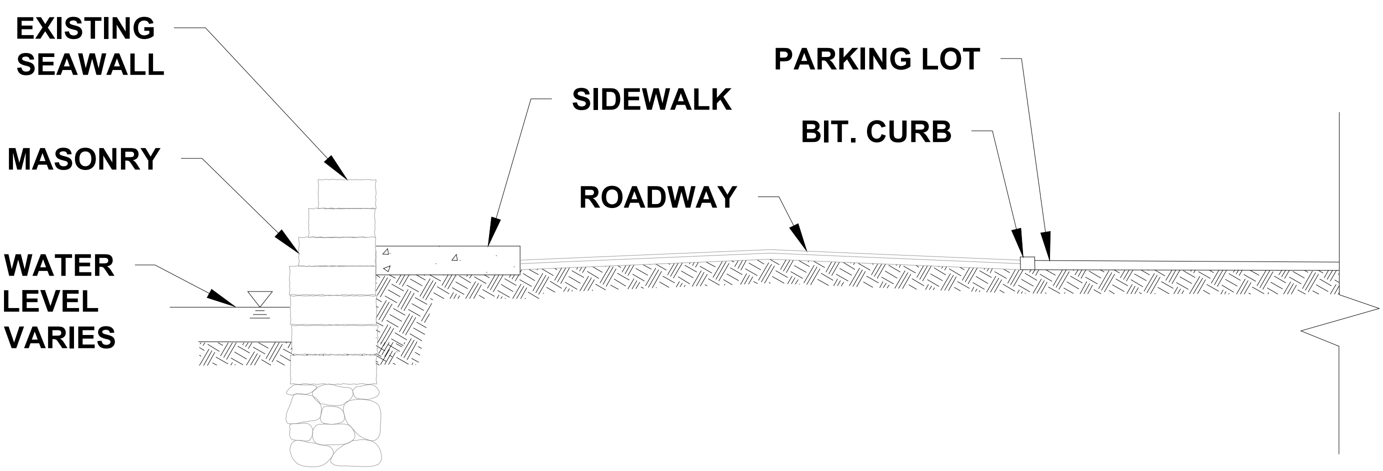
ORIENTATION	TITLE
	USACE HURRICANE EVACUATION MAP
	PROJECT
	HOLMES STREET SEAWALL STONINGTON, CONNECTICUT NEW LONDON COUNTY

DATE	04/2023	FIGURE
DRWN BY	VS	FIGURE 4
CHKD BY	JM	
PRJ. NO.	ENG23-0002	
REV. NO.	-	



SECTION A-A'

SKETCH NOT TO SCALE



SECTION B-B'

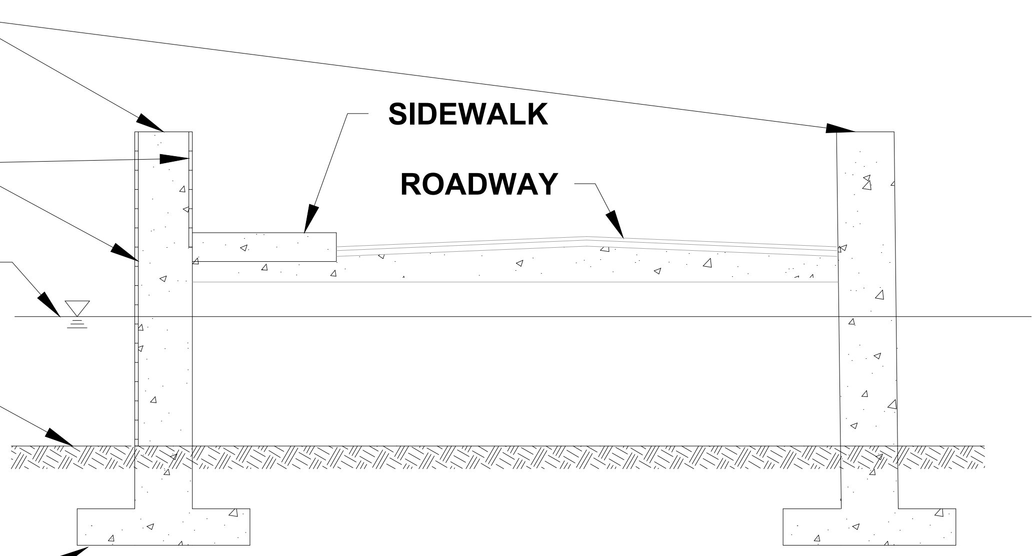
SKETCH NOT TO SCALE

EXISTING CONDITONS

Weston & Sampson

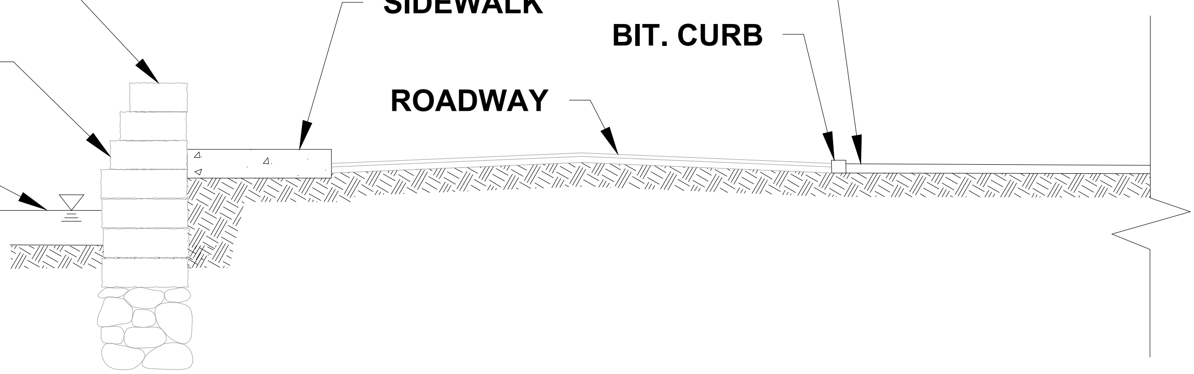
FIGURE 5
ROADWAY CROSS SECTIONS

HOLMES STREET SEAWALL
STONINGTON, CONNECTICUT
NEW LONDON COUNTY



SECTION A-A'

SKETCH NOT TO SCALE



SECTION B-B'

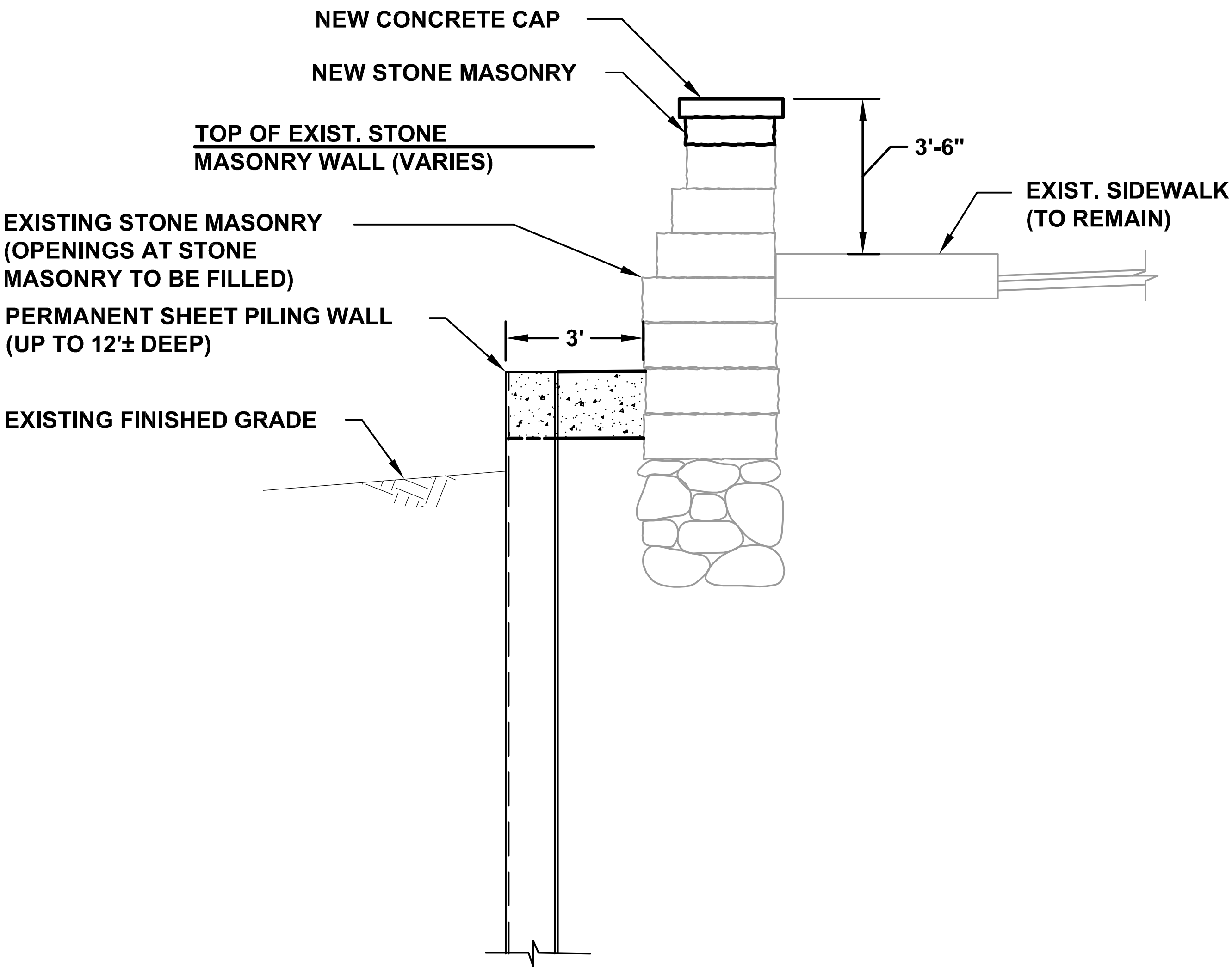
SKETCH NOT TO SCALE

Weston & Sampson℠

FIGURE 5
ROADWAY EXISTING CONDITIONS
CROSS SECTIONS

HOLMES STREET SEAWALL
STONINGTON, CONNECTICUT
NEW LONDON COUNTY

P:\CT\Stonington CT\ENG23-0002 Holmes St Seawall\3.1 Geotech\3.0 CAD\Cross Sections_2023.03.30.dwg



SECTION

SKETCH NOT TO SCALE

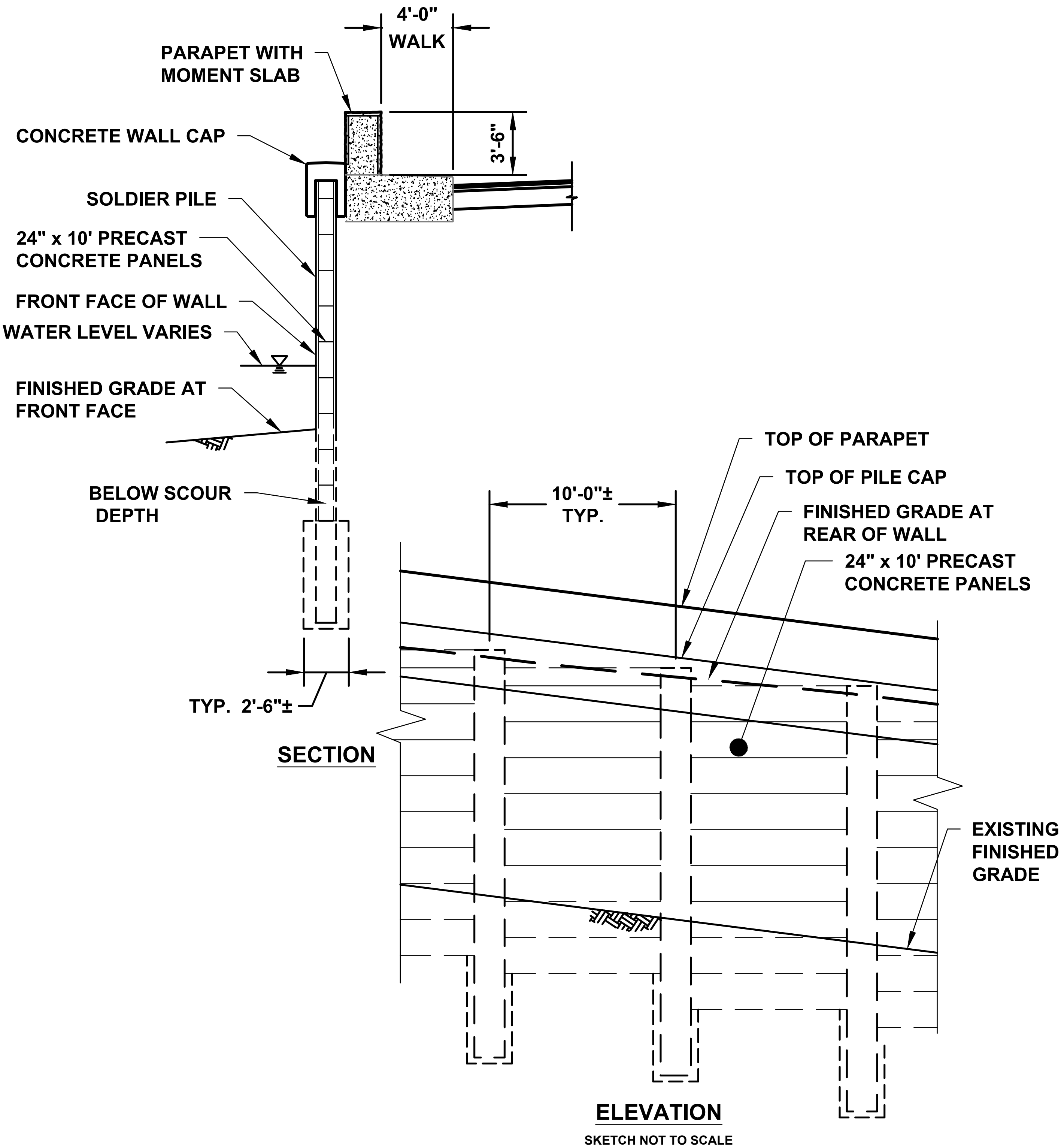
P:\CT\Stonington CT\ENG23-0002 Holmes St Seawall\3.1 Geotech\3.0 CAD\Sketch Sheet Pile Support and Existing Wall Rehab_2023.03.30.dwg

Weston & Sampson

FIGURE 6

SHEET PILE SUPPORT OF EXISTING WALL SKETCH

HOLMES STREET SEAWALL
STONINGTON, CONNECTICUT
NEW LONDON COUNTY



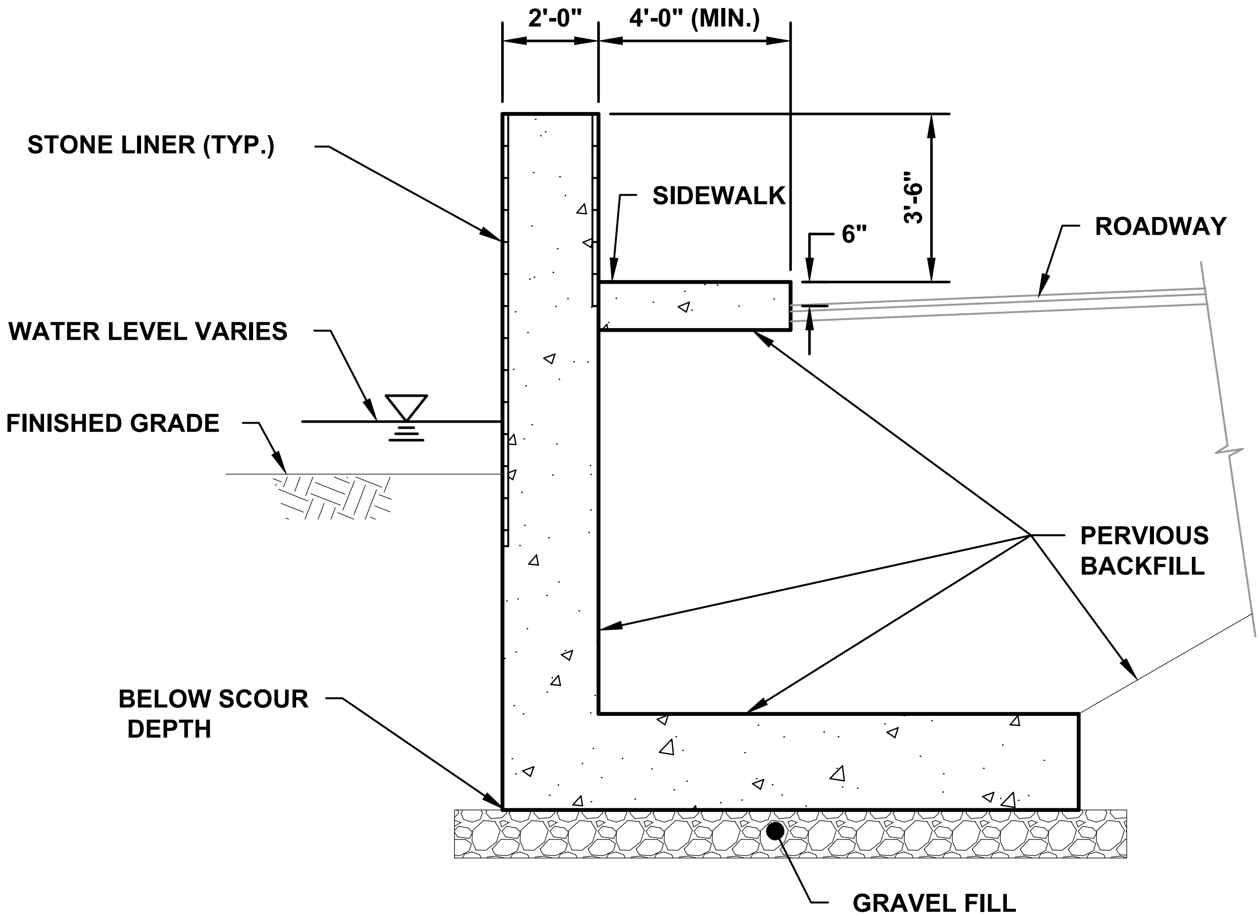
Weston & Sampson

FIGURE 7

SOLDIER PILE LAGGING WALL SKETCH

HOLMES STREET SEAWALL
STONINGTON, CONNECTICUT
NEW LONDON COUNTY

P:\CT\Stonington CT\ENG23-0002 Holmes St Seawall\3.1 Geotech\3.0 CAD\Sketch Soldier Pile Lagging Wall_2023.03.30.dwg



SECTION

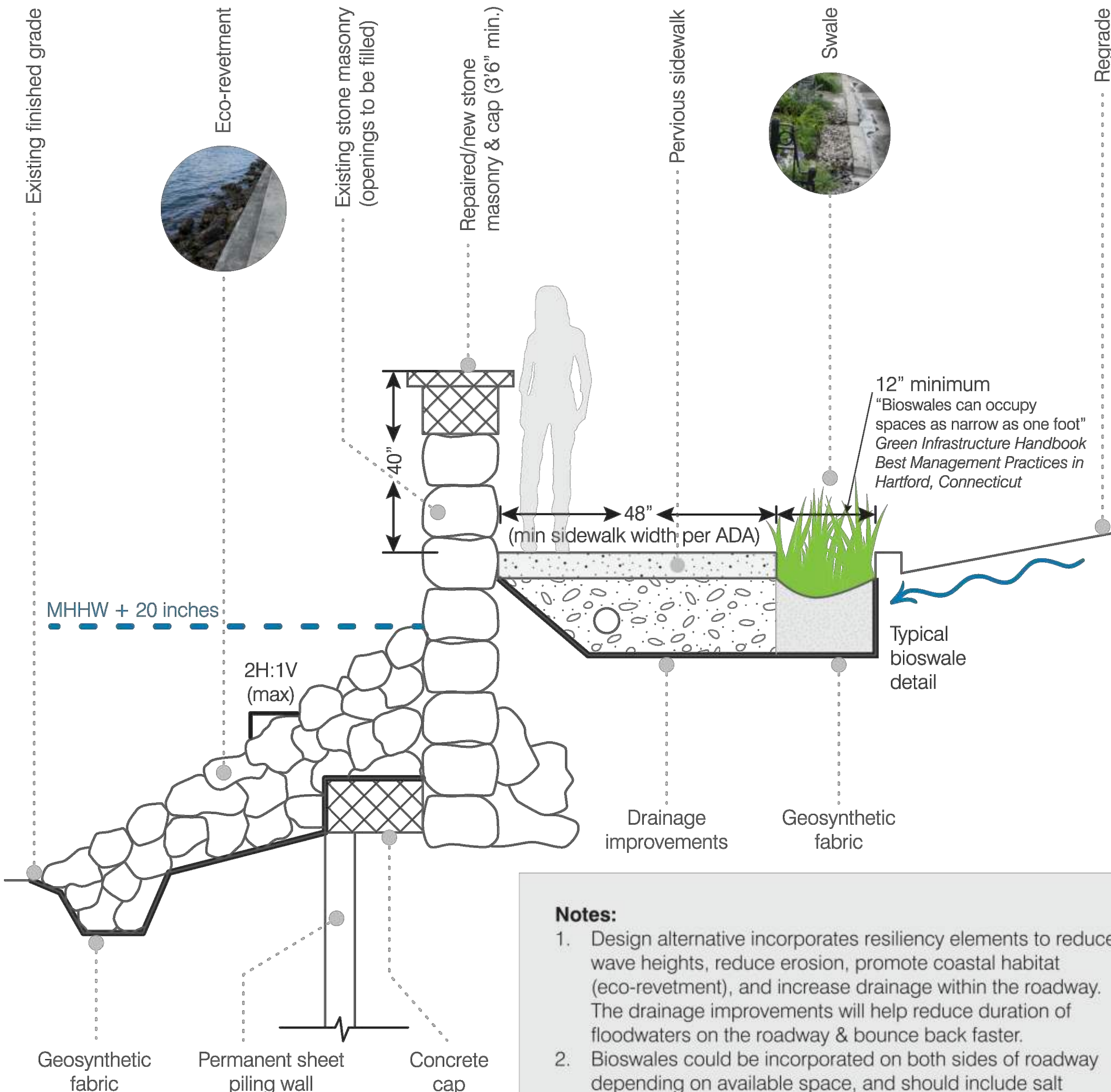
SKETCH NOT TO SCALE

Weston & Sampson

FIGURE 8
CONCRETE RETAINING WALL SKETCH

HOLMES STREET SEAWALL
STONINGTON, CONNECTICUT
NEW LONDON COUNTY

P:\CT\Stonington CT\ENG23-0002 Holmes St Seawall\3.1 Geotech\3.0 CAD\Sketch Concrete Retaining Wall_2023.03.30.dwg



Notes:

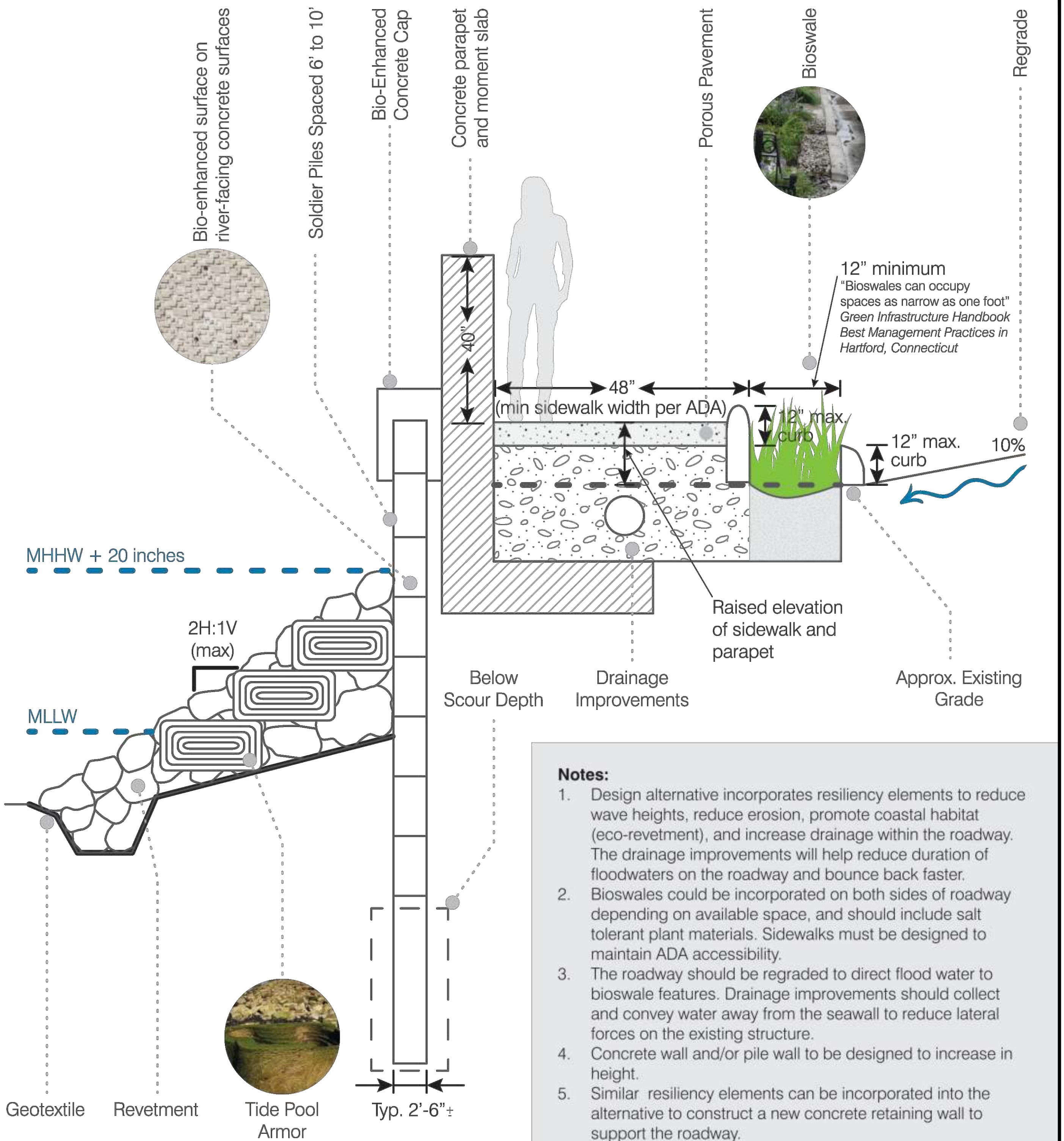
1. Design alternative incorporates resiliency elements to reduce wave heights, reduce erosion, promote coastal habitat (eco-revetment), and increase drainage within the roadway. The drainage improvements will help reduce duration of floodwaters on the roadway & bounce back faster.
2. Bioswales could be incorporated on both sides of roadway depending on available space, and should include salt tolerant plant materials. Sidewalks must be designed to maintain ADA accessibility.
3. The roadway should be regraded to direct flood water to bioswale features. Drainage improvements should collect and convey water away from the seawall to reduce lateral forces on the existing structure.

Weston & Sampson℠

FIGURE 9

INCORPORATING RESILIENCY WITH SUPPORT OF EXISTING SEAWALL

HOLMES STREET SEAWALL
STONINGTON, CONNECTICUT
NEW LONDON COUNTY



Notes:

1. Design alternative incorporates resiliency elements to reduce wave heights, reduce erosion, promote coastal habitat (eco-revetment), and increase drainage within the roadway. The drainage improvements will help reduce duration of floodwaters on the roadway and bounce back faster.
2. Bioswales could be incorporated on both sides of roadway depending on available space, and should include salt tolerant plant materials. Sidewalks must be designed to maintain ADA accessibility.
3. The roadway should be regraded to direct flood water to bioswale features. Drainage improvements should collect and convey water away from the seawall to reduce lateral forces on the existing structure.
4. Concrete wall and/or pile wall to be designed to increase in height.
5. Similar resiliency elements can be incorporated into the alternative to construct a new concrete retaining wall to support the roadway.

Weston & Sampson

FIGURE 10

INCORPORATING RESILIENCY WITH RECONSTRUCTION OF THE SEAWALL

HOLMES STREET SEAWALL
STONINGTON, CONNECTICUT
NEW LONDON COUNTY

\\wse03.local\WSE\Projects\CT\Stonington CT\ENG23-0002 Holmes St Seawall\3.1 Geotech\3.0 CAD\Resiliency new sea wall.dwg

APPENDIX A

Site Photos

Photo 1: Overview of seawall looking northeast

Photo 2: Guard rail at southwest end of seawall

Photo 3: Overview of seawall looking southwest

Photo 4: Close up of change in stone masonry

Photo 5: stone masonry pilaster

Photo 6: Guard rail at south west end of seawall

APPENDIX B

Boring Logs

Weston & Sampson

WSE Project: ENG23-0002

Holmes Street Seawall
Stonington, CT

BORING ID: B-1

CONTRACTOR:	**NE Boring Contractors, Inc.**	BORING LOCATION:	**See attached plan**	DATE START:	**November 22, 2022**
FOREMAN:	**Rick Prosa**	ADVANCE METHOD:	**Rotary Wash Drilling**	DATE FINISH:	**November 22, 2022**
LOGGED BY:	**Nicole King**	AUGER DIAMETER:	**N/A**	GROUND EL:	**Not Available**
CHECKED BY:	**Jenn MacGregor, PE**	SUPPORT CASING:	**Driven Flush-Joint Casing (4" ID)**	FINAL DEPTH:	**35.0 ft.**
EQUIPMENT:	**Truck Mounted Drill Rig**	CORING METHOD:	**N/A**	GRID COORDS:	
SPT HAMMER:	**Automatic (140-lb.)**	BACKFILL MATERIAL:	**Drill Cuttings and Asphalt Patch**	GRID SYSTEM:	**NAD83 State Plane (MA)**

DEPTH BELOW GROUND SURFACE [VERTICAL FT.]	SAMPLE ID NUMBER AND RECOVERY RATIO [IN./IN.]	SPT BLOWS / 6 IN. (OR) CORE RATE / 12 IN. [MIN.]	GEOTECHNICAL TEST DATA: ● N-Value, Raw (bpf)	STRATUM IDENTIFICATION AND DESCRIPTION	REMARKS, OTHER TESTS, AND INSTALLATIONS
				Surface: Asphalt concrete pavement.	Note: Values in brackets preceeding a remark indicate depth below ground surface (in feet) corresponding to the remark.
				Asphalt concrete pavement - 5 inches thick.	
	S-1 19/24	28 38 24 27	>> 62	**Poorly graded sand with silt and gravel (SP-SM)** - Very dense; dark brown and gray; dry; mostly fine to coarse SAND, little fine to coarse gravel, few non plastic fines; occasional debris (pavement). **[FILL]**	
	S-2 14/24	20 17 15 7	32	**Silty sand with gravel (SM)** - Dense; brown; dry to wet; mostly fine to coarse SAND, little fine to coarse gravel, little non plastic fines. **[FILL]**	
5	S-3 18/24	5 7 8 10	15	**Poorly graded sand (SP)** - Medium dense; brown with orange; wet; mostly fine to coarse SAND, trace fine gravel, trace non plastic fines.	
	S-4 21/24	7 9 6 6	15	**Sandy organic soil (OL)** - Stiff; brown with orange; wet; mostly organic non plastic FINES, some fine to coarse sand, trace fine gravel.	
10	S-5 24/24	4 6 14 17	20		
				Poorly graded sand (SP) - Very loose; brown; wet; mostly fine to medium SAND, trace non plastic fines.	
15	S-6 21/24	2 3 1 2	4		
20	S-7 0/24	13 18 13 18	31	*No Recovery.*	
				Poorly graded sand (SP) - Medium dense; gray to brown; wet; mostly fine SAND, trace non plastic fines.	

Refer to the attached index sheets for important information about this log including general notes, legends, and guidance on description methods and procedures.

Weston & Sampson

WSE Project: ENG23-0002

Holmes Street Seawall
Stonington, CT

BORING ID: B-1

DEPTH BELOW GROUND SURFACE [VERTICAL FT.]	SAMPLE TYPE GRAPHIC	SAMPLE ID NUMBER AND RECOVERY RATIO [IN./IN.]	SPT BLOWS / 6 IN. (OR) CORE RATE / 12 IN. [MIN.]	GEOTECHNICAL TEST DATA (● N-Value, Raw (bpf); ⊠ Organic Content (%); ⊕ Moisture Content (%); ▶ Plastic Limit, PL (%); ◀ Liquid Limit, LL (%))	STRATIGRAPHY LOG	STRATUM IDENTIFICATION AND DESCRIPTION	REMARKS, OTHER TESTS, AND INSTALLATIONS
							Note: Values in brackets preceeding a remark indicate depth below ground surface (in feet) corresponding to the remark.
		S-8 24/24	5 7 8 8	15		**Poorly graded sand (SP)** - Medium dense; gray to brown; wet; mostly fine SAND, trace non plastic fines.	
30		S-9 20/24	6 6 8 6	14			
		S-10 21/24	7 7 5 6	12			
35							**Exploration ended at 35.0 ft.**
40							
45							
50							

Geotechnical test data axis scales: 10, 20, 30, 40; 25, 50, 75, 100

Refer to the attached index sheets for important information about this log including general notes, legends, and guidance on description methods and procedures.

Weston & Sampson

Holmes Street Seawall
Stonington, CT

BORING ID: B-2

WSE Project: ENG23-0002

CONTRACTOR:	**NE Boring Contractors, Inc.**	BORING LOCATION:	**See attached plan**	DATE START:	**November 21, 2022**
FOREMAN:	**Rick Prosa**	ADVANCE METHOD:	**Rotary Wash Drilling**	DATE FINISH:	**November 22, 2022**
LOGGED BY:	**Nicole King**	AUGER DIAMETER:	**N/A**	GROUND EL:	**Not Available**
CHECKED BY:	**Jenn MacGregor, PE**	SUPPORT CASING:	**Driven Flush-Joint Casing (4" ID)**	FINAL DEPTH:	**32.0 ft.**
EQUIPMENT:	**Truck Mounted Drill Rig**	CORING METHOD:	**N/A**	GRID COORDS:	
SPT HAMMER:	**Automatic (140-lb.)**	BACKFILL MATERIAL:	**Drill Cuttings and Asphalt Patch**	GRID SYSTEM:	**NAD83 State Plane (MA)**

DEPTH BELOW GROUND SURFACE [VERTICAL FT.]	SAMPLE ID NUMBER AND RECOVERY RATIO [IN./IN.]	SPT BLOWS / 6 IN. (OR) CORE RATE / 12 IN. [MIN.]	GEOTECHNICAL TEST DATA: N-Value, Raw (bpf)	STRATUM IDENTIFICATION AND DESCRIPTION	REMARKS, OTHER TESTS, AND INSTALLATIONS
				Surface: Asphalt concrete pavement.	Note: Values in brackets preceeding a remark indicate depth below ground surface (in feet) corresponding to the remark.
0				Asphalt concrete pavement - 6 inches thick.	
	S-1 19/24	32 45 38 33	>> 83	**Poorly graded sand with silt and gravel (SP-SM)** - Very dense to dense; dark brown and gray; moist; mostly fine to coarse SAND, little fine to coarse gravel, few non plastic fines; trace to occasional debris (coal tar). **[FILL]**	
	S-2 17/24	30 22 20 19	42		
5	S-3 8/24	3 3 1 0	4	**Sandy silt with gravel (ML)** - Soft; dark brown; moist; mostly non plastic FINES, some fine to medium sand, little fine to coarse gravel. **[FILL]**	
	S-4 16/24	1 2 1 2	3	**Sandy organic soil with gravel (OL)** - Soft; dark brown; wet; mostly organic non plastic FINES, some fine to coarse sand, little fine to coarse gravel; common peat. **[ORGANIC DEPOSIT]**	
10	S-5 21/24	5 5 12 11	17	**Poorly graded sand with silt (SP-SM)** - Medium dense; dark brown; wet; mostly fine to coarse SAND, few fine to coarse gravel, few non plastic fines; occasional peat.	
				Poorly graded sand (SP) - Medium dense; brown with mottled orange; wet; mostly fine to coarse SAND, trace non plastic fines.	[13.0 - 15.0] Roller bit grinding on possible cobbles/boulders.
15	S-6 15/24	4 7 7 9	14		
				Poorly graded sand (SP) - Medium dense; brown; wet; mostly fine to medium SAND, trace fine gravel, trace non plastic fines.	
20	S-7 24/24	7 6 9 9	15		
				Poorly graded sand (SP) - Medium dense; gray; wet; mostly fine SAND, trace non plastic fines.	

Refer to the attached index sheets for important information about this log including general notes, legends, and guidance on description methods and procedures.

GEOTECHNICAL TEST DATA: ● N-Value, Raw (bpf) (scale 10, 20, 30, 40); ⊠ Organic Content (%); ⊕ Moisture Content (%); ▶ Plastic Limit, PL (%); ◀ Liquid Limit, LL (%) (scale 25, 50, 75, 100)

Note: Values in brackets preceeding a remark indicate depth below ground surface (in feet) corresponding to the remark.

DEPTH BELOW GROUND SURFACE [VERTICAL FT.]	SAMPLE ID NUMBER AND RECOVERY RATIO [IN./IN.]	SPT BLOWS / 6 IN. (OR) CORE RATE / 12 IN. [MIN.]	N-Value, Raw (bpf)	STRATUM IDENTIFICATION AND DESCRIPTION	REMARKS, OTHER TESTS, AND INSTALLATIONS
	S-8 21/24	7, 5, 7, 9	12	**Poorly graded sand (SP)** - Medium dense; gray; wet; mostly fine SAND, trace non plastic fines.	
30	S-9 24/24	8, 6, 10, 8	16		
32.0					**Exploration ended at 32.0 ft.**
35					
40					
45					
50					

Weston & Sampson

Holmes Street Seawall
Stonington, CT

BORING ID: B-3

WSE Project: ENG23-0002

CONTRACTOR:	**NE Boring Contractors, Inc.**	BORING LOCATION:	**See attached plan**	DATE START:	**November 21, 2022**
FOREMAN:	**Rick Prosa**	ADVANCE METHOD:	**Hollow-Stem Auger to Rotary Wash**	DATE FINISH:	**November 21, 2022**
LOGGED BY:	**Nicole King**	AUGER DIAMETER:	**4-1/4" ID (Stem), 7-5/8" OD (Flights)**	GROUND EL:	**Not Available**
CHECKED BY:	**Jenn MacGregor, PE**	SUPPORT CASING:	**Driven Flush-Joint Casing (4" ID)**	FINAL DEPTH:	**12.0 ft. (Refusal)**
EQUIPMENT:	**Truck Mounted Drill Rig**	CORING METHOD:	**N/A**	GRID COORDS:	
SPT HAMMER:	**Automatic (140-lb.)**	BACKFILL MATERIAL:	**Cuttings, Grout, AC Patch**	GRID SYSTEM:	**NAD83 State Plane (MA)**

GEOTECHNICAL TEST DATA: ● N-Value, Raw (bpf); ⊠ Organic Content (%); ⊕ Moisture Content (%); ▶ Plastic Limit, PL (%); ◀ Liquid Limit, LL (%)

DEPTH BELOW GROUND SURFACE [VERTICAL FT.]	SAMPLE ID NUMBER AND RECOVERY RATIO [IN./IN.]	SPT BLOWS / 6 IN. (OR) CORE RATE / 12 IN. [MIN.]	N-Value, Raw (bpf)
0.5–2.5	S-1 18/24	41, 46, 45, 55	>> 91
3–5	S-2 16/24	38, 25, 9, 6	34
5–7	S-3 18/24	3, 4, 3, 4	7
7–9	S-4 4/24	6, 6, 4, 3	10
10–12	S-5 0/24	0, 3, 1, 2	4

STRATUM IDENTIFICATION AND DESCRIPTION

Surface: Asphalt concrete pavement.

Depth (ft)	Description
0–0.5	Asphalt concrete pavement - 6 inches thick.
0.5–5.3	**Poorly graded gravel with silt and sand (GP-GM)** - Very dense; brown; dry; mostly fine to coarse GRAVEL, some fine to coarse sand, few non plastic fines. **[FILL]** **Poorly graded sand with silt and gravel (SP-SM)** - Dense; dark brown and gray; dry; mostly fine to coarse SAND, little fine to coarse gravel, few non plastic fines; occasional debris (ash). **[FILL]**
5.3–5.8	**Peat (PT)** - Brown; mostly non plastic FINES. **[ORGANIC DEPOSIT]**
5.8–12.0	**Silty sand (SM)** - Loose; dark gray; wet; mostly fine to coarse SAND, little non plastic fines. **Silty sand (SM)** - Loose to very loose; dark brown; wet; mostly fine to coarse SAND, little non plastic fines, trace fine gravel.

REMARKS, OTHER TESTS, AND INSTALLATIONS

Note: Values in brackets preceeding a remark indicate depth below ground surface (in feet) corresponding to the remark.

Boring backfilled with cuttings from bottom to 2 feet and then with grout up to 0.5 feet. An asphalt patch was placed for the remaining depth to the surface.

Metal pin fell into hole at 12.0 ft. Offset 11 inches SE and begin drilling at 15 ft bgs. Refer to Log B-3A.

CONTRACTOR:	**NE Boring Contractors, Inc.**	BORING LOCATION:	**See attached plan**	DATE START:	**November 21, 2022**
FOREMAN:	**Rick Prosa**	ADVANCE METHOD:	**Rotary Wash Drilling**	DATE FINISH:	**November 21, 2022**
LOGGED BY:	**Nicole King**	AUGER DIAMETER:	**N/A**	GROUND EL:	**Not Available**
CHECKED BY:	**Jenn MacGregor, PE**	SUPPORT CASING:	**Driven Flush-Joint Casing (4" ID)**	FINAL DEPTH:	**32.0 ft.**
EQUIPMENT:	**Truck Mounted Drill Rig**	CORING METHOD:	**N/A**	GRID COORDS:	
SPT HAMMER:	**Automatic (140-lb.)**	BACKFILL MATERIAL:	**Cuttings, Grout, AC Patch**	GRID SYSTEM:	**NAD83 State Plane (MA)**

GEOTECHNICAL TEST DATA: ● N-Value, Raw (bpf); ⊠ Organic Content (%); scale 10, 20, 30, 40. ⊕ Moisture Content (%); ▶ Plastic Limit, PL (%); ◀ Liquid Limit, LL (%); scale 25, 50, 75, 100.

REMARKS, OTHER TESTS, AND INSTALLATIONS: Note: Values in brackets preceeding a remark indicate depth below ground surface (in feet) corresponding to the remark.

DEPTH BELOW GROUND SURFACE [VERTICAL FT.]	SAMPLE TYPE GRAPHIC	SAMPLE ID NUMBER AND RECOVERY RATIO [IN./IN.]	SPT BLOWS / 6 IN. (OR) CORE RATE / 12 IN. [MIN.]	GEOTECHNICAL TEST DATA	STRATIGRAPHY LOG	STRATUM IDENTIFICATION AND DESCRIPTION	REMARKS, OTHER TESTS, AND INSTALLATIONS
0						Surface: Asphalt concrete pavement.	
0–15						See B-3 for more information on soil characteristics from 0-15 ft.	
15		S-1 24/24	2 0 1 2	N = 1		**Organic soil (OL)** - Very soft; dark gray; wet; mostly organic low plasticity FINES, trace fine sand; Sulfur odor; common peat.	
18.5						**Sandy silt with gravel (ML)** - Loose; dark brown; wet; mostly non plastic FINES, some fine to coarse sand, little fine gravel; Sulfur odor; common peat.	
20		S-2 17/24	2 2 6 8	N = 8			
23.5						**Well graded sand with silt and gravel (SW-SM)** - Dense; brown; wet; mostly fine to coarse SAND, little fine to coarse gravel, few non plastic fines.	

DEPTH BELOW GROUND SURFACE [VERTICAL FT.]	SAMPLE ID NUMBER AND RECOVERY RATIO [IN./IN.]	SPT BLOWS / 6 IN. (OR) CORE RATE / 12 IN. [MIN.]	GEOTECHNICAL TEST DATA: ● N-Value, Raw (bpf); ⊠ Organic Content (%); ⊕ Moisture Content (%); ▶ Plastic Limit, PL (%); ◀ Liquid Limit, LL (%)	STRATUM IDENTIFICATION AND DESCRIPTION	REMARKS, OTHER TESTS, AND INSTALLATIONS
					Note: Values in brackets preceeding a remark indicate depth below ground surface (in feet) corresponding to the remark.
	S-3 15/24	9 11 20 28	31	**Well graded sand with silt and gravel (SW-SM)** - Dense; brown; wet; mostly fine to coarse SAND, little fine to coarse gravel, few non plastic fines.	
30	S-4 0/24	17 18 19 19	37	**Poorly graded sand with silt and gravel (SP-SM)** - Dense; brown and gray; wet; mostly fine to coarse SAND, some fine to coarse gravel, few non plastic fines. *No Recovery.*	
					Exploration ended at 32.0 ft.
35					
40					
45					
50					

Refer to the attached index sheets for important information about this log including general notes, legends, and guidance on description methods and procedures.

GUIDE TO SUBSURFACE EXPLORATION LOGS

Weston & Sampson℠

INDEX SHEET 1 GENERAL INFORMATION

GENERAL NOTES AND USE OF LOGS

1.) Explorations were made by ordinary and conventional methods and with care adequate for Weston & Sampson's study and/or design purposes. The exploration logs are part of a specific report prepared by Weston & Sampson for the referenced project and client, and are an integral part of that report. Information and interpretations are subject to the explanations and limitations stated in the report. Weston & Sampson is not responsible for any interpretations, assumptions, projections, or interpolations made by others.

2.) Exploration logs represent general conditions observed at the point of exploration on the date(s) stated. Boundary lines separating soil and rock layers (strata) represent approximate boundaries only and are shown as solid lines where observed and dashed lines where inferred based on drilling action. Actual transitions may be gradual and changes may occur over time.

3.) Soil and rock descriptions are based on visual-manual examination of recovered samples, direct observation in test pits (when permissible), and laboratory testing (when conducted).

4.) Water level observations were made at the times and under the conditions stated. Fluctuations should be be expected to vary with seasons and other factors. Use of fluids during drilling may affect water level observations. The absence of water level observations does not necessarily mean the exploration was dry or that subsurface water will not be encountered during construction.

5.) Standard split spoon samplers may not recover particles with any dimension larger than 1-3/8 inches. Reported gravel conditions or poor sample recovery may not reflect actual in-situ conditions.

6.) Sections of this guide provide a general overview of Weston & Sampson's practices and procedures for *identifying* and *describing* soil and rock. These procedures are predominantly based on ASTM D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*, the International Society of Rock Mechanics (ISRM) standards, and the *Engineering Geology Field Manual* published by the Bureau of Reclamation. Not all aspects of this guide relating to description and identification procedures of soil and rock may be applicable in all circumstances.

SAMPLER GRAPHICS

- Split Spoon (Standard) — 2" OD, 1-3/8" ID
- Split Spoon (Oversize) — 3" OD, 2-3/8" ID
- Shelby or Piston Tube — 3" OD, 2-7/8" ID
- Double-Tube Rock Core Barrel — 2" Core Diameter
- Direct Push with Acetate Liner — Various Liner Sizes
- A — Auger Sample *(from cuttings or hand auger)*
- G — Grab Sample *(manual, from discrete point)*
- C — Composite Sample *(multiple grab samples)*

WELL GRAPHICS

- Cement concrete seal around casing or riser pipe
- Bentonite seal around casing or riser pipe
- Cement grout seal around casing or riser pipe
- Soil backfill around riser pipe or beneath screen
- Gravel backfill around screen or riser pipe
- Sand backfill around screen or riser pipe (filter sand)
- Solid-wall riser; Sch. 40 PVC, 1" ID unless noted otherwise
- Slotted screen; Sch. 40 PVC, 1" ID with machined slots

CAVING / SEEPAGE TERMS

The following caving and/or seepage terms may appear on a test pit log.

Caving Term	Criteria
Minor	less than 1 cubic ft.
Moderate	1 to 3 cubic ft.
Severe	greater than 3 cubic ft.

Seepage Term	Criteria
Slow	less than 1 gpm
Moderate	1 to 3 gpm
Fast	greater than 3 gpm

KEY TO WATER LEVELS

- ▼ Observed in exploration during advancement.
- ▽ Measured in exploration at completion, prior to backfilling or well installation.
- Measured in exploration after the stated stabilization period, prior to backfilling, or in well installation if noted.

DEFINITIONS OF COMMON TERMS

Sample Recovery Ratio - The length of material recovered in a drive or push type sampler over the length of sampler penetration, in inches (e.g. 18/24).

Standard Penetration Test (*SPT*) - An in-situ test where a standard split-spoon sampler is driven a distance of 12 or 18 inches (after an initial 6-inch seating interval) using a 140-lb. hammer falling 30 inches for each blow.

SPT Blows - The number of hammer blows required to drive a split-spoon sampler each consecutive 6-inch interval during a *Standard Penetration Test*. If no discernable advancement of a split spoon sampler is made after 50 consecutive hammer blows, 50/X indicates *sampler refusal* and is the number of blows required to drive the sampler X inches.

SPT N-Value (*N*) - The uncorrected blow count representation of a soil's penetration resistance over a 12-inch interval after an initial 6-in. seating interval, reported in blows per foot (bpf). The N-value is correlated to soil engineering properties.

Auger Refusal - No discernable advancement of the auger over a period of 5 minutes with full rig down pressure applied.

Casing Refusal (Driven) - Casing penetration of less than 6 inches after a minimum 50 blows of a drop hammer weighing 300 lbs. or a minimum 100 blows of a drop hammer weighing 140 lbs.

PID Measurement - A measurement (electronic reading) taken in the field using a photoionization detector (PID) to detect the presence of volatile organic compounds in a soil sample. Values are reported as benzene equivalent units in parts per million (ppm) unless noted otherwise.

Rock Quality Designation (RQD) - A qualitative index measure of the degree of jointing and fracture of a rock core taken from a borehole. The RQD is defined as the sum length of solid core pieces 4 inches or longer divided by the run (cored) length, expressed as a percentage. Higher RQD values may indicate fewer joints and fractures in the rock mass.

Fill (Made Ground) - A deposit of soil and/or artificial waste materials that has been placed or altered by human processes.

LABORATORY TESTS AND FIELD MEASUREMENTS

MC	Moisture Content	IC	1D Incremental Consolidation
OC	Organic Content	VS	Laboratory Vane Shear
PL	Plastic Limit	US	Unconfined Compression
LL	Liquid Limit	TC	Triaxial Compression
GC	Gravel Content	PP	Pocket (Hand) Penetrometer
SC	Sand Content	TV	Torvane (Hand Vane)
FC	Fines Content	PID	Photoionization Detector
DS	Direct Shear	FID	Flame Ionization Detector

BORING ADVANCEMENT METHODS

Hollow-Stem Auger Drilling - Utilizes continuous flight auger sections with hollow stems to advance the borehole. Drill rods and a plug are inserted into the auger stem to prevent the entrance of soil cuttings into the augers.

Rotary Wash Drilling - Utilizes downward pressure and rotary action applied to a non-coring bit while washing the cuttings to the surface using a circulating fluid injected down the drill rods. The borehole is supported with either steel casing or the drilling fluid. Where a casing is used, the borehole is advanced sequentially by driving the casing to the desired depth and then cleaning out the casing. The process of driving and cleaning the casing is commonly referred to as the 'drive-and-wash' technique.

Continuous Sampling - Includes a variety of methods and procedures during which the borehole is advanced via continuous recovery of soil samples. *Direct Push* sampling is a common method that uses static downward pressure combined with percussive energy to drive a steel mandrel into the ground at continuous intervals while recovering soil samples in disposable acetate liners.

Rock Coring - Utilizes downward pressure and rotary action applied to a core barrel equipped with a diamond-set or tungsten carbide coring bit. During conventional coring, the entire barrel is retrieved from the hole upon completion of a core run. Wireline coring allows for removal of the inner barrel assembly containing the actual core while the the drill rods and outer barrel remain in the hole. Various types and sizes of core barrels and bits are used.

GUIDE TO SUBSURFACE EXPLORATION LOGS

Weston & Sampson℠

INDEX SHEET 2
SOIL DESCRIPTION

SOIL CONSTITUENTS

Naturally occurring soils consist of one or more of the following matrix constituents defined in terms of particle size.

Constituent		U.S. Sieve Size			Observed Size (in.)		
Gravel	(Coarse)	3/4 in.	-	3 in.	3/4	-	3
Gravel	(Fine)	No. 4	-	3/4 in.	1/5	-	3/4
Sand	(Coarse)	No. 10	-	No. 40	1/16	-	1/5
Sand	(Medium)	No. 40	-	No. 10	1/64	-	1/16
Sand	(Fine)	No. 200	-	No. 40	1/300	-	1/64
Fines	(Silt or Clay)	Smaller than		No. 200	Less than		1/300

SOIL IDENTIFICATION

Soil identification refers to the grouping of soils with similar physical characteristics into a category defined by a **group name** and corresponding **group symbol** based on estimation of the matrix soil constituents to the nearest 5% and simple manual tests. Proportions of cobbles, boulders, and other non-matrix soil materials are not considered during this procedure but are included in the overall soil description if observed or thought to be present. Refer to the following descriptions and tables adapted from ASTM D2488.

Coarse-Grained Soil - Coarse-grained soils contain fewer than 50% fines and are identified based on the following table.

Primary Constituent	Fines Percent	Type of Fines and Gradation		Group Symbol	Group Name [1]
GRAVEL	≤ 5%	well graded		GW	Well graded gravel
% gravel		poorly graded		GP	Poorly graded gravel
>	10%	clayey	well graded	GW-GC	Well graded gravel with clay
% sand		fines	poorly graded	GP-GC	Poorly graded gravel with clay
		silty	well graded	GW-GM	Well graded gravel wth silt
		fines	poorly graded	GP-GM	Poorly graded gravel with silt
	15% to	clay fines		GC	Clayey gravel
	45%	silt fines		GM	Silty gravel
SAND	≤ 5%	well graded		SW	Well graded sand
% sand		poorly graded		SP	Poorly graded sand
≥	10%	clayey	well graded	SW-SC	Well graded sand with clay
% gravel		fines	poorly graded	SP-SC	Poorly graded sand with clay
		silty	well graded	SW-SM	Well graded sand with silt
		fines	poorly graded	SP-SM	Poorly graded sand with silt
	15% to	clay fines		SC	Clayey sand
	45%	silt fines		SM	Silty sand

(1) If soil is a gravel and contains 15% or more sand, add "with sand" to the group name. If soil is a sand and contains 15% of more gravel, add "with gravel" to the group name.

Inorganic Fine-Grained Soil - Fine-grained soils contain 50% or more fines and are identified based on the following table.

Plasticity Criteria	Dry Strength	Coarse Fraction S = Sand, G = Gravel		Group Symbol	Group Name [1]
Medium	Medium	< 15% S + G		CL	Lean clay
	to high	≥ 30%	% S ≥ % G	CL	Sandy lean clay
		S + G	% S < % G	CL	Gravelly lean clay
Non-	None	< 15% S + G		ML	Silt
plastic	to low	≥ 30%	% S ≥ % G	ML	Sandy silt
		S + G	% S < % G	ML	Gravelly silt
High	High to	< 15% S + G		CH	Fat clay
	very high	≥ 30%	% S ≥ % G	CH	Sandy fat clay
		S + G	% S < % G	CH	Gravelly fat clay
Low to	Low to	< 15% S + G		MH	Elastic silt
Medium	medium	≥ 30%	% S ≥ % G	MH	Sandy elastic silt
		S + G	% S < % G	MH	Gravelly elastic silt

(1) If soil contains 15% to 25% sand or gravel, add "with sand" or "with gravel" to the group name.

Organic Fine-Grained Soil - Fine-grained soils that contain enough organic particles to influence the soil properties are identified as Organic Soil and assigned the group symbol **OL** or **OH**.

Highly Organic Soil (Peat) - Soils composed primarily of plant remains in various stages of decomposition are identified as Peat and given the group symbol **PT**. Peat usually has an organic odor, a dark brown to black color, and a texture ranging from fibrous (original plant structure intact or mostly intact) to amorphous (plant structure decomposed to fine particles).

SOIL DESCRIPTION

Soils are *described* in the following general sequence. Deviations may occur in some instances.

Identification Components

(1) Group Name and Group Symbol

Description Components

(2) Consistency (Fine-Grained) or Apparent Density (Coarse-Grained)
(3) Color (*note, the term "to" may be used to indicate a gradational change*)
(4) Soil Moisture
(5) Matrix Soil Constituents (Gravel, Sand, Fines)
  └→ Proportion (*by weight*), particle size, plasticity of fines, angularity, etc.
(6) Non-Matrix Soil Materials and Proportions (*by volume*)
(7) Other Descriptive Information (Unusual Odor, Structure, Texture, etc.)
(8) [Geologic Formation Name or Soil Survey Unit]

SPT N-VALUE CORRELATIONS

Consistency	SPT N-Value	Apparent Density	SPT N-Value
Very soft	0 - 2	Very loose	0 - 5
Soft	2 - 4	Loose	5 - 10
Medium stiff	4 - 8	Medium dense	10 - 30
Stiff	8 - 15	Dense	30 - 50
Very stiff	15 - 30	Very dense	> 50
Hard	> 30		

SOIL MOISTURE

Dry............................... Apparent absence of moisture; dry to the touch.
Moist............................Damp but no visible water.
Wet............................. Visible free water; saturated.

PROPORTIONS / PERCENTAGES

Proportions of gravel, sand, and fines (excluding cobbles, boulders, and other constituents) are stated in the following terms indicating a range of percentages by weight (to nearest 5%) of the minus 3-in. soil fraction and add up to 100%.

Mostly .... 50% - 100%
Some .... 30% - 45%
Little .... 15% - 25%
Few .... 5% - 10%
Trace........................ Less than 5%

Proportions of cobbles, boulders, and other non-matrix soil materials including artificial debris, roots, plant fibers, etc. are stated in the following terms indicating a range of percentages by volume (to the nearest 5%) of the total soil.

Numerous .... 40% - 50%
Common .... 25% - 35%
Occasional .... 10% - 20%
Trace........................ Less than 5%

PLASTICITY (FINES ONLY)

Non-plastic..................Dry specimen ball falls apart easily. Cannot be rolled into thread at any moisture content.
Low.............................Dry specimen ball easily crushed with fingers. Can be rolled into 1/8-in. thread with some difficulty.
Medium........................Difficult to crush dry specimen ball with fingers. Easily rolled into 1/8-in. thread.
High............................ Cannot crush dry specimen ball with fingers. Easily rolled and re-rolled into 1/8-in. thread.

COBBLES AND BOULDERS

Cobbles - Particles of rock that will pass a 12-in. square opening and be retained on a 3-in. sieve.

Boulders - Particles of rock that will not pass a 12-in. square opening.

Note: Where the percentage (by volume) of cobbles and/or boulders cannot be accurately or reliably estimated, the terms "with cobbles", "with boulders", or "with cobbles and boulders" may be used to indicate observed or inferred presence.

GUIDE TO SUBSURFACE EXPLORATION LOGS

Weston & Sampson

INDEX SHEET 3
ROCK DESCRIPTION

ROCK DEFINITION

Where reported on an exploration log, *rock* is defined as any naturally formed aggregate of mineral matter occurring in larges masses or fragments. This definition of rock should not be taken as a replacement for any definitions relating to rock and/or rock excavation defined in construction documents. Intensely weathered or decomposed rock that is friable and can be reduced to gravel size particles or smaller by normal hand pressure is identified and described as soil. Poorly indurated formational materials which display both rock-like and soil-like properties are identified and described as rock followed by the soil description. In such cases, the term "poorly indurated" or "weakly cemented" is added to the rock name (e.g. weakly cemented sandstone).

ROCK IDENTIFICATION

Rock is identified by a combination of *rock type* (igneous, metamorphic, or sedimentary) followed by the the *rock name* (e.g. granite, schist, sandstone).

ROCK DESCRIPTION

Rock descriptions are presented in the following general sequence. The detail of description is dictated by the complexity and objectives of the project.

Identification Components

(1) Rock Type and Name

Description Components

(2) Rock Grain Size (*for clastic sedimentary rock*)
(3) Crystal Size (*for igneous and metamorphic rock*)
(4) Bedding Spacing (*for sedimentary rock*)
(5) Color
(6) Hardness and Weathering Descriptors
(7) Fracture Density
(8) [Geologic Formation Name]

ROCK QUALITY DESIGNATION

$$RQD\ (\%) = \frac{\Sigma \text{ Length of intact core pieces} \geq 4 \text{ inches}}{\text{Total length of core run (inches)}} \times 100$$

The RQD should correlate with the fracture density in most cases. Higher RDQ values generally indicate fewer joints and fractures.

GRAIN / CRYSTAL SIZE

Grain Size for Clastic Sedimentary Rock

The names of clastic sedimentary rocks are generally based on their predominant clast or grain size (e.g. fine sandstone, medium sandstone, coarse gravel conglomerate, cobble conglomerate, siltstone, claystone).

Crystal Size for Igneous and Metamorphic Rock

Grain Size Description	Average Crystal Size (in.)
Very coarse grained (pegmatitic)	Greater than or equal to 3/8
Coarse-grained	Between 3/16 and 3/8
Medium-grained	Between 1/32 and 3/16
Fine-grained	Between 1/250 and 1/32
Aphanitic	Less than or equal to 1/250

BEDDING SPACING

Bedding Description	Thickness / Spacing
Massive	Less than 10 ft.
Very thickly bedded	3 ft. to 10 ft.
Thickly bedded	1 ft. to 3 ft.
Moderately bedded	4 in. to 1 ft.
Thinly bedded	1 in. to 4 in.
Very thinly bedded	1/4 in. to 1 in.
Laminated	Less than 1/4 in.

Note: Bedding is generally only applicable to sedimentary or bedded volcanic rocks.

HARDNESS

Hardness	Criteria
Extremely hard	Cannot be scratched with a pocketknife or sharp pick. Can only be chipped with repeated heavy hammer blows.
Very hard	Cannot be scratched with a pocketknife or sharp pick with difficulty. Breaks with repeated heavy hammer blows.
Hard	Can be scratched with with a pocketknife or sharp pick with difficulty. Breaks with heavy hammer blows.
Moderately hard	Can be scratched with a pocketknife or sharp pick with light or moderate pressure. Breaks with moderate hammer blows.
Moderately soft	Can be grooved 1/16 in. deep with a pocketknife or sharp pick with moderate or heavy pressure. Breaks with light hammer blow or heavy manual pressure.
Soft	Can be grooved or gouged easily with a pocketknife or sharp pick. Breaks with light to moderate manual pressure.
Very soft	Can be readily indented, grooved, or gouged with fingernail, or carved with a pocketknife. Breaks with light manual pressure.

WEATHERING (INTACT ROCK)

Weathering Description	Discoloration and/or Oxidation	General Characteristics
Fresh	Body of rock and fracture surfaces are not discolored or oxidized.	Rock texture unchanged. Hammer rings when crystalline rocks are struck.
Slightly weathered	Discoloration or oxidation limited to surface of, or short distance from, fractures. Most surfaces exhibit minor to complete discoloration.	Rock texture preserved. Hammer rings when crystalline rocks are struck. Body of rock not weakened.
Moderately weathered	Discoloration or oxidation extends usually throughout. Fe-Mg minerals appear rusty. All fracture surfaces are discolored or oxidized.	Rock texture generally preserved. Hammer does not ring when rock is struck. Body of rock slightly weakened.
Intensely weathered	Discoloration or oxidation throughout. Feldspar and Fe-Mg minerals altered to clay to some extent. All fracture surfaces are discolored or oxidized and friable.	Rock texture altered by chemical disintegration. Can usually be broken with moderate to heavy manual pressure or by light hammer blow . Body of rock is significantly weakened.
Decomposed	Discoloration or oxidation throughout but resistant minerals such as quartz may be unaltered. All feldspar and Fe-Mg minerals are completely altered to clay.	Resembles a soil; partial or complete remnant rock structure may be preserved. Can be granulated by hand. Resistant minerals may present as stringers or dikes.

FRACTURE DENSITY

Description	Observed Fracture Density
Unfractured	No fractures
Very slightly fractured	Core lengths greater than 3 ft.
Slightly fractured	Core lengths mostly from 1 ft. to 3 ft.
Moderately fractured	Core lengths mostly from 4 in. to 1 ft.
Intensely fractured	Core lengths mostly from 1 in. to 4 in.
Very intensely fractured	Mostly chips and fragments

Note: Fracture density is based on the fracture spacing in recovered core, measured along the core axis (excluding mechanical breaks).

APPENDIX C

Test Pit Logs

TEST PIT LOG

PROJECT NAME	Holmes Street Seawall [ENG23-0002]			TEST PIT NUMBER	
LOCATION	Stonington, CT			TP-1	
CLIENT	Town of Stonington			PLAN DIMENSIONS	
CONTRACTOR	Stonington DPW	FOREMAN	Nate	SEEPAGE / GROUNDWATER	Slow Seepage
EQUIPMENT	Hydrualic Excavator, Medium	BUCKET	36-in. (10.6 cf)	CAVING	
OBSERVED BY	N. King	DATE	11/22/22		
CHECKED BY	J. MacGregor	DATE	11/22/22		

DEPTH BELOW GROUND SURFACE (FT)	SAMPLE ID	PID	STRATA	SOIL DESCRIPTION	WALL CONSTRUCTION
0–0.25				4" concrete sidewalk	**Stacked 8-inch stones**
0.25–2.5 (1, 2)				**Silty sand with gravel (SM)** - Brown, dry. Mostly fine to coarse sand, some fine to coarse gravel; little non-plastic silt; numerous subangular cobbles; trace brick fragments. [FILL]	**Stacked 10-inch stones**
2.5–4.5 (3, 4)				**Silty sand with gravel (SM)** - Brown, dry, organic odor. Mostly fine to coarse sand, some non-plastic silt; little fine to coarse gravel; numerous angular cobbles; occasional organics.	**Soil**
4.5– (5)				Groundwater seepage at 4.75 feet. 2 inches recorded at approx. 11 AM. Bottom of test pit at 4.75 feet. End of Exploration. Backfilled with soil cuttings up to 0.5 below ground surface. Sidewalk was paved to above ground surface at a later date.	

NOTES

Weston & Sampson

TEST PIT PHOTOS

PROJECT NAME	Holmes Street Seawall [ENG23-0002]			**TEST PIT NUMBER**
LOCATION	Stonington, CT			TP-1
CLIENT	Town of Stonington			Pg. 1 of 1
CONTRACTOR	Stonington DPW	FOREMAN	Nate	
OBSERVED BY	N. King	DATE	11/22/22	
CHECKED BY	J. MacGregor	DATE	11/22/22	

Photo 1: Side view of Test Pit

Photo 2: Top view of Test Pit

Weston & Sampson[SM]

TEST PIT LOG

PROJECT NAME	Holmes Street Seawall [ENG23-0002]		
LOCATION	Stonington, CT		
CLIENT	Town of Stonington		
CONTRACTOR	Stonington DPW	FOREMAN	Nate
EQUIPMENT	Hydrualic Excavator, Medium	BUCKET	36-in. (10.6 cf)
OBSERVED BY	N. King	DATE	11/22/22
CHECKED BY	J. MacGregor	DATE	11/22/22

TEST PIT NUMBER

TP-2

PLAN DIMENSIONS	Length: 6.0 ft, Width: 3.0 ft
SEEPAGE / GROUNDWATER	Slow Seepage
CAVING	

DEPTH BELOW GROUND SURFACE (FT)	SAMPLE ID	PID	STRATA	SOIL DESCRIPTION	WALL CONSTRUCTION
				4" concrete sidewalk	**Stacked 8-inch stones**
				Silty sand with gravel (SM) - Brown, dry. Mostly fine to coarse sand, some fine to coarse gravel, little non-plastic silt; numerous subangular cobbles. **[FILL]**	
1					**Stacked 10-inch stones**
2					**Stacked 10-inch stones / 18-inch wide void** **(Refer to Photo 2 of TP-2 Photos)**
3				Bottom of test pit at 32 inches. End of exploration. Backfilled up to 0.5 feet below ground surface with 1/4-inch crushed stone wrapped in filter fabric and to ground surface with excavated soil (refer to Photo 4 of TP-2 Photos). Sidewalk was paved to above ground surface at a later date.	**Loose cobbles and boulders below void** **(Refer to Photo 1 of TP-2 Photos)**
4					

NOTES

Weston & Sampson

\\wse03.local\WSE\Projects\CT\Stonington CT\ENG23-0002 Holmes St Seawall\3.1 Geotech\2.0 Field\Logs\[Holmes St_TP logs_2023.01.23.xls]TP-1 log

TEST PIT PHOTOS

PROJECT NAME	Holmes Street Seawall [ENG23-0002]		
LOCATION	Stonington, CT		
CLIENT	Town of Stonington		
CONTRACTOR	Stonington DPW	FOREMAN	Nate
OBSERVED BY	N. King	DATE	11/22/22
CHECKED BY	J. MacGregor	DATE	11/22/22

TEST PIT NUMBER
TP-2
Pg. 1 of 2

Photo 1: View into void space

Photo 2: Undermined test pit section of seawall

Weston & Sampson

TEST PIT PHOTOS

PROJECT NAME	Holmes Street Seawall [ENG23-0002]			**TEST PIT NUMBER**
LOCATION	Stonington, CT			TP-2
CLIENT	Town of Stonington			Pg. 2 of 2
CONTRACTOR	Stonington DPW	FOREMAN	Nate	
OBSERVED BY	N. King	DATE	11/22/22	
CHECKED BY	J. MacGregor	DATE	11/22/22	

Photo 3: side view of test pit

Photo 4: Backfill of test pit with filter fabric, crushed stone, and excavated material

Weston & Sampson

TEST PIT LOG

PROJECT NAME	Holmes Street Seawall [ENG23-0002]	TEST PIT NUMBER	TP-3
LOCATION	Stonington, CT	PLAN DIMENSIONS	4 ft x 9 ft
CLIENT	Town of Stonington	SEEPAGE / GROUNDWATER	Slow Seepage
CONTRACTOR	Stonington DPW	FOREMAN	Nate
EQUIPMENT	Hydrualic Excavator, Medium	BUCKET	36-in. (10.6 cf)
OBSERVED BY	N. King	DATE	11/22/22
CHECKED BY	J. MacGregor	DATE	11/22/22
CAVING			

DEPTH BELOW GROUND SURFACE (FT)	SAMPLE ID	PID	STRATA	SOIL DESCRIPTION	WALL CONSTRUCTION
0				4" concrete sidewalk	**Stacked 10-inch stones**
0–3.5				Poorly Graded Sand with Silt and Gravel (SP-SM) - Brown, dry. Mostly fine to coarse sand, little fine to coarse gravel, few non-plastic silt; common subangular cobbles. [FILL] Similar material as above except light brown.	**Soil**
3.5–7				[3.5 ft] - slow groundwater seepage encountered at approx. 10 AM. 1.5 inches recorded before excavation continued at approx. 1 PM.	**Soil**
7				[7.0 ft] - slow groundwater seepage encountered at approx. 3 PM. Bottom of test pit at 7 feet. End of exploration. Backfilled with soil cuttings up to 0.5 feet below ground surface. Asphalt-pavement was laid and compacted at ground surface at a later date.	

Depth scale: 1, 2, 3, 4, 5, 6, 7

NOTES

Weston & Sampson

TEST PIT PHOTOS

PROJECT NAME	Holmes Street Seawall [ENG23-0002]		
LOCATION	Stonington, CT		
CLIENT	Town of Stonington		
CONTRACTOR	Stonington DPW	FOREMAN	Nate
OBSERVED BY	N. King	DATE	11/22/22
CHECKED BY	J. MacGregor	DATE	11/22/22

TEST PIT NUMBER

TP-3

Pg. 1 of 1

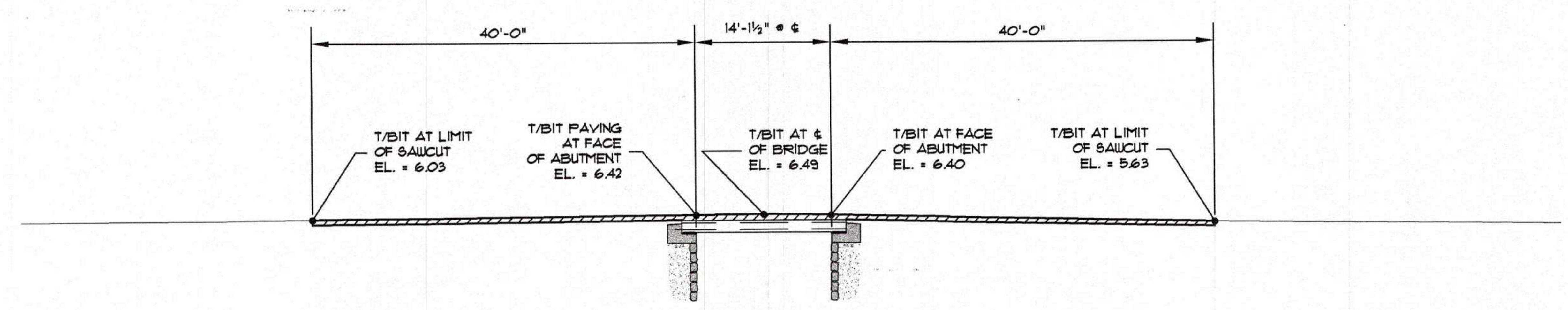
Photo 1: Side view of Test Pit

Photo 2: Top view of Test Pit

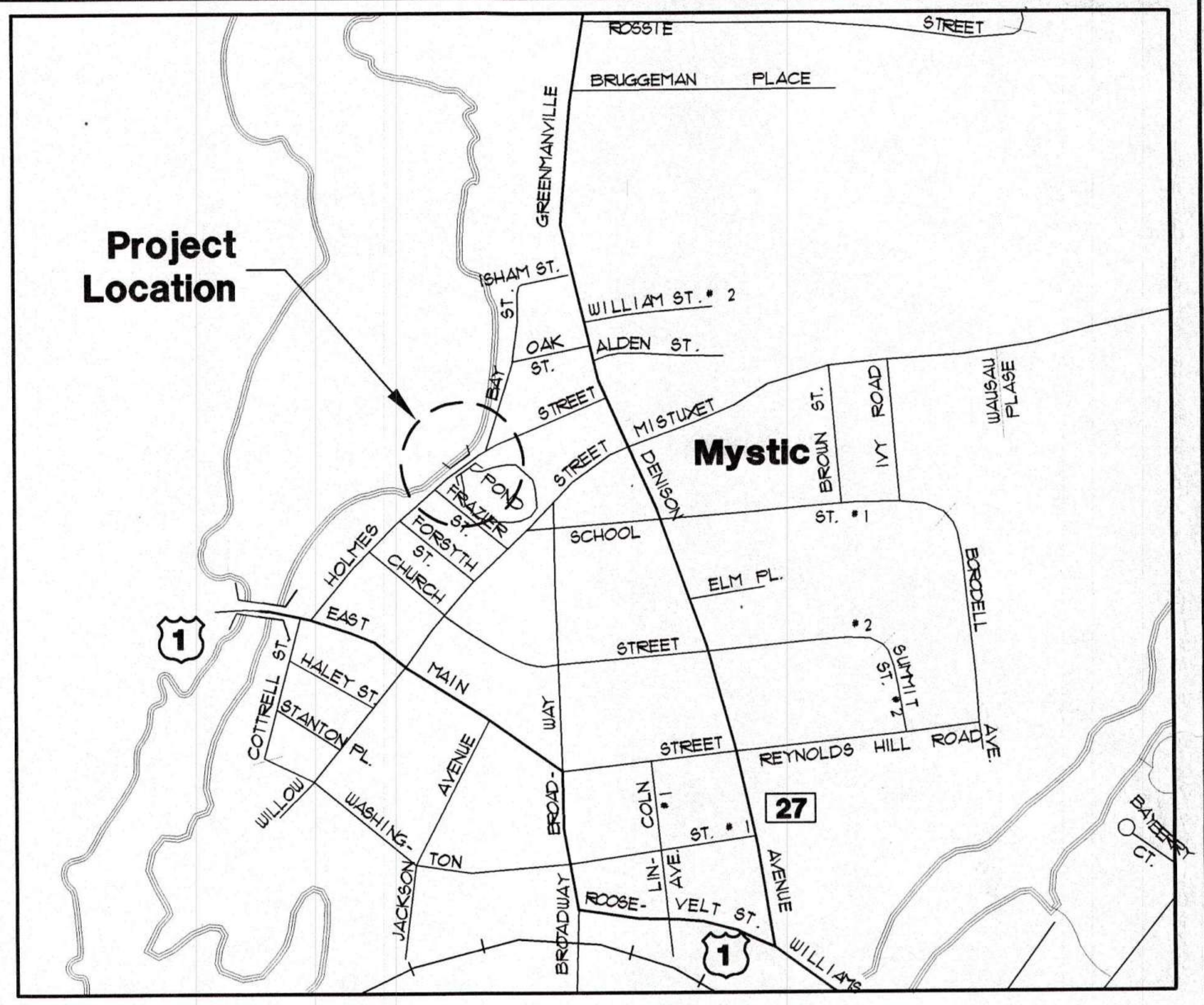
Weston & Sampson

APPENDIX D

1991 Bridge Drawings



Profile at Centerline of Bridge
Scale: 1" = 10'



Location Plan
N.T.S.

Site Plan
Scale: 1" = 10'

No.	Date	Revision

CLA Engineers, Inc.
Civil • Structural • Survey
317 Main Street Norwich, Connecticut
(860) 886-1966 Fax (860) 886-9165
CLAengrs@aol.com CLAengrs@snet.net

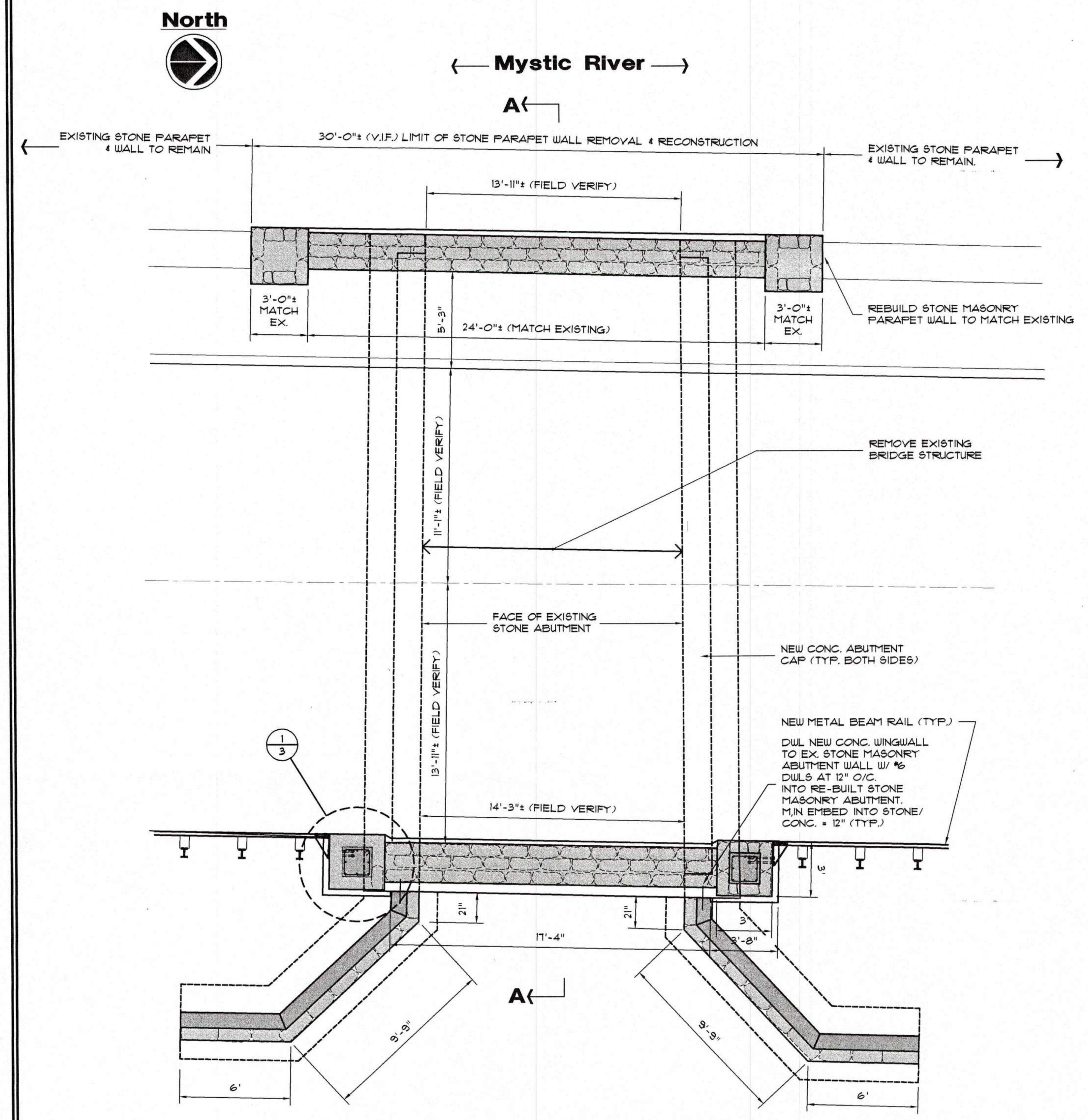
Town of Stonington

Replacement of Holmes Street Bridge

Site Plan

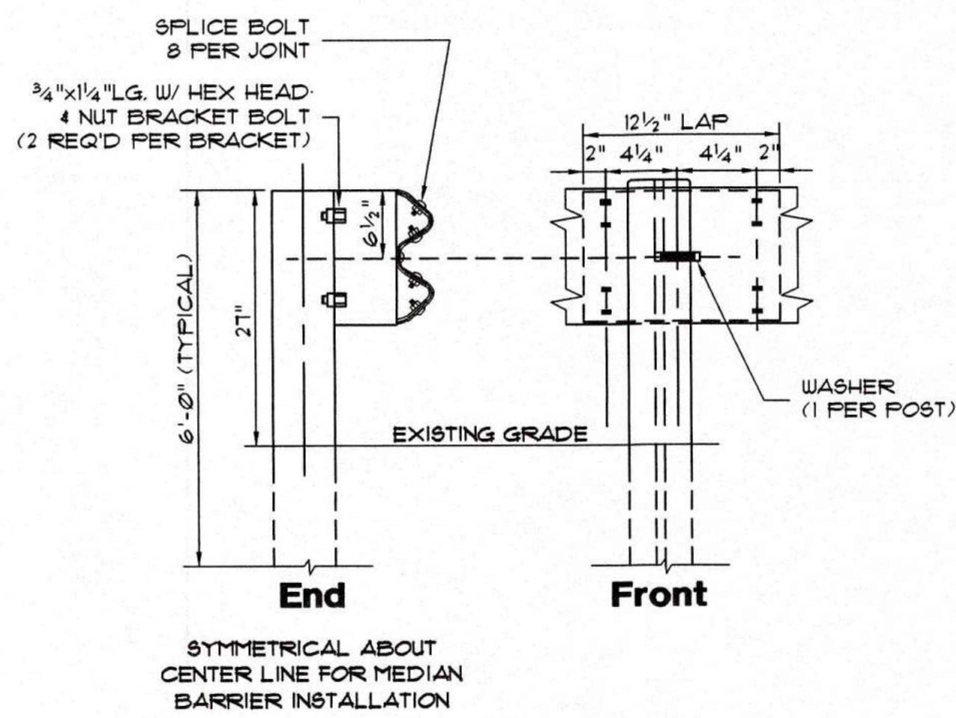
Project No. CL-96-1673
Proj. Engineer: T.K.G.
Date: 4/8/99
Sheet No. 1

CLA



Bridge Plan

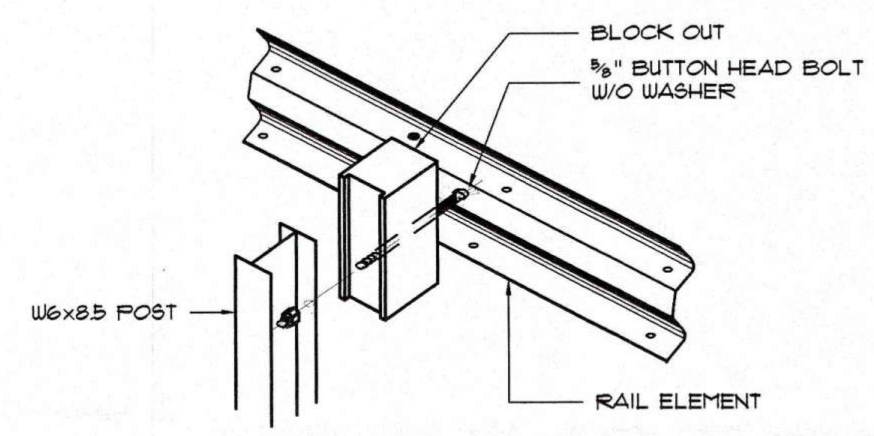
SCALE : ¼" = 1'-0"



Metal Beam Rail Detail

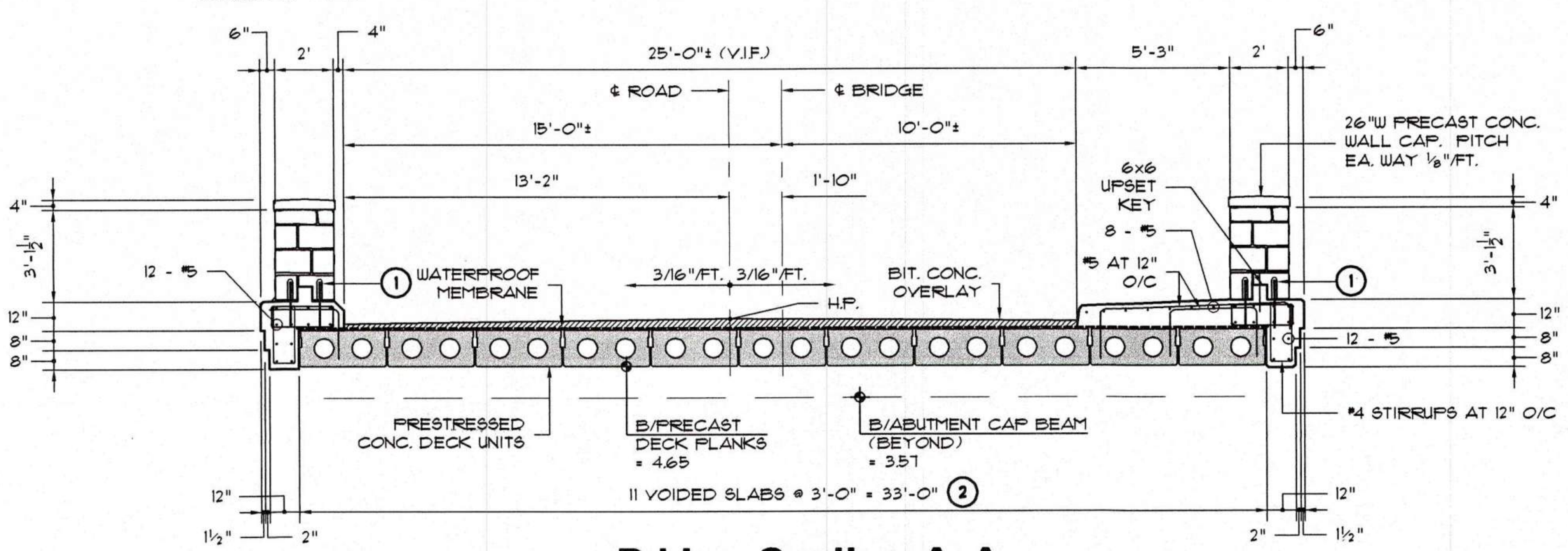
NTS

INSTALLATION TO BE IN ACCORDANCE WITH THE REQUIREMENTS OF CT. D.O.T.



Rail Mounting Detail

Scale: ¼ = 1'-0"

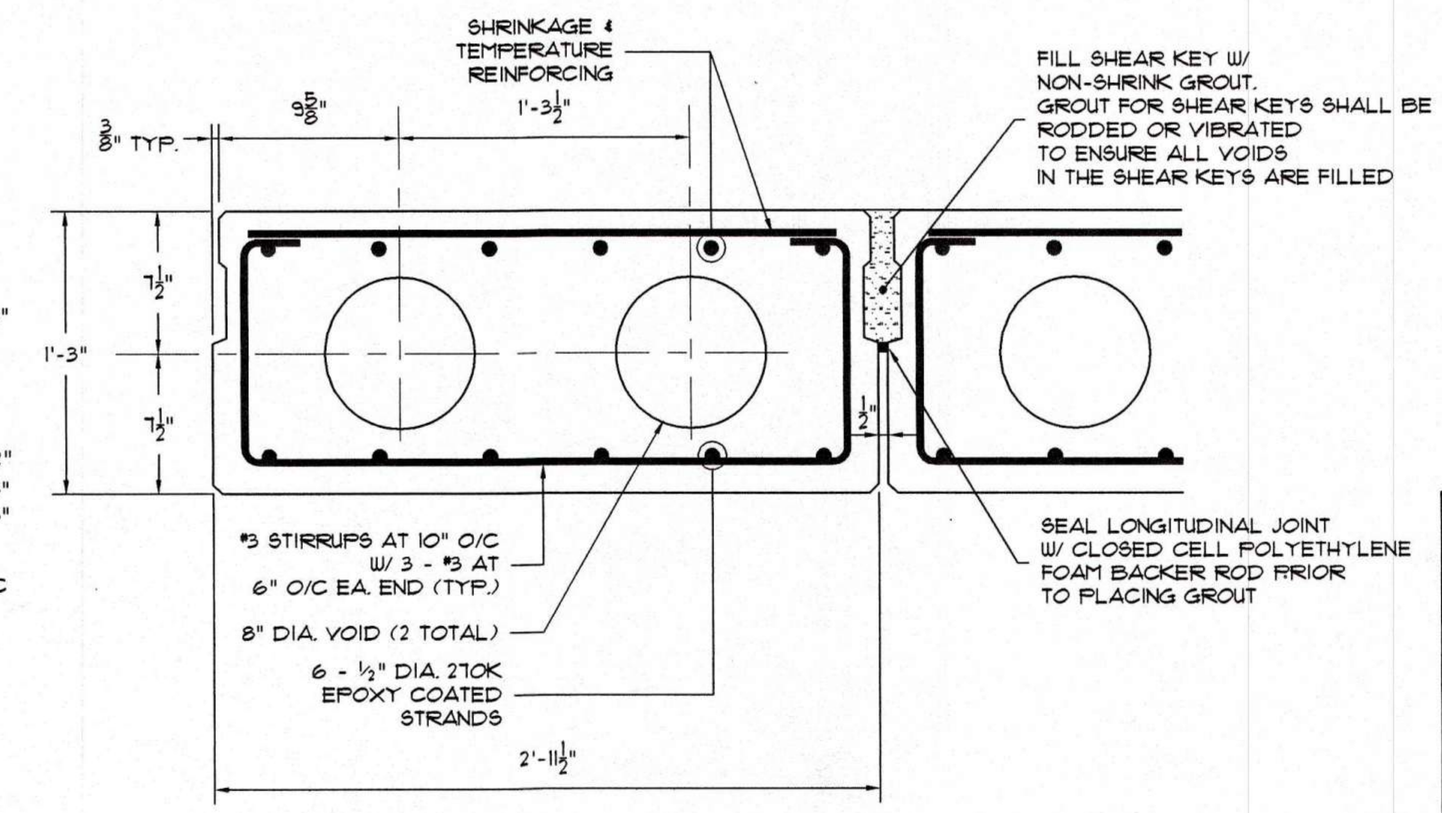


Bridge Section A-A

SCALE : ¼" = 1'-0"

(1) - #5 DWLS AT 12" O/C STAGGERED PRE-DRILL 2" DIA. HOLE IN ASHLAR STONE MASONRY & GROUT ROD SOLID W/ 5 STAR GROUT OR APPROVED EQ. MIN EMBED INTO STONE = 12". MIN. EMBED INTO CONC. = 12"

(2) - THE DECK UNITS SHALL BE PLACED AT THE NOMINAL SPACING SHOWN ON THE PLANS WITH A ½" WIDE GAP BETWEEN THE UNITS (DISTANCE TAKE FROM BOTTOM OF UNIT) THE WIDTH OF THIS GAP CAN VARY DUE TO THE SWEEP OF THE UNITS.



Typical Section Thru Pre-Cast Voided Slab Unit

Scale: 1½" = 1'-0"

General Notes

1. SPECIFICATIONS: Connecticut Department of Transportation Form 814A, 1995.
2. DESIGN SPECIFICATIONS: Standard Specifications for Highway Bridges (AASHTO-year), with the Interim Specifications as supplemented by the Connecticut Department of Transportation Bridge Manual.
3. EXISTING DIMENSIONS: Dimensions of the existing structure shown on these plans are for general reference only. The Contractor shall take all field measurements necessary to assure proper fit of the finished work and shall assume full responsibility for their accuracy. When shop drawings based on field measurements are submitted for approval, the field measurements shall also be submitted for reference by the reviewer.
4. ALLOWABLE DESIGN STRESSES:
   Class "A" concrete based on f'c = 3,000 psi
   Class "F" concrete based on f'c = 4,000 psi
   Reinforcement
   (ASTM A615 Grade 60) fs = 24,000 psi
5. LIVE LOAD: HS 20-44
6. FUTURE PAVING ALLOWANCE: None
7. CLASS "A" CONCRETE: Class "A" Concrete shall be used for the sidewalks.
8. CLASS "F" CONCRETE: Class "F" Concrete shall be used for substructure, parapets and wingwalls.
9. JOINT SEAL: Per Form 814A.
10. EXPOSED CONCRETE: All Exposed concrete to receive a smooth-rubbed finish.
11. EXPOSED EDGES: Exposed edges of concrete shall be beveled 1" x 1" unless dimensioned otherwise.
12. REINFORCEMENT: All reinforcement shall be ASTM A615 Grade 60.
13. EPOXY COATED REINFORCING BARS: All reinforcement in the superstructure except for voided slab unit reinforcing shall be epoxy coated unless otherwise noted. These bars shall be included in the pay item for "Deformed Steel Bars (Epoxy Coated)."
14. BITUMINOUS CONCRETE OVERLAY: This shall consist of two lifts. The first shall be Bituminous Concrete - Class (12) (1" thick) and the second shall be Bituminous Concrete - Class (1) (thickness varies - see plan).
15. CONSTRUCTION JOINTS: Construction joints, other than those shown on the plans, will not be permitted without the prior approval of the Engineer.

Concrete Distribution

CONCRETE DISTRIBUTION	
WING WALLS	12 cy
SUBSTRUCTURE	25 cy
FOOTINGS	13 cy
TOTAL	50 cy

No.	Date	Revision

CLA Engineers, Inc.
Civil • Structural • Survey
317 Main Street Norwich, Connecticut
(860) 886-1966 Fax (860) 886-9165
CLAengrs@aol.com CLAengrs@snet.net

STATE OF CONNECTICUT LICENSED PROFESSIONAL ENGINEER No. 18221 4-8-99

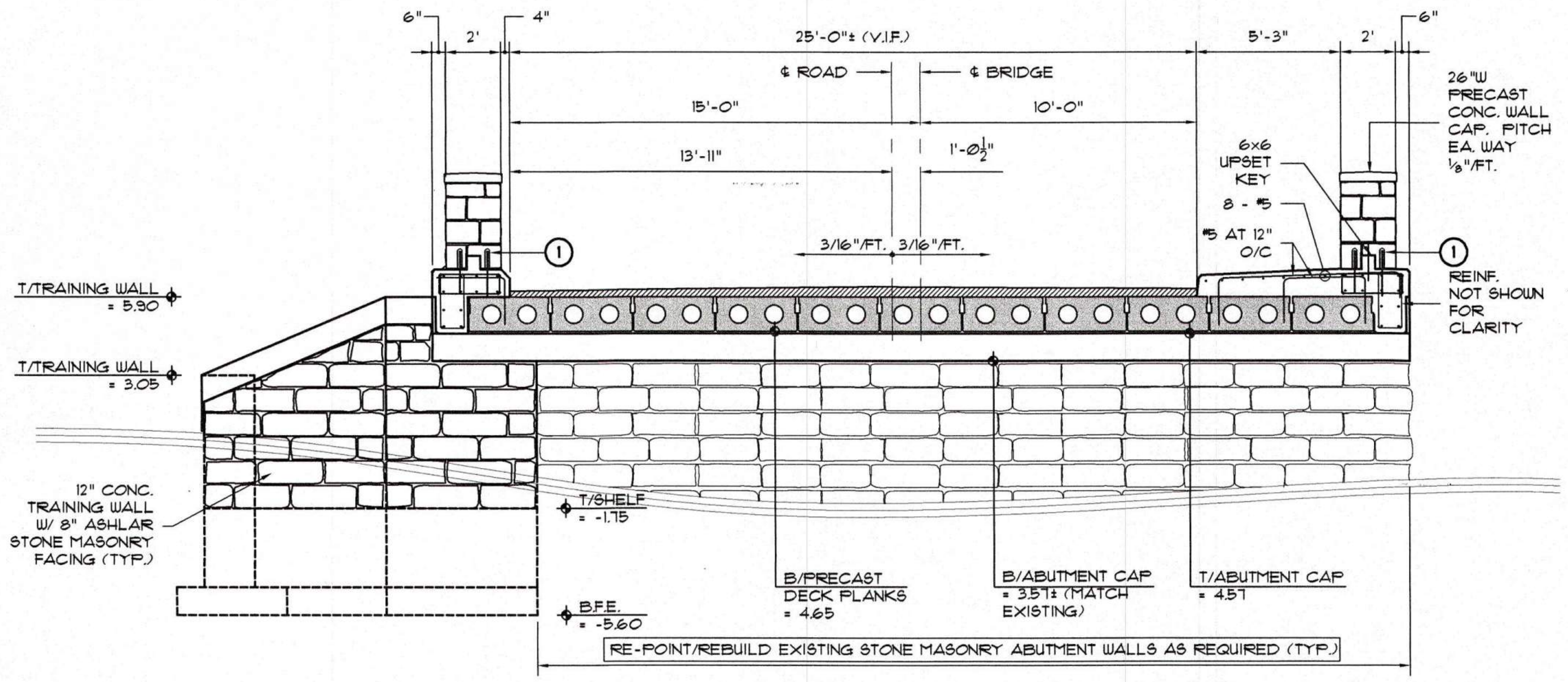
Town of Stonington

Replacement of Holmes Street Bridge

Plan & Section

Project No. CL-96-1673
Proj. Engineer: T.K.G.
Date: 4/8/99
Sheet No. 2

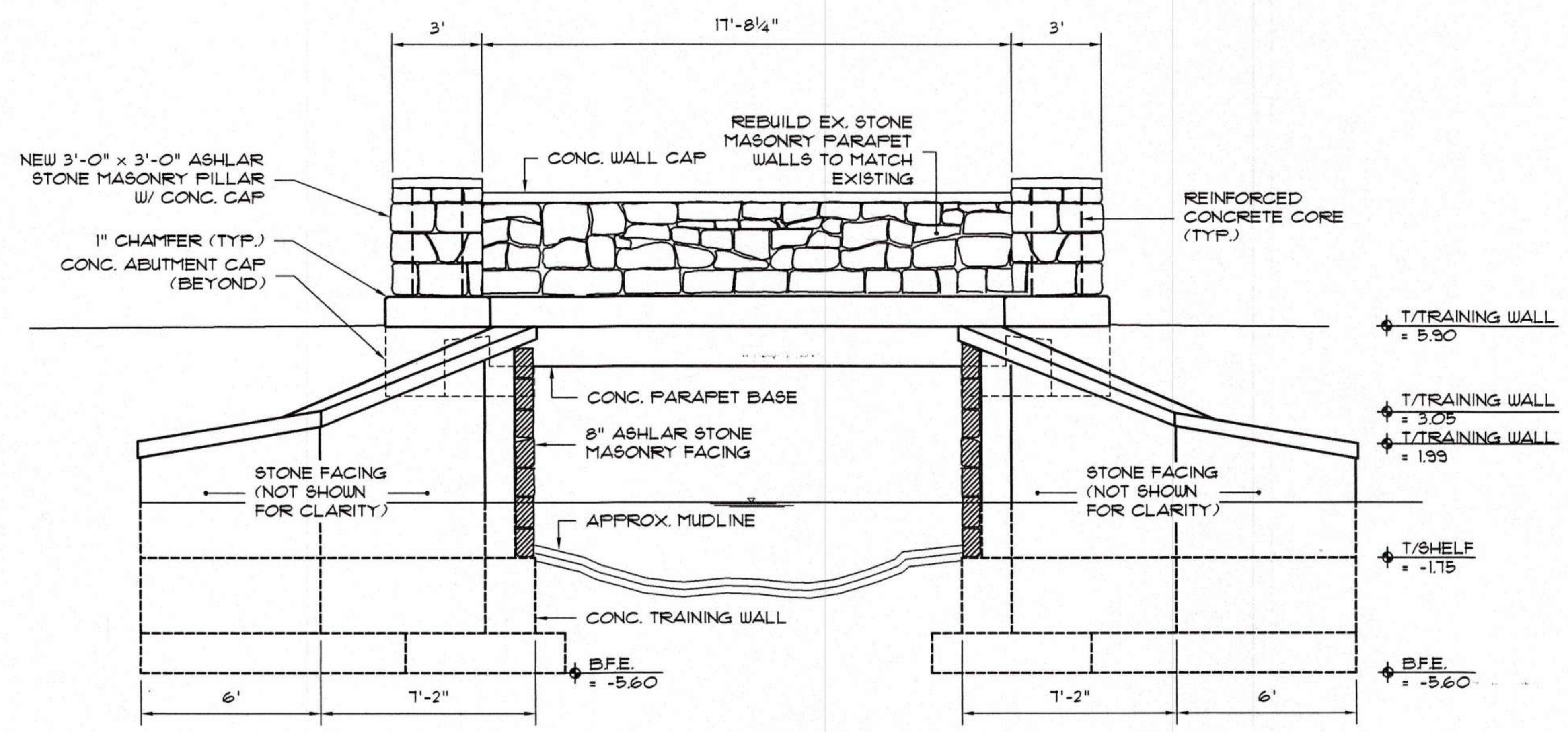
CLA



Bridge Section at South Abutment (North Abutment Similar)

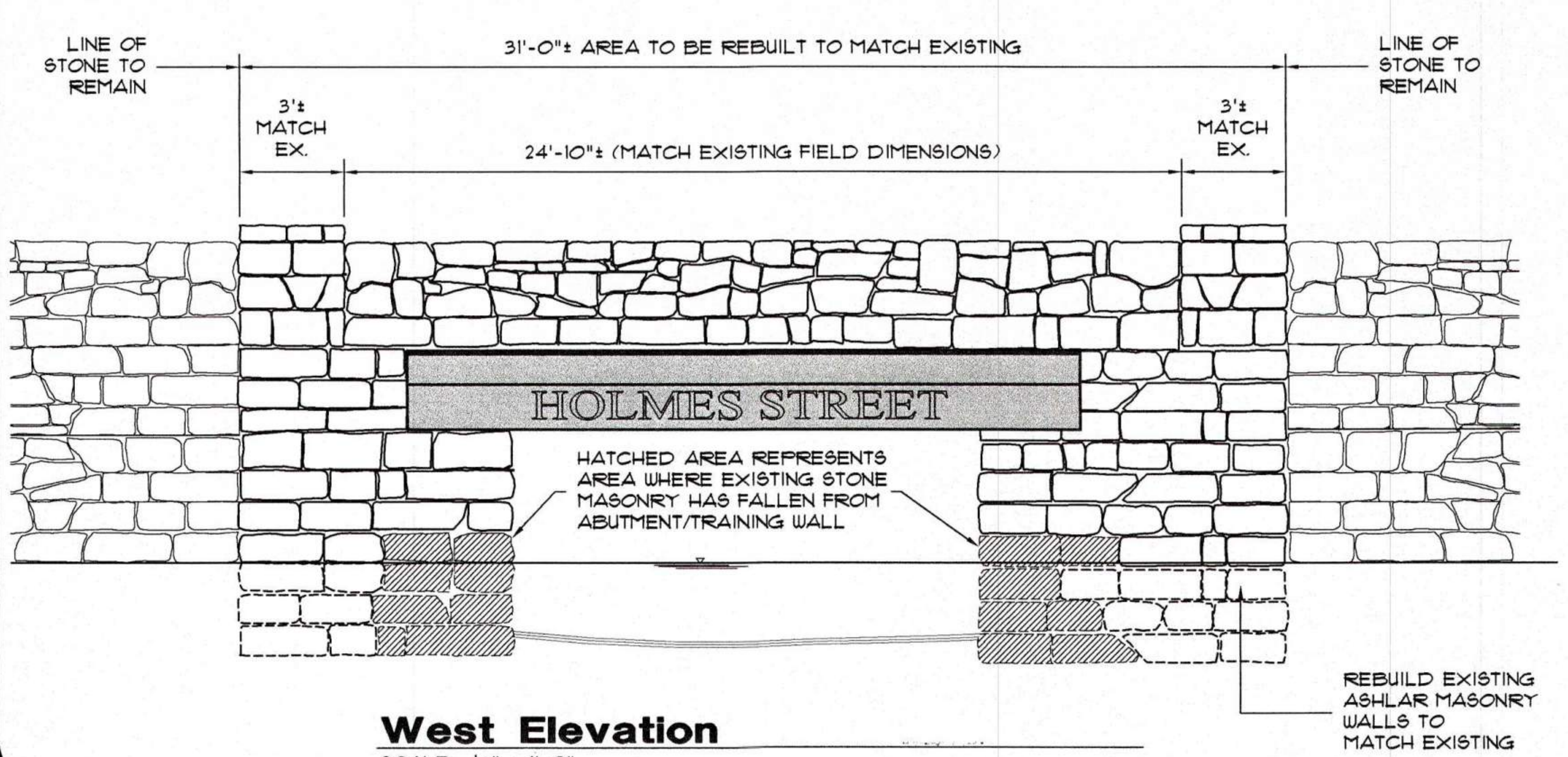
SCALE : ¼" = 1'-0"

1 - #6 DWLS AT 12" O/C STAGGERED PRE-DRILL 2" DIA. HOLE IN ASHLAR STONE MASONRY & GROUT ROD SOLID W/ 5 STAR GROUT OR APPROVED EQ. MIN EMBED INTO STONE = 12", MIN. EMBED INTO CONC. = 12"



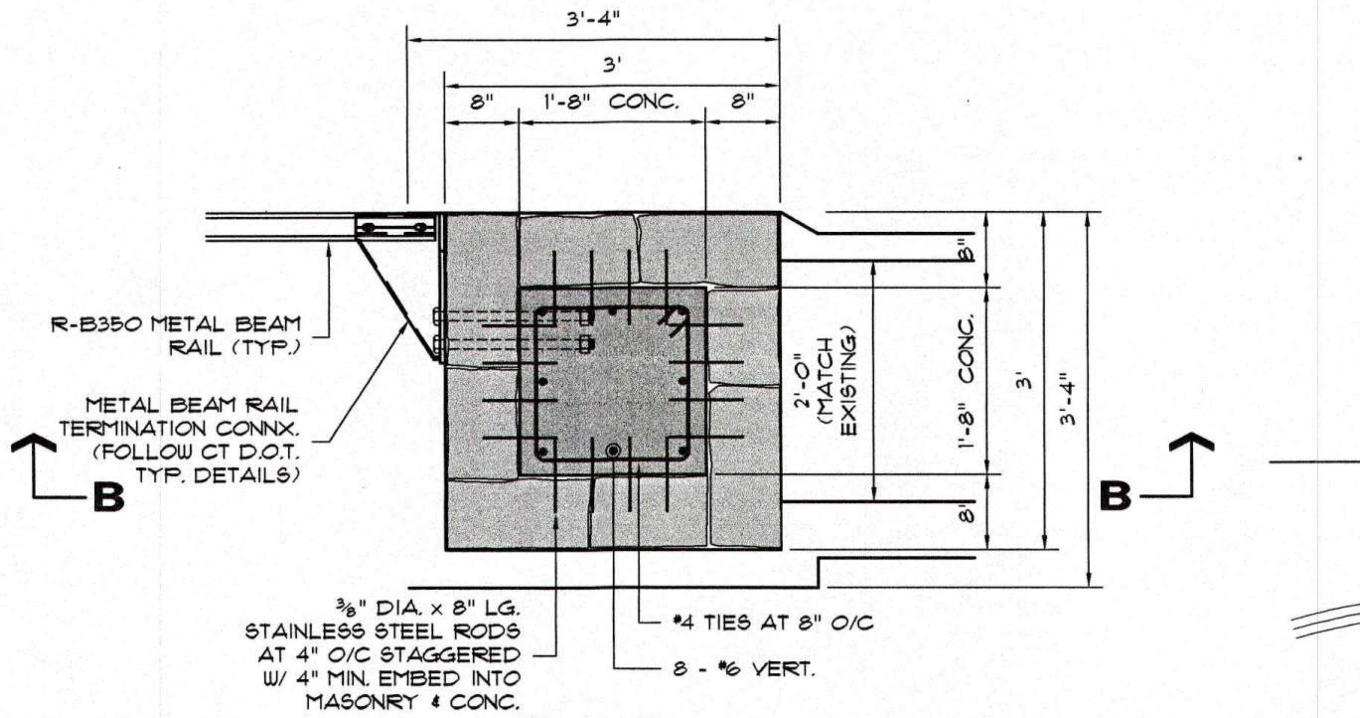
East Elevation

SCALE : ¼" = 1'-0"



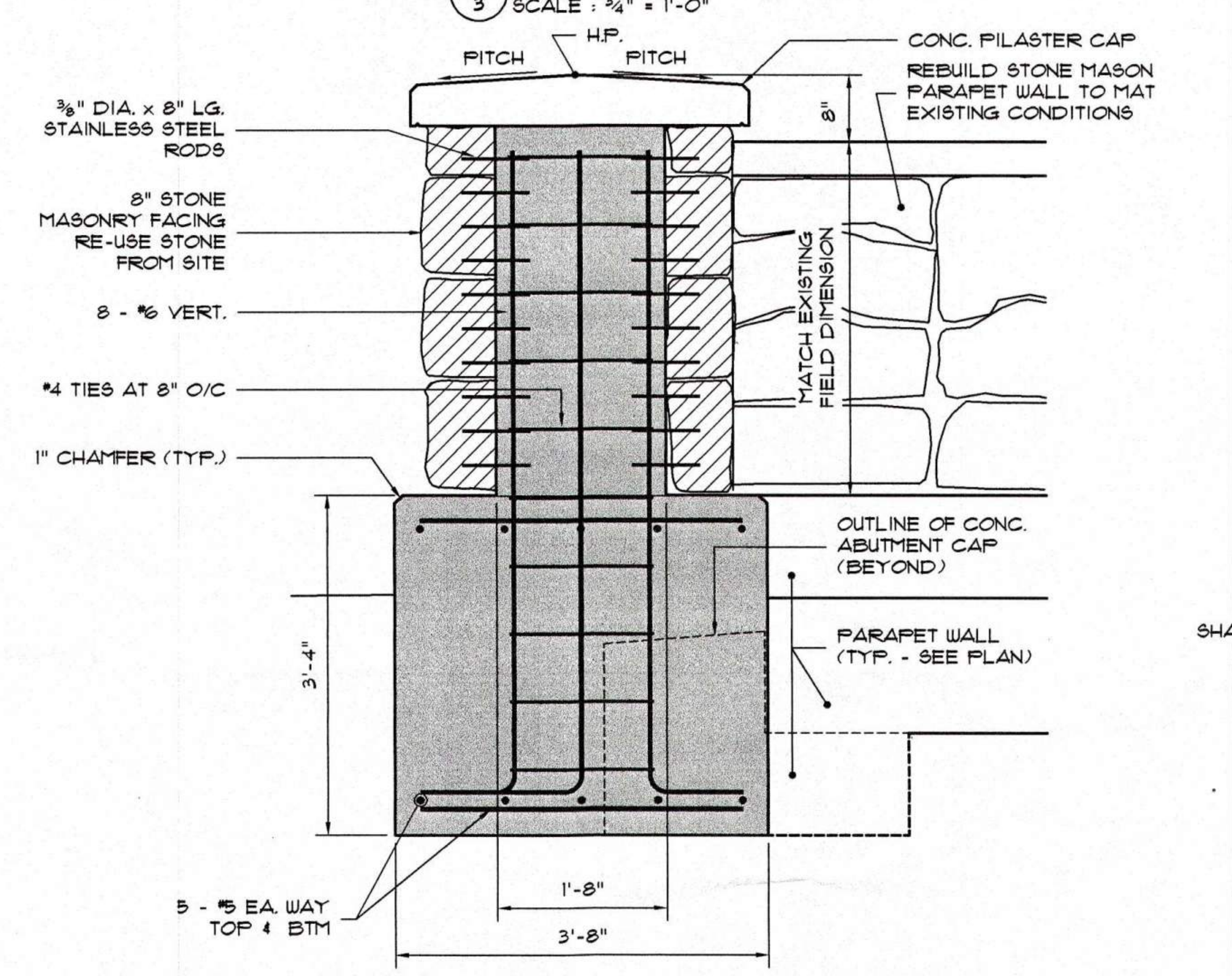
West Elevation

SCALE : ¼" = 1'-0"



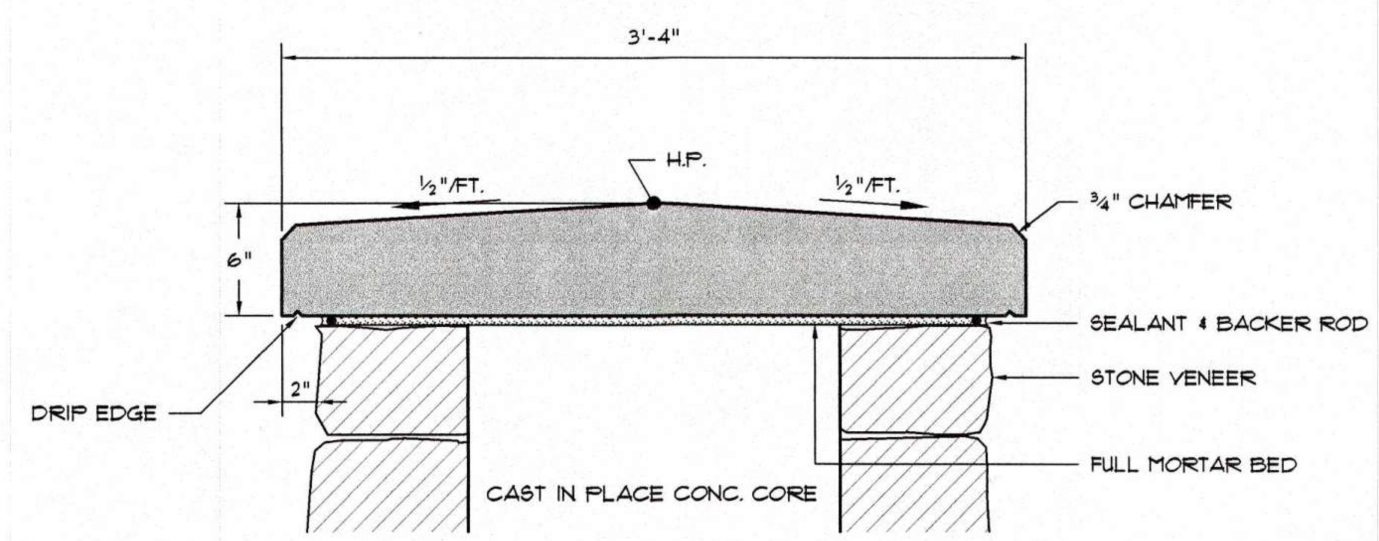
Detail

1/3 SCALE : ¾" = 1'-0"



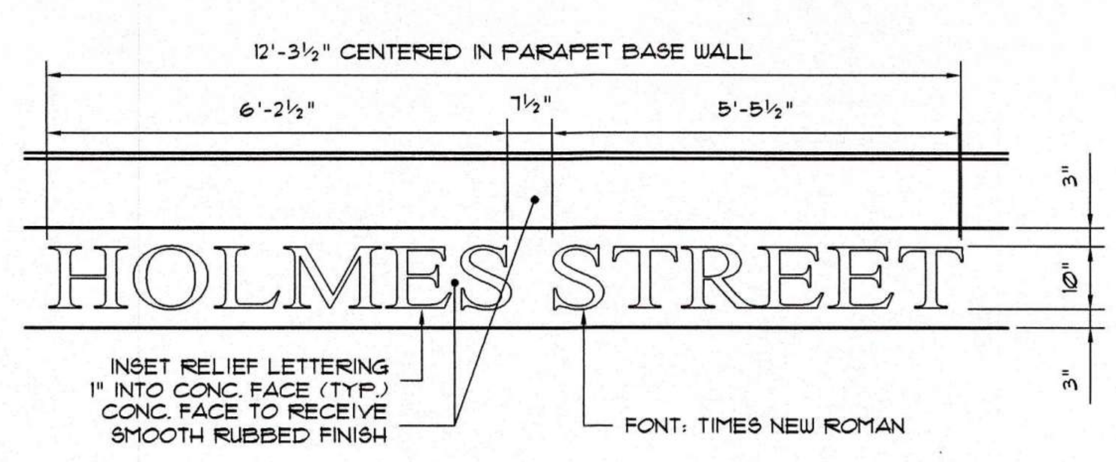
Detail B-B

SCALE : ¾" = 1'-0"



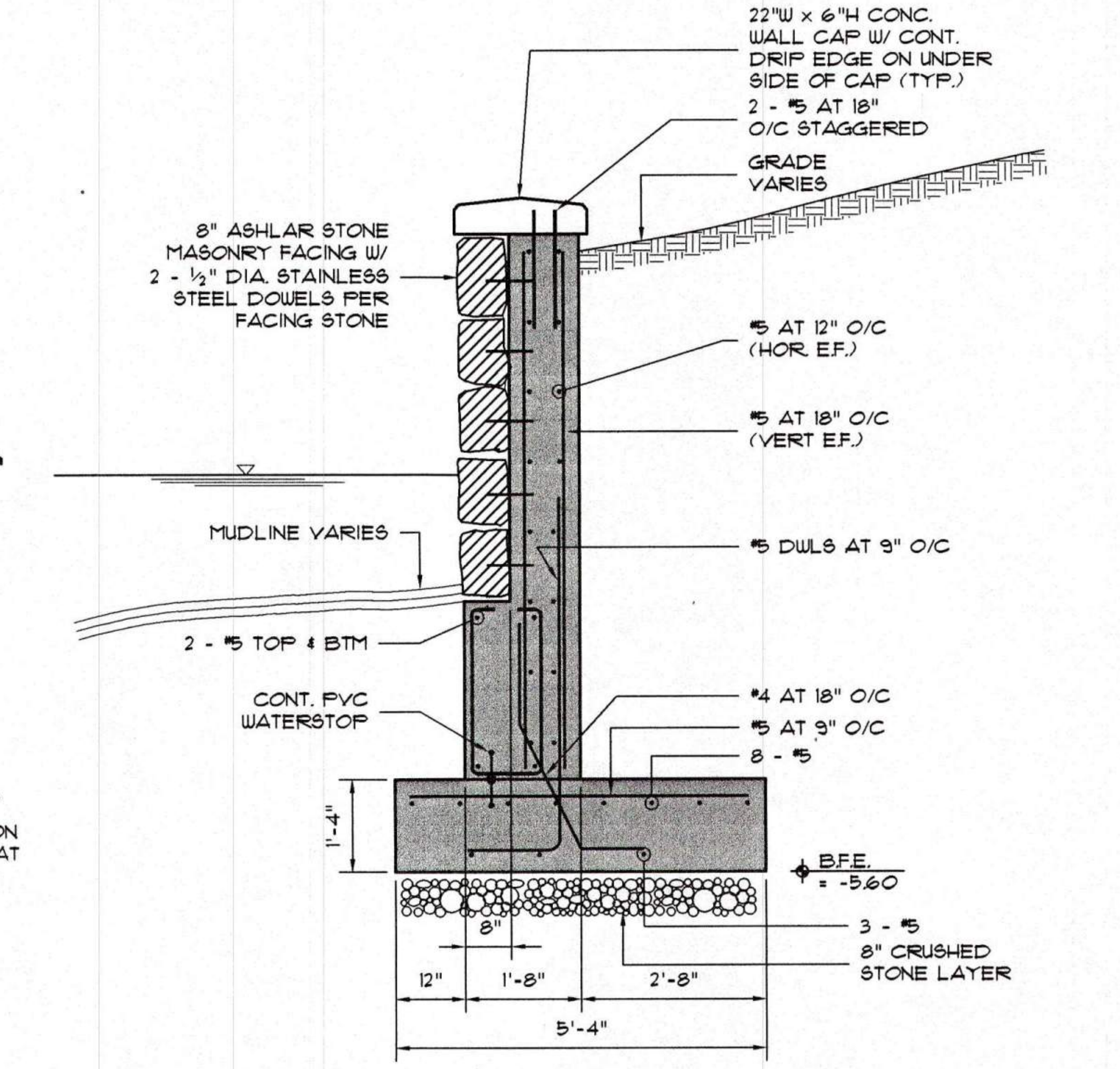
Pre-Cast Conc. Cap Detail

SCALE : 1½" = 1'-0"



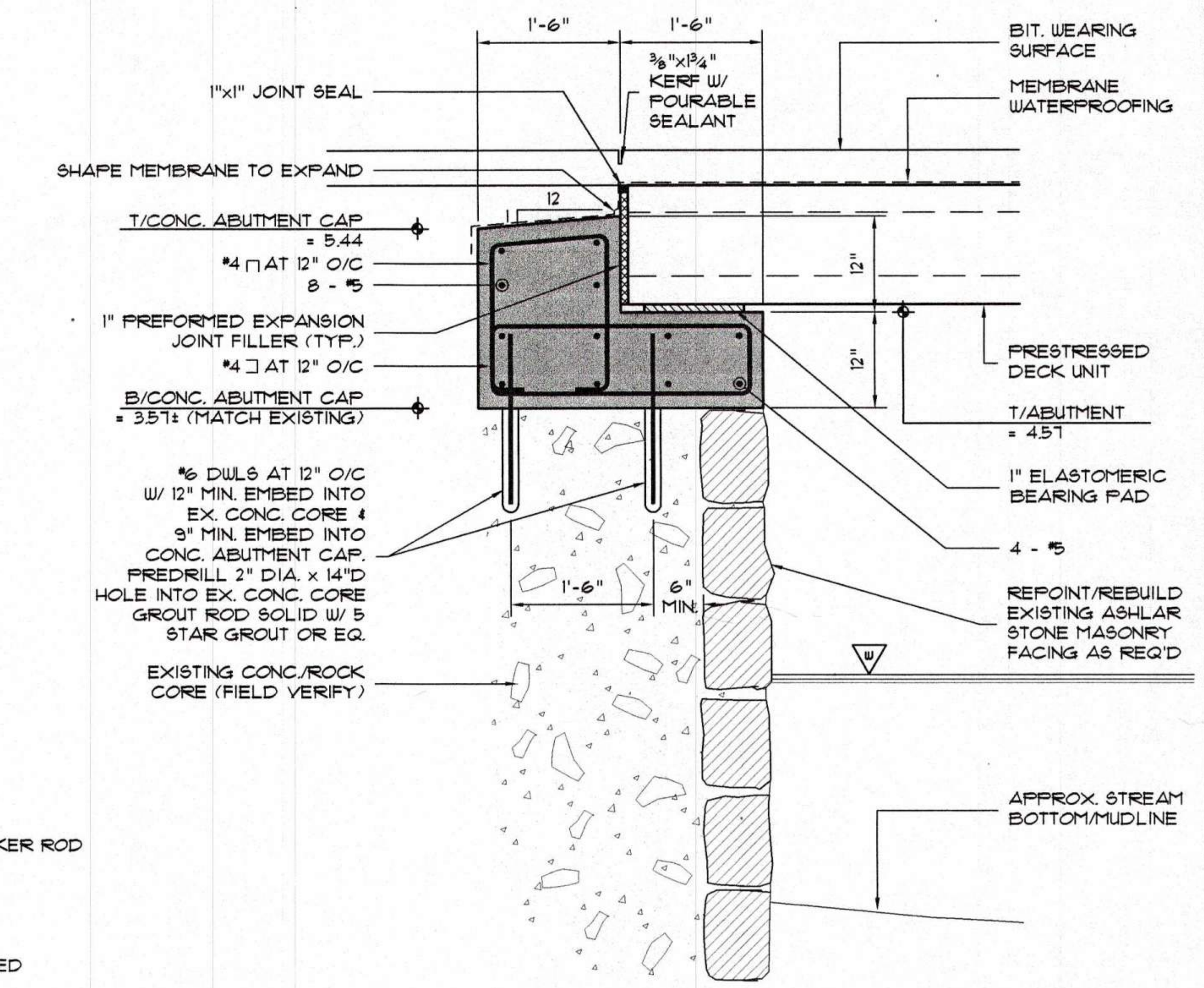
West Parapet Signage Elevation

SCALE : ½" = 1'-0"



Typical Training Wall Section

SCALE : ¼" = 1'-0"



Typical Section Thru Abutment at Bearing

SCALE : ¾" = 1'-0"

No.	Date	Revision

CLA Engineers, Inc.
Civil • Structural • Survey
317 Main Street Norwich, Connecticut
(860) 886-1966 Fax (860) 886-9165
CLAengrs@aol.com CLAengrs@snet.net

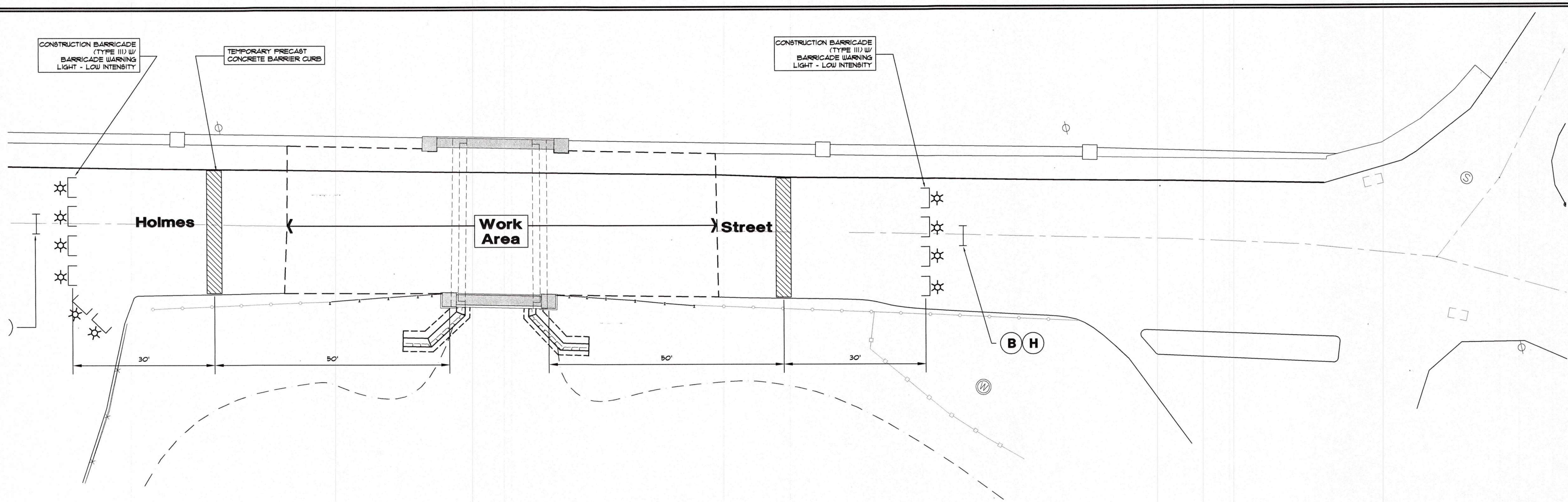
Town of Stonington

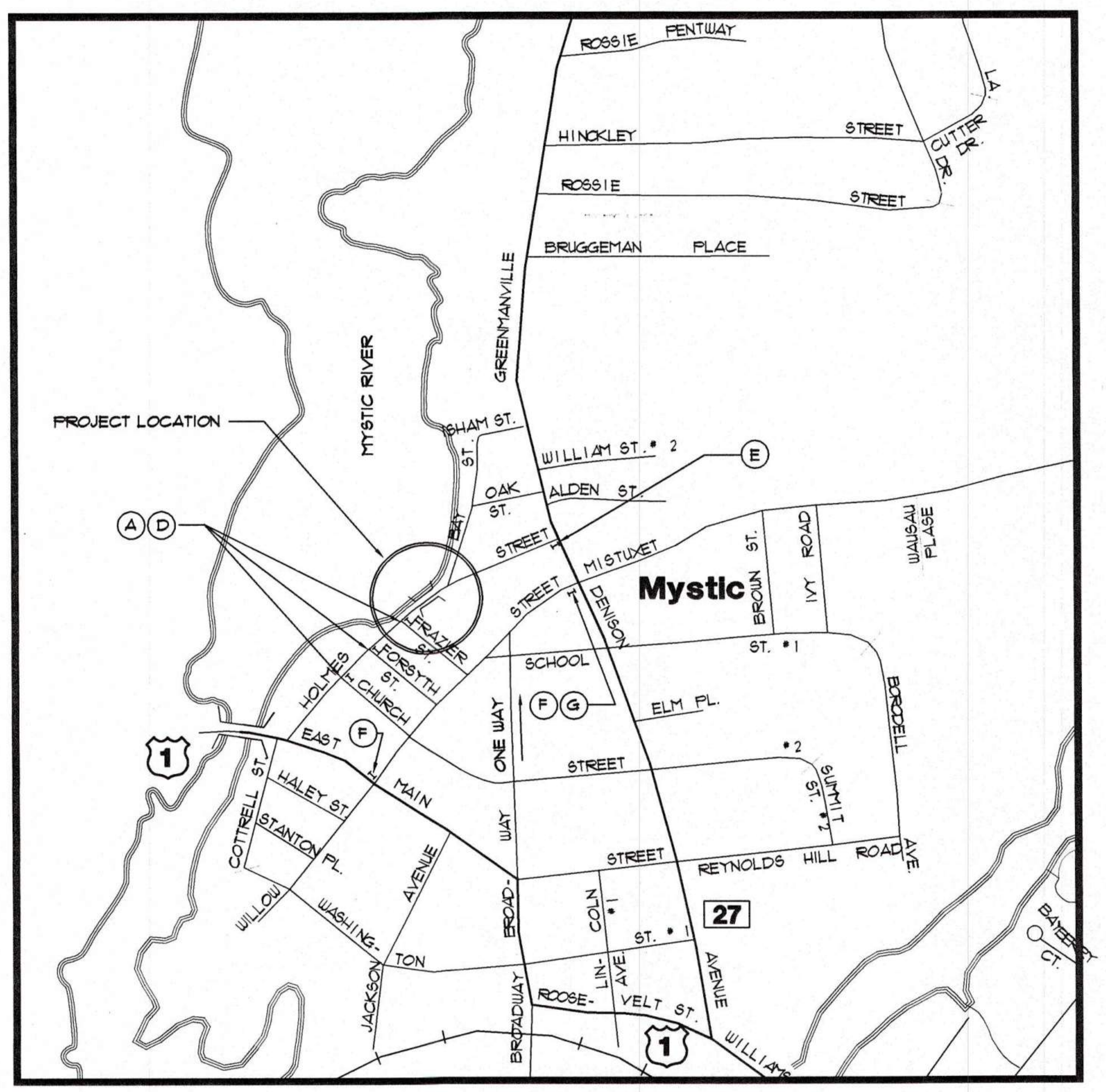
Replacement of Holmes Street Bridge

Sections & Elevations

Project No. CL-96-1673
Proj. Engineer: T.K.G.
Date: 4/8/99
Sheet No. 3

CLA





Traffic Control Plan

Sign Legend

(A)	INSTALL R11-3b CT DOT* 80-0278	BRIDGE CLOSED AHEAD LOCAL TRAFFIC ONLY
(B)	INSTALL R11-2 CT DOT* 80-0282	BRIDGE OUT
(C)	INSTALL M4-10(L) CT DOT* 80-1402	DETOUR (arrow left)
(D)	INSTALL M4-10(R) CT DOT* 80-1401	DETOUR (arrow right)
(E)		HOLMES STREET BRIDGE CLOSED AHEAD
(F)		TO DRAW BRIDGE
(G)		TO ROUTE 1
(H)	INSTALL M8-10c CT DOT*	PEDESTRIANS PROHIBITED

CONSTRUCTION BARRICADE TYPE III

BARRICADE WARNINGLIGHT (LOW INTENSITY)

CONSTRUCTION SIGN SUPPORT

Notes:

1. EXISTING SIGNS WHICH CONFLICT WITH TEMPORARY SIGNS SHALL BE COVERED AS DIRECTED BY THE ENGINEER.
2. SIGNS ARE TO UNCOVERED UPON COMPLETION OF PROJECT.
3. REFER TO CONN DOT DRAWINGS "SIGNS FOR CONSTRUCTION AND PERMIT OPREATIONS" AND "TYPICAL CONSTRUCTION SIGN SUPPORTS AND CHANNELIZING DEVICES" FOR FURTHER INFORMATION.
4. USE TRAFFIC CONTROL PLAN TO RE-DIRECT HOLMES STREET TRAFFIC.

No.	Date	Revision

CLA Engineers, Inc.
Civil • Structural • Survey
317 Main Street Norwich, Connecticut
(860) 886-1966 Fax (860) 886-9165
CLAengrs@aol.com CLAengrs@snet.net

STATE OF CONNECTICUT LICENSED PROFESSIONAL ENGINEER No. 13228

Town of Stonington

Replacement of Holmes Street Bridge

Maintenance & Traffic Plan

Project No.	CL-96-1673
Proj. Engineer:	T.K.G.
Date:	4/8/99
Sheet No.	4

CLA

APPENDIX E

"Important Information about this Geological Engineering Report" by GBA

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are <u>not</u> final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are <u>Not</u> Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will <u>not</u> of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are <u>not</u> building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org