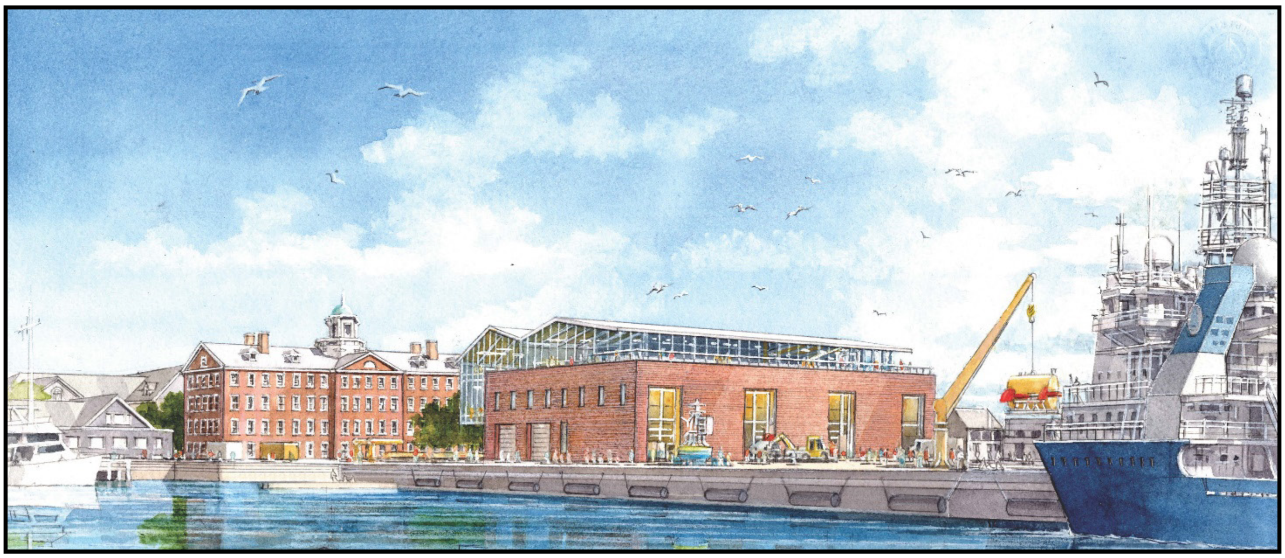
Notice of Intent

Massachusetts Wetlands Protection Act (M.G.L. c.131 s.40)
Plymouth Wetlands Bylaw (Chapter 235)

Complex for Waterfront Access to Exploration and Research (CWATER)
Woods Hole, Massachusetts



Submitted to:
Falmouth Conservation Commission
18 Town Hall Square
Falmouth, MA 02540

Submitted by:
Woods Hole Oceanographic Institution
569 Woods Hole Road
Falmouth, MA 02543

Prepared by:
Epsilon Associates, Inc.
3 Mill & Main Place, Suite 250
Maynard, MA 01754

In Association with:
Moffatt & Nichol
Payette
Dewing Schmid Kearns
Woods Hole Group

August 11, 2021

WOODS HOLE OCEANOGRAPHIC INSTITUTION | CWATER Ocean Exploration Starts Here

Epsilon ASSOCIATES INC.

Epsilon
ASSOCIATES INC.

August 11, 2021

PRINCIPALS

Theodore A Barten, PE
Margaret B Briggs
Dale T Raczynski, PE
Cindy Schlessinger
Lester B Smith, Jr
Robert D O'Neal, CCM, INCE
Michael D Howard, PWS
Douglas J Kelleher
AJ Jablonowski, PE
Stephen H Slocomb, PE
David E Hewett, LEED AP
Dwight R Dunk, LPD
David C Klinch, PWS, PMP
Maria B Hartnett
Richard M Lampeter, INCE
Geoff Starsiak, LEED AP BD+C
Marc Bergeron, PWS, CWS

ASSOCIATES

Alyssa Jacobs, PWS
Holly Carlson Johnston
Brian Lever
Dorothy K. Buckoski, PE

3 Mill & Main Place, Suite 250
Maynard, MA 01754
www.epsilonassociates.com

978 897 7100
FAX 978 897 0099

Ms. Jennifer Lincoln, Administrator
Falmouth Conservation Commission
59 Town Hall Square
Falmouth MA 02540

Subject: Woods Hole Oceanographic Institution
Complex for Waterfront Access to Exploration and Research (CWATER)
Notice of Intent Submittal

Dear Jen:

On behalf of the Woods Hole Oceanographic Institution ("WHOI"), I am pleased to submit the enclosed Notice of Intent ("NOI") for the proposed CWATER Project, located at 86 Water Street in Woods Hole.

The CWATER Project is envisioned to replace the Iselin Marine Facility with a more modern and resilient port facility that will serve WHOI's needs for the next century. The Project includes the reconstruction of the existing pile-supported dock, bulkhead replacement, dredging activities, installation of a robotic vessel port, small boat slip reconfiguration, and construction of a new waterfront building.

The CWATER Project meets all performance standards that are prescribed under the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00 *et seq.*) but cannot satisfy two performance standards established in the Falmouth Wetlands Protection Regulations ("FWR"), specifically:

- The NWB, although being moved further landward from the Federal Emergency Management Agency ("FEMA") mapped VE-Zone boundary cannot be sited in a manner that provides 25-feet of separation from the FEMA mapped VE-Zone as currently mapped. Relief from regulation **FWR 10.38(4)(d)** is therefore requested to allow construction of the NWB within 25 feet of the VE-Zone as established by FEMA.

- The proposed dock replacement and minor alignment modifications will require installing marine infrastructure within fifty feet of eelgrass beds located at the Eel pond entrance channel and in shallow water adjacent to the west edge of the dock. Relief from regulation **FWR 10.16 (1)(h)(5)** is therefore requested to allow for the reconstruction of the Iselin Marine Facility with modifications within fifty feet of eelgrass beds.

Because, the CWATER project cannot satisfy these two performance standards, WHOI respectfully requests that the Falmouth Conservation Commission grant a variance pursuant FWR 10.13 so that an Order of Conditions for the CWATER Project can be issued pursuant to the Falmouth Wetlands Bylaw, Chapter 235 of the Code of Falmouth. The enclosed NOI includes a thorough review of the pertinent sections of FWR 10.13 to support this request for a variance.

We look forward to presenting this project to the Falmouth Conservation Commission at the June 16 public meeting, or next available date. If you have any questions about the project, please contact me at jvaccaro@epsilonassociates.com or by phone at (508) 274-0706.

Sincerely,

EPSILON ASSOCIATES, INC.

Jack Vaccaro
Senior Consultant

Enc.

Copy to: DEP/SERO
Division of Marine Fisheries
Gregg, Fraser, Falmouth Harbormaster

Table of Contents

Table of Contents

WPA FORM 3 – NOTICE OF INTENT

ATTACHMENT A-PROJECT NARRATIVE

Table of Contents (cont.)

Form 3 Notice of Intent

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 3 – Notice of Intent

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

tab

return

Note: Before completing this form consult your local Conservation Commission regarding any municipal bylaw or ordinance.

A. General Information

1. Project Location (**Note:** electronic filers will click on button to locate project site):

86 Water Street
a. Street Address

Falmouth (Woods Hole)
b. City/Town

02543
c. Zip Code

Latitude and Longitude:

41.52402 N
d. Latitude

70.67122 W
e. Longitude

489A-02
f. Assessors Map/Plat Number

000K-001
g. Parcel /Lot Number

2. Applicant:

a. First Name

b. Last Name

Woods Hole Oceanographic Institution
c. Organization

569 Woods Hole Road
d. Street Address

Falmouth (Woods Hole))
e. City/Town

MA
f. State

02543
g. Zip Code

h. Phone Number

i. Fax Number

j. Email Address

3. Property owner (required if different from applicant): ☐ Check if more than one owner

a. First Name

b. Last Name

c. Organization

d. Street Address

e. City/Town

f. State

g. Zip Code

h. Phone Number

i. Fax Number

j. Email address

4. Representative (if any):

Jack
a. First Name

Vaccaro
b. Last Name

Epsilon Associates, Inc.
c. Company

3 Mill & Main Place, Suite 250
d. Street Address

Maynard
e. City/Town

MA
f. State

01754
g. Zip Code

(978) 461-6256
h. Phone Number

(978) 897-0099
i. Fax Number

jvaccaro@epsilonassociates.com
j. Email address

5. Total WPA Fee Paid (from NOI Wetland Fee Transmittal Form):

$1,950
a. Total Fee Paid

$962.50
b. State Fee Paid

$987.50
c. City/Town Fee Paid

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 3 – Notice of Intent
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

A. General Information (continued)

6. General Project Description:

Woods Hole Oceanographic Institution neeeds to replace the existing 50+ year old dock thatsupports the Iselin Marine Facility. This needed replacment projet will involve work in to Land Under the Ocean, Land Subject to Tidal Action, Land Containing Shellfish, Coastal Bank, and Land Subject to Coastal Storm Flowage.

7a. Project Type Checklist: (Limited Project Types see Section A. 7b.)

1. ☐ Single Family Home
2. ☐ Residential Subdivision
3. ☐ Commercial/Industrial
4. ☒ Dock/Pier
5. ☐ Utilities
6. ☐ Coastal engineering Structure
7. ☐ Agriculture (e.g., cranberries, forestry)
8. ☐ Transportation
9. ☐ Other

7b. Is any portion of the proposed activity eligible to be treated as a limited project (including Ecological Restoration Limited Project) subject to 310 CMR 10.24 (coastal) or 310 CMR 10.53 (inland)?

1. ☐ Yes ☒ No If yes, describe which limited project applies to this project. (See 310 CMR 10.24 and 10.53 for a complete list and description of limited project types)

2. Limited Project Type

If the proposed activity is eligible to be treated as an Ecological Restoration Limited Project (310 CMR10.24(8), 310 CMR 10.53(4)), complete and attach Appendix A: Ecological Restoration Limited Project Checklist and Signed Certification.

8. Property recorded at the Registry of Deeds for:

Barnstable a. County	b. Certificate # (if registered land)
01262 c. Book	0328 d. Page Number

B. Buffer Zone & Resource Area Impacts (temporary & permanent)

1. ☐ Buffer Zone Only – Check if the project is located only in the Buffer Zone of a Bordering Vegetated Wetland, Inland Bank, or Coastal Resource Area.
2. ☐ Inland Resource Areas (see 310 CMR 10.54-10.58; if not applicable, go to Section B.3, Coastal Resource Areas).

Check all that apply below. Attach narrative and any supporting documentation describing how the project will meet all performance standards for each of the resource areas altered, including standards requiring consideration of alternative project design or location.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 3 – Notice of Intent
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

B. Buffer Zone & Resource Area Impacts (temporary & permanent) (cont'd)

For all projects affecting other Resource Areas, please attach a narrative explaining how the resource area was delineated.

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
a. ☐ Bank	1. linear feet	2. linear feet
b. ☐ Bordering Vegetated Wetland	1. square feet	2. square feet
c. ☐ Land Under Waterbodies and Waterways	1. square feet	2. square feet
	3. cubic yards dredged	

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
d. ☐ Bordering Land Subject to Flooding	1. square feet	2. square feet
	3. cubic feet of flood storage lost	4. cubic feet replaced
e. ☐ Isolated Land Subject to Flooding	1. square feet	
	2. cubic feet of flood storage lost	3. cubic feet replaced
f. ☐ Riverfront Area	1. Name of Waterway (if available) - **specify coastal or inland**	

2. Width of Riverfront Area (check one):

☐ 25 ft. - Designated Densely Developed Areas only

☐ 100 ft. - New agricultural projects only

☐ 200 ft. - All other projects

3. Total area of Riverfront Area on the site of the proposed project: ______ square feet

4. Proposed alteration of the Riverfront Area:

a. total square feet ______ b. square feet within 100 ft. ______ c. square feet between 100 ft. and 200 ft. ______

5. Has an alternatives analysis been done and is it attached to this NOI? ☐ Yes ☐ No

6. Was the lot where the activity is proposed created prior to August 1, 1996? ☐ Yes ☐ No

3. ☒ Coastal Resource Areas: (See 310 CMR 10.25-10.35)

Note: for coastal riverfront areas, please complete **Section B.2.f.** above.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 3 – Notice of Intent
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

B. Buffer Zone & Resource Area Impacts (temporary & permanent) (cont'd)

Online Users: Include your document transaction number (provided on your receipt page) with all supplementary information you submit to the Department.

Check all that apply below. Attach narrative and supporting documentation describing how the project will meet all performance standards for each of the resource areas altered, including standards requiring consideration of alternative project design or location.

Resource Area	Size of Proposed Alteration	Proposed Replacement (if any)
a. ☐ Designated Port Areas	Indicate size under Land Under the Ocean, below	
b. ☒ Land Under the Ocean	10,375 1. square feet 2,600 2. cubic yards dredged	
c. ☐ Barrier Beach	Indicate size under Coastal Beaches and/or Coastal Dunes below	
d. ☐ Coastal Beaches	1. square feet	2. cubic yards beach nourishment
e. ☐ Coastal Dunes	1. square feet	2. cubic yards dune nourishment

	Size of Proposed Alteration	Proposed Replacement (if any)
f. ☒ Coastal Banks	830 (bulkhead replacement) 1. linear feet	
g. ☐ Rocky Intertidal Shores	1. square feet	
h. ☐ Salt Marshes	1. square feet	2. sq ft restoration, rehab., creation
i. ☐ Land Under Salt Ponds	1. square feet 2. cubic yards dredged	
j. ☐ Land Containing Shellfish	1. square feet	
k. ☐ Fish Runs	Indicate size under Coastal Banks, inland Bank, Land Under the Ocean, and/or inland Land Under Waterbodies and Waterways, above 1. cubic yards dredged	
l. ☒ Land Subject to Coastal Storm Flowage	30,000 1. square feet	

4. ☐ Restoration/Enhancement
If the project is for the purpose of restoring or enhancing a wetland resource area in addition to the square footage that has been entered in Section B.2.b or B.3.h above, please enter the additional amount here.

a. square feet of BVW	b. square feet of Salt Marsh

5. ☐ Project Involves Stream Crossings

a. number of new stream crossings	b. number of replacement stream crossings

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 3 – Notice of Intent
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

C. Other Applicable Standards and Requirements

☐ This is a proposal for an Ecological Restoration Limited Project. Skip Section C and complete Appendix A: Ecological Restoration Limited Project Checklists – Required Actions (310 CMR 10.11).

Streamlined Massachusetts Endangered Species Act/Wetlands Protection Act Review

1. Is any portion of the proposed project located in **Estimated Habitat of Rare Wildlife** as indicated on the most recent Estimated Habitat Map of State-Listed Rare Wetland Wildlife published by the Natural Heritage and Endangered Species Program (NHESP)? To view habitat maps, see the *Massachusetts Natural Heritage Atlas* or go to http://maps.massgis.state.ma.us/PRI_EST_HAB/viewer.htm.

   a. ☐ Yes ☒ No

   If yes, include proof of mailing or hand delivery of NOI to:

   Natural Heritage and Endangered Species Program
   Division of Fisheries and Wildlife
   1 Rabbit Hill Road
   Westborough, MA 01581

   August 1, 2017
   b. Date of map

   If *yes*, the project is also subject to Massachusetts Endangered Species Act (MESA) review (321 CMR 10.18). To qualify for a streamlined, 30-day, MESA/Wetlands Protection Act review, please complete Section C.1.c, and include requested materials with this Notice of Intent (NOI); *OR* complete Section C.2.f, if applicable. *If MESA supplemental information is not included with the NOI, by completing Section 1 of this form, the NHESP will require a separate MESA filing which may take up to 90 days to review (unless noted exceptions in Section 2 apply, see below).*

   c. Submit Supplemental Information for Endangered Species Review*

      1. ☐ Percentage/acreage of property to be altered:

         (a) within wetland Resource Area ________ percentage/acreage

         (b) outside Resource Area ________ percentage/acreage

      2. ☐ Assessor's Map or right-of-way plan of site

2. ☐ Project plans for entire project site, including wetland resource areas and areas outside of wetlands jurisdiction, showing existing and proposed conditions, existing and proposed tree/vegetation clearing line, and clearly demarcated limits of work **

   (a) ☐ Project description (including description of impacts outside of wetland resource area & buffer zone)

   (b) ☐ Photographs representative of the site

* Some projects **not** in Estimated Habitat may be located in Priority Habitat, and require NHESP review (see https://www.mass.gov/ma-endangered-species-act-mesa-regulatory-review).
Priority Habitat includes habitat for state-listed plants and strictly upland species not protected by the Wetlands Protection Act.

** MESA projects may not be segmented (321 CMR 10.16). The applicant must disclose full development plans even if such plans are not required as part of the Notice of Intent process.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 3 – Notice of Intent
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

C. Other Applicable Standards and Requirements (cont'd)

(c) ☐ MESA filing fee (fee information available at https://www.mass.gov/how-to/how-to-file-for-a-mesa-project-review).
Make check payable to "Commonwealth of Massachusetts - NHESP" and ***mail to NHESP*** at above address

Projects altering ***10 or more acres*** *of land, also submit:*

(d) ☐ Vegetation cover type map of site

(e) ☐ Project plans showing Priority & Estimated Habitat boundaries

(f) OR Check One of the Following

1. ☐ Project is exempt from MESA review.
Attach applicant letter indicating which MESA exemption applies. (See 321 CMR 10.14, https://www.mass.gov/service-details/exemptions-from-review-for-projectsactivities-in-priority-habitat; the NOI must still be sent to NHESP if the project is within estimated habitat pursuant to 310 CMR 10.37 and 10.59.)

2. ☐ Separate MESA review ongoing. ____ a. NHESP Tracking # ____ b. Date submitted to NHESP

3. ☐ Separate MESA review completed.
Include copy of NHESP "no Take" determination or valid Conservation & Management Permit with approved plan.

3. For coastal projects only, is any portion of the proposed project located below the mean high water line or in a fish run?

a. ☐ Not applicable – project is in inland resource area only b. ☒ Yes ☐ No

If yes, include proof of mailing, hand delivery, or electronic delivery of NOI to either:

South Shore - Cohasset to Rhode Island border, and the Cape & Islands:

Division of Marine Fisheries -
Southeast Marine Fisheries Station
Attn: Environmental Reviewer
836 South Rodney French Blvd.
New Bedford, MA 02744
Email: dmf.envreview-south@mass.gov

North Shore - Hull to New Hampshire border:

Division of Marine Fisheries -
North Shore Office
Attn: Environmental Reviewer
30 Emerson Avenue
Gloucester, MA 01930
Email: dmf.envreview-north@mass.gov

Also if yes, the project may require a Chapter 91 license. For coastal towns in the Northeast Region, please contact MassDEP's Boston Office. For coastal towns in the Southeast Region, please contact MassDEP's Southeast Regional Office.

c. ☐ Is this an aquaculture project? d. ☐ Yes ☒ No

If yes, include a copy of the Division of Marine Fisheries Certification Letter (M.G.L. c. 130, § 57).

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 3 – Notice of Intent
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

C. Other Applicable Standards and Requirements (cont'd)

Online Users: Include your document transaction number (provided on your receipt page) with all supplementary information you submit to the Department.

4. Is any portion of the proposed project within an Area of Critical Environmental Concern (ACEC)?

   a. ☐ Yes ☒ No If yes, provide name of ACEC (see instructions to WPA Form 3 or MassDEP Website for ACEC locations). **Note:** electronic filers click on Website.

   b. ACEC

5. Is any portion of the proposed project within an area designated as an Outstanding Resource Water (ORW) as designated in the Massachusetts Surface Water Quality Standards, 314 CMR 4.00?

   a. ☐ Yes ☒ No

6. Is any portion of the site subject to a Wetlands Restriction Order under the Inland Wetlands Restriction Act (M.G.L. c. 131, § 40A) or the Coastal Wetlands Restriction Act (M.G.L. c. 130, § 105)?

   a. ☐ Yes ☒ No

7. Is this project subject to provisions of the MassDEP Stormwater Management Standards?

   a. ☒ Yes. Attach a copy of the Stormwater Report as required by the Stormwater Management Standards per 310 CMR 10.05(6)(k)-(q) and check if:
      1. ☐ Applying for Low Impact Development (LID) site design credits (as described in Stormwater Management Handbook Vol. 2, Chapter 3)
      2. ☐ A portion of the site constitutes redevelopment
      3. ☒ Proprietary BMPs are included in the Stormwater Management System.

   b. ☐ No. Check why the project is exempt:
      1. ☐ Single-family house
      2. ☐ Emergency road repair
      3. ☐ Small Residential Subdivision (less than or equal to 4 single-family houses or less than or equal to 4 units in multi-family housing project) with no discharge to Critical Areas.

D. Additional Information

☐ This is a proposal for an Ecological Restoration Limited Project. Skip Section D and complete Appendix A: Ecological Restoration Notice of Intent – Minimum Required Documents (310 CMR 10.12).

Applicants must include the following with this Notice of Intent (NOI). See instructions for details.

Online Users: Attach the document transaction number (provided on your receipt page) for any of the following information you submit to the Department.

1. ☒ USGS or other map of the area (along with a narrative description, if necessary) containing sufficient information for the Conservation Commission and the Department to locate the site. (Electronic filers may omit this item.)

2. ☒ Plans identifying the location of proposed activities (including activities proposed to serve as a Bordering Vegetated Wetland [BVW] replication area or other mitigating measure) relative to the boundaries of each affected resource area.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 3 – Notice of Intent

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

D. Additional Information (cont'd)

3. ☐ Identify the method for BVW and other resource area boundary delineations (MassDEP BVW Field Data Form(s), Determination of Applicability, Order of Resource Area Delineation, etc.), and attach documentation of the methodology.

4. ☒ List the titles and dates for all plans and other materials submitted with this NOI.

CWATER PROJECT-ISELIN DOCK REPLACEMENT - 30% Civil and Structural Plan Sets
a. Plan Title

Moffatt & Nichol
b. Prepared By

c. Signed and Stamped by

May 12, 2021
d. Final Revision Date

Plan Set with Multiple Scales
e. Scale

f. Additional Plan or Document Title

g. Date

5. ☐ If there is more than one property owner, please attach a list of these property owners not listed on this form.

6. ☐ Attach proof of mailing for Natural Heritage and Endangered Species Program, if needed.

7. ☒ Attach proof of mailing for Massachusetts Division of Marine Fisheries, if needed.

8. ☒ Attach NOI Wetland Fee Transmittal Form

9. ☒ Attach Stormwater Report, if needed.

E. Fees

1. ☐ Fee Exempt: No filing fee shall be assessed for projects of any city, town, county, or district of the Commonwealth, federally recognized Indian tribe housing authority, municipal housing authority, or the Massachusetts Bay Transportation Authority.

Applicants must submit the following information (in addition to pages 1 and 2 of the NOI Wetland Fee Transmittal Form) to confirm fee payment:

43771
2. Municipal Check Number

5/17/2021
3. Check date

43770
4. State Check Number

5/17/2021
5. Check date

Espilon Associates, Inc.
6. Payor name on check: First Name

7. Payor name on check: Last Name

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 3 – Notice of Intent

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP:

MassDEP File Number

Document Transaction Number

Falmouth
City/Town

F. Signatures and Submittal Requirements

I hereby certify under the penalties of perjury that the foregoing Notice of Intent and accompanying plans, documents, and supporting data are true and complete to the best of my knowledge. I understand that the Conservation Commission will place notification of this Notice in a local newspaper at the expense of the applicant in accordance with the wetlands regulations, 310 CMR 10.05(5)(a).

I further certify under penalties of perjury that all abutters were notified of this application, pursuant to the requirements of M.G.L. c. 131, § 40. Notice must be made by Certificate of Mailing or in writing by hand delivery or certified mail (return receipt requested) to all abutters within 100 feet of the property line of the project location.

1. Signature of Applicant — 2. Date 08/05/2021

3. Signature of Property Owner (if different) — 4. Date

5. Signature of Representative (if any) — 6. Date 8/9/21

For Conservation Commission:
Two copies of the completed Notice of Intent (Form 3), including supporting plans and documents, two copies of the NOI Wetland Fee Transmittal Form, and the city/town fee payment, to the Conservation Commission by certified mail or hand delivery.

For MassDEP:
One copy of the completed Notice of Intent (Form 3), including supporting plans and documents, one copy of the NOI Wetland Fee Transmittal Form, and a **copy** of the state fee payment to the MassDEP Regional Office (see Instructions) by certified mail or hand delivery.

Other:
If the applicant has checked the "yes" box in any part of Section C, Item 3, above, refer to that section and the Instructions for additional submittal requirements.

The original and copies must be sent simultaneously. Failure by the applicant to send copies in a timely manner may result in dismissal of the Notice of Intent.

Attachment A

Project Narrative

Attachment A

PROJECT NARRATIVE

1.0 INTRODUCTION

Founded in 1930, Woods Hole Oceanographic Institution ("WHOI" or "Institution") is the largest private, non-profit institution in the world dedicated to ocean science, education, and engineering. WHOI employs over 1,000 scientists, engineers, technicians, seafarers and administrators, and hosts over 400 affiliates, including graduate students in a joint Ph.D. program with the Massachusetts Institute of Technology, post-doctoral scholars, undergraduate interns, and guest investigators. WHOI has two campuses in Woods Hole: the Quissett Campus and the Woods Hole Village Campus, which includes its working waterfront known as the Iselin Marine Facility. See **Attachment B, Figure 1 - USGS Locus Map** and **Figure 2 - Aerial Locus Map** for the project location. From this base of operations, WHOI deploys research vessels, submersible vehicles, and scientists to the far reaches of the world's oceans seeking answers to the most fundamental and pressing questions about the ocean.

WHOI's Complex for Waterfront Access to Exploration and Research ("CWATER") Project, involves the replacement of the existing Iselin Marine Facility ("IMF"), and is key to meeting the Institution's research needs for the next century. CWATER builds upon WHOI's 90-year history of providing the ocean science community access to the sea through the modernization of its water-dependent facilities that support WHOI's mission of research, science, and education, while being resilient in the face of climate change, sea level rise, and storm events. Moreover, as described below, WHOI also underpins the economic vitality of the blue economy on Cape Cod and beyond.

This Notice of Intent ("NOI") is being submitted to the Falmouth Conservation Commission (the "Commission") on behalf of WHOI (the "Applicant") for the proposed replacement of the existing Iselin Marine Facility. As described below and in the attached supporting documents, the Applicant is proposing to replace the existing Iselin Marine Facility through the modernization of its water dependent facilities. The proposed work will involve work in Land Under the Ocean, Land Subject to Tidal Action, Coastal Bank, Land Containing Shellfish, and Land Subject to Coastal Storm Flowage. It will also require alterations to land within 100 feet of eelgrass habitat.

This narrative provides a description of the site and the wetland resource areas present there, a summary of the proposed construction activities, a discussion of anticipated alterations to resource areas, proposed measures to mitigate potential impacts, and a summary of how the proposed work complies with the applicable performance standards to protect the interests of the Massachusetts Wetlands Protection Act (MGL c.131, §40) (the "Act") and established in the Wetland Protection Regulations (310 CMR 10.00) (the "Regulations"); as well as the Town of Falmouth Wetlands Bylaw, Chapter 235 of the Code of Falmouth ("Bylaw") and the Town of Falmouth Wetland Regulations ("FWR"). The Applicant respectfully requests that the Falmouth Conservation Commission issue an Order of Conditions authorizing WHOI to proceed with the CWATER Project.

1.1 Project Need

The IMF is comprised of a pile-supported dock and solid fill landform confined by a sheet pile bulkhead that provides a platform for water dependent buildings as well as stationary and mobile equipment used for vessel loading and unloading. Several buildings provide interior space for vessel or ocean-going sensors and vehicles fabrication, maintenance, and repair that are used to conduct marine research. These buildings are individually known as the Iselin Laboratory, Alvin High Bay, Smith Connector Building, and Flume Building. See **Attachment B, Figure 3 – Iselin Marine Facility-Site Orientation** and **Attachment K, Project Plans, Civil Design Package - Sheets V-100 through V-103**, and **Structural Design Package - Sheet G-101** for the Existing Conditions. The most seaward of these buildings, the Iselin Laboratory is located partly on the pile-supported dock, and partly upon the solid fill pier.

The Iselin Marine Facility was originally constructed in 1969 and the pile supported dock has reached the end of its 50-year design life. Over the course of time, sections of the concrete deck have undergone repair or replacement, and the repairs needs continue to increase making it difficult to keep up with the advancing deterioration of the structure. Such repair efforts are not financially or structurally sustainable and are inhibiting the Institution's ability to meets its mission. While these maintenance costs escalate, it is anticipated that the existing dock will be more susceptible to flooding due to sea level rise.

In light of these concerns WHOI needs to replace and rebuild the Iselin Marine Facility and the buildings situated upon it and has envisioned the CWATER Project to provide a more modern and resilient marine support facility that will serve the institution's needs for the next century. See **Attachment K, Project Plans, Civil Design Package – Sheet CS100 Overall Site Plan,** and **Structural Design Package – Sheet G-102 Overall Site Plan.**

1.2 Request for Variance from the Provisions of Falmouth Wetland Regulation

As will be demonstrated in the following sections, the CWATER Project meets all performance standards that are prescribed in the Regulations, but cannot satisfy certain performance standards established in the FWR, specifically:

1. The project includes replacing the existing Iselin Building and other structures with a New Waterfront Building ("NWB"). The NWB will be relocated landward of the existing Federal Emergency Management Agency ("FEMA") mapped VE-Zone (velocity zone) boundary, which is a positive change from the current Iselin Building's location partially over water. However, due to site constraints, it cannot be sited greater than 25-feet from the FEMA mapped VE-Zone. Since the FWR presumes the VE-Zone boundary is 25 feet landward of the FEMA mapped boundary relief from regulation **FWR 10.38(4)(d)** is therefore requested to allow construction of the NWB within 25 feet of the existing FEMA mapped VE-Zone.

2. There are mapped eel grass beds present within 50 feet of the existing Iselin Dock. The needed in-kind and in-place dock replacement with minor bulkhead re-alignment modifications will require work within 50 feet of eelgrass beds located to the east within the Eel Pond entrance channel and in shallow water adjacent to the westerly edge of the dock. Relief from regulation **FWR 10.16(1)(h)(5)** is therefore requested to reconstruct the IMF as depicted on the attached project plans (**Attachment K, Project Plans, Civil Design Package – Sheet CS100 Overall Site Plan,** and **Structural Design Package – Sheet G-102 Overall Site Plan**) within 50 feet of eelgrass beds.

Because the CWATER Project cannot satisfy these two performance standards, WHOI respectfully requests that the Falmouth Conservation Commission grant a variance pursuant FWR 10.13 so that an Order of Conditions for the CWATER Project can be issued pursuant to the Falmouth Wetlands Bylaw, Chapter 235 of the Code of Falmouth.

The detailed variance request is submitted concurrent with the NOI as **Attachment F, Variance Request.**

2.0 EXISTING CONDITIONS

WHOI's Iselin Marine Facility (or "Site") is located at 86 Water Street in the village of Woods Hole and consists of approximately 2.8 acres of developed waterfront that serves as the homeport for WHOI's fleet of research vessels. See **Attachment B, Figure 1 – USGS Locus Map** and **Figure 2 – Aerial Locus Map**. The Site is amid a busy harbor with significant vessel traffic, including regular ferry service provided by the Woods Hole, Martha's Vineyard and Nantucket Steamship Authority, as well as that of smaller pleasure craft. Vessel traffic within the adjacent Eel Pond Entrance Channel is significant particularly during the summer season. According to records maintained by the Water Street drawbridge keepers, peak weekend vessel traffic within the entrance channel is estimated at 67 transits per day.

The IMF includes a pile supported dock and pier on solid fill confined by a bulkhead and upland. Combined the dock, pier, and upland provide a platform for both stationary and mobile equipment that is used for vessel loading and unloading. The dock is also occupied by several institution buildings, individually known as the Iselin Laboratory, Alvin High Bay, Smith Connector Building, and Flume Building. See **Attachment B, Figure 3 – Iselin Marine Facility-Site Orientation**. The most seaward of these buildings, the Iselin Laboratory is located partly on the pile-supported dock, and partly upon the solid fill pier. The buildings provide interior space to fabricate, maintain, and repair research vehicles plus work needed to perform on-site vessel repairs and maintenance.

Vehicle access to the IMF is by a one-way single lane access drive that enters the Site east of the Smith Building and exits onto Water Street between the Smith and Bigelow Buildings. On-Site parking is currently limited to twenty-five spaces, two of which are reserved for handicapped access. Other site features include the seawater intake, various subsurface utilities, and several sheds and Connex boxes that are used for storage of equipment and external lab space. See **Attachment C, Representative Site Photography** and **Attachment K, Project Plans, Civil Design Package - Sheets V-100 through V-103**, and **Structural Design Package - Sheet G-101** for Existing Conditions.

Other important dock facilities include lifting platforms and dock cranes, a float system used for robotics vehicle access, three small boat slips, and a test well where data-gathering apparatus is routinely tested prior to being placed on research vessels for deployment at sea. A licensed intake structure intake draws in seawater for use in the WHOI's Redfield Laboratory. The intake is located beneath the pile-supported dock. Refer to **Attachment H, Chapter 91 License #5153.** The existing seawater intake system has been providing a constant 100 gallons per minute (144,000 gallons per day) of ambient unfiltered seawater to the Redfield Seawater Laboratory since the mid-1960's. The seawater pumps operate 24-hours/365 days a year and provide seawater to support the many seawater research projects conducted by the Institution's Marine Biologists over the past 50+ years. There is no seawater heating or cooling, and therefore there is no temperature differential between the intake and outfall.

The pile-supported dock is triangular and has an area of approximately 37,100 square feet ("sf"). Its west berth extends seaward from the bulkhead approximately 250 feet over Great Harbor. It has a reinforced concrete deck that is supported by 232 steel encased concrete piles. The dock provides wide berths for WHOI's two global-class research vessels: the 238-foot *RV Neil Armstrong* and 273-

foot *RV Atlantis II* as well as the 60-foot *RV Tioga* and other smaller vessels. The current berthing positions for these vessels are shown on the attached existing conditions plan, see **Attachment K, Overall Site Plan Sheet G-102XXX.**

The 750 linear-foot ("lf") bulkhead is constructed of steel sheet piles back-filled with bank run gravel. The western 500 lf of the bulkhead is primarily below the pile-supported dock and supported by either riprap embankment or tied-back to dead men. The remaining 250 lf of the structure located along the Eel Pond entrance channel is cantilevered.

The water depths along the west side of the dock range from under 10-feet mean lower low water ("MLLW") at the northwest corner to almost 70-feet MLLW at the seaward end. Within the Eel Pond entrance channel, the depths are generally 8- to 10-feet MLLW. See **Attachment B, Figure 4 – Site Bathymetry.**

The current deck elevation of the Iselin Dock is approximately 6.5 feet North American Vertical Datum of 1988 ("NAVD88"), with slightly higher elevations in the northern portion of the Site. Landward of the bulkhead, the Site slopes gently toward the east with elevations ranging between 6.5 feet NAVD88 at the northwest corner to approximately 3.5 feet NAVD88 at the rear of the parking area near the Eel Pond entrance channel. Most of the Site is within special flood hazard zone AE (Elevation 12-feet NAVD88) as determined by FEMA, with VE-Zone mapped slightly inboard from the dock edge. See **Attachment B, Figure 6 – FEMA Flood Insurance Rate Map (FIRM).**

2.1 Chapter 91 Jurisdiction

The Site includes an area of historic tidelands that were filled most recently in the late 1960's for the expansion of the solid fill bulkhead. Most of the buildings on the Iselin Marine Facility lie landward of the historic shoreline except for portions of the Iselin Laboratory and the Smith Connector Building. The area landward of the historic shoreline represents approximately 1.5 acres of the 2.8-acre Site. All uses in Chapter 91 jurisdiction for both the existing and proposed conditions are water-dependent.

The Chapter 91 License No. 5153 issued on October 26, 1966 authorized the construction of the existing dock. Refer to **Attachment H, Chapter 91 License #5153.**

2.2 Wetland Resource Areas and Environmental Characteristics

The coastal wetland resource areas at the Site include Land Under the Ocean, Coastal Bank, Land Containing Shellfish, and Land Subject to Coastal Storm Flowage. A summary of these resource areas and other environmental characteristics is provided below. See **Attachment K, Project Plans,**

Civil Design Package - Sheets V-100 through V-103, and **Structural Design Package - Sheet G-101** which depict the resource area boundaries.

2.2.A Land Under the Ocean

Land Under the Ocean is defined in 310 CMR 10.25(2) as *"… land extending from the mean low water line seaward to the boundary of the municipality's jurisdiction and includes land under estuaries."*

At the Site, Land Under the Ocean ("LUO") includes the submerged lands under Great Harbor and those beneath portions of the existing pile supported dock. A predominately sandy bottom substrate is present in the shallower waters and in the deeper waters adjacent to the dock more variable bottom types are present including small boulders, cobbles, gravel, sand with shell hash, and sandy mud.

2.2.B Land Subject to Tidal Action

Land Subject to Tidal Action is defined in 310 CMR 10.04 as *"… land subject to the periodic rise and fall of a coastal water body, including spring tides."*

At this Site land Subject to Tidal Action is coincident with LUO.

2.2.C Coastal Bank

Coastal Bank is defined in 310 CMR 10.30(2) as *"… the seaward face or side of any elevated landform, other than a coastal dune, which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland."*

The approximately 750 lf of bulkhead on the Site is regulated as Coastal Bank. The bulkhead was constructed c. 1969 in accordance with Chapter 91 License No. 5153. See **Attachment H** for a copy of the License and License Plans. It is constructed of steel sheet piles backfilled with bank run gravel. The western 500 lf of the bulkhead is primarily below the pile-supported dock and supported by either riprap embankment or tied-back to deadmen. The remaining 250 lf of the bulkhead located along the Eel Pond entrance channel is a cantilevered bulkhead.

2.2.D Land Containing Shellfish

Land Containing Shellfish is defined at 310 CMR 10.34(2) as *"Land Containing Shellfish means land under the ocean, tidal flats, rocky intertidal shores, salt marshes and land under salt ponds when any such land contains shellfish."*

The Massachusetts Division of Marine Fisheries ("DMF") has mapped suitable shellfish habitat within Eel Pond and a portion of the entrance channel near the northeast corner of the IMF.

Although, the harvesting of shellfish is prohibited from the waters adjacent to the IMF, these areas nonetheless represent Land Containing Shellfish as defined in the Regulations.

An independent benthic survey was conducted in June 2020 which identified only two commercial species of shellfish, quahog (*Mercenaria mercenaria*) and the Atlantic razor clam (*Siliqua costata*). Those were collected in very low numbers proximate to the west berth. Refer to **Attachment D, Benthic Habitat Survey Report.**

2.2.E Land Subject to Coastal Storm Flowage

Land Subject to Coastal Storm Flowage ("LSCSF") is defined at 310 CMR 10.04 as *"… land subject to any inundation caused by coastal storms up to and including that caused by the 100-year storm, surge of record or storm of record, whichever is greater."* The FEMA Flood Insurance Rate Map ("FIRM") defines the 100-year floodplain, and these areas are used to delineate LSCSF.

Most of the Site is within special flood hazard AE Zone to elevation "el." 12 feet NAVD88, as determined by FEMA, with VE-Zone mapped inboard from the edges of the dock. Only the existing robotics vessel access floats and the small boat slips extend into the adjacent velocity zone. See **Attachment B, Figure 6 – FEMA FIRM** and **Attachment K, Project Plans, Civil Design Package - Sheets V-100 through V-103**, and **Structural Design Package - Sheet G-101**.

2.2.F Rare Species Habitat

According to the Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program ("NHESP") [Natural Heritage Atlas, 2017], there are no mapped Priority or Estimated Habitats present on the Site, but mapped habitat is present over the water sheet of Great Harbor some 150 feet off the most seaward extent of the dock. See **Attachment B, Figure 5 – Environmental Resources Map**.

2.2.G Eelgrass Beds

Eelgrass habitat has been identified adjacent to the IMF by the Massachusetts Department of Environmental ("DEP") in the shallow regions on either side of the dock. An in-water video survey performed June 30 to July 1, 2020 confirmed the presence, and accurately mapped the eelgrass meadow boundaries. The site-specific mapping effort documented an estimated 5,800 sf meadow on the western side of the Iselin Dock and a 15,000 sf meadow on the eastern side near the Eel Pond channel. Refer to **Attachment D, Benthic Habitat Survey Report**.

3.0 PROJECT DESCRIPTION

The IMF was originally constructed in 1969 and has reached the end of its 50-year design life. Over the course of its lifespan, sections of the concrete deck have undergone repair or replacement, but these efforts are not sustainable, and the Institution is increasingly unable to keep up with the advancing deterioration of the structure. While these maintenance frequency increases and costs escalate, it is anticipated that the existing dock will be more susceptible to flooding due to sea level rise.

In light of these concerns WHOI needs to replace and rebuild the IMF and the buildings that are situated upon and has envisioned the CWATER Project to provide a more modern and resilient marine support facility that will serve the Institution's needs for the next century. Refer to **Attachment K, Project Plans, Civil Design Package - Sheets V-100 through V-103**, and **Structural Design Package - Sheet G-101** for the existing conditions and **Attachment K, Overall Site Plan, Civil Design Package – Sheet CS100,** and **Structural Design Package – Sheet G-102** for proposed conditions.

3.1 Proposed Dock Reconstruction

The new dock will replace the existing dock in-place and in-kind as a pile-supported structure essentially within its existing footprint. There are minor bulkhead alignment modifications to enhance dock operations, improve berthing positions, facilitate vessel loading/unloading, and navigation. These modifications include purpose planning and establishing a formal Robotics Port on the west berth (to launch and retrieve unmanned autonomous vessels), reconfiguring the bulkhead in the vicinity of the small boat slips along the Eel Pond entrance channel, and relocating the large test well. The relocated test well will allow WHOI scientists and engineers to gain access to the deeper water at the dock's southern end and will be contained within the existing dock footprint. None of these modifications will result in an increase in vessel berths or intensity of use of this port facility. See **Attachment K, Project Plans, Civil Design Package Sheets - CD100 through CD103,** and **Structural Design Package - Sheets SD101 and SD102** for the proposed dock demolition plans, and **Structural Design Package - Sheets G-102, S-101 through S-302** for the proposed replacement dock configuration.

3.2 Dredging Requirements

As part of the Project, WHOI needs to expand the previously authorized dredge depths along the dock's west berth where riprap that was placed seaward of the sheet pile bulkhead has since slumped into the vessel berthing area. Dredging in this area will extend slightly beyond previously authorized dredge limits and will increase depth to -24 feet MLLW. This dredging, is estimated to be approximately 420 cubic yards of sediment, will occur on approximately 4,850 sf of the harbor bottom (regulated as Land Under the Ocean) and will be performed largely within dredge limits previously authorized under the existing Chapter 91 license. See **Attachment B, Attachment H, Chapter 91 License #5153**, and **Attachment K, Project Plans, Structural Design Package – Sheet G-102 Overall Site Plan**. Initial discussions with DEP staff indicate this is considered to be maintenance dredging.

The Project will also require the temporary removal and replacement of 3-6 foot diameter riprap boulders that are located directly adjacent to the existing bulkhead to install the new steel sheet pile seaward of the existing bulkhead. The total volume of the riprap that will be temporarily removed and replaced for the new bulkhead installation is approximately 2,425 cubic yards.

Dredging along the east berth is proposed immediately adjacent to the re-aligned small boat slips where a triangular section of the bulkhead will be removed. Dredging in this location is needed to transition the existing bathymetry to the re-aligned bulkhead and also to accommodate the new berthing program along the east berth.

Because dredged material at the west berth will consist both of marine sediments and riprap boulders, dredge operations will be performed using a combination of clamshell and hydraulic dredge machinery accompanied by a container barge. Temporarily displaced riprap will be replaced along the bulkhead as construction advances. All dredged sediments will be discharged at an authorized upland site or at an approved landfill to be determined in consultation with DEP.

3.3 Design Elevations

WHOI has embraced the concept that the new facilities should be built in an adaptable and forward-looking fashion that anticipates projected sea-level rise ("SLR"). This construct has formed the underpinning for alternatives in development, as well as strategies to construct the new facility. Additionally, engagement with subject matter experts within the WHOI coupled with modeling completed by external consultants has provided a clearer understanding of the risks associated with SLR and climate change in Woods Hole as well as reinforcing uncertainty associated with long-range projections.

The combined results of these analyses are reflected in the proposed Site elevations, which set the base elevations for both the new dock and high bays (the portions of the NWB that are functionally dependent on the dock) at el. 9 feet NAVD88 or 2.5 feet above the existing dock elevation. The first-floor elevation of the non-functionally dependent portion of the NWB will be at or above el. 13 feet NAVD 88. The dock and high bays are designed to be raised an additional 1.5 feet in the future to accommodate SLR as needed. See **Attachment B, Figure 7 - Site Elevation Cross Section**.

3.4 New Waterfront Building (NWB)

In 2018 the Institution performed an assessment of the facilities currently located at the waterfront and highlighted those programs that are critical to remain at the dock. These include: expanded high bays, allowing for multiple vessels to be worked on at once; dive operations and diver training, with expanded locker and operations space; the Ocean Systems Laboratory ("OSL"), which supports unmanned underwater vehicle development, fabrication, repair, and maintenance; the Advanced Fabrication Lab; Shipboard Scientific Services Group ("SSSG"); Marine Operations office; and operational and flex lab spaces supporting mobilization and demobilization efforts. The three-story NWB will be constructed entirely landward of the bulkhead directly behind the Smith Building, where it will be located outside of the existing FEMA mapped VE-Zone boundary.

The primary purpose of the NWB is to replace and right size existing facilities on Woods Hole's waterfront campus that will need to come offline as part of the dock replacement. The Project will remove the existing Iselin Laboratory, Alvin High Bay, Smith Connector Building and the Flume Building, which collectively total approximately 48,000 sf of gross floor area and replace that with the NWB which will provide approximately 45,000 sf of gross floor area and, therefore, post-redevelopment conditions result in a decrease of approximately 3,000 sf of gross floor area. Compare the existing conditions in **Attachment K, Project Plans, Civil Design Package - Sheets V-100 through V-103**, and **Structural Design Package - Sheet G-101** to the proposed conditions in **Civil Design Package – Sheet CS100,** and **Structural Design Package – Sheet G-102.**

3.5 Energy Conservation Measures

To reduce fossil fuel consumption and carbon emissions, the CWATER Project envisions utilizing a seawater sourced electric heat pump to warm and cool the NWB. Water sourced Electric Heat Pumps have a COP (Coefficient of Performance) greater than 2.5 compared to 0.9 with fossil fuel source equipment, i.e., almost 3-times more efficient. To minimize the environmental impact of harvesting energy from the ocean, WHOI intends to install a titanium closed loop immersed heat exchanger system below the dock. Unlike an open-source seawater system, the closed loop system will eliminate any impingement and entrapment of marine life. The tidal waters move quickly beneath the dock providing rapid thermal mixing.

The building design is also envisioned to incorporate a high-performance building systems approach that uses heat recovery, on-site energy generation, and energy efficient lighting to reduce energy consumption. The building will also use a series of passive, architectural strategies to reduce energy usage and increase occupant comfort. These include a careful treatment to the different facades of the building, for example the south façade presents an opportunity to leverage solar heat gain in the winter. The Project also includes a high performance, thermally broken envelope, efficient triple pane glazing, and natural ventilation where appropriate.

3.6 Public Accommodations

The CWATER Project will also foster and promote centralized and interactive public visitor experience. Serving as a new public face of the Institution with an enhanced exhibit experience and the ability for visitors to see into the workspace, providing a broader understanding of the mission and work of the Institution. The third floor of the building houses the culmination of the public visitor experience: an event and exhibit space, accessed via a three-story atrium, which will provide a prime vantage point from which to view the activities on the dock with spectacularly expansive views out to the harbor, the Elizabeth Islands, and Martha's Vineyard.

Purpose-built publicly accessible exterior space near the building and adjacent to Water Street will welcome the public onto the Site with views of the working waterfront and will provide an invitation to public exhibits and other events to be held within the NWB. See **Attachment B, Figure 8 – Conceptual Landscape Improvements and Figure 9 – Conceptual Architectural Renderings**.

Ongoing discussions are being held with other Woods Hole science entities regarding potential collaboration in the design and use of the public space to showcase the full scope and breadth of research and conservation activities supported by the Woods Hole research community.

3.7 Stormwater Management Improvements

The site currently has a limited and outdated stormwater management system. The Project will include a comprehensive stormwater management system that will utilize landscape design features to retain and infiltrate stormwater and will incorporate other Best Management Practices ("BMPs") to meet DEP Stormwater Management Regulations to the extent practicable for this waterfront parcel. With the proposed improvements in stormwater management and a net reduction of impervious surface area, the Project will improve the quality stormwater discharged to receiving waters compared to existing conditions. See **Attachment G, Stormwater Management Report.**

3.8 Construction Phasing

Maintaining operations of water-dependent activities during construction is the goal of the project phasing. Although the exact order of construction activities is difficult to establish due to project financing uncertainties, the construction of the CWATER Project is expected to be completed over a 2- to 3-year time period. The current proposed construction phasing is the same as that as provided in the Massachusetts Environmental Policy Act ("MEPA") Environmental Notification Form ("ENF") as follows:

1. Demolish and remove the Smith Connector and Smith Flume Buildings.
2. Replace, relocate, and increase the resiliency of site utilities.

3. Construct the NWB.
4. Demolish and remove the Iselin Laboratory and Alvin High Bay.
5. Demolish and remove the pile-supported dock.
6. Dredging at the west berth.
7. Replace the steel sheet pile bulkhead and construct the new dock.

3.9 Anticipated Impacts

The CWATER Project involves replacing the 50 plus year old IMF (an active marine port facility) within the footprint of the existing facility, and without increasing vessel berthing locations or uses at this port facility.. The only disturbances beyond the current dock are related to the proposed dock edge modifications, which are needed to establish a formal Robotics Port, realign the small boat slips, and perform dredging immediately adjacent to the dock. All other improvements are within the footprint of the dock and adjacent landside campus.

The proposed modifications will result in a slight increase in the overall footprint of the dock, however the proposed conditions will improve site conditions relative to the interests of storm damage prevention and flood control. Those benefits are achieved by constructing the NWB using a smaller building footprint as compared to the existing buildings, locating the NWB out of the existing FEMA mapped VE-Zone, and siting it further inboard from the dock edge as compared to the existing buildings. Also reconstructing the dock at a higher elevation will shift the future VE Zone boundary to the edge of the site and lower the AE zone to el. 11 feet NAVD88. See the "Evaluation of July 16, 2014 Federal Emergency Management Agency Flood Insurance Study for the Woods Hole Oceanographic Institution Facilities in Woods Hole, MA" prepared by the Wood Hole Group provided in **Attachment L** for more details about the existing and proposed flood conditions at the Site.

The CWATER Project will require both temporary and permanent alterations to wetland resource areas. The demolition of the Iselin Marine Facility will entail the removal of 246 steel piles of various diameters, and installation of 89 new 36-inch piles to support the replacement dock. The use of fewer but wider diameter piles results in an increase in the bottom contact area of 333 square feet beneath the dock. An additional net increase of 5 square feet of pile contact results from the structures related to the proposed dock modifications. Thus, the total net increase in pile contact area is 338 square feet within Land Under the Ocean ("LUO").

The proposed bulkhead reconstruction and small boat slip modification will result in the permanent fill of approximately 6,339 sf of LUO This is partially offset by the bulkhead reconfiguration (the removal of a jog on the bulkhead south of the small vessel slips), which will restore approximately

814 square feet of previously filled LUO. Thus, the net increase of fill within LUO is approximately 5,525 sf.

The small boat slip reconfiguration at the Eel Pond entrance channel will increase the area of floats in this area by approximately 227 sf. The total area of floats and other structures associated with the robotics vehicle port is approximately 1,452 sf .

Finally, maintenance and improvement dredging is needed adjacent to the west berth and will impact approximately 4,850 sf of LUO. In total the net alteration of LUO from dredge and fill activities is approximately 10,375 square feet of LUO.

The activities described above will result in both temporary and permanent alterations to Land Under the Ocean, Coastal Bank, Land Containing Shellfish, Land Subject to Tidal Action[1], and Land Subject to Coastal Storm Flowage. There will be no impacts to the other resource areas on or adjacent to the Site, and the anticipated project impacts are quantified in Table 1 below.

Table 1 Summary of CWATER Wetland Resource Area Alteration

	Land Under the Ocean		Coastal Bank		LSCSF	
Project Element	Temp.	Perm.	Temp.	Perm.	Temp.	Perm.
Dredge (West Berth)	-	4,850 sf/ 420 cy	-	-	-	-
Wave Fence (West Berth)	-	41 lf	-	-	-	-
Wave Fence (East Berth)	-	24 lf	-	-	-	-
Pile Removal	334 sf	-	-	-	-	-
Pile Installation	-	670 sf	-	-	-	-
Bulkhead Reconstruction	-	5,525 sf	-	830 lf	-	-
Building Demolitions	-	-	-	-	48,000 GSF	-
Building Construction	-	-	-	-	-	45,000 GSF
Site Work	-	-	-	-		1.4 Ac

[1] At the WHOI Land Subject to Tidal Action is coincident with Land Under the Ocean and therefore is not tallied into Table 1 to avoid double counting impacts.

4.0 Mitigation Measures

As described above, the CWATER Project will require unavoidable temporary and permanent impacts to coastal wetland resource areas (Land Under the Ocean, Coastal Bank, Land Containing Shellfish, and Land Subject to Coastal Storm Flowage), and mitigation measures are proposed to minimize potential adverse effects to the environment and compensate for unavoidable alterations of coastal wetland resource areas.

4.1 Long-Term Measures

4.1.1 Eelgrass Avoidance and Protection

The CWATER Project was designed to avoid and minimize impacts to sensitive benthic habitat, specifically eelgrass, which occurs in the shallower areas near the northwest corner of the dock and within the Eel Pond Entrance Channel to the north east. Largely, this has been accomplished by configuring the proposed modifications for the Robotics Port and small boat slip so that they do not encroach upon eelgrass plants. Nevertheless, the Project will require construction within 50 feet of extant eelgrass meadows and appropriate mitigation is proposed to ensure that eel grass impacts will be minimized during construction.

In consultation with the U.S. Environmental Protection Agency ("EPA"), DMF, Falmouth Conservation Commission Staff and the Falmouth Harbormaster, the project specific Draft Eelgrass Avoidance and Protection Plan was developed and will be employed to minimize adverse effects on the known eelgrass habitat proximate to the Site. This plan describes the strategies and measures proposed to avoid and minimize alteration to nearby eelgrass meadows, and the mitigation proposed for any unavoidable alteration. Refer to **Attachment E, Draft Eelgrass Avoidance and Protection Plan.**

4.1.2 Changes to Floodplain

WHOIs Water Street campus is located in LSCSF, **see Figure 6 – FEMA Flood Map**. The flood zones on the site are mapped as: (1) AE-Zone to el. 12 feet NAVD 88, area of predominantly still water flooding, and (2) VE-Zone to el. 15 feet NAVD88. The velocity zone is mapped landward of the Iselin Dock edge. The FEMA FIRM is based on the flooding analysis that uses data and modeling along a series of transect generally perpendicular to the shoreline. There are several FEMA transects established in Woods Hole to prepare the currently effective FIRM, however none of those transects go through the site.

The CWATER Project will include raising the Iselin Dock by 2.5 feet initially and an additional 1.5 feet in the future to accommodate sea level rise. To understand the extent of flooding for the proposed conditions, WHOI retained the Woods Hole Group, Inc. ("WHG") to perform a flood plain analysis to calculate the extent of flooding across the site after the dock is raised by 2.5 feet. See **Attachment L, WHG Flood Analysis Study**.

To perform that analysis WHG established a site specific transect through the Iselin Dock and evaluated the extent and depth of flooding for existing conditions to calibrate the model and confirm results. This exercise validated the site specific the AE-Zone elevation of el. 12 feet NAVD88 for existing conditions, and the site specific VE-zone at el. 15 feet NAVD88 for the existing conditions, plus the VE-Zone boundary. The WHG flood zones for existing conditions are depicted in the is depicted in the WHG study. Comparing Figures 5 and 6 in the WHG Study one notices that the WHG site specific VE-Boundary is coincident with the FEMA FIRM VE-Zone boundary.

Examination of these figures reveals a difference in the limit of moderate wave action ("LiMWA") (the limit of waves of 1.5 feet) along the seaward side of the dock. This minor difference is most likely due to the greater wave height used by WHG for this site-specific model as compared to the wave height used by FEMA. Thus, the WHG model is more "conservative" than the FEMA model. This difference in the LiMWA does not change the VE-Zone boundary determination or the AE-Zone and VE-Zone heights. Therefore, the WHG flood plain analysis confirms the FEMA VE-Zone is accurately mapped on the FIRM.

The WHG Study evaluated flooding in the future condition, (i.e. after the CWATER Project is completed and the Iselin Dock is raised by 2.5 feet to el. 9 feet NAVD88). In the future condition, the higher dock elevation will serve a more effective vertical buffer to waves. Based on those future conditions the WHG model shows that the AE-Zone elevation will be reduced by one foot to el. 11 feet NAVD88 and the VE-Zone boundary will follow along the edge of the dock, and not extend landward from the edge of the dock. Based on this model result the proposed NWB will be located greater than 25 feet from the future VE-Zone Boundary. See attached Figure 6 and Figure 7 which depict the existing VE-Zone Boundary for the existing and future conditions on the site plan.

4.2 Construction-Period Mitigation Measures

4.2.1 Material Handling and Disposal

During construction a floating silt curtain fitted with a surface boom will be installed and maintained around the active work zone and barge. The floating boom will trap and contain floating debris to prevent the release of construction related debris into the waters of Great Harbor, while the submerged curtain will limit the transport of suspended sediment from the work zone.

Covered receptacles to hold and store construction related debris, and any other solid waste, generated from the construction will be maintained on site. These receptacles will remain covered at all times except when being loaded or unloaded.

4.2.2 Spill Prevention and Response

A spill containment kit will be kept on site and aboard all work barges during construction. Personnel will be available to respond quickly in the case of a leak or spill. Equipment will be kept in a condition that prevents leaks or discharge of pollutants. Fuel, oil, hydraulic fluids, petroleum products and/or other chemicals will be stored in water-tight containers. In the event there is an accidental release during construction, the contractor will notify the appropriate authorities (Falmouth Fire Department, Falmouth Harbor Master, Falmouth Conservation Commission, MassDEP, U.S. Coast Guard, etc.).

4.3 Time of Year Restriction

With the proposed work activities being located within LUO, it is anticipated that Time-of-Year ("TOY") restrictions related to the spawning period of winter flounder may be applied to the CWATER Project to minimize potential impacts to winter flounder. As such, a copy of this Notice of Intent has been submitted to DMF for comment.

5.0 Compliance with the State and Local Performance Standards

The Project was designed to avoid altering wetland resource areas to the maximum extent practicable. As discussed above, portions of the proposed work will occur within Land Under the Ocean, Land Subject to Tidal Action, Land Containing Shellfish, Coastal Bank, and Land Subject to Coastal Storm Flowage, and the 100-foot buffer zone to Coastal Bank. WHOI, the project engineers, project architects and environmental consultants collaborated to advance a design that meets all State Wetland Protection Regulations performance standards. As summarized above in the Introduction, the Falmouth Wetland regulations are more stringent relative to LSCSF and work in LUO near eel grass. For those provisions of the FWR, WHOI respectfully requests a Variance. Refer to **Attachment F, Variance Request**. Compliance with the state and local performance standards is described below.

5.1 Compliance with the Wetland Protection Act Regulations

The Project was designed to meet all applicable performance standards established in the State Wetland Protection Regulations. The standards are presented in italics typeface with the compliance described in normal typeface.

5.1.A Land Under the Ocean

In accordance with 310 CMR 10.25(3) through (7), activities conducted within land under the ocean will contribute to the protection of the interests identified in the Wetlands Protection Act by complying with the following general performance standards:

> ***310 CMR 10.25(3):*** *"Improvement dredging for navigational purposes affecting land under the ocean shall be designed and carried out using the best available measures so as to minimize adverse effects on such interests caused by changes in:*
>
> *a) Bottom topography which will result in increased flooding or erosion caused by an increase in the height or velocity of waves impacting the shore;*
> *b) Sediment transport processes which will increase flood or erosion hazards by affecting the natural replenishment of beaches;*
> *c) Water circulation which will result in an adverse change in flushing rate, temperature, or turbidity levels; or*
> *d) Marine productivity which will result from the suspension or transport of pollutants, the smothering of bottom organisms, the accumulation of pollutants by organisms, or the destruction of marine fisheries habitat or wildlife habitat."*

The easterly dock realignment requires limited dredging to accommodate the bulkhead removal and the reconfigured berth layout. This would be categorized as improvement dredging. Dredging will remove 420 cubic yards of sediment in an approximately 4,850 s.f. area along the dock to match the adjacent contours to the south. See **Attachment K, Project Plans, Structural Design Package - Sheet G-102 Overall Site Plan,** which depicts the dredge footprint.

Minimizing the footprint to only that area needed and matching the adjacent depths will not increase flooding or erosion. Water quality (circulation, temperature, and flushing rate) parameters in the Eel Pond Entrance Channel and Great Harbor will not be affected by this limited dredge volume and footprint. The dredge envelope is proximate to eel grass and to address this issue WHOI coordinated with EPA, DMF and the Town to prepare the Draft Eelgrass Avoidance and Protection Plan, see **Attachment E**. During construction best available measures as described in the Draft Eelgrass Avoidance and Protection Plan will be employed to minimize potential construction-period impacts, e.g., installing a turbidity curtain around the work zone to control the dispersion of suspended sediments, and positioning equipment to avoid spudding or anchoring in the eel grass meadow.

> ***310 CMR 10.25(4):*** *"Maintenance dredging for navigational purposes affecting land under the ocean shall be designed and carried out using the best available measures so as to minimize adverse effects on such interests caused by changes in marine productivity which will result from the suspension or transport of*

pollutants, increases in turbidity, the smothering of bottom organisms, the accumulation of pollutants by organisms, or the destruction of marine fisheries habitat or wildlife habitat."

WHOI intends to perform dredging activities along the dock's west berth which is characterized as improvement dredging. See **Attachment H, Chapter 91 License #5153** which depicts the previously authorized dredge envelope. The proposed dredging will occur in an approximately 1,700 square foot area that extends beyond the previously authorized dredge limits. This dredging activity primarily involves relocating riprap boulders and also 420 cy of marine sediments. The boulders have slumped off the rip rap toe protection used to support the adjacent bulkhead. These will not be removed, but rather will be re-positioned along the replacement bulkhead after it is installed. As described in the Draft Eelgrass Avoidance and Protection Plan during construction best available will be employed to minimize potential construction impacts and those include installing the turbidity curtain around the work zone to control the dispersion of suspended sediments, and positioning equipment to avoid spudding or anchoring in the eel grass meadow.

310 CMR 10.25(5): *"Projects not included in 310 CMR 10.25(3) or (4) which affect nearshore areas of land under the ocean shall not cause adverse effects by altering the bottom topography so as to increase storm damage or erosion of coastal beaches, coastal banks, coastal dunes, or salt marshes."*

The two dredge areas do not significantly deepen the harbor bottom adjacent to the IMF, and therefore no change in erosion or flooding is anticipated. The nearshore areas do not support coastal beaches, coastal dunes, or salt marshes and therefore the proposed dredging will not affect those resource areas. The adjacent sheet pile bulkhead adjacent to the dredge areas is regulated as Coastal Bank, and the dredging will not affect the stability of that man-made Coastal Bank.

310 CMR 10.25(6): *"Projects not included 310 CMR 10.25(3) which affect land under the ocean shall if water-dependent be designed and constructed, using best available measures, so as to minimize adverse effects, and if non-water-dependent, have no adverse effects, on marine fisheries habitat or wildlife habitat caused by:*

a) Alteration in water circulation;
b) Destruction of eelgrass (Zostera marina) or widgeon grass (Rupia maritina) beds;
c) Alterations in the distribution of sediment grain size;
d) Changes in water quality, including, but not limited to, other than natural fluctuations in the level of dissolved oxygen, temperature or turbidity, or the addition of pollutants; or
e) Alterations of shallow submerged lands with high densities of polychaetes, mollusks or macrophytic algae."

The proposed Project is water-dependent. The two dredge envelopes are limited in their size and proposed depths are designed to match adjacent grades as closely as possible. By not significantly changing depth the dredging will not have an effect on the water circulation, sediment grain size or water quality parameters of the Eel Pond Channel or Great Harbor more broadly. The proposed Eelgrass Avoidance and Protection Plan developed in consultation with the EPA, DMF and the Town of Falmouth will employ measures minimize adverse effects on the known eelgrass habitat proximate to dredging.

> ***310 CMR 10.25(7):*** *"Notwithstanding the provisions of 310 CMR 10.25(3) through (6), no project may be permitted which will have any adverse effect on specified habitat sites of rare vertebrate or invertebrate species as identified by procedures under 310 CMR 10.37."*

The Project Site is not located with NHESP mapped habitat of rare vertebrate or invertebrate species.

5.1.B Coastal Bank

The Coastal Bank at the Iselin Marine Facility is a man-made sheet pile bulkhead. As such, in accordance with 310 CMR 10.30, it is a Coastal Bank that is considered to be significant to storm damage prevention or flood control because it provides a vertical buffer to storm waters. Therefore, the following performance standards 310 CMR 10.30(6) to (8) apply:

> ***310 CMR 10.30(6):*** *"Any Project on such a coastal bank or within 100 feet landward of the top of such a coastal bank shall have no adverse effects on the stability of the coastal bank."*

The existing 50 plus year-old sheet bulkhead will be retained, and new sheet pile bulkhead will be installed seaward of it to maintain the structural stability of the bulkhead and the portion along the Eel Pond entrance channel will be reconfigured to accommodate the proposed vessel berthing program. The proposed work on and within 100 feet of the Coastal Bank are needed to improve the stability of the bulkhead (Coastal Bank) and therefore meets this standard.

> ***310 CMR 10.30(7):*** *"Bulkheads, revetments, seawalls, groins or other coastal engineering structures may be permitted on such a coastal bank except when such bank is significant to storm damage prevention or flood control because it supplies sediment to coastal beaches, coastal dunes, and barrier beaches."*

The Coastal Bank at the Project site is located behind a steel bulkhead, and therefore does not provide sediment to coastal beaches, coastal dunes, or barrier beaches. Therefore, this performance standard does not apply.

> ***310 CMR 10.30(8):*** *"Notwithstanding the provisions of 310 CMR 10.30(3) through (7), no project may be permitted which will have any adverse effect on specified habitat of rare vertebrate or invertebrate species, as identified by the procedures established under 310 CMR 10.37."*

The Project Site is not located with NHESP mapped habitat of rare vertebrate or invertebrate species.

5.1.C Land Containing Shellfish

In accordance with 310 CMR 10.34(4) through 10.34(8), activities proposed within land containing shellfish will contribute to the protection of the interests identified in the Wetlands Protection Act by complying with the following general performance standards:

> ***310 CMR 10.34(4):*** *"Except as provided in 310 CMR 10.34(5), any project on land containing shellfish shall not adversely affect such land or marine fisheries by a change in the productivity of such land caused by:*
>
> *a) alterations of water circulation;*
> *b) alterations in relief elevation;*
> *c) the compacting of sediment by vehicular traffic;*
> *d) alterations in the distribution of sediment grain size;*
> *e) alterations in natural drainage from adjacent land; or*
> *f) changes in water quality, including, but not limited to; other than natural fluctuations in the levels of salinity, dissolved oxygen, nutrients, temperature or turbidity, or the addition of pollutants.*

The DMF has mapped suitable shellfish habitat within Eel Pond and a portion of the Eel Pond Entrance Channel near the northeast corner of the IMF. See **Attachment B, Figure 5 - Environmental Resource Map** which depicts the limit of suitable shellfish. No work is proposed within mapped suitable shellfish habitat, additionally shellfish harvesting from the waters adjacent to the IMF is prohibited.

The Project is limited to replacing the pile supported pier in-place and in-kind. The bulkhead will be stabilized by installing a new sheet pile bulkhead immediately seaward of the existing bulkhead, with minor bulkhead re-alignment along the easterly berth. Although no work is proposed in mapped suitable shellfish habitat, implementing the proposed Eelgrass Avoidance and Protection Plan will minimize water quality impacts during construction. For the long-term, re-constructing the IMF in-place and in-kind will yield no significant change to bottom habitat or pelagic conditions as compared to existing conditions.

> ***310 CMR 10.34(5):*** *"Notwithstanding the provisions of 310 CMR 10.34(4), projects which temporarily have an adverse effect on the shellfish productivity but which do not permanently destroy the habitat may be permitted if the land containing shellfish can and will be returned substantially to its former productivity in less than on year from the commencement of work, unless an extension of the Order of Conditions is granted, in which case such restoration shall be completed within one year of such extension."*

The temporary activities in LUO are not expected to have any short-term adverse effect on shellfish productivity and will not destroy benthic habitat that may support shellfish. The in-kind and in-place dock replacement plus bulkhead replacement represents no substantial change to benthic habitat compared to existing conditions, therefore the substrate at the IMF post-construction is presumed to provide substantially equivalent productivity as existing conditions.

> ***310 CMR 10.34(6):*** *"In the case of land containing shellfish defined as significant in 310 CMR 10.34(3)(b)(i.e., those areas identified on the basis of maps and designations of the Shellfish Constable), except in Areas of Critical Environment Concern, the issuing authority may, after consultation with the Shellfish Constable, permit the shellfish to be moved from such area under the guidelines of, and to a suitable location approved by, the Division of Marine Fisheries, in order to permit a proposed project on such land. Any such project shall not be commenced until after the moving and replanting of the shellfish have been commenced."*

The Project does not currently include the relocation of shellfish given the low number of shellfish observed proximate to the dock during the June 2020 Benthic Habitat Survey, see **Attachment D**. Regardless, the Project will avoid adverse effects to shellfish habitat to the greatest extent practicable by replacing the dock in-place and implementing best practices as described in this NOI to minimize sediment transport during construction.

> ***310 CMR 10.34(7):*** *"Notwithstanding 310 CMR 10.34(4) through (6), projects approved by the Division of Marine Fisheries that are specifically intended to increase the productivity of land containing shellfish may be permitted. Aquaculture projects approved by the appropriate local and state authority may also be permitted."*

Not Applicable. This Project is not an aquaculture project.

> ***310 CMR 10.34(8):*** *"Notwithstanding the provisions of 310 CMR 10.34(4) through (7), no project may be permitted which will have any adverse effect on specified habitat of rare vertebrate or invertebrate species, as identified by procedures established under 310 CMR 10.37."*

The Project Site is not located with NHESP mapped habitat of rare vertebrate or invertebrate species.

5.1.D Land Subject to Coastal Storm Flowage

There are currently no performance standards identified in the State Regulations for Land Subject to Coastal Storm Flowage. However, the proposed Project will not have an adverse effect on the ability of the LSCSF to contribute to the protection of the interests of storm damage prevention and flood control.

The CWATER Project includes the following elements to advance those interests:

1. The NWB is located outside of the existing FEMA mapped VE-Zone. The single NWB replaces several existing buildings, portions of which are within the VE-Zone.

2. The replacement dock and first floor of the NWB, which houses functionally dependent waterfront uses, will be raised 2.5 feet above existing elevations (from el. 6.5 feet NAVD88 to el. 9 feet NAVD88). This will reduce the frequency and depth of flooding.

3. The lowest level on the NWB that supports other uses (i.e., not functionally dependent on the dock) is at el. 13 feet NAVD88, one foot above the FEMA determined AE Zone (el. 12 feet NAVD88).

4. A dry-floodproofing system has been designed and will be employed by WHOI to protect the lowest functionally dependent levels from flooding.

5. In the built condition, with the replacement dock at el. 9 feet NAVD88, project-specific modeling prepared by the Woods Hole Group, documents that the AE Zone will be reduced el. 11 feet NAVD88 and the VE Zone will follow along the edge of the dock. These changes are the result of raising the dock 2.5 feet which is like raising the height of a breakwater

5.2 Compliance with the Falmouth Wetland Regulations

The Falmouth Wetland Regulations ("FWR") include additional standards that for several resource areas are more stringent than those in the State Regulations, reviewed above. There are also additional performance standards for local wetland resource areas that are not regulated in the State regulations. A compliance review of the applicable FWR performance standards is provided below.

5.2.A Land Under the Ocean – FWR 10.25

Compliance with the performance standards for Land Under the Ocean are provided in FWR 10.25(4) through (12). Compliance with the applicable performance standards is provided below.

(4) General Performance Standards

(a) When land under the ocean underlies an anadromous/catadromous fish run, FWR 10.35 shall apply.
(b) When land under the ocean is land containing shellfish, FWR 10.34 shall apply.

(c) When land under the ocean or nearshore areas of land under the ocean are found to be significant to fisheries, wildlife habitat, storm damage prevention, flood control, recreation or aesthetics FWR 10.25(5) through (7) shall apply.

There is no anadromous or catadromous fish run identified at the Site, therefore FWR 10.35 does not apply. The Site does contain Land Containing Shellfish; however it is mapped as suitable shellfish habitat by DMF. FWR 10.34 applies, and the compliance review is provided below in Section 5.2.C. below.

Land Under the Ocean at the Site is significant to the characteristics listed in FWR 10.25(4)(c) therefore compliance with FWR 10.25(5) through (7) is provided below.

(5) Improvement dredging for navigational purposes affecting land under the ocean shall be designed and carried out using the best available measures so as to minimize adverse effects on such interests caused by changes in:

(a) Bottom topography which will result in increased flooding or Erosion caused by an increase in the height or velocity of waves impacting the shore;
(b) Sediment transport processes which will increase flood or erosion hazards by affecting the natural replenishment of beaches;
(c) Water circulation which will result in adverse change in flushing rate, temperature, or turbidity levels; or
(d) Marine productivity which will result from the suspension or transport of pollutants, the smothering of bottom organisms, the accumulation of pollutants by organisms, or the destruction of marine fisheries or wildlife habitat.

Improvement dredging is proposed along the east berth, primarily associated with the bulkhead re-alignment and berthing changes. These performance standards mirror those in 310 CMR 10.25(3), see compliance review for these standards above in Section 5.1.A

(6) Maintenance dredging for navigational purposes affecting land under the ocean shall be designed and carried out using the best available measures so as to minimize adverse effects on such interests caused by changes in marine productivity which will result from the suspension or transport of pollutants, increases in turbidity, the smothering of bottom organisms, the accumulation of pollutants by organisms, or the destruction of fisheries habitat or wildlife habitat.

Dredging activities along the dock's west berth are categorized as maintenance dredging as it is generally within the dredge envelope of the previously authorized dredge limits, see **Attachment H, Chapter 91 License #5153.** These performance standards mirror those in 310 CMR 10.25(4), see compliance review for these standards above in Section 5.1.A

(7) Projects not included in FWR 10.25(5) or 10.25(6) which affect nearshore areas of land under the ocean shall not cause adverse effects by altering the bottom topography so as to increase storm damage or erosion of coastal beaches, coastal banks, coastal dunes, or salt marshes.

See compliance response to 310 CMR 10.25(5) above in Section 5.1.A.

(8) Projects not included in FWR 10.25(5) or 10.25(6) which affect nearshore areas of land under the ocean shall not cause adverse effects by altering the bottom topography so as to impede navigation for recreational vessels, or by impeding an open line of sight.

Neither the proposed improvement dredging, nor the replacement pile support dock will cause any adverse effects on bottom topography that impede navigation for recreational vessels. Nor will the replacement dock impede an open line of site for recreational craft as compared to existing conditions.

(9) Projects not included in FWR 10.25(5) which affect land under the ocean shall if water-dependent be designed and constructed, using best available measures, so as to minimize adverse effects, and if non-water-dependent, have no adverse effects, on fisheries habitat or wildlife habitat caused by:

(a) Alterations in water circulation;
(b) Alterations in the distribution of sediment grain size;
(c) Changes in water quality, including, but not limited to, other than natural fluctuations in the level of dissolved oxygen, temperature or turbidity, or the addition of pollutants; or
(d) Alterations of shallow submerged lands with high densities of polychaetes, mollusks or macrophytic algae.

The proposed Project is water-dependent and will be designed and constructed using best available measures to yield no significant effects on water circulation or sediment grain size. See compliance response to 310 CMR 10.25(6) above in Section 5.1.A.

(10) Notwithstanding the provisions of FWR 10.25(5) through (9), no project shall be permitted which will have any adverse effect on habitat sites of rare species.

The Project Site is not located with NHESP mapped habitat of rare vertebrate or invertebrate species.

(11) Notwithstanding the provisions of FWR 10.25(5) and (7) through (9), no project shall be permitted which will result in the destruction of eel grass (Zostera marina) or widgeon grass (Ruppia maritima) beds;

Work is proposed within 50 feet of eel grass meadows. An Eelgrass Avoidance and Protection Plan was developed in consultation with the EPA, DMF and Town of Falmouth. Best available measures will be employed to avoid damage to eelgrass habitat and proactive mitigation in the form of conservation mooring conversions is being proposed to compensate for any temporary or permanent alteration of eelgrass that may occur as a result of construction or vessel shading. See **Attachment E, Draft Eelgrass Avoidance and Protection Plan.**

> *(12) Where projects are proposed subject to the provisions of FWR 10.25 (5) and 10.25(6) and the U.S. Army Corps of Engineers dredged material disposal criteria are met, all dredged material must be disposed of so as to be available for transport to adjacent coastal beaches and dunes within the littoral transport system.*

The dredge material will consist of both marine sediments and riprap boulders. All dredge sediments will be transported to an approved upland disposal site or landfill to be determined in consultation with DEP and other permitting agencies. The rip rap boulders will be reused on site.

5.2.B Coastal Bank – FWR 10.30

In accordance with FWR 10.30(4), when a Coastal Bank is determined to be significant to storm damage prevention, flood control, wildlife habitat, or erosion and sedimentation control, FWR 10.30(5) through (11) shall apply.

> *(5) No new bulkhead, revetment, seawall, groin or other coastal engineering structure shall be permitted on such a Coastal Bank except that such a coastal engineering structure shall be permitted when required to prevent storm damage to buildings constructed prior to March 22, 1989, or constructed pursuant to a permit application filed prior to March 22, 1989, including reconstructions of such buildings subsequent to March 22, 1989, provided that the following requirements are met.*
>
> - *(a) A coastal engineering structure or modification thereto shall be designed and constructed so as to minimize, using the best available measures, adverse effects on adjacent or nearby coastal beaches due to changes in wave action.*
> - *(b) The applicant demonstrates that no method of protecting the building other than the proposed coastal engineering structure is feasible (moving the building to an alterative location on the same lot or adjacent lot under the ownership of control of the applicant shall be presumed feasible.); and*
> - *(c) The best available measures utilized to minimize adverse effects on adjacent or nearby coastal beaches due to changes in wave action shall include beach nourishment activities.*

The existing bulkhead at the Site was constructed in the 1960s, authorized by the Chapter 91 License as described in this NOI (refer to **Attachment H** for a copy of this license and license plans). The reconfiguration of the bulkhead at the Eel Pond entrance channel was designed and will be constructed using the best available measures to minimize adverse effects on adjacent coastal resource areas. The Project is water-dependent and there is no alternative location on the same lot or adjacent lot under the control of the Applicant that would be feasible to relocate the NWB or the existing structures. The Project will have no adverse effect on adjacent or nearby coastal beaches due to wave action and no beach nourishment is proposed.

> *(6) Any project on a coastal bank or within one hundred (100) feet landward of the top of a coastal bank, other than a structure permitted by FWR 10.30(5), shall not have an adverse effect due to wave action on the movement of sediment from the coastal bank to coastal beaches or land subject to tidal action.*

The proposed Project is permitted by FWR 10.30(5) and the coastal bank is the existing sheet pile bulkhead, which is a non-eroding man-made structure. Therefore, the Project will not have an adverse effect due to wave action on the movement of sediment from the coastal bank to coastal beaches or land subject to tidal action.

> *(7) Except as permitted under FWR 10.30(5), no project shall be permitted on:*
>
> *(a) An eroding coastal bank;*
> *(b) Any portion of a coastal bank that is within a V-zone;*
> *(c) That portion of a coastal bank with a slope greater or equal to 4:1;*
> *(d) That portion of a coastal bank that is within:*
> *1. One hundred (100) feet of:*
> *a. Land under the ocean;*
> *b. Salt marsh; or*
> *c. Banks of salt ponds, estuaries, and ponds, and streams which flow throughout the year; or*
> *2. Seventy-five (75) feet of:*
> *a. Land subject to tidal action;*
> *b. Freshwater wetlands; or*
> *c. Banks of intermittent streams.*
> *3. Notwithstanding the provisions of FWR 10.30(7)(d), activities listed in FWR 10.18(9) and FWR 10.18(10) may be permitted in the areas described in FWR 10.30(7)(d) provided that all other provisions of FWR 10.30 are met.*

The Project is to be permitted under FWR 10.30(5); therefore, this standard does not apply.

> *(8) The permit and the Certificate of Compliance for any new building within one hundred (100) feet landward of the top of a coastal bank permitted by the Commission under Chapter 235 of the Code of Falmouth shall contain the specific condition: FWR 10.30(5), promulgated under Chapter 235 of the Code of Falmouth, requires that no coastal engineering structure, such as a bulkhead, revetment, or seawall shall be permitted on an eroding bank at any time in the future to protect the project allowed by this permit.*

The on-site coastal bank is the existing sheet pile bulkhead, it is not an eroding coastal bank, therefore this standard is not applicable.

(9) Any project on such a coastal bank or within one hundred (100) feet landward of the top of such coastal bank shall have no adverse effect on the stability of the coastal bank.

The Coastal Bank at the Site is the bulkhead and portions of which are proposed to be reconfigured to accommodate the CWATER Project. The proposed work on and within 100 feet of the Coastal Bank have been designed to have no adverse effects its stability. The new bulkhead to be installed in front of the existing bulkhead is proposed to provide long-term stabilization.

(10) Notwithstanding the provisions of FWR 10.30(5) through (8), protective planting designed to reduce erosion may be permitted.

This standard is not applicable as the coastal bank is a man-made sheet pile bulkhead.

(11) Notwithstanding the provisions of FWR 10.30(5) through (10), no project may be permitted which will have any adverse effect on habitat of rare species.

The Project Site is not located with NHESP mapped habitat of rare vertebrate or invertebrate species.

5.2.C Land Containing Shellfish – FWR 10.34

The Falmouth Wetland Regulations at FWR 10.34(5) state "When a resource area, including rocky intertidal shores, salt marshes, land under the ocean, coastal beaches, land under salt ponds is determined to be significant to the protection of shellfish and therefore to the protection of recreation and the protection of fisheries, FWR 10.34(6) through (8) shall apply.

(6) Any project on land containing shellfish shall not adversely affect any portion of such land or marine fisheries by a change in the productivity of such land caused by:

- *(a) Alterations of water circulation.*
- *(b) Alterations in relief elevation,*
- *(c) The compacting of sediment by vehicular traffic,*
- *(d) Alterations in the distribution of sediment grain size,*
- *(e) Alterations in natural drainage from adjacent land, or*
- *(f) Changes in water quality, including, but not limited to, other than natural fluctuations in the levels of salinity, dissolved oxygen, nutrients, temperature or turbidity, or the addition of pollutants.*

These standards mirror the State regulations at 310 CMR 10.34(4). See response to Section 5.1.C. above.

(7) Notwithstanding FWR 10.34(6) and 10.34(7), projects approved by DMF that are specifically intended to increase the productivity of land containing shellfish may be permitted.

The Project is not specifically intended to increase the productivity of land containing shellfish; therefore, this standard does not apply.

(8) Notwithstanding the provisions of FWR 10.35(6) and (7), no project may be permitted which will have any adverse effect on habitat sites of rare species.

The Project Site is not located with NHESP mapped habitat of rare vertebrate or invertebrate species.

5.2.D Land Subject to Coastal Storm Flowage – FWR 10.38

The Falmouth Wetland Regulations at FWR 10.38(4) provide the general performance standards for Land Subject to Coastal Storm Flowage. Compliance with these applicable performance standards is provided below.

(4) General Performance Standards

(a) When the Commission determines that land subject to coastal storm flowage (AE, AO, and/or VE zones) overlays other resource areas listed in FWR 10.00, the applicable performance standards for each resource area shall be independently and collectively applied and the project shall be appropriately conditions to protect all stated resource area values.

Project compliance with the applicable performance standards for each locally protected resource area is provided in this NOI in Section 5.2.

(b) When land subject to coastal storm flowage (AE, AO and/or VE zones) is significant to the resource area values of flood control and storm damage prevention, the following performance standards shall apply:

1. *Any activity shall not have an adverse effect by increasing the elevation or velocity of floodwaters or by increasing flows due to a change in drainage or flowage characteristics (e.g., change in direction) on the subject site, adjacent properties, or any public or private way.*

    a. *Relative sea level rise and the landward migration of resource areas in response to relative sea level rise shall be incorporated into the design and construction of structures and other activities proposed in land subject to coastal storm flowage.*

    b. *At a minimum, for activities proposed in AE-Zones, the historic rate of relative sea level rise in Massachusetts of one foot per 100 years shall be incorporated into the project design and construction.*

    c. *At a minimum, for activities proposed in the VE-zone, a two-foot elevation per 100 years shall be incorporated into the project design and construction.*

    d. *Any activity within the ten-year floodplain of land subject to coastal storm flowage shall not have an adverse effect by impeding the landward migration of other resource areas within this area of the floodplain.*

The CWATER Project will not result in a vertical or horizontal increase in flooding, nor will it increase flood velocities. The NWB is located landward of the existing FEMA mapped VE zone and it will be further inboard from the edge of the dock as compared to existing on-site buildings. As described above in Section 4.1.2, the raised dock will lower the AE Zone elevation from el. 12 feet NAVD88 to el. 11 feet NAVD and shift the VE Zone to the edge to raised dock. See **Attachment L, WHG Flood Analysis Study**.

The landward portions of the site are confined by a sheet pile bulkhead which prevent landward migration of resource areas in response to relative sea level rise. The NWB was designed to accommodate sea level rise by establishing the floor of the lowest functionally dependent level to match the raised dock elevation of 9 feet NAVD88 (2.5 feet above existing elevation) and designing the building and dock to accommodate an additional 1.5 feet of rise to elevation 10.5 feet NAVD88 in the future as needed. The lowest level of the NWB is functionally dependent on the dock and therefor it needs to be at the same elevation as the dock. All other levels are greater than two feet above the base flood elevation. See **Attachment B, Figure 7 – Site Elevation Cross Section.**

(c) When an A-zone that is hydraulically constricted is significant to the interests of flood control or storm damage prevention, the following additional performance standards shall apply:

1. *A proposed activity, shall not result in flood damage due to filling which causes lateral displacement of floodwaters that, in the judgement of the Commission, would otherwise be confined within said area; unless,*
2. *Compensatory storage is provided for all flood storage volume that will be lost as a result of a proposed project within this area when, in the judgement of the Commission, said loss will cause an increase or contribute incrementally to an increase in the horizontal extent and level of floodwaters.*

Not applicable, the AE Zone is not hydraulically constricted. In the future built condition, the higher dock elevation will serve a more effective vertical buffer to wave action. Modeling of the future conditions shows that the AE-Zone elevation, which extends across the site will be reduced by one foot to el. 11 feet NAVD88 and the VE-Zone boundary will follow along the edge of the dock. See **Attachment L, WHG Flood Analysis Study**.

(d) A proposed project within a Velocity zone shall not destroy or otherwise impair the function of any portion of said landform and/or shall not have an adverse effect on adjacent wetland resource areas. Activities and their ancillary uses in Velocity zones which result in alterations to vegetative cover, interruptions in the supply of sediment to other wetland resources, and/or changes to the form or volume of a dune or beach will have an adverse effect on said landform's ability to provide storm damage prevention and flood control and are, therefore, prohibited. These activities include, but are not limited to:

Construction of

1. *New structures, including buildings, sheds and garages, and additions or substantial improvements to existing structures;*
2. *Foundations other than open pilings or columns;*
3. *New or proposed expansions of roads, driveways or parking lots, or impermeable paving for existing unpaved roads, driveways or parking lots;*
4. *New or proposed expansions of coastal engineering structures;*
5. *New septic systems.*

The NWB will be relocated landward of the existing Federal Emergency Management Agency ("FEMA") mapped VE-Zone (velocity zone) boundary. However, due to site constraints, it cannot be sited greater than 25-feet from the FEMA mapped VE-Zone. Since the FWR presumes the VE-Zone boundary is 25 feet landward of the FEMA mapped boundary relief from regulation **FWR 10.38(4)(d)** is therefore requested to allow construction of the NWB within 25 feet of the existing FEMA mapped VE-Zone, refer to **Attachment F, Variance Request**.

(e) *Notwithstanding the provisions of FWR 10.38(4)(a) through (d), the Commission may permit the following activities provided that the Applicant demonstrates, the satisfaction of the Commission, that best available measures are utilized to minimize adverse effects on all critical characteristics of land subject to coastal storm flowage, and provided that all other performance standards in FWR are met:*

1. *Beach, dune and bank nourishment and restoration projects, including fencing and other devises designed to increase dune development and plantings compatible with natural vegetative cover;*
2. *Boat launching facilities used in the service of public and navigational aids;*
3. *Improvements necessary to maintain the structural integrity/stability of existing coastal engineering structures;*
4. *A project which will restore, rehabilitate or create a salt marsh or freshwater wetland;*
5. *Projects that are approved in writing, or conducted by the Division of Marine Fisheries that are specifically intended to increase the productivity of land containing shellfish, or to maintain or enhance fisheries;*
6. *Projects that are approved, in writing, or conducted by the Division of Marine Fisheries that are specifically intended to enhance or increase wildlife habitat.*

Not appliable. The Project is not a nourishment or restoration project, nor does it include boat launching facilities used in service of public and navigational aids. The Project does not include the restoration, rehabilitation or creation of salt marsh or freshwater wetland. Lastly, the Project is not intended to increase the productivity of land containing shellfish, or to enhance or increase wildlife habitat.

The Project will provide improvements necessary to maintain the structural integrity and stability of existing coastal engineering structures and the best available measures will be employed to minimize adverse effects on all critical characteristics of Land Subject to Coastal Storm Flowage.

(f) Notwithstanding the provisions of FWR 10.38(4)(a) through (e), the Commission may approve small additions to an existing structure provided:

1. *All other provisions of FWR are met;*
2. *The structure is not in any resource area other than land subject to coastal storm flowage;*
3. *The structure is not in an area subject to FWR 10.18 Resource Area Buffer and*
4. *The cumulative size of addition(s) to the structure since (effective date) does not exceed 200 square feet.*

This standard is not applicable as no small additions to an existing structure is proposed.

(g) Notwithstanding the provisions of FWR 10.38(4)(a) through (f), no project may be permitted which will have any adverse effect on habitat sites of rare species.

The Project Site is not located with NHESP mapped habitat of rare vertebrate or invertebrate species.

5.2.E Rare Species – FWR 10.19

The Falmouth Wetland Regulations at FWR 10.19 provide the general performance standard for the protection of rare species. Compliance with this performance standard is provided below.

(4) No project shall be permitted which will have an adverse effect on habitat sites of rare species.

The Project Site is not located with NHESP mapped habitat of rare vertebrate or invertebrate species. **See Figure 5 – Environmental Resource Map**.

5.2.F Specific Activities Regulated – FWR 10.16

FWR 10.16 establishes standards for activities in certain areas that are subject to conditions by the Commission. The applicable activities and compliance are provided below.

(1) Coastal Docks and Piers

(c) Design Specifications and Performance Standards for Commercial Harbors:

1. *Docks and piers shall be constructed in proportion to vessel(s) that the dock or pier will serve. No dock may be constructed of a length that interferes with the recreational interests protected under the bylaw.*

The Project was designed to accommodate both the current and future anticipated uses of the Institution. The in-kind and in-place replacement dock provides berths for WHOI's two larger research vessels: the 238-foot RV Neil Armstrong and 273-foot RV Atlantis II as well as the 60-foot RV Tioga and other smaller vessels and will not change the overall dimension of the existing dock and thus will not interfere with recreational interests protected by the bylaw.

2. *To keep disturbance of the bottom minimal at all times during both construction and use, the water depth at the end of the dock shall be a minimum of four feet at the time of mean low water or three feet greater than the draft of vessels served by the dock or pier, whichever is the greatest depth.*

The water depths along the west side of the existing dock range from under 10 feet MLLW at the northwest corner to almost 70 feet MLLW at the seaward end. Proposed in this Project is the dredging of the west berth to an approximate depth of 22 feet MLLW.

3. *The landward approach to a dock shall not harm vegetation on a coastal wetland, freshwater wetland or coastal bank.*

Not Applicable. There is no vegetation on the existing dock.

4. *Except for floating portions of a dock, the decking surface shall not reduce ambient lighting, i.e., sunlight, by more than 50 percent.*

The proposed in-kind replacement dock will not reduce the ambient lighting greater than that of the current dock.

(h) General Requirements and Prohibitions all Docks and Piers:

1. *No new docks or piers or extension of an existing dock or pier may be constructed in any portion of FEMA designated velocity zone (V-Zone) unless the applicant demonstrates that there will be public benefit from the project. The Commission shall weigh the potential likelihood of damage and harm that any such dock or pier would cause during a storm event with the public benefit demonstrated by the applicant in determining whether the project should be allowed.*

The CWATER Project will serve as the new public face of the Institution. Public visitor space has been incorporated into the Project design, along with other publicly accessible and usable spaces such as an event and exhibit space. Public interactive spaced extends outside the NWB through purpose-built publicly accessible open space near the building entrance. These open space systems will welcome the public onto the Site from Water Street and provide views to the working waterfront and will provide an invitation to public and highlight WHOI's educational mission.

2. *No new dock or pier shall be allowed if, within 25 feet of the area designated by the applicant as the mooring field, designated as an Area A in FWR 10.34(4)(d), there are significant quantities of shellfish as defined by FWR 10.34(3) and the area has been historically used for shellfishing or has the potential for shellfishing, and the sediment provides a viable shellfish habitat.*

There is no mooring field within 25 of the area. No work is proposed within suitable shellfish habitat as mapped by DMF. Eel pond and a segment of the entrance channel is mapped by DMF as suitable shellfish habitat, however shell fishing in this area is prohibited. Based on the independent benthic survey conducted in June 2020, very low numbers of shellfish were collected adjacent to the Site.

> *3. If, within the area designated as Area B, as in FWR 10.34(4)(d) sampled for shellfish under FWR 10.34(4) there are significant quantities of shellfish as defined by FWR 10.34(3) or the area has been historically used for shellfishing or has the potential for shellfishing, or the sediment provides a viable shellfish habitat, the applicant shell provide a shellfish mitigation plan.*

The area adjacent to the Site has been mapped by DMF as suitable shellfish habitat, however shell fishing in this area is prohibited. Based on the independent benthic survey conducted in June 2020 very low numbers of shellfish were collected adjacent to the Site.

4. *The Commission shall presume that there are significant quantities of shellfish in any area actively shellfished within the previous six months of the shellfish survey.*

Shell fishing in the area adjacent to the Site is prohibited. Therefore, this standard does not apply.

5. *No new, replacement, or substantial alteration of an existing dock or pier shall be permitted within 50 feet of an area of eel grass (Zostera marina).*

The Project cannot meet the performance standards under FWR 10.16(1)(h)5., therefore a variance request is required, refer to **Attachment F, Variance Request.** The inability to meet compliance is the result of the proposed dock replacement and minor alignment modifications will require installing marine infrastructure within fifty (50) feet of eelgrass beds located within the Eel Pond entrance channel and in shallow water adjacent to the west edge of the dock.

6. *No CCA-treated materials may be used to construct a dock or pier.*

No CCA-treated materials are proposed to be used to construct the dock.

7. *For singular purpose of ownership docks, any floating section of a dock or pier shall have a minimum water depth of three feet under all portions of that floating section of the dock or pier including times of extreme low water. This depth shall be measured as the shortest distance from any portion of the bottom of the floating section to the seabed.*

The water depths along the west side of the existing dock range from under 10 feet MLLW at the northwest corner to almost 70 feet MLLW at the seaward end.

6.0 Conclusions

The information contained in this NOI, the accompanying permit drawings, and other supporting documentation describes the site, proposed work, and compliance with state and local Regulations. The proposed work will contribute to the protection of the interests of the Act and Bylaw by complying with the applicable performance standards. As discussed, a variance is requested for siting the NWB within 25 feet of the FEMA mapped VE Zone [**FWR 10.38(4)(d)]** as well as construction of docks and re-construction and re-alignment of the bulkhead within 50 feet of eelgrass [**FWR 10.16(1)(h)(5)**]. The Applicants therefore respectfully request the Commission approve the variance request and issue an Order of Conditions approving the CWATER Project with pragmatic conditions to protect those interests identified in M.G.L. c. 131, §40 and the Falmouth Wetlands Protection Bylaw.

Attachment B

Figures

G:\Projects2\MA\Falmouth\5660\MXD\USGS.mxd

Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

Woods Hole Oceanographic Institution, CWATER Project **Falmouth, Massachusetts**

WOODS HOLE OCEANOGRAPHIC INSTITUTION | CWATER Ocean Exploration Starts Here

Figure 1

USGS Locus Map

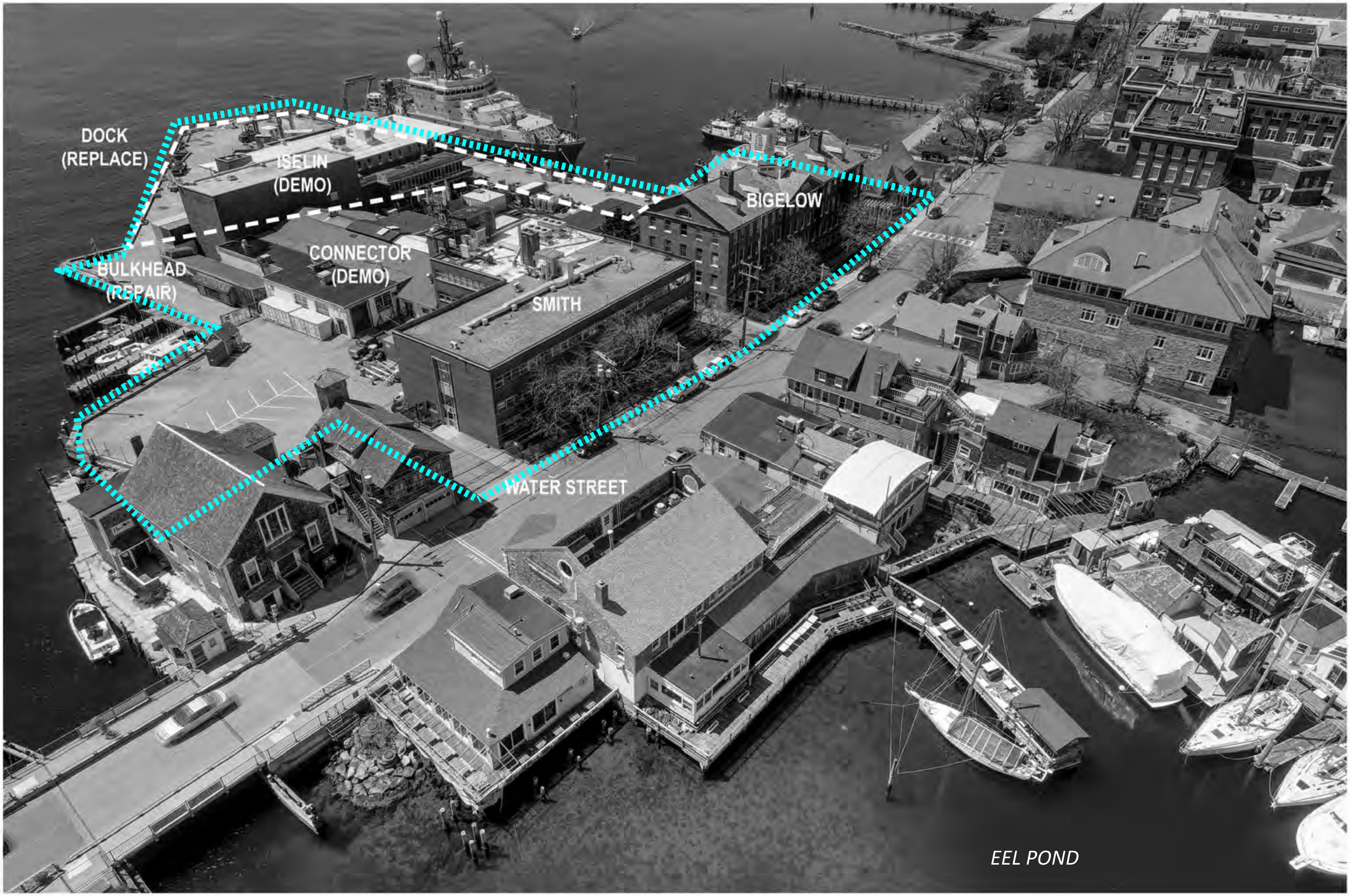
Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

Woods Hole Oceanographic Institution, CWATER Project **Falmouth, Massachusetts**

WOODS HOLE OCEANOGRAPHIC INSTITUTION | CWATER Ocean Exploration Starts Here

Figure 2

Aerial Locus Map

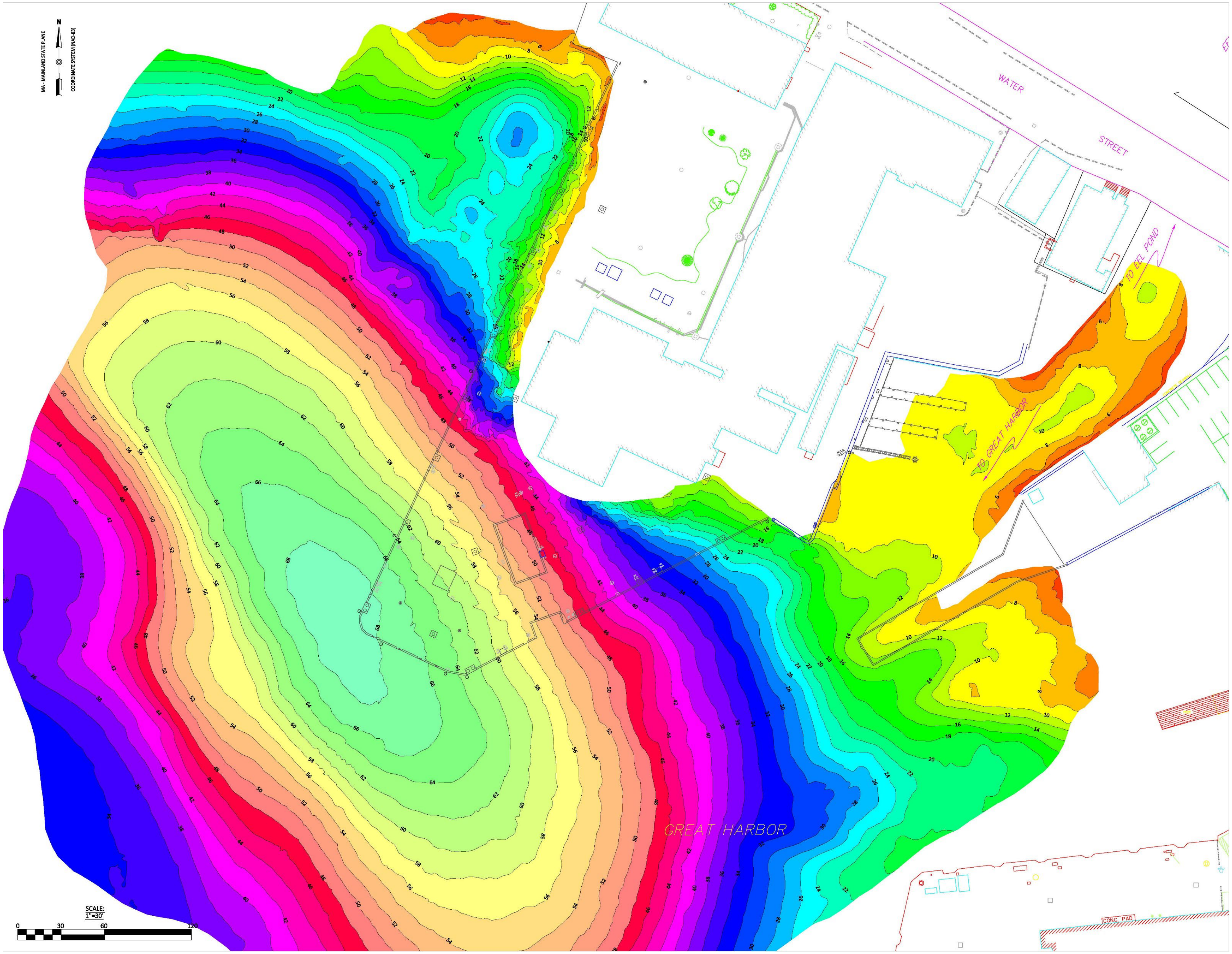


Woods Hole Oceanographic Institution, CWATER Project   Falmouth, Massachusetts

WOODS HOLE OCEANOGRAPHIC INSTITUTION | CWATER Ocean Exploration Starts Here

Figure 3

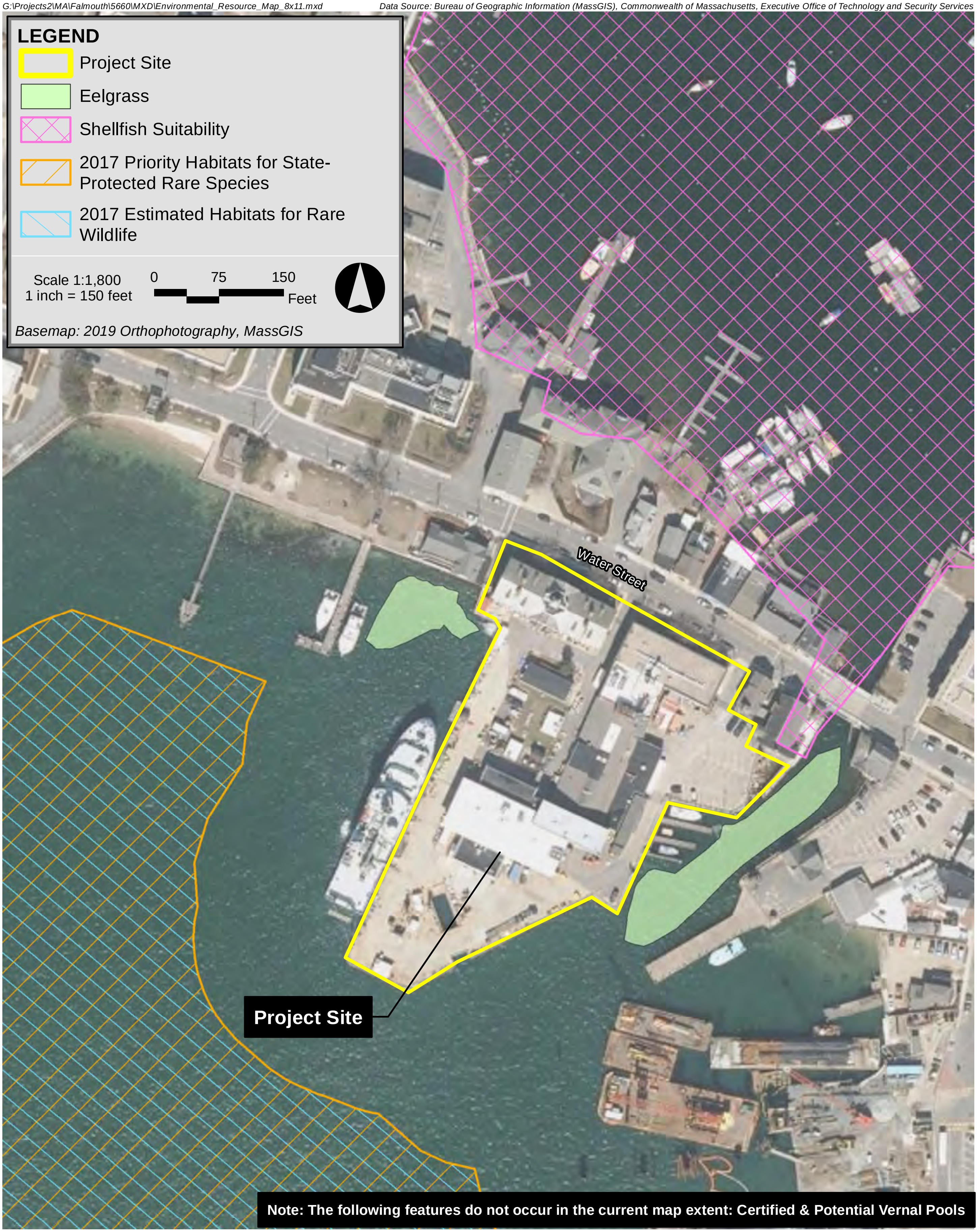
Iselin Marine Facility – Site Orientation



Source: Waterfront Structural Consulting, 2018

Figure 4

Site Bathymetry



Woods Hole Oceanographic Institution, CWATER Project **Falmouth, Massachusetts**

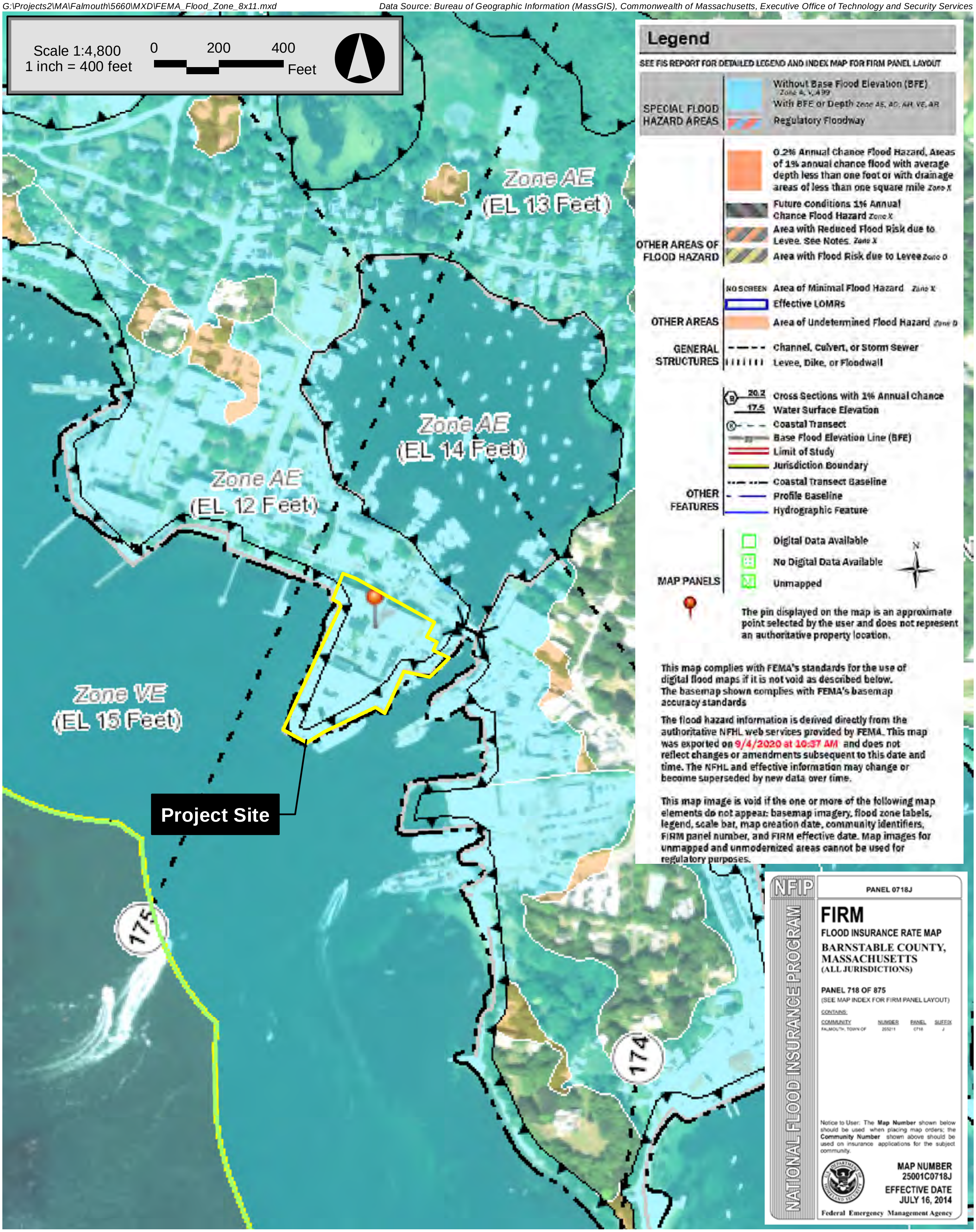
WOODS HOLE OCEANOGRAPHIC INSTITUTION | CWATER Ocean Exploration Starts Here

Figure 5

Environmental Resource Map

G:\Projects2\MA\Falmouth\5660\MXD\FEMA_Flood_Zone_8x11.mxd

Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services



Woods Hole Oceanographic Institution, CWATER Project Falmouth, Massachusetts

WOODS HOLE OCEANOGRAPHIC INSTITUTION

CWATER Ocean Exploration Starts Here

Figure 6

FEMA Flood Map (Panel 25001C0718J)

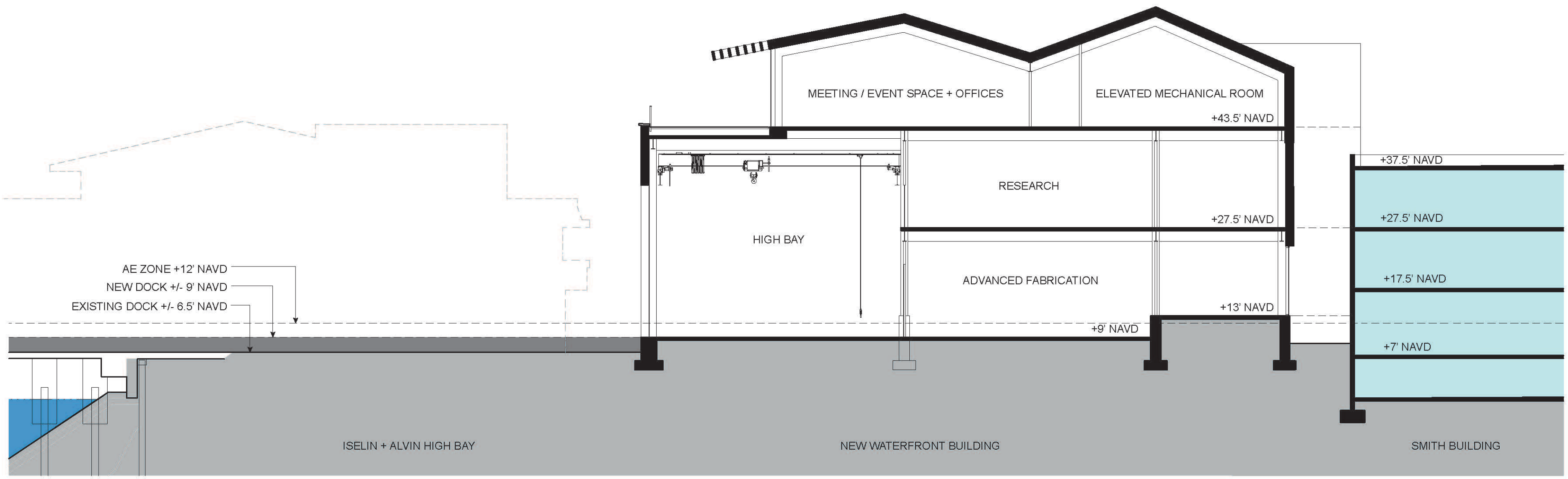
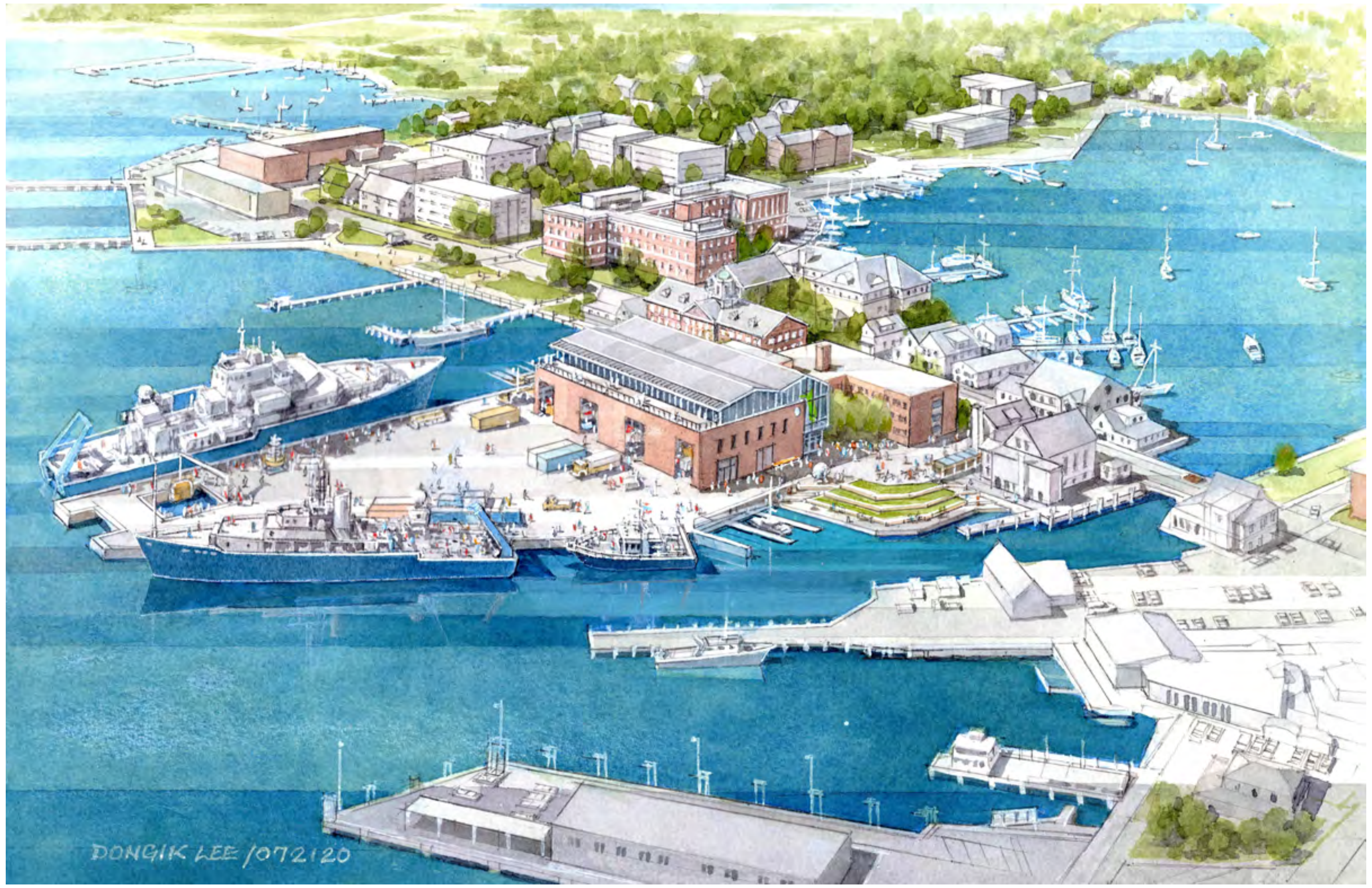


Figure 7

Site Elevation Cross Section

Proposed Streetscape with sidewalk improvements including benches fencing, pavers, and groundcovers

Illustration of new publicly accessible waterfront park, main entry and terrace garden.



Woods Hole Oceanographic Institution, CWATER Project   Falmouth, Massachusetts

Figure 9

Conceptual Architectural Renderings

Attachment C

Representative Site Photography


BIGELOW BLDG
SMITH BLDG
SMITH CONNECTOR
ALVIN HIGH BAY
Eel Pond
ISELIN BLDG
SMALL BOAT SLIPS
EAST BERTH
WEST BERTH
TEST WELL
ISELIN DOCK
Great Harbor

Photograph 1 – An overhead drone view from the southwest

Photograph 2 – A view landward showing the northwest edge of Iselin Dock near the West Berth. The building in the foreground is the Iselin Building and the Bigelow Building is in the background.

Photograph 3 – A water level view of the northwest edge of Iselin Dock taken from the West Berth. The buildings visible are the Bigelow Building (left), Smith Building (top center), and the Iselin Building (right).

Photograph 4 – Test well located in the southern part Iselin Dock near the East Berth.

Photograph 5 – A view seaward showing the southeast edge of Iselin Dock.

Photograph 6 – A view of the Iselin Dock near the southeast corner of the Iselin Building and the Eel Pond Channel.

Photograph 7 – A view showing configuration of small boat slips with wave deflector in foreground near the Eel Pond Channel.

Attachment D

Benthic Habitat Survey Report

EELGRASS, SHELLFISH, AND BENTHIC SURVEYS
June 30 – July 1, 2020

WHOI CWATER Iselin Dock Modernization
Woods Hole, MA

Dense eelgrass observed in the Eel Pond Channel east of the WHOI Iselin Dock

Prepared By:

CR Environmental, Inc.
639 Boxberry Hill Road
East Falmouth, MA 02536

Prepared For:

Epsilon Associates
3 Mill & Main Place
Maynard, MA 01754

August 2020

TABLE OF CONTENTS

TABLES

FIGURES

PLATES

APPENDICES

1.0 INTRODUCTION

On June 30 and July 1, 2020, CR Environmental, Inc. (CR) conducted an eelgrass survey, shellfish survey, and benthic grab sampling for chemistry, physical properties and benthic community analysis for Epsilon Associates in support of permitting for the Woods Hole Oceanographic Institution (WHOI) Iselin Dock modernization in the village of Woods Hole, Falmouth, Massachusetts. Work is part of the proposed Complex for Waterfront Access to Exploration and Research (CWATER) which includes replacement of the existing dock infrastructure, and the dockside research laboratory buildings. WHOI's dive operations team identified eelgrass at the northern ends of the western and eastern extents of the dock during the Iselin Dock Feasibility Study (Moffatt & Nichol, May 24, 2018). CR's June 2020 surveys to map out the extent of eelgrass consisted of a combination of single beam echo sounding with precision navigation and underwater video.

2.0 METHODS

2.1 Vessel and Navigation

Vessel operations were performed from CR's 26-foot custom built aluminum landing craft style vessel, R/V *Lophius.* The vessel has a large enclosed pilothouse, benches for survey equipment, over-the-side transducer boom, stern mounted davit and hauler, bow mounted A-frame and hydraulic winch. Dockage for R/V *Lophius* was provided at one of the slips on the east side of the WHOI Iselin Dock. The WHOI ships R/V *Neil Armstrong* and R/V *Tioga* were out of port during the survey and sampling operations.

Navigation for the bathymetric portion of the survey was accomplished using a Hemisphere VS330 Real-time Kinematic Global Positioning System (RTK GPS) mounted directly above the transducer. The horizontal accuracy of the navigation system is approximately 1 centimeter horizontally and 2 centimeters vertically (Root Mean Squared 1-sigma). Horizontal accuracy in differential or float mode is approximately 1 foot. RTK corrections were provided via NTRIP internet connection by KeyNet GPS, Inc.

The RTK GPS was serially interfaced to a shipboard computer running HYPACK 2015 hydrographic surveying software. This system calculated X and Y positions in the desired grid system (MA State Plane, NAD83, US Foot), recorded the water depth, navigation data, and provided a steering display for the vessel captain. The progress of the survey and sampling operations was followed in HYPACK using georeferenced imagery (e.g. orthophotos) as a background file ensuring the entire survey area was adequately insonified, and samples were collected at the designated positions.

Navigation for the video and shellfish portion of the survey was accomplished using a Hemisphere VS104 GPS with built in heading. The horizontal accuracy of the navigation system is approximately 1 foot horizontally. Offset measurements were applied to the navigation system so that coordinates recorded were directly below the A-frame.

2.2 Bathymetric Methods

Single beam bathymetric soundings were taken to map the presence of eelgrass in the vicinity of the Iselin Dock on June 30, 2019. Bathymetric soundings covered waters adjacent to the bulkhead from the entrance to Eel Pond, out around the southern end of the Iselin Dock, and along the western side (Figure 1).

Bathymetric data were acquired using a Teledyne Odom Hydrographic Echotrac CV-100 single (vertical) beam echo sounder (VBES) equipped with an 8-degree 200-kHz transducer. Approximately 10 to 15 survey lines with 10-foot spacing were occupied around the pier. In shallower portions of the survey area, additional survey lines were added to create an approximately 5-foot line spacing once the echo sounder display indicated potential submerged aquatic vegetation (SAV) i.e. the rooted, vascular plant eelgrass (Figure 1).

Processing of the single beam echo sounder data consisted of the removal of outlying data points associated with water column interference (e.g., fish, debris). Data cleaning was guided by detailed inspection of profile echograms for each line file. Portions of data files without signatures associated with SAV were deleted, yielding a database indicating SAV presence. These SAV points were plotted in GIS and used to digitize a shapefile depicting the extent of the SAV.

2.3 Underwater Video Methods

Underwater video was taken in the afternoon of June 30, 2020 to ground truth the SAV boundary derived from the echo sounder data, and confirm the presence of eelgrass. Video also provided photographic documentation of eelgrass density, plant health, bottom substrate, and biota. A total of nine video transects (CW-1, -2, -3, -4, -5, -6, -8, -9 and -10) from 3 to 6 minutes in duration were occupied along the WHOI Iselin Dock (Figure 2). CW-7 along the west side of the dock was terminated when the video grab system became entangled in a mooring line from the Ryan Marine Vessel, R/V *Discovery*.

Underwater video data were collected with CR's video grab system, consisting of a stainless steel 0.1 m^2 Van-Veen grab sampler, stabilization fin, Outland Technologies' high-definition color camera, and two wide-angle LED video lights with variable output control. The video camera was cabled to an OTI-1080 HD DVR recorder and high resolution daylight monitor at the surface. The video grab was raised and lowered using the bow mounted A-frame, and the height of the system off the bottom was continually adjusted to achieve the best bottom coverage and video quality. When the video camera was one foot off the bottom, the viewing area of the camera was approximately 1.5 feet x 1.5 feet (18 inches x 18 inches), and the video quality was optimal for bottom sediment characterizations and biota identifications.

The underwater video data were reviewed by a marine biologist at the CR office, and the presence or absence of eelgrass was noted, as well as, the bottom substrate and biota. Representative underwater video screen captures were created for the nine video transects.

2.4 Sediment Benthic Sampling and Shellfish Collection Methods

2.4.1 Benthic Community Sampling Methods

Four sediment grab samples (CWB-1C, CWB-2C, CWB-3C and CWB-4C) for benthic infauna analysis were collected at stations designated by Epsilon on June 30, 2020 adjacent to the WHOI Iselin Dock using a Ted Young modified Van Veen 0.04 m^2 sediment grab sampler (Figure 3). Two were taken on the eastern side of the dock, and two on the western side. The samples were sieved in the field through a 500 µm sieve and preserved in a 10% formalin solution of formaldehyde and seawater. The samples were delivered to Ocean's Taxonomic Services where they were transferred to ethanol with a rose bengal stain to facilitate the sorting process. Ocean's Taxonomic Services performed the sorting, identifications, and enumeration of the organisms.

2.4.2 Sediment Grab Sampling Methods for Chemistry and Sediment Physical Properties

Sediment grabs (CWS-1, CWS-2B, CWS-3, and CWS-4) were collected on June 30, 2020 using a 0.1m^2 modified Van Veen grab sampler for sediment chemistry (volatiles, semivolatiles, petroleum hydrocarbons, metals), total organic carbon (TOC) and grain size at the four benthic sampling stations (Figure 3). The sediment samples were transferred to the Epsilon representative aboard the vessel, and subsequently to Alpha Analytical Laboratory, Mansfield, MA. The grain size data are discussed in relation to the infauna results, however, the sediment chemistry data is discussed elsewhere.

2.4.3 Shellfish Collection Methods

A shellfish survey was performed on July 1, 2020 at 32 stations using a 0.1 m^2 Ted Young modified Van Veen grab (Figure 4). Sampling station positions were provided by Epsilon. Following collection the sediment grabs were washed through a quarter inch screen and species identifications and measurements performed onboard by CR personnel prior to returning all biota to the seabed. Underwater video data were obtained of the seabed prior to the collection of each shellfish grab. Grabs had to be moved slightly in a few instances to avoid live eelgrass.

3.0 RESULTS

3.1 Bathymetric and Submerged Aquatic Vegetation Results

Examination of the single beam trackline echograms indicated SAV in the entrance channel to Eel Pond and in the shallower depths along the west side of the Iselin Dock. The echograms showed a distinct acoustic signature indicating dense stands of SAV rising above the seabed (Figure 5). The total area of SAV was estimated to be approximately 20,717 square feet (14,936 square feet on the eastern side of the Iselin Dock and 5,781 square feet on the western side of the dock). The SAV square footage was estimated by drawing a shape file in ArcGIS around the tracklines where SAV was present (Figure 6).

3.2 Underwater Video Eelgrass Ground Truth Results

Underwater video data confirmed that the SAV mapped by the single beam echosounder throughout the survey area was eelgrass (*Zostera marina*). Eelgrass was growing in a moderate to dense meadow in the Eel Pond channel, and the shallow survey areas at the northwestern extent of the Iselin Dock between the R/V *Tioga* berth and the R/V *Discovery* on the MBL dock. Underwater video screen captures of the eelgrass video data are presented in Plates 1 through 9.

On the eastern side of the dock, moderate to dense eelgrass was observed on video transects CW-2 and CW-3 in the Eel Pond channel from south of the Eel Pond bridge to the southern end of Dyers Dock to a depth of approximately 15 feet mean low water (MLW) (Figure 2). Dense eelgrass was also observed at the northern end of transects CW-1 and CW-4 in the Eel Pond channel. No eelgrass was observed at the start of CW-1 in one of the slips most likely due to shading from boats.

On the western side of the Iselin dock, dense eelgrass was observed on the northern half of transects CW-5, CW-6, and CW-8. Dense eelgrass was observed only at the northern end of transect CW-9. The remainder of CW-9 which ran approximately parallel to the western side of the Iselin Dock had a coarser bottom substrate of predominantly sand and gravel. Eelgrass was moderate to dense along CW-10 except at the southern end near the bow of R/V Discovery in deeper water.

The two eelgrass meadows were relatively dense with a plant height ranging from 2 to 5 feet (Figure 5). Plants were generally free of epiphytic algae and bryozoans and appeared in good health. Water column visibility was clear, and limited macro algae were present. Macro algae observed included kelp, rockweed, sea lettuce, and branching red algae.

A predominantly sandy bottom substrate was present in the shallow waters where the eelgrass was observed (Plate 5, CW-5B). In the deeper water adjacent to the dock more variable bottom types were observed including: small boulders, cobbles, gravel, sand with shell hash, and sandy mud, (Plates CW-9 and CW-10)

Very few macro invertebrates and fish species were observed during the video survey. They included horseshoe crab, (*Limulus polyphemus),* Forbes sea star (*Asterias forbesi),* summer flounder (*Paralichthys dentatus),* tautog (*Tautoga onitis*), cunner (*Tautogolabrus adspersus).*
A few other fish were observed but could not be identified.

3.3 Sediment Grab Sampling Results

Grab sampling locations are shown on Figure 3 for chemistry sediment properties and benthic enumeration and Figure 4 for the shellfish survey. Sample station coordinates are provided in Table 1.

3.3.1 Shellfish Survey Results

Only two commercial species, quahogs and Atlantic razor clam were collected at the 32 grab stations and in very low numbers, 5 and 1 respectively (Table 2). Other bivalve species collected included Morton's egg cockle, Northern dwarf tellin, Atlantic awning clam, file yoldia, and common cockle. The overall low numbers of bivalves present within the sampling area could be attributed to the deeper water depths and gravelly bottom observed at several stations, and the rafts of decaying dead eelgrass and macro algae on the western side of the dock that may be reducing oxygen levels in the sediments. Decaying eelgrass was also observed at two of the stations in the boat slip on the east side of the dock possibly due to shading from the boats. Images of the bottom substrate from screen captures of the underwater video footage taken prior to grab sampling are provided on Plates 10 – 17.

Photographs of the grab samples following sieving showing the bivalves present and the gravel and shell hash within several of the samples are provided on Plates 18 – 31.

3.3.2 Benthic Infauna and Grain Size Results

The four benthic samples yielded a total of 2,367 individuals. Of the 2,367 individuals, 2,348 were identified to the species level. There were 61 unique species identified and 4 categorized as juveniles (19 individuals) (Appendix A). Of the major groups, polychaetes were dominant comprising 72.8% of the total number of individuals (1,723/ 2,367), followed by another annelid, the oligochaetes with 16.1% (382/ 2,367), and crustaceans with 8.1% (191/2367). The remaining major groups represented included mollusks with 54 individuals (2.3%), nemertea with 16 individuals (0.7%) and a single anemone (Figure 7).

The most abundant individual species found were the Capitellid polychaete, *Mediomastus ambiseta*, with a total of 925 individuals, 826 of which were found in one sample (CWB-1C) off the northwestern extent of the dock, followed by another Capitellid *Capitella capitata* with 222 individuals, and the oligochaete Tubificoides sp. 1 (188 individuals) (Table 3). Only three species were found at all four stations: *M. ambiseta*, the amphipod *Ericthonius rubricornis*, and the gastropod *Astyris lunata*. The top ten most abundant species by station are shown in Table 4. Either capitellids or oligochaetes dominated each station, though Station CWB-4C is a mix of both as is shown by the shading in Table 4.

Abundance by major group for each station is found on Figure 8. Station CWB-1C is very skewed by the extremely dominant polychaete *M. ambiseta*. Polychaetes dominated at all stations, but stations CWB-2C, -3C and -4C were a better mix of organisms from all or most major groups.

Abundance varied in the four stations, with abundance relatively high in stations CWB-1C (1007 individuals) and CWB-4C (823 individuals), and considerably lower at CWB-2C (174 individuals) and CWB-3C (363 individuals). However, the number of species was consistent with Station CWB-1C at 32 species, CWB-2C at 31, and CWB-3C and CWB-4C at 29 species each.

Stations CWB-1C and CWB-2C had <10% fine materials, CWB-3C had 20% and CWB-4C had 38% fines (Alpha Analytical, 2020 - Appendix B). Stations CWB-1C and CWB-2C were 63.3% and 47.0% gravel and coarse sand combined respectively, while CWB-3C had only 8.4% and CWB-4C had 7.1% coarse material. This may account for the difference in dominant species type, Capitellid polychaete versus Oligochaeta, though all stations except for CWB-1C had a mix of both in the top 10 dominants (Table 3). All infauna data are presented in Appendix A.

4.0 DISCUSSION

Detailed review of the June 30, 2020 single beam bathymetric survey data and underwater video documented eelgrass beds ranging from 2 to 5 feet in height along the northern extent of the eastern and western sides of the Iselin Dock (Figures 1 and 6). The eelgrass was generally free of epiphytic algae and bryozoans, and appeared to be in good condition. The estimated areal coverage by the eelgrass beds was 20,717 square feet. At depths greater than about 15 feet eelgrass was absent.

Despite 32 grabs taken to characterize shellfish abundance very few were observed. Only two commercial species, quahogs and Atlantic razor clams, were collected and they had low abundance. The other 5 non-commercial species of bivalve had similarly low abundances. Only 27 individual bivalves were observed in the 32 shellfish grabs, five quahogs, one razor clam, and the remaining individuals were non-commercial species. The low numbers of shellfish could be the result of deeper water depths, the gravelly substrate, and decaying dead eelgrass and macro algae observed at several of the sampling stations.

Benthic infauna analysis identified 61 unique species and a total of 2,367 individuals in the four samples collected near the Iselin Dock. Of the 2,367 individuals, 72.8% were polychaetes followed by 16.1% oligochaetes. The remaining groups (crustaceans, mollusks, and nemertea) comprised about 11% of the individuals. Capitellids and tubificid oligochaetes are typically indicators of organic enrichment and hypoxic conditions which is not surprising given the amount of decomposing macro algae and eelgrass that was observed in the shellfish grabs.

TABLES

TABLE 1

Benthic, Shellfish, Grain Size and Chemistry Sediment Grab Coordinates

Station Name	Grab Type	Easting (X)	Northing (Y)	Date-time
CWB-1C	Benthic	882944.4	2652859.2	6/30/2020 12:51
CWB-2C	Benthic	882930.0	2652828.3	6/30/2020 13:31
CWB-3C	Benthic	883153.9	2652602.8	6/30/2020 14:08
CWB-4C	Benthic	883176.1	2652638.1	6/30/2020 14:32
CWS-1	Chemistry/Grain size	882947.4	2652855.2	6/30/2020 12:42
CWS-2B	Chemistry/Grain size	882927.9	2652826.4	6/30/2020 13:22
CWS-3	Chemistry/Grain size	883153.2	2652606.4	6/30/2020 13:59
CWS-4	Chemistry/Grain size	883176.5	2652638.1	6/30/2020 14:25
G-1	Shellfish	882936.0	2652847.9	7/1/2020 8:12
G-2	Shellfish	882918.7	2652859.3	7/1/2020 8:21
G-3	Shellfish	882899.0	2652866.6	7/1/2020 8:29
G-4	Shellfish	882932.6	2652840.4	7/1/2020 8:38
G-5	Shellfish	882915.9	2652849.3	7/1/2020 8:46
G-6	Shellfish	882897.1	2652858.3	7/1/2020 8:55
G-7	Shellfish	882929.2	2652832.0	7/1/2020 9:02
G-8	Shellfish	882911.2	2652839.6	7/1/2020 9:11
G-9B	Shellfish	882892.4	2652848.3	7/1/2020 9:23
G-10	Shellfish	882924.3	2652822.0	7/1/2020 9:33
G-11	Shellfish	882907.2	2652829.3	7/1/2020 9:41
G-12	Shellfish	882888.8	2652839.0	7/1/2020 9:48
G-13B	Shellfish	882916.3	2652814.6	7/1/2020 9:59
G-14	Shellfish	882902.0	2652821.2	7/1/2020 10:20
G-15	Shellfish	882882.6	2652830.5	7/1/2020 10:30
G-16C	Shellfish	882915.8	2652803.6	7/1/2020 10:53
G-17B	Shellfish	882894.3	2652813.4	7/1/2020 11:06
G-18	Shellfish	882880.0	2652821.8	7/1/2020 11:17
G-19	Shellfish	882910.6	2652794.6	7/1/2020 11:35
G-20	Shellfish	882892.2	2652805.0	7/1/2020 11:48
G-21	Shellfish	882874.8	2652812.8	7/1/2020 11:56
G-22	Shellfish	882905.0	2652785.5	7/1/2020 12:04
G-23	Shellfish	882890.0	2652795.6	7/1/2020 12:12
G-24C	Shellfish	882866.9	2652805.2	7/1/2020 12:24
G-25	Shellfish	883171.3	2652640.0	7/1/2020 13:12
G-26	Shellfish	883189.3	2652635.6	7/1/2020 13:20
G-27	Shellfish	883207.5	2652624.7	7/1/2020 13:27
G-28	Shellfish	883230.0	2652613.7	7/1/2020 13:39
G-29	Shellfish	883174.4	2652597.1	7/1/2020 13:49
G-30	Shellfish	883153.3	2652603.2	7/1/2020 13:56
G-31	Shellfish	883131.7	2652546.3	7/1/2020 14:02
G-32	Shellfish	883155.8	2652568.7	7/1/2020 14:08

TABLE 2

Shellfish Survey - WHOI Iselin Dock, July 1, 2020

	Northern Dwarf Tellin	Atlantic Awning Clam	Quahog	Atlantic Razor Clam	Morton's Egg Cockle	Common Cockle	File Yoldia
	Ameritella agilis	Solemyidae sp. (likely *Solemya velum*)	*Mercenaria mercenaria*	*Siliqua costata*	*Laevicardium mortoni*	*Cerastoderma edule*	*Yoldia limatula*
TOTAL	**6**	**4**	**5**	**1**	**7**	**1**	**3**
Grab-1			*1*		*1*		
Grab-2							
Grab-3							
Grab-4							
Grab-5			*1*				
Grab-6							
Grab-7							
Grab-8							
Grab-9B							
Grab-10			*1*				
Grab-11							
Grab-12							
Grab-13B							
Grab-14					*1*		
Grab-15	*5*	*2*		*1*	*1*		*1*
Grab-16C		*1*					
Grab-17B							*1*
Grab-18							
Grab-19		*1*			*2*		*1*
Grab-20							
Grab-21							
Grab-22					*2*		
Grab-23							
Grab-24C	*1*						
Grab-25			*1*				
Grab-26							
Grab-27						*1*	
Grab-28							
Grab-29							
Grab-30							
Grab-31			*1*				
Grab-32							

TABLE 3

Top Ten Dominant Species by Station from Benthic Infauna Samples (collected June 30, 2020)

Species	CWB-1C	Species	CWB-2C	Species	CWB-3C	Species	CWB-4C
Mediomastus ambiseta	826	*Capitella capitata*	34	*Limnodriloides* sp. 1	70	*Tubificoides* sp. 1	173
Polydora cornuta	36	*Exogene verugera*	20	*Tubificoides intermedius*	56	*Capitella capitata*	169
Ampelisca abdita	29	*Naidinae spp. juv*	16	*Polydora cornuta*	45	*Cheatozone setosa*	156
Scoletoma tenuis	16	*Tubificoides apectinatus*	15	*Mediomastus ambiseta*	32	*Ampelisca abdita*	82
Exogene verugera	16	*Ericthonius rubricornis*	13	*Polycirrus eximius*	20	*Mediomastus ambiseta*	59
Sphaerosyllis taylori	13	*Ampharete arctica*	9	*Capitella capitata*	19	*Oxydromus obscurus*	34
Carinomella lactea	9	*Prionospio heterobranchia*	8	*Ericthonius rubricornis*	19	*Polycirrus eximius*	32
Clymenella zonalis	8	*Mediomastus ambiseta*	8	*Tubificoides* sp. 1	15	*Polydora cornuta*	25
Ericthonius rubricornis	7	*Limnodriloides* sp. 1	7	*Ampharete arctica*	15	*Cylichnella oryza*	18
Glycera americana	5	*Amphiporus angulatus*	5	*Prionospio heterobranchia*	11	*Leucon americanus*	17
Eumida sanguinea							
Polycirrus eximius							

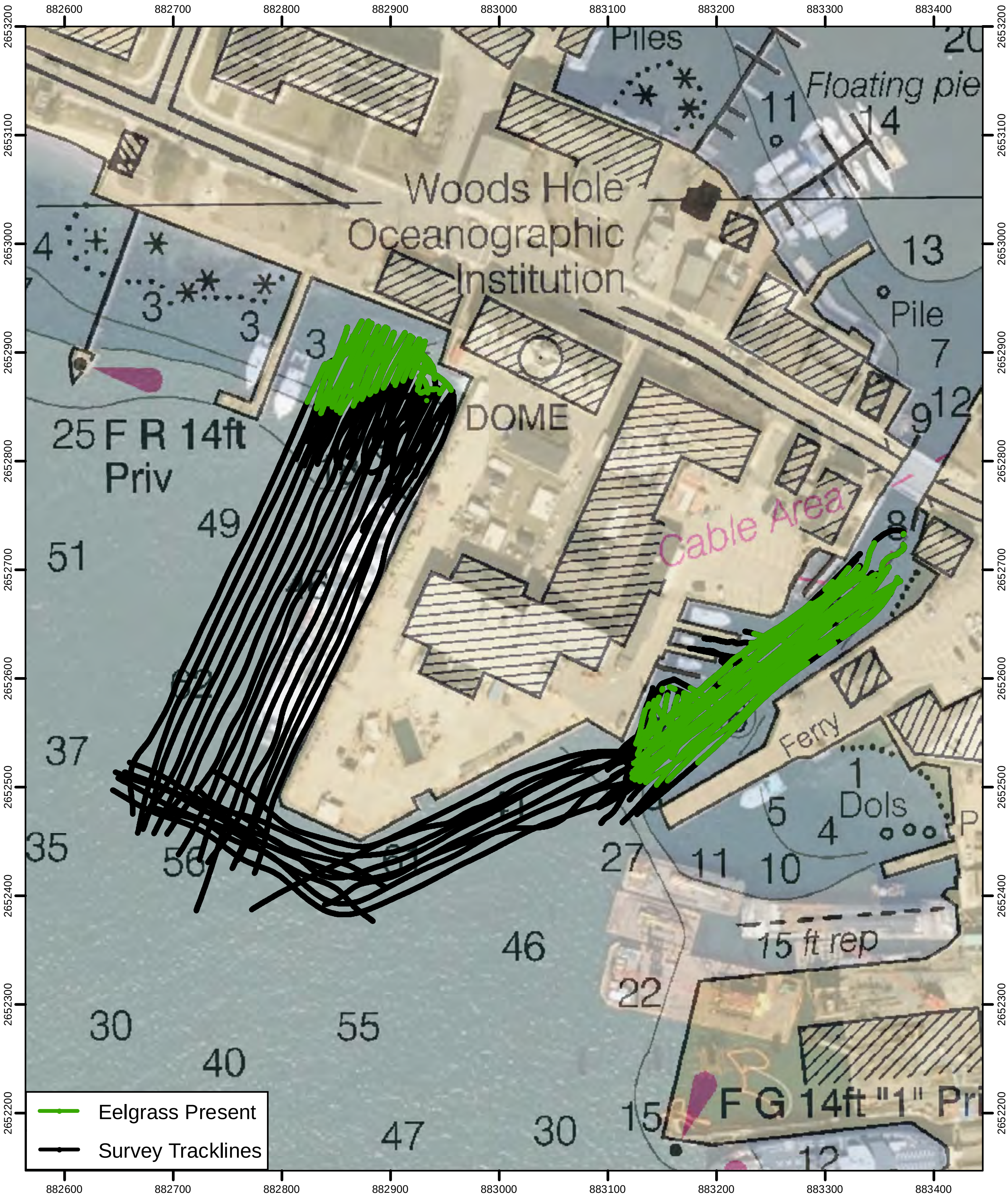
Notes: Blue shading indicates dominant species of Capitellid polychaetes, red shading indicates dominant species of Oligochaeta. Reference Figure 3 for grab station locations.

TABLE 4

Top 10 Overall Dominant Species Found in Benthic Infauna Samples (collected June 30, 2020)

Species	Total
Mediomastus ambiseta	925
Capitella capitata	222
Tubificoides sp. 1	188
Cheatozone setosa	162
Ampelisca abdita	111
Polydora cornuta	106
Limnodriloides sp. 1	88
Tubificoides intermedius	62
Polycirrus eximius	57
Oxydromus obscurus	44

FIGURES



www.crenvironmental.com

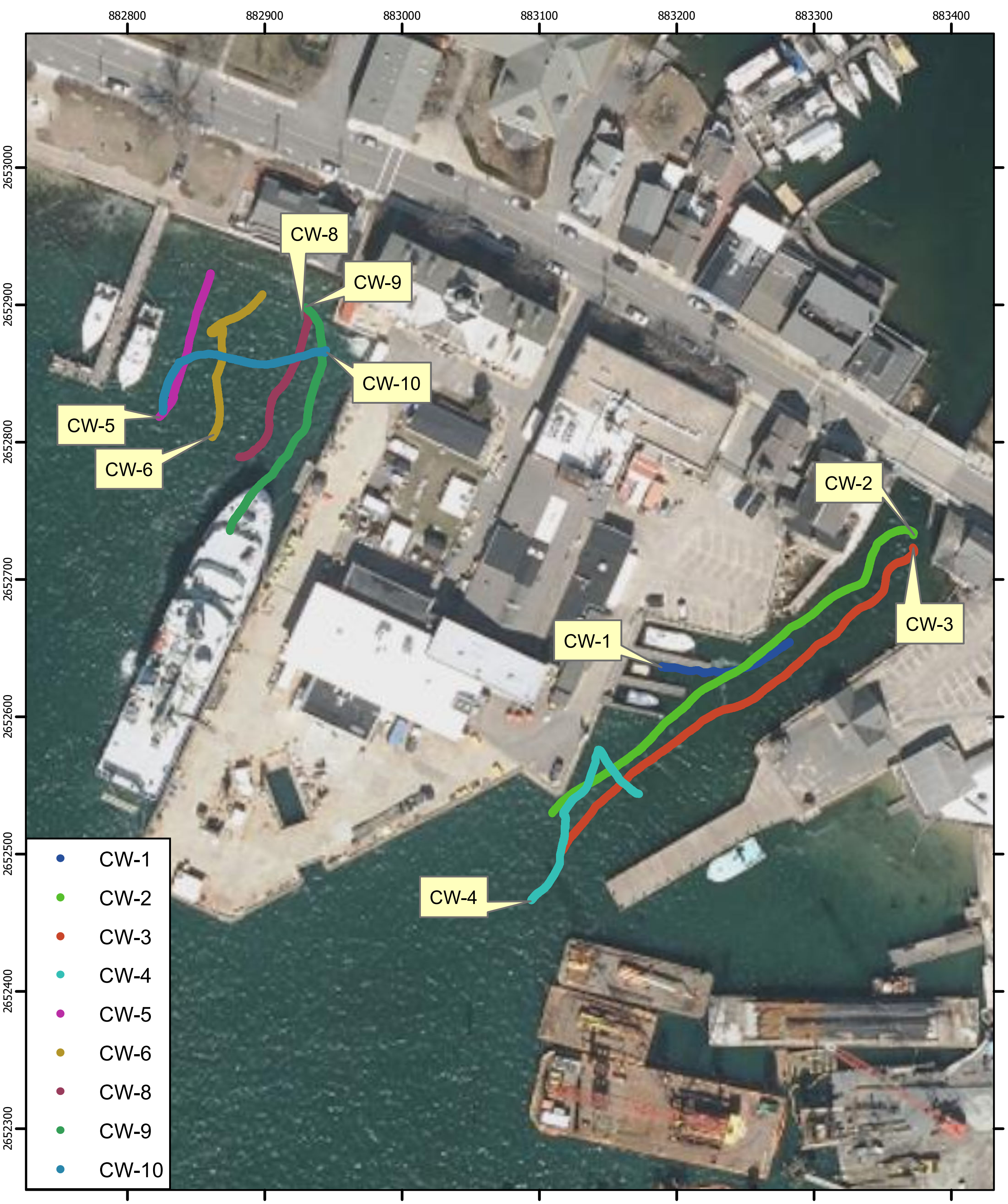
BATHYMETRIC TRACKLINES AND
EELGRASS DISTRIBUTION
Woods Hole, Massachusetts

N
W E
S

NOTES:
1) Survey conducted June 30, 2020.
2) Grid MA State Plane,Mainland, NAD 83, US Foot.

Feet
0 50 100

Figure 1



www.crenvironmental.com

UNDERWATER VIDEO TRANSECTS
Woods Hole, Massachusetts

NOTES:
1) Survey conducted June 30, 2020.
2) Grid MA State Plane,Mainland, NAD 83, US Foot.
3) Transects labeled at beginning of video recording.

Feet
0 50 100

Figure 2

www.crenvironmental.com

BENTHIC/CHEMISTRY GRABS
Woods Hole, Massachusetts

NOTES:
1) Samples collected June 30, 2020.
2) Grid MA State Plane,Mainland, NAD 83, US Foot.

Feet
0 25 50

N W E S

Figure 3

www.crenvironmental.com

SHELLFISH GRAB SAMPLE LOCATIONS
Woods Hole, Massachusetts

NOTES:
1) Samples collected July 1, 2020.
2) Grid MA State Plane,Mainland, NAD 83, US Foot.

Feet
0 25 50

N W E S

Figure 4

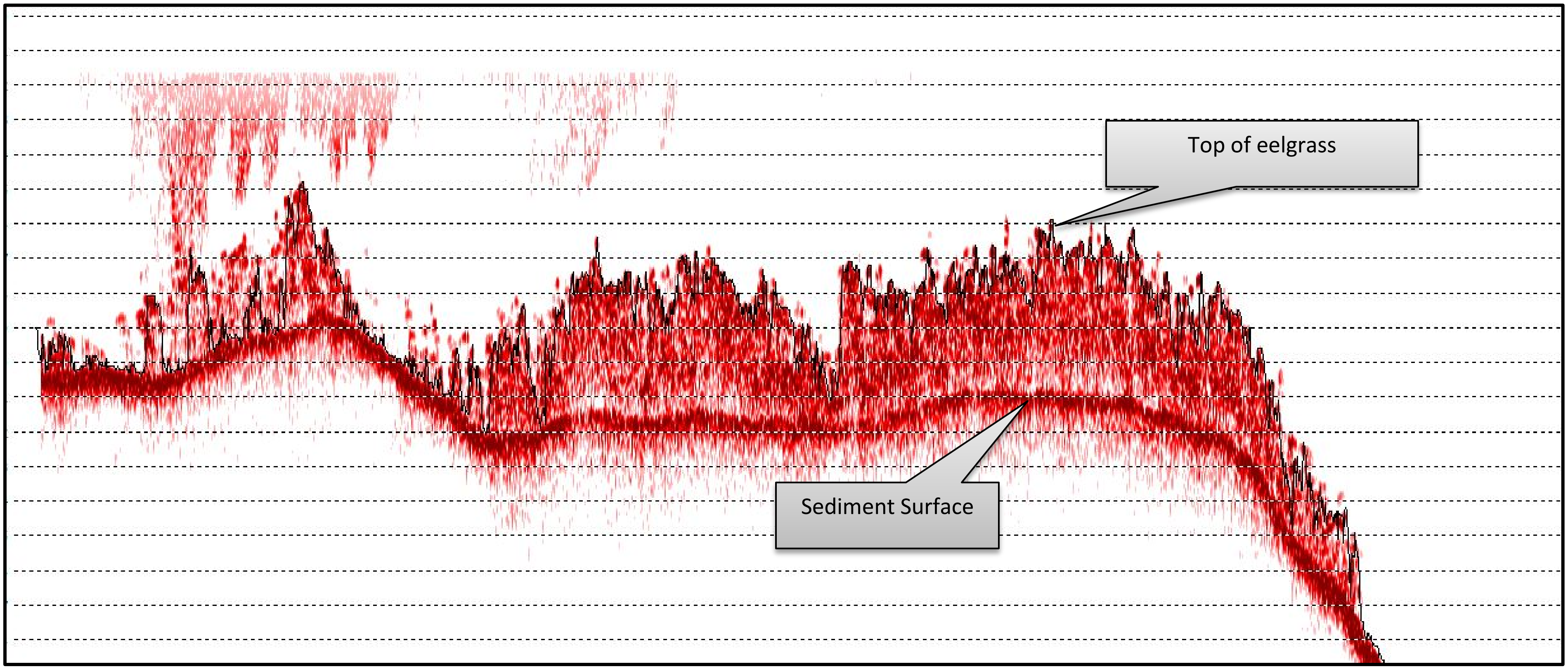
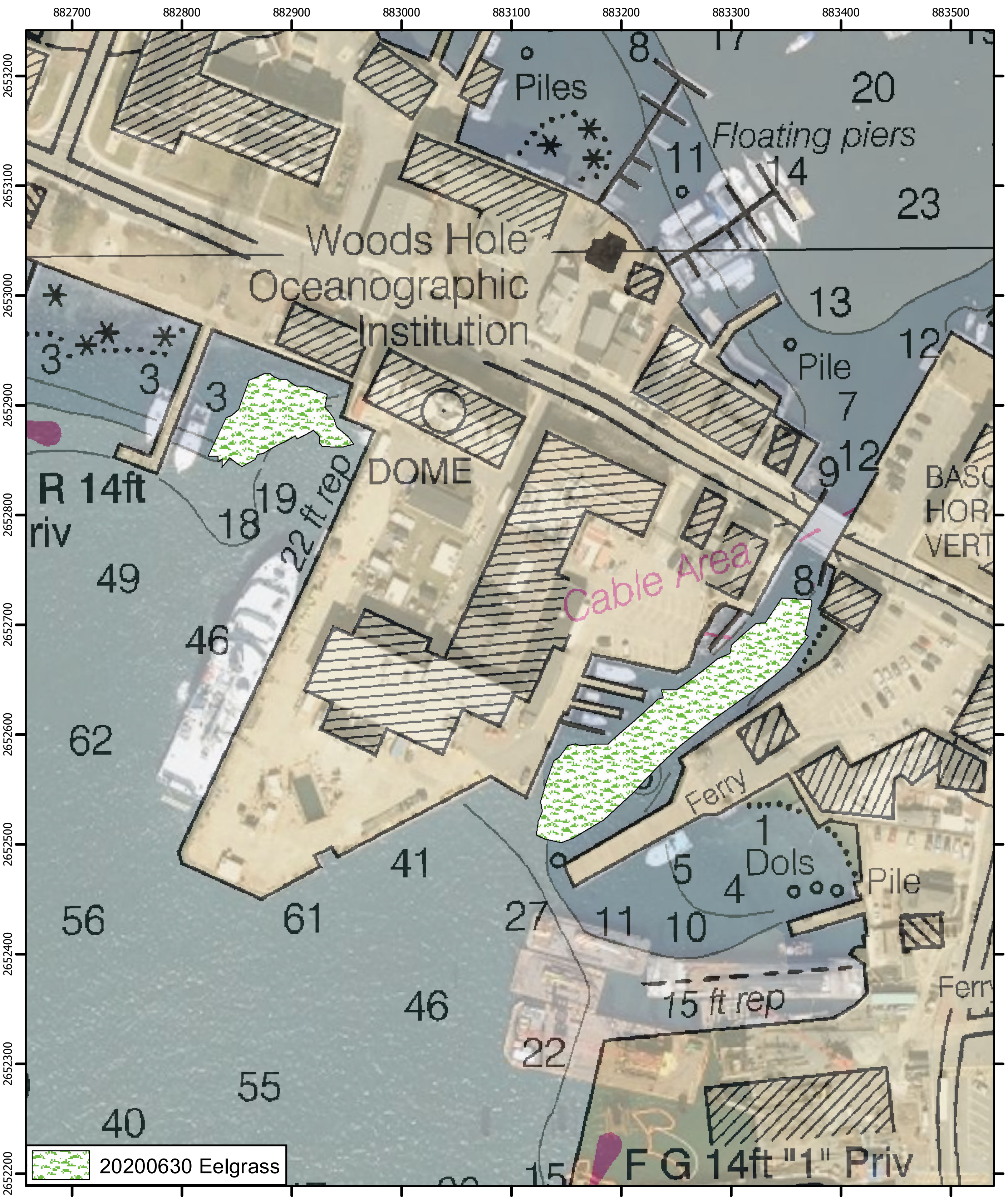


FIGURE 5 Echogram Showing Eelgrass Height above the Sediment Surface

(Dashed horizontal lines are one-foot increments)



www.crenvironmental.com

EELGRASS DISTRIBUTION ESTIMATED
USING SINGLE-BEAM SONAR
Woods Hole, Massachusetts

NOTES:
1) Survey conducted June 30, 2020.
2) Grid MA State Plane,Mainland, NAD 83, US Foot.

Feet
0 50 100

Figure 6

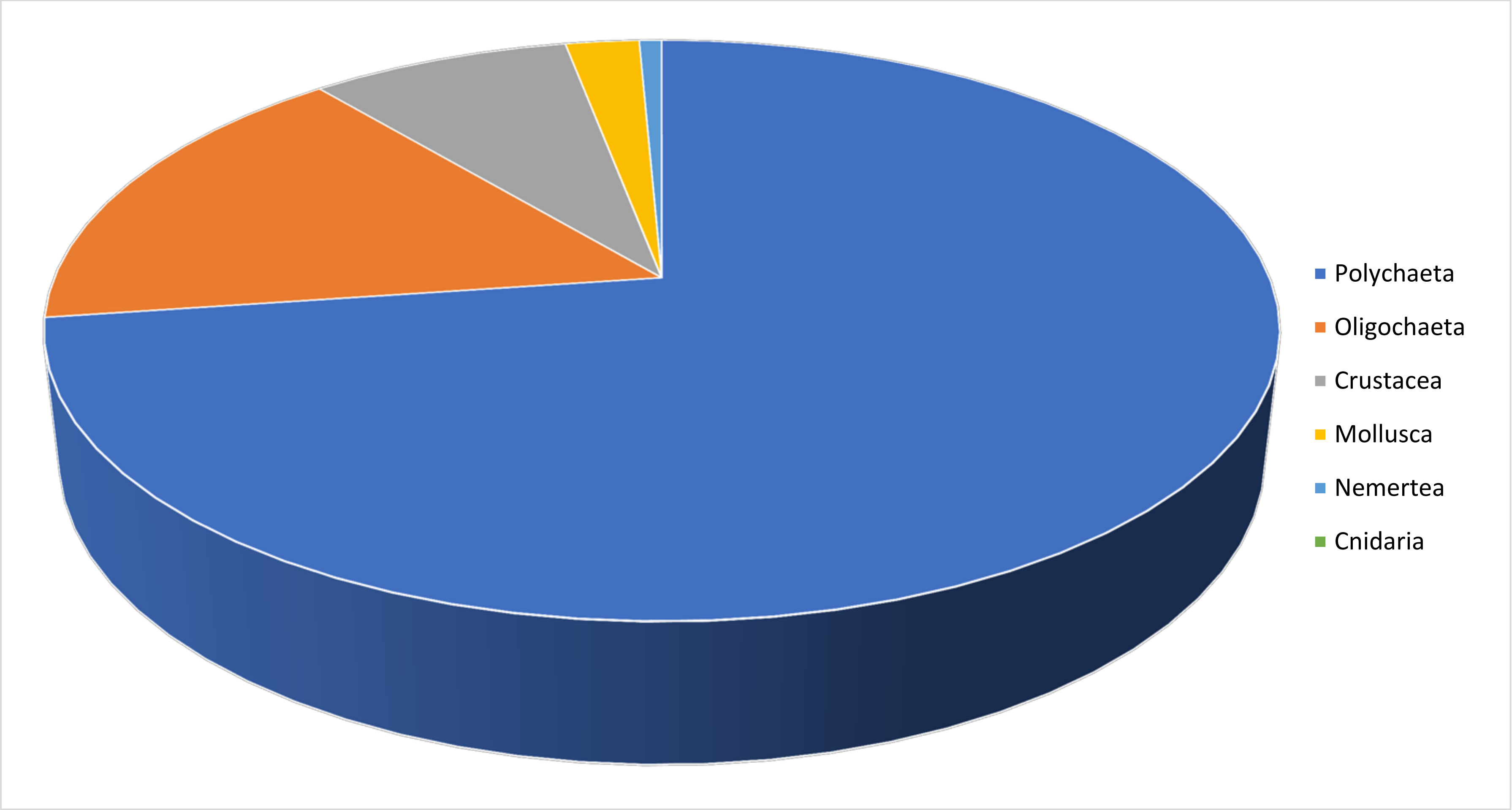


FIGURE 7 Percentage of Total Number of Individuals by Major Group

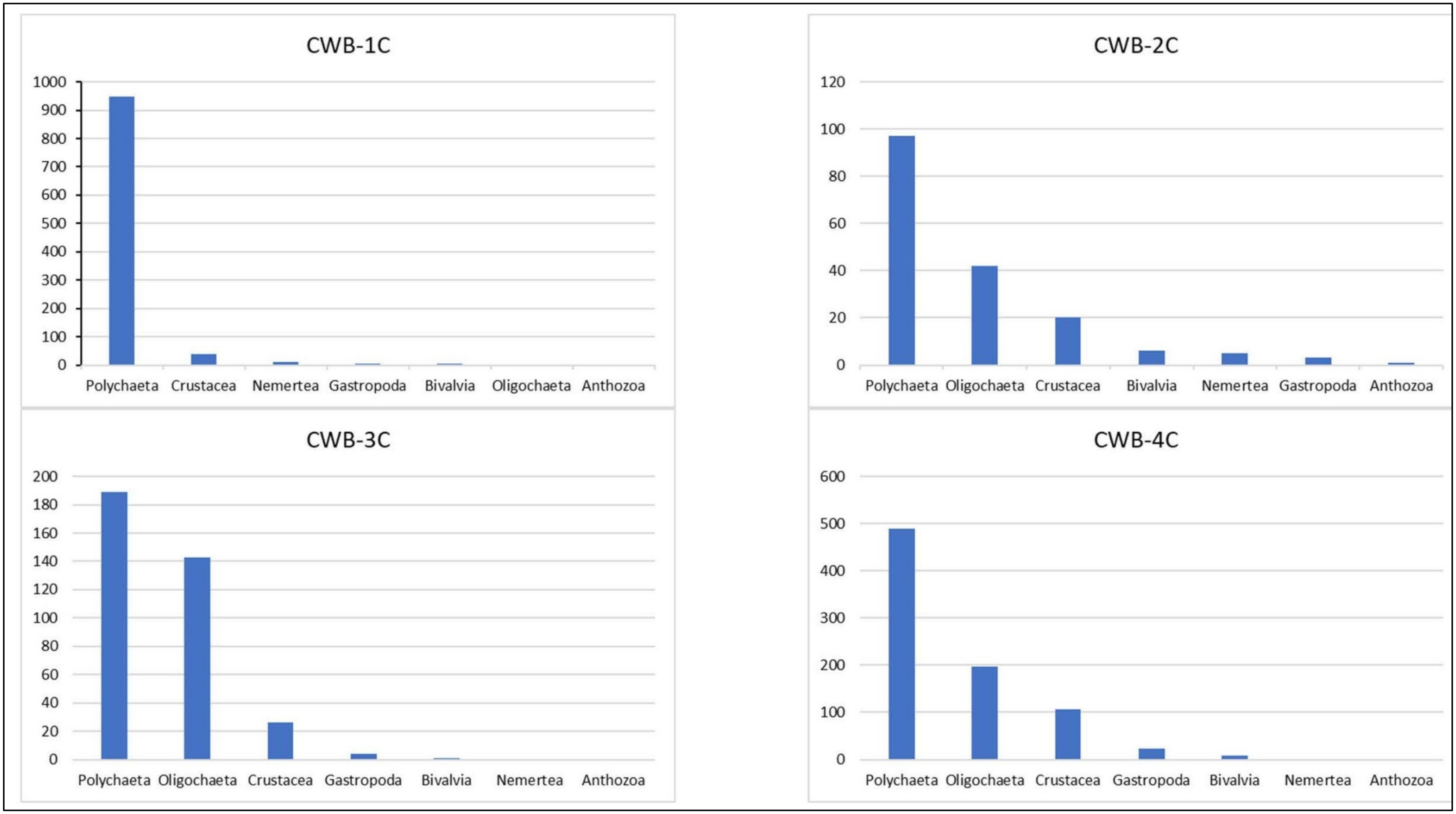


FIGURE 8 Abundance by Major Group for Each of the Four Benthic Grab Stations

PLATES

Video Screen Captures to Document the Presence of Eelgrass

Video Screen Captures of Bottom Substrate, Macro Algae and Biota at Grab Sample Stations

Photographs of Sieved Shellfish Grabs and Infauna

UNDERWATER VIDEO SCREEN CAPTURES

TO DOCUMENT THE PRESENCE OF EELGRASS

(Transects CW-1, CW-2, CW-3, CW-4, CW-5, CW-6, CW-8, CW-9, CW-10)

CW-1A Horseshoe crab, macroalgae on sandy silt bottom at the middle slip on the eastern side of the Iselin Dock

CW-1B Dense eelgrass with patchy sand in the Eel Pond channel

CW-1C Dense elgrass with large patch of sand at the northern end of transect

Plate 1 Transect CW- 1 underwater video screen captures

CW-2A Start of dense eelgrass near the Eel Pond bridge

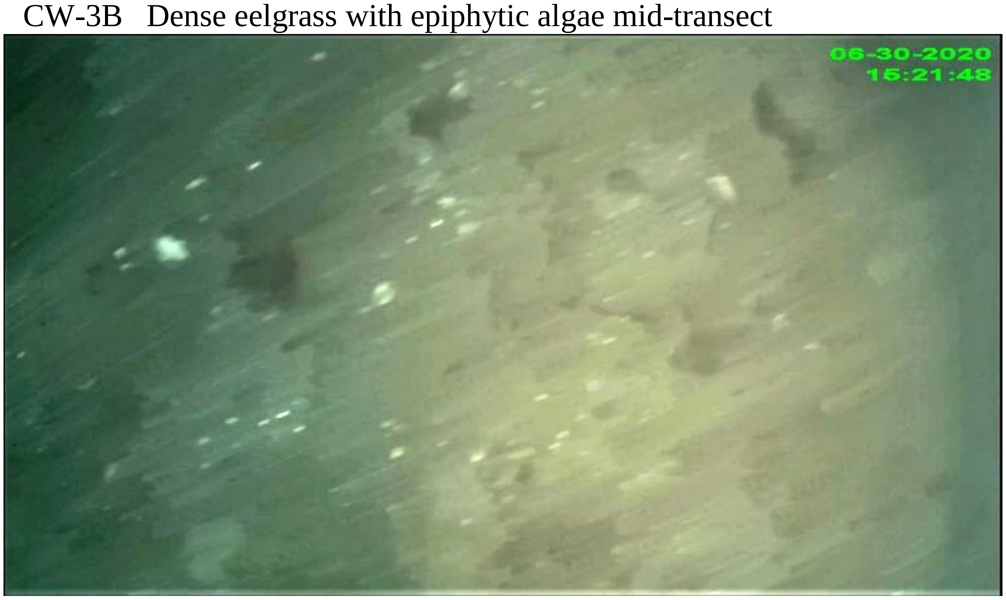
CW-2B Dense eelgrass mid- transect in the Eel Pond channel

CW-2C Dense eelgrass near the southern end of the transect

Plate 2 Transect CW-2 underwater video screen captures

CW-3A Summer flounder in moderate eelgrass with sand patches and shell at the start of transect near the Eel Pond bridge

CW-3B Dense eelgrass with epiphytic algae mid-transect

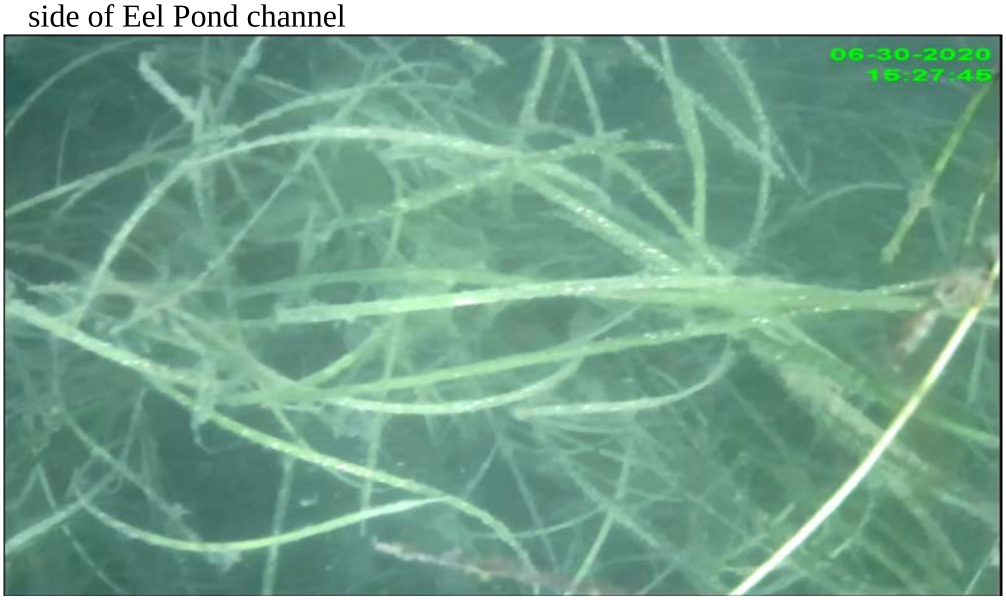


CW-3C Flat sand bottom with shell hash at the southern end of transect

Plate 3 Transect CW-3 underwater video screen captures

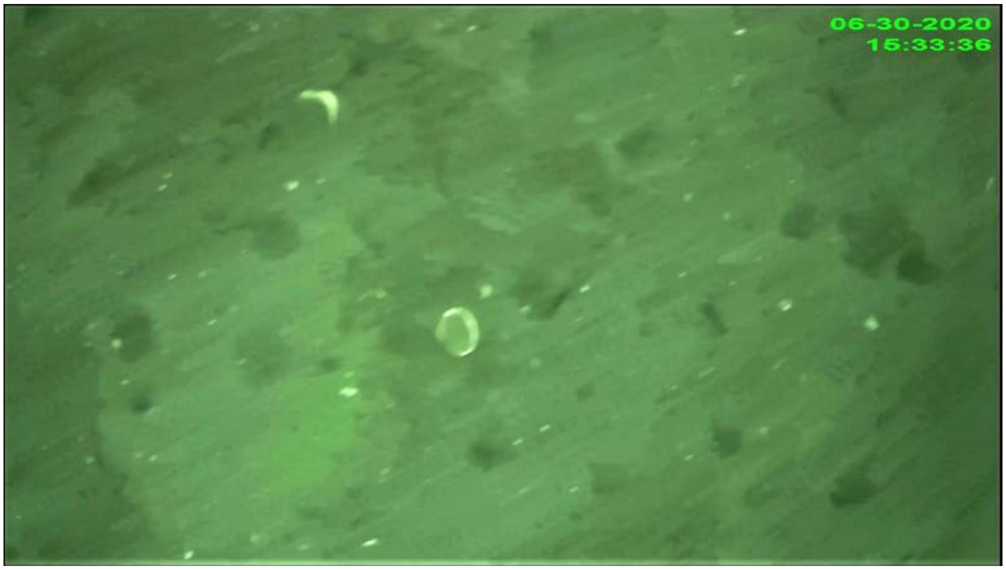
CW-4A Moderate eelgrass with large tire mid-transect close to the Islelin Dock

CW-4B Open sand bottom with macro algae, and shell hash on the west side of Eel Pond channel



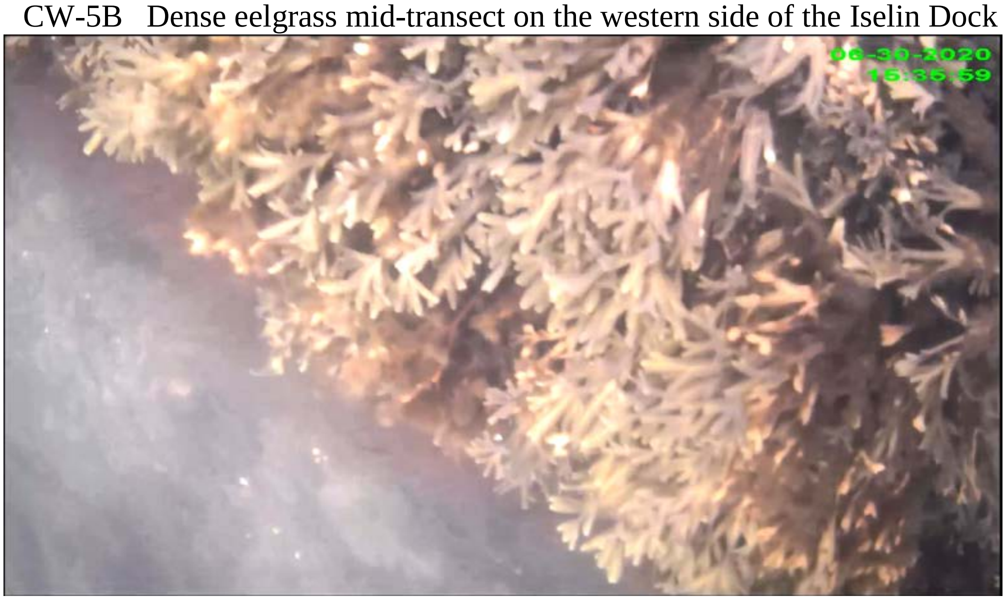
CW-4C Dense eelgrass mid-Eel Pond channel at the end of the transect

Plate 4 Transect CW-4 underwater video screen captures



CW-5A Sand bottom with shell at the start of the transect

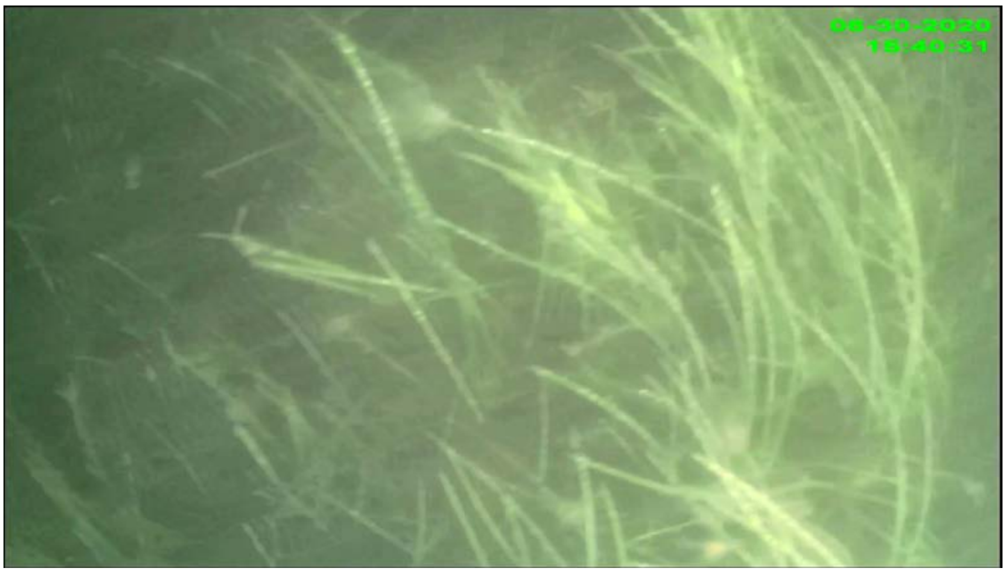
CW-5B Dense eelgrass mid-transect on the western side of the Iselin Dock



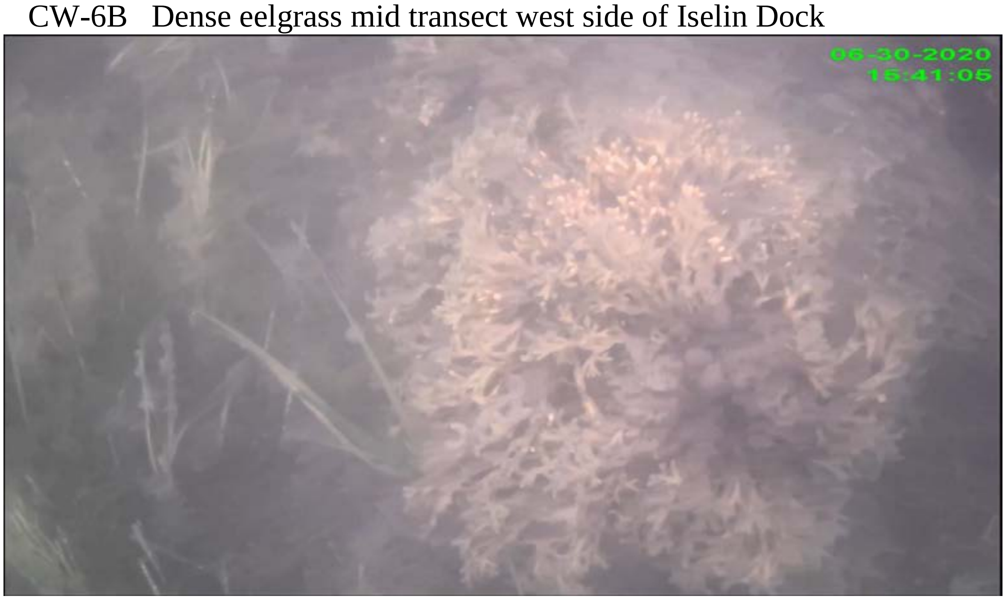
CW-5C Boulder with rockweed at the end of the transect nearshore

Plate 5 Transect CW-5 underwater video screen captures

CW-6A   Sparse eelgrass (single plant) macroalgae on sandy silt bottom at offshore end of transect



CW-6B   Dense eelgrass mid transect west side of Iselin Dock

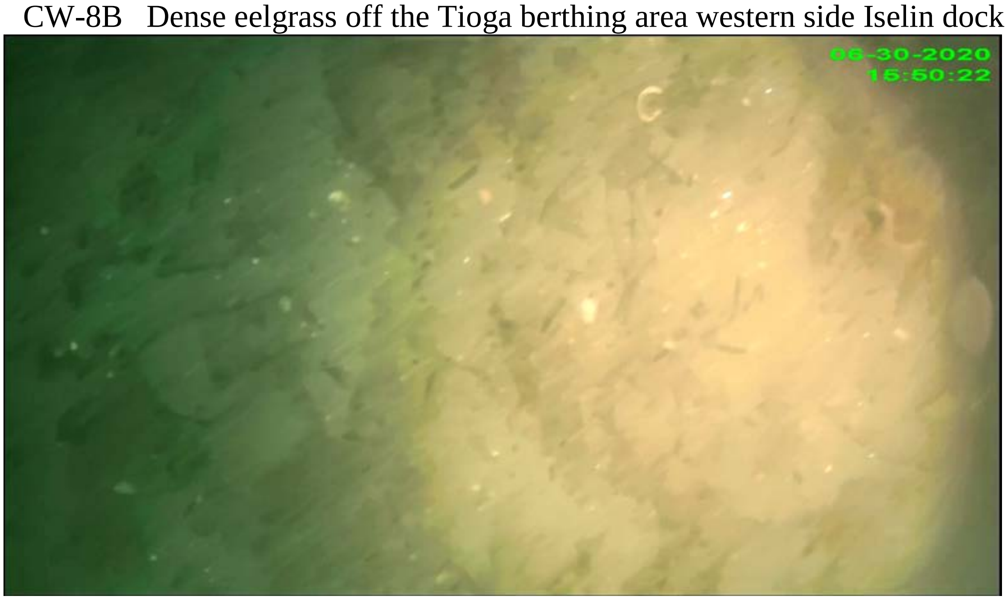


CW-6C   Moderate eelgrass, and boulder with rockweed inshore

Plate 6   Transect CW-6 underwater video screen captures

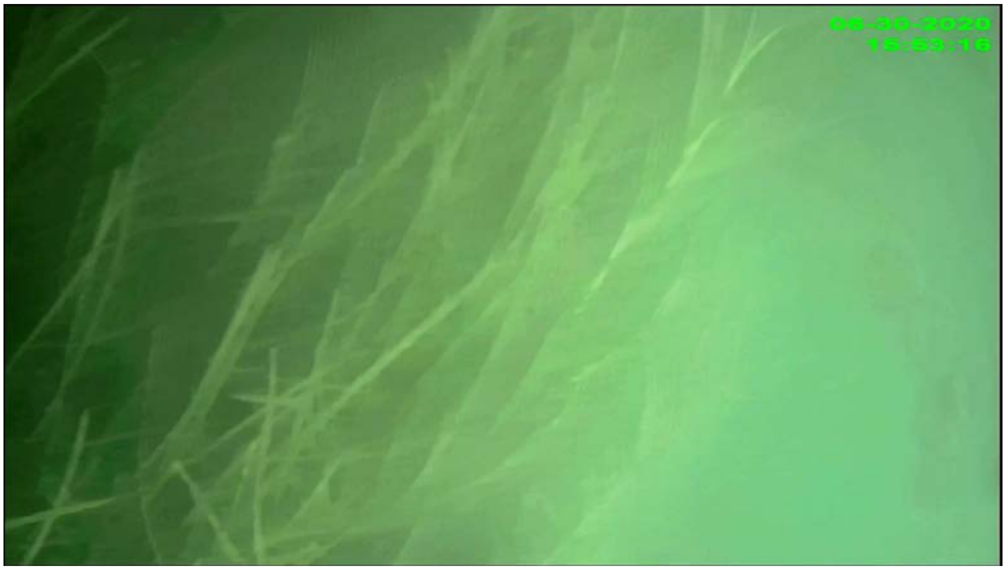
CW-8A Moderate eelgrass at the northern inshore end of transect


CW-8B Dense eelgrass off the Tioga berthing area western side Iselin dock

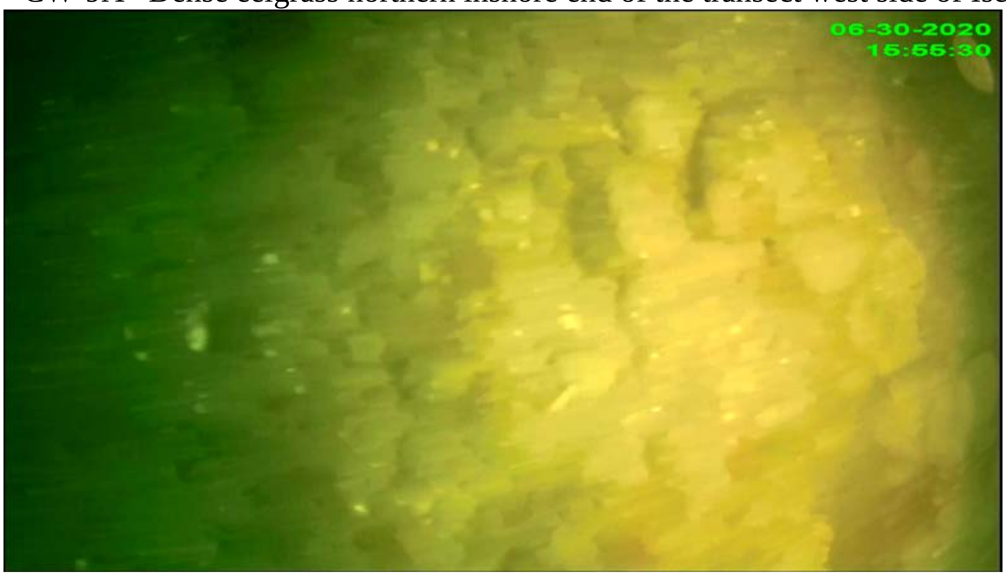


CW-8C Sandy bottom with cobbles and macroalgae offshore end of transect

Plate 7 Transect CW-8 underwater video screen captures



CW-9A   Dense eelgrass northern inshore end of the transect west side of Iselin Dock



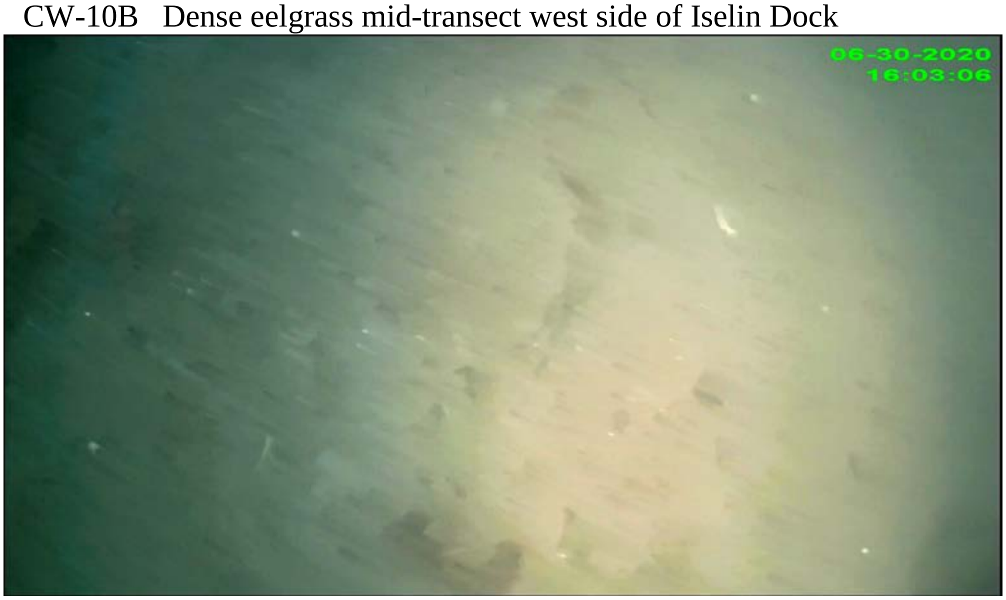
CW-9B   Cobbles and pebbles mid-transect

CW-9C   Cobbles and pebbles with macro algae offshore end of the transect

Plate 8 Transect CW-9 underwater video screen captures

CW-10A Moderate eelgrass at the eastern end of the transect

CW-10B Dense eelgrass mid-transect west side of Iselin Dock



CW-10C Sandy mud bottom no eelgrass present at offshore end of the transect

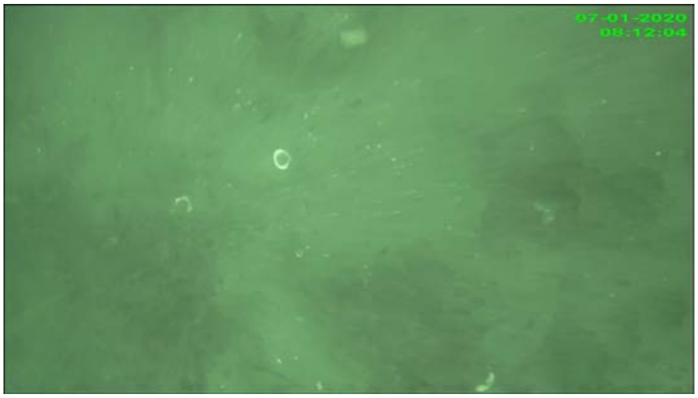
Plate 9 Transect CW-10 underwater video screen captures

VIDEO SCREEN CAPTURES OF BOTTOM SUBSTRATE,

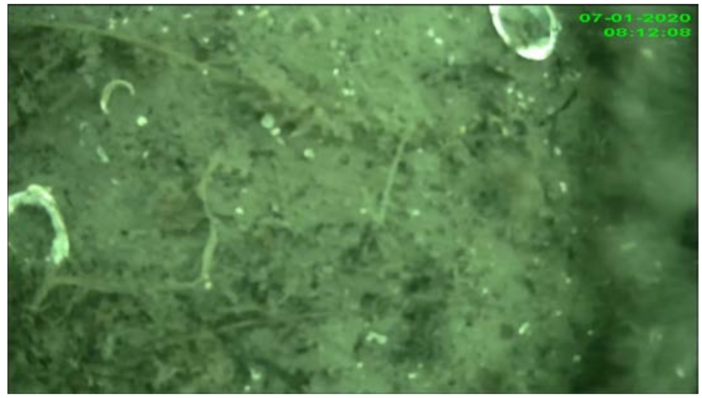
MACRO ALGAE AND BIOTA AT SHELLFISH

GRAB SAMPLE STATIONS

(G1 through G32)

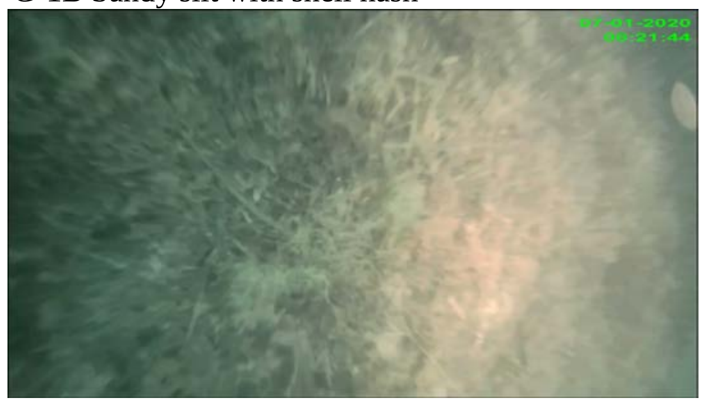


G-1A Sandy silt with algae and trace shell hash



G-1B Sandy silt with shell hash

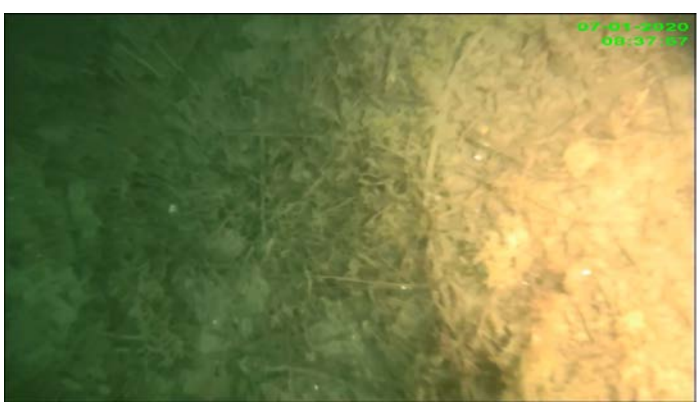
G-2A eelgrass sparse in top left corner sandy silt bottom



G-2B Algae and dead plant matter over organic rich silt

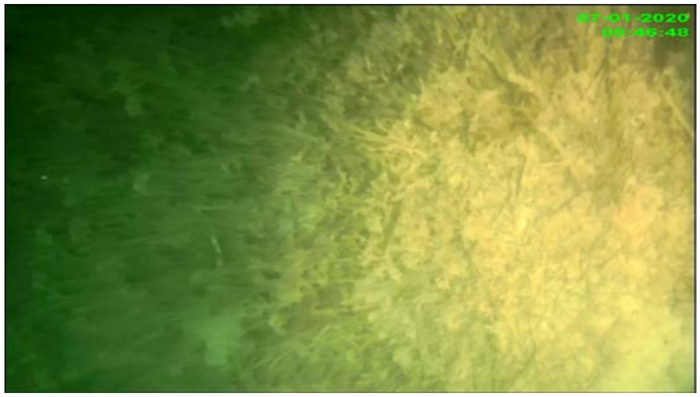
G-3A eelgrass sparse with pebbles and algae

G-3B Sandy silt with some pebbles and shell hash



G-4A Silt bottom with decomposing eelgrass and algae

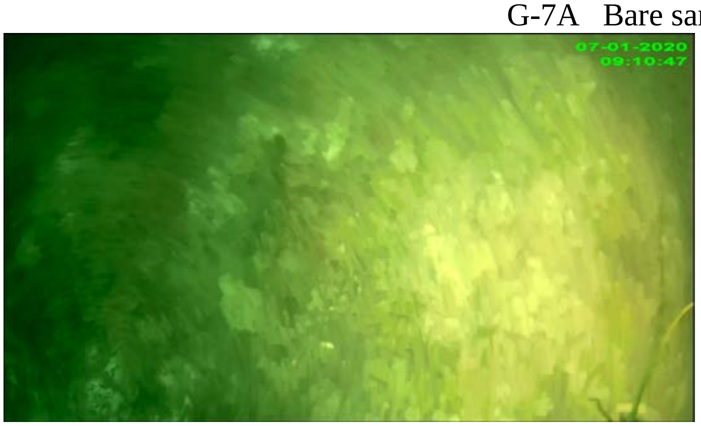
Plate 10 Grab Sample Video Screen Captures of the Bottom Substrate at G-1 through G-4



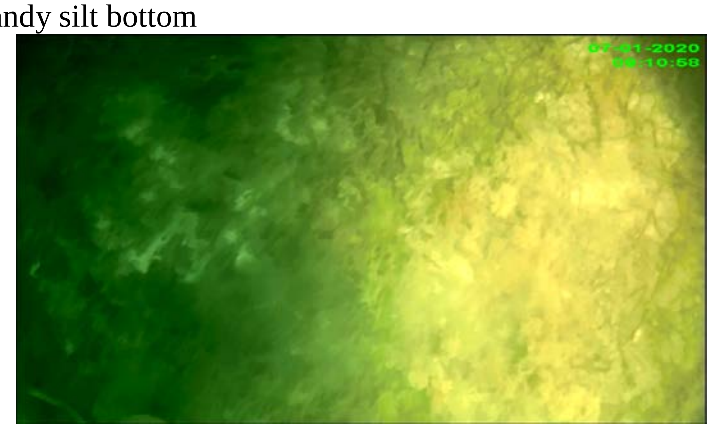
G-5A   Sandy silt bottom with algae and trace sea lettuce

G-6A   Sandy silt bottom with algae, trace shell hash and decaying eelgrass

G-7A   Bare sandy silt bottom

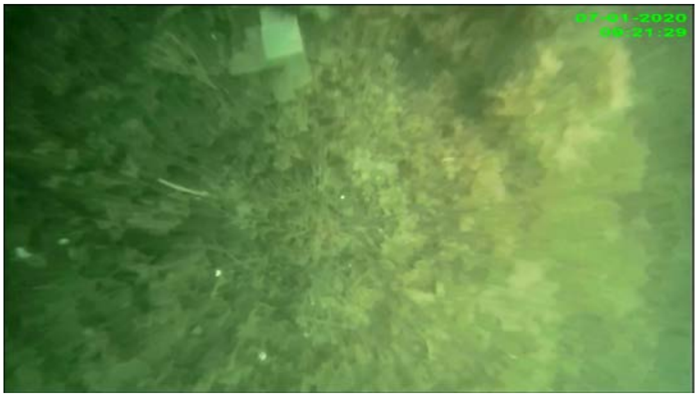


G-8A Fish (tautog) left of center



G-8B Sandy slit bottom with algae

Plate 11   Grab Sample Video Screen Captures of the Bottom Substrate at G-5 through G-8

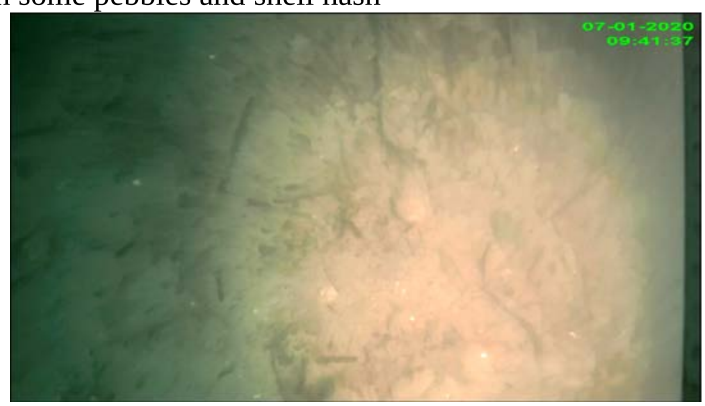


G-9A Sandy silt bottom with abundant algae

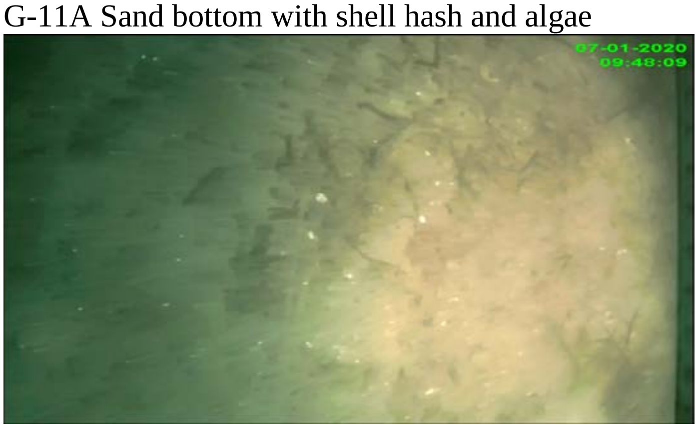
G9-B Silt bottom with algae and shell hash

G-10A Bare sand Bottom with some pebbles and shell hash

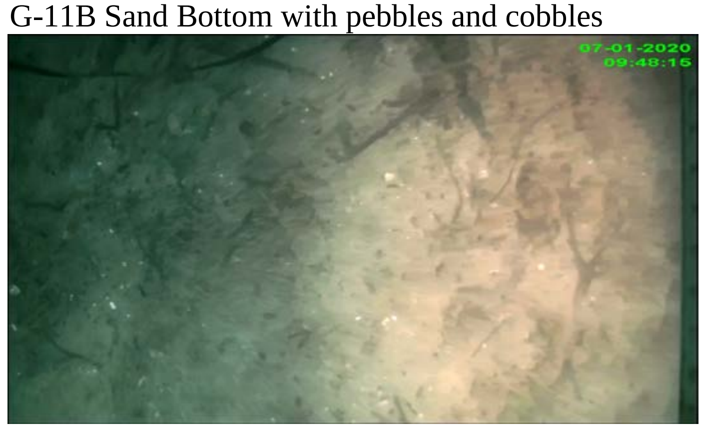
G-11A Sand bottom with shell hash and algae



G-11B Sand Bottom with pebbles and cobbles

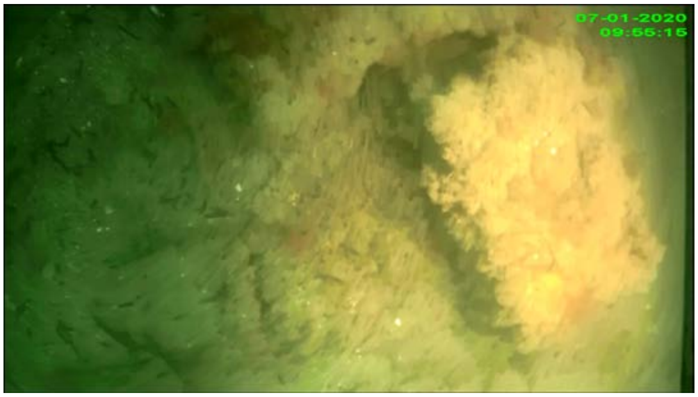


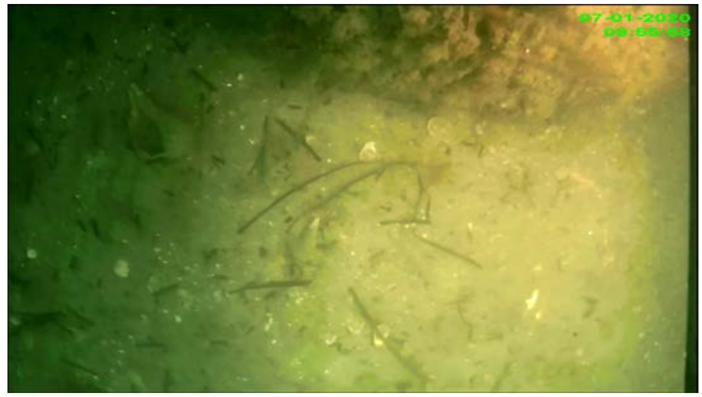
G-12A Sandy silt with shell hash



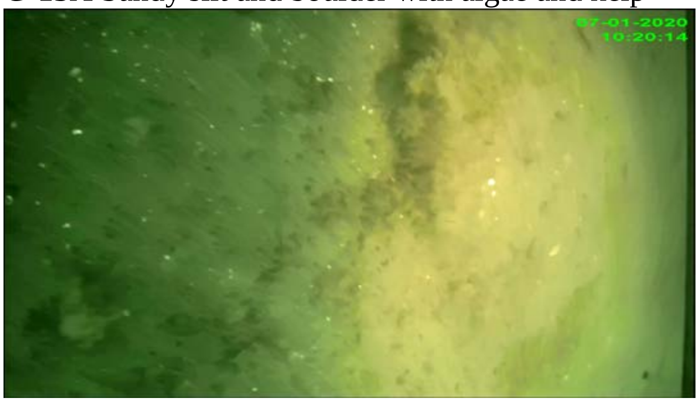
G-12B Sandy silt with shell hash pebbles and algae

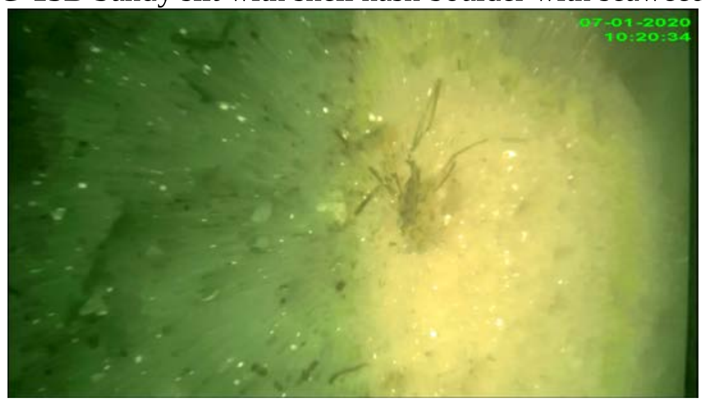
Plate 12 Grab Sample Video Screen Captures of the Bottom Substrate at F-9 through G-12



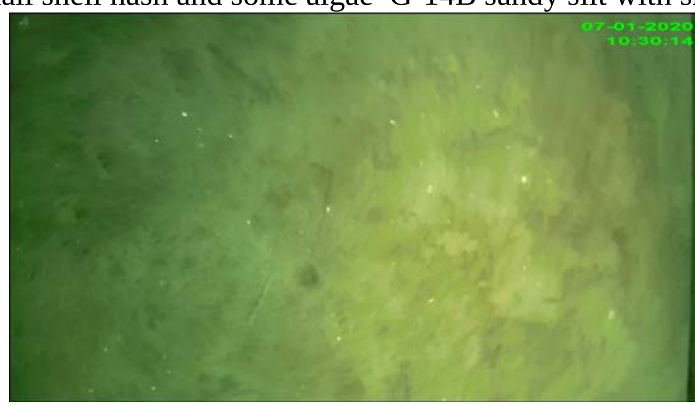


G-13A Sandy silt and boulder with algae and kelp G-13B Sandy silt with shell hash boulder with seaweed

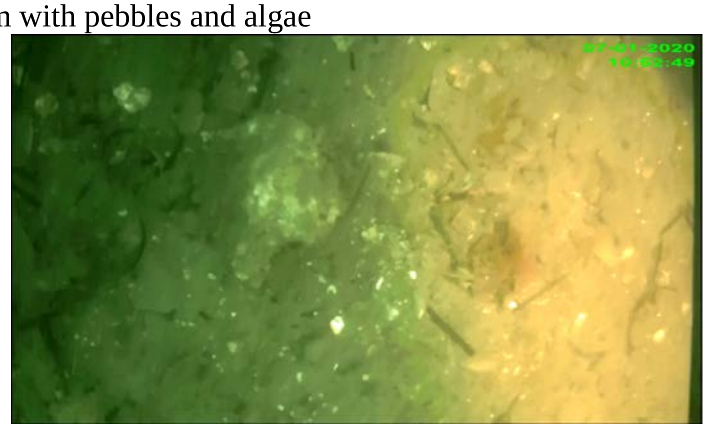




G-14A Sandy silt with small shell hash and some algae G-14B sandy silt with small shell hash and pebbles

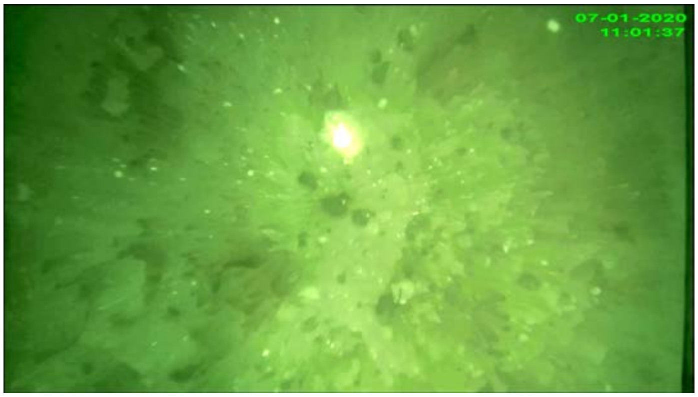


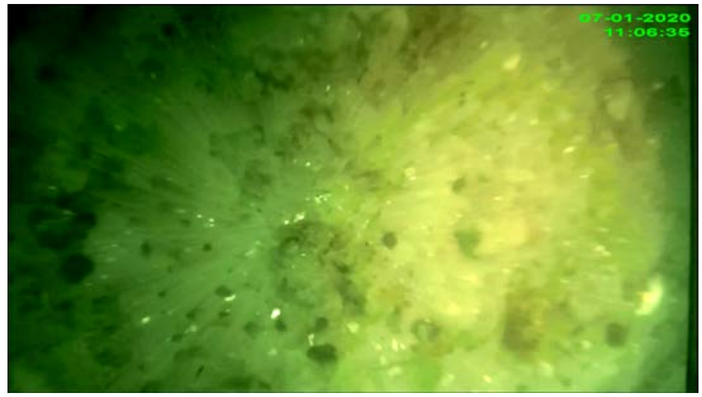
G-15A Sandy silt bottom with pebbles and algae



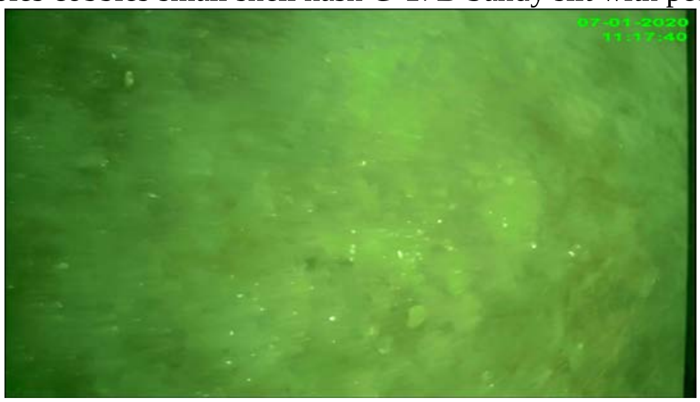
G-16A Sandy silt with debris (brick), trace shell hash G-16B Sand with pebbles, cobbles, and shell hash

Plate 13 Grab Sample Video Screen Captures of the Bottom Substrate at G-13 through G-16

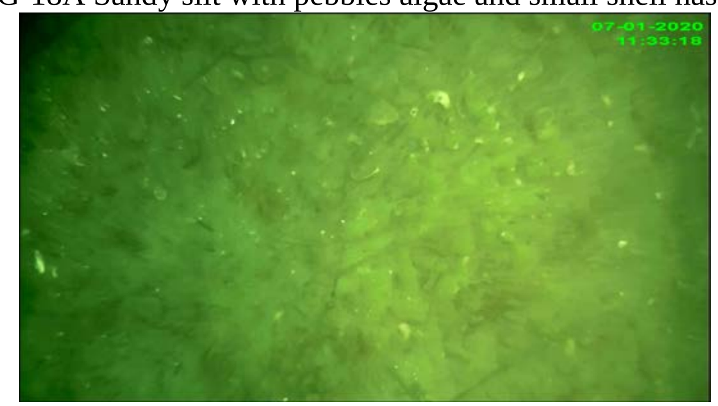




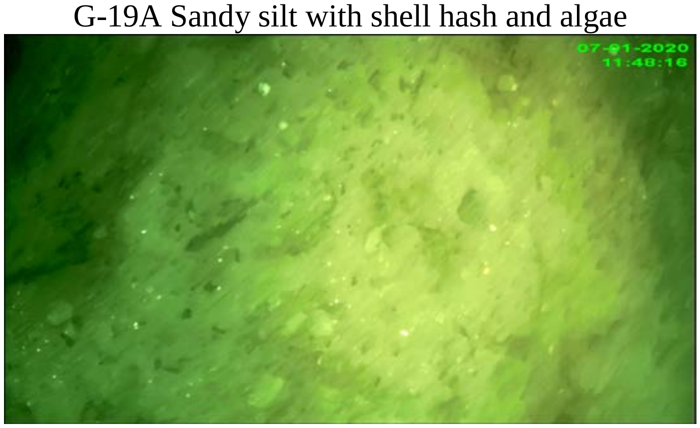
G-17A Sandy silt with pebbles cobbles small shell hash G-17B Sandy silt with pebbles cobbles and shell hash



G-18A Sandy silt with pebbles algae and small shell hash

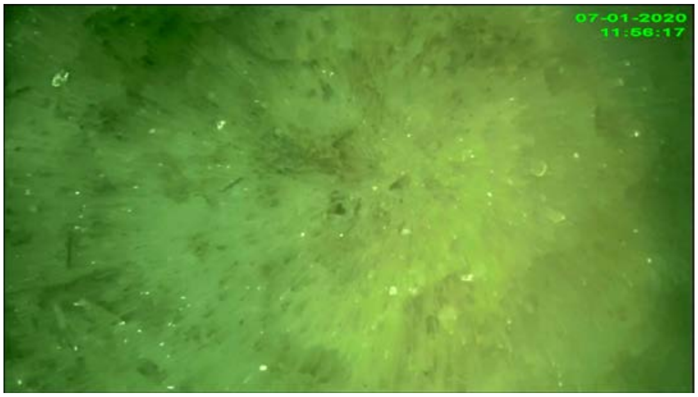


G-19A Sandy silt with shell hash and algae

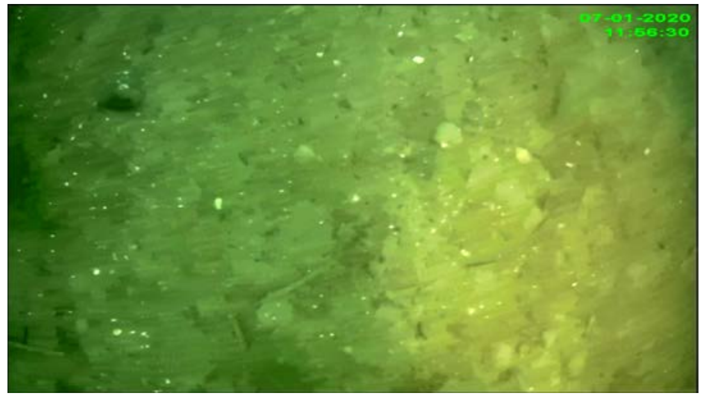


G-20A sand with pebbles, cobbles, algae, and small shell hash

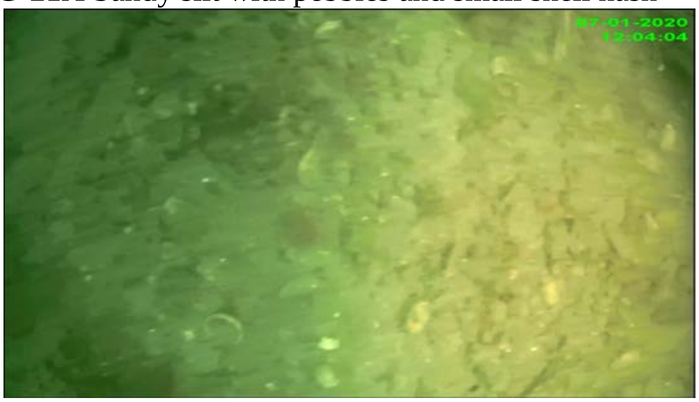
Plate 14 Grab Sample Video Screen Captures of Bottom Substrate at G-17 through G-20



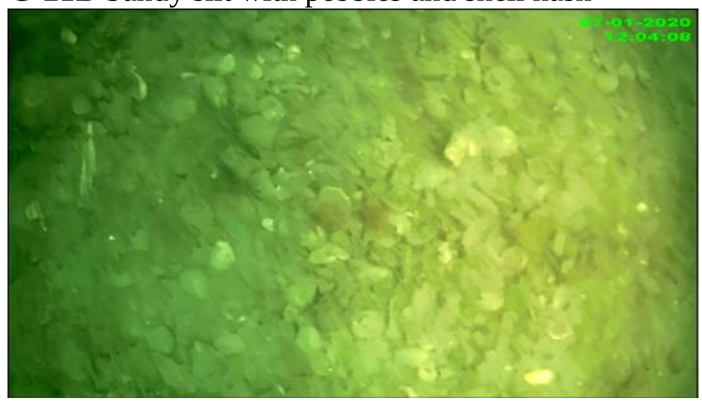
G-21A Sandy silt with pebbles and small shell hash



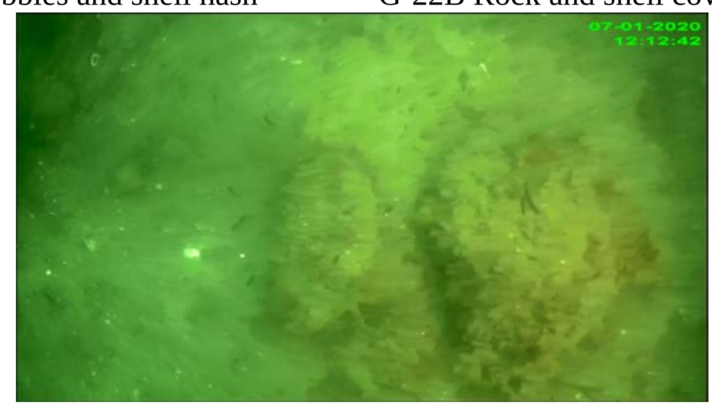
G-21B Sandy silt with pebbles and shell hash



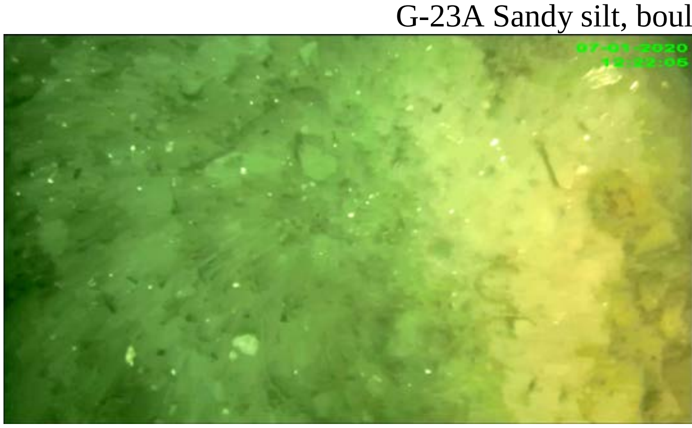
G-22A Sandy silt with pebbles and shell hash



G-22B Rock and shell covered with algae and kelp



G-23A Sandy silt, boulders with algae and kelp



G-24A Sandy silt bottom with pebbles and algae

G-24B sandy silt with large chain pebbles and algae

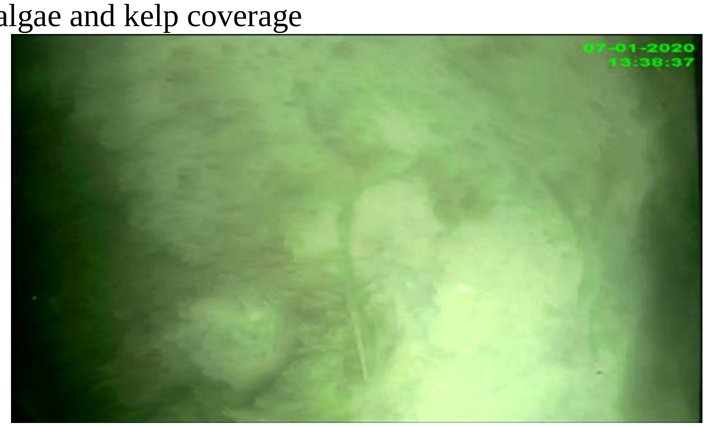
Plate 15 Grab Sample Video Screen Captures of Bottom Substrate at G-21 through G-24

G-25A Sandy silt with cobbles algae and kelp

G-26A Sandy silt with algae cover

G-27A Sandy silt with algae and kelp coverage

G-28A Moderate eelgrass adjacent to sandy silt patch



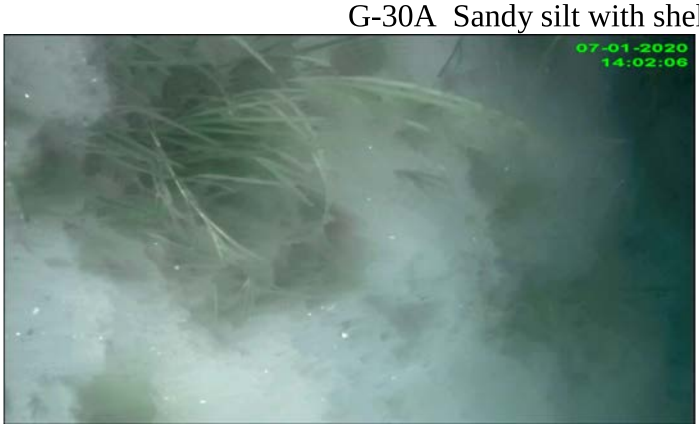
G-28B EG sparse sandy silt patches with some algae

Plate 16 Grab Sample Video Screen Captures of Bottom Substrate at G-25 through G-28

G-29A Dense eelgrass

G-29B Sandy silt with algae and sea lettuce

G-30A Sandy silt with shell hash algae and sea lettuce



G-31A Moderate eelgrass, sandy silt with algae

G-31B Sparse eelgrass, sandy silt bottom post grab

G-32A Moderate eelgrass with sandy patches

G-32B Dense eelgrass

Plate 17   Grab Sample Video Screen Captures of Bottom Substrate at G-29 through G-32

PHOTOGRAPHS OF SIEVED SHELLFISH GRABS

(G1 through G32)

G-1 Sieved - shell hash and pebbles; 2 quahogs 1.75" and 3/8"

G-2 Sieved - decomposing eelgrass

G-3 Sieved - decomposing eelgrass with sparse sticks and leaves

Plate 18 Sieved Grab Sample and Infauna Photographs G-1, G-2 and G-2

G-4 Sieved Decomposing eelgrass, pebbles, and cobbles with barnacles

G-5 Sieved Cobbles and pebbles with trace kelp, sea lettuce, and algae; (1) Quahog 1.75”

G-6 Sieved Decomposing eelgrass with trace shell and leaves

Plate 19 Sieved Grab Sample and Infauna Photographs G-4 through G-6

G-7 Sieved Mostly pebbles and cobbles with shell hash

G-8 Sieved Decaying eelgrass and leaves with traces shell hash

G-9 Sieved Decaying eelgrass cobble and trace sea lettuce and algae

Plate 20 Sieved Grab Sample and Infauna Photographs G7 through G-9

G-10A Sieved Mostly pebbles and cobbles with sparse shell hash; (1) Quahog 1.25”

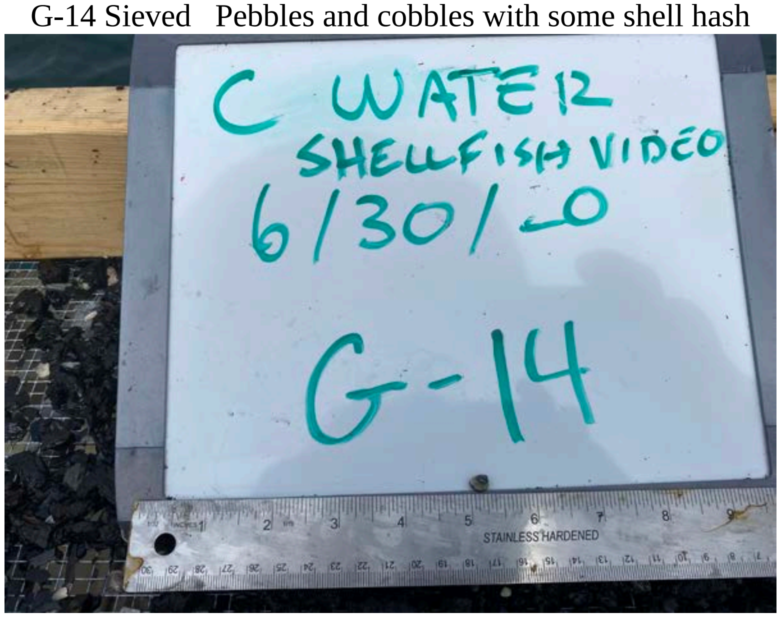
G-11 Sieved Cobbles and pebbles

G-12 Sieved Pebbles and cobbles

Plate 21 Sieved Grab Sample and Infauna Photographs G-10 through G-12

G-13B Sieved   Mostly pebbles with a few cobbles

G-14 Sieved   Pebbles and cobbles with some shell hash

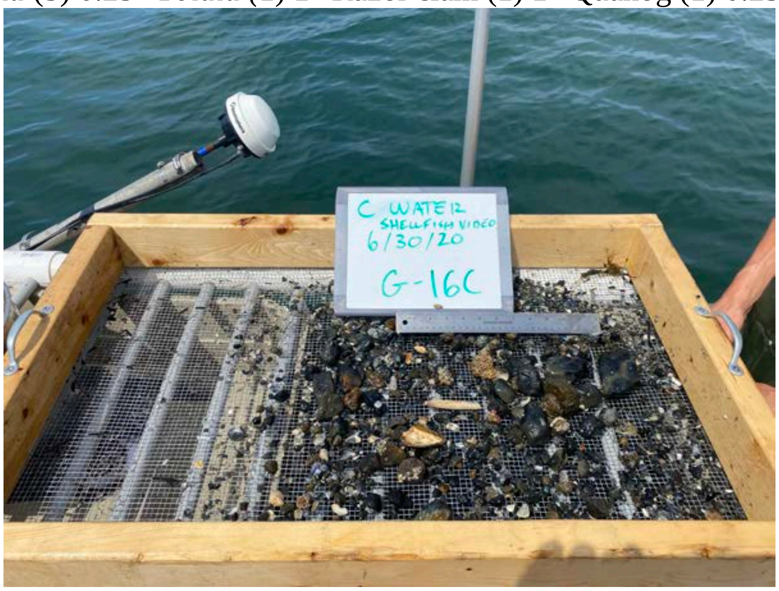


G-14 Infauna   1 quahog 5/16”

Plate 22 Sieved Grab Sample and Infauna Photographs G-13 and G-14

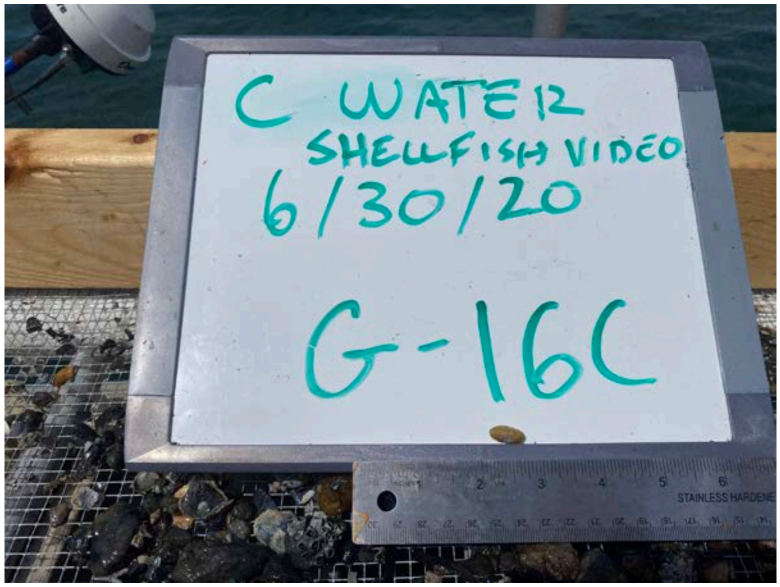
G-15 Sieved   Pebbles and cobbles with trace shell hash

G-15 Infauna   *Macoma* (5) 0.25" *Yoldia (*1) 1" Razor clam (1) 1" Quahog (1) 0.25" Solemyidae (2) 0.5"



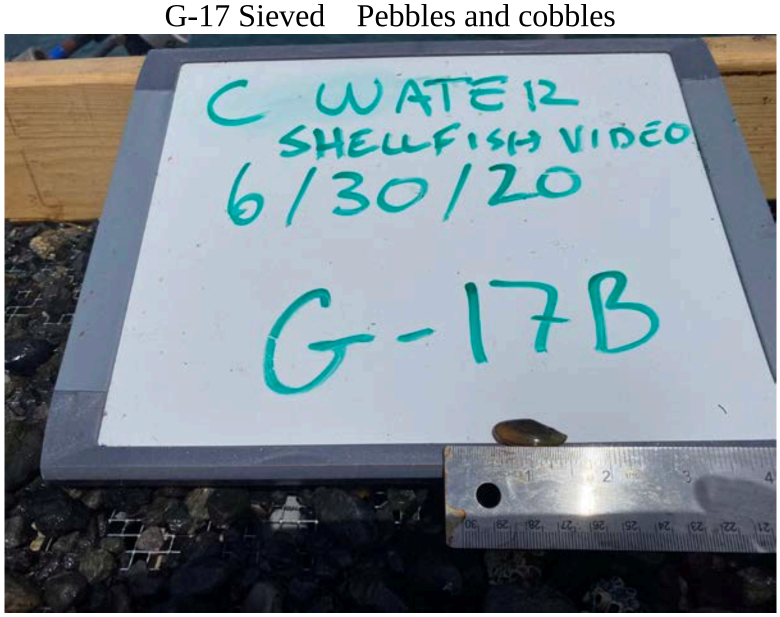
G-16 Sieved   Pebbles and cobbles with shell hash

Plate 23   Sieved Grab Sample and Infauna Photographs G-15 and G-16



G-16C Infauna (1) Razor clam 0.5”

G-17 Sieved Pebbles and cobbles

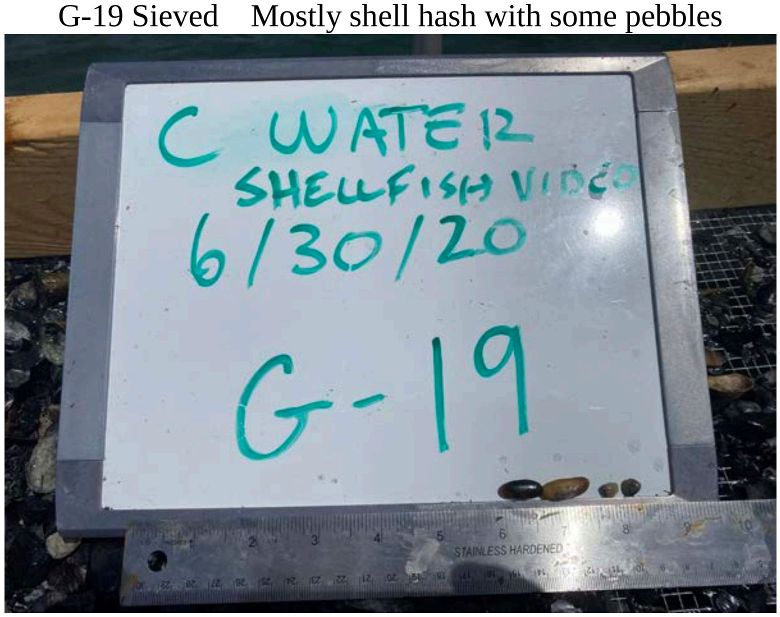


G-17B Infauna (1) *Yoldia* 1”

Plate 24 Sieved Grab Sample and Infauna Photographs G-16 and G-17

G-18 Sieved Pebbles and cobbles

G-19 Sieved Mostly shell hash with some pebbles



G-19 Infauna Quahogs (2) 0.25” Razor Clam (1) 0.75” *Yoldia* (1) 0.65”

Plate 25 Sieved Grab Sample and Infauna Photographs G-18 and G-19

G-20 Sieved   Pebbles and cobbles, debris (weathered metal rod)

G-21 Sieved   Pebbles and cobbles

G-22 Sieved   Pebbles and cobbles

Plate 26   Sieved Grab Sample Photographs G-20 through G-22

G-22 Infauna Quahogs (3) 0.25”

G-23 Sieved Pebbles and a few cobbles

G-24 Sieved Pebbles and cobbles

Plate 27 Sieved Grab Sample and Infauna Photographs G-22 through G-24

G-24 Infauna Northern dwarf tellin (1) 0.5”

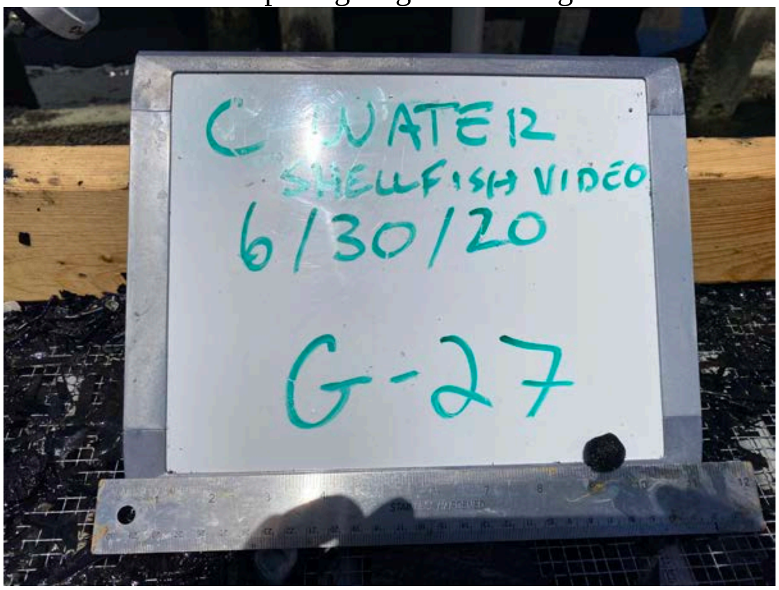
G-25 Sieved Shell hash trace algae, kelp and decaying material

G-25 Infauna Quahog(1) 1.75”

Plate 28 Sieved Grab Sample and Infauna Photographs G-24 and G-25

G-26 Sieved Mostly decomposing eelgrass and leaves with some shell

G-27 Sieved Decomposing eelgrass with algae and some shell

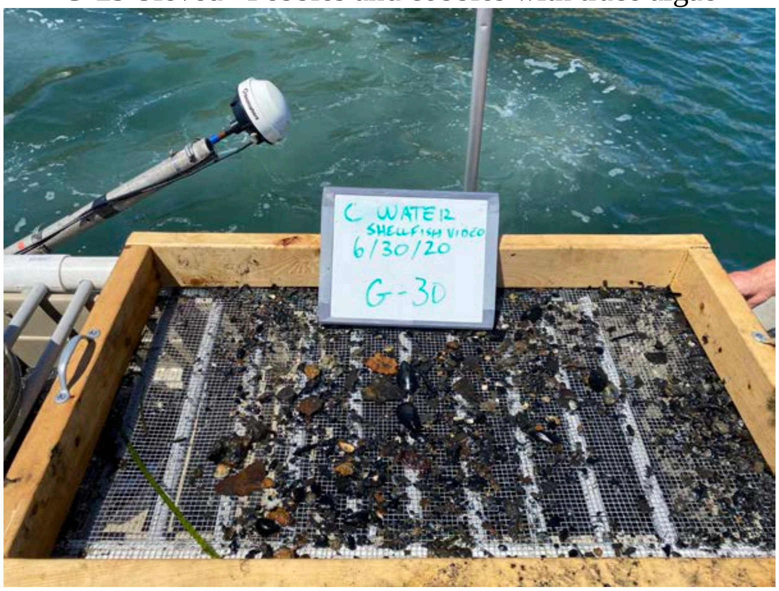


G-27 Infauna cockle clam (1) 0.75”

Plate 29 Sieved Grab Sample and Infauna Photographs G-26 and G-27

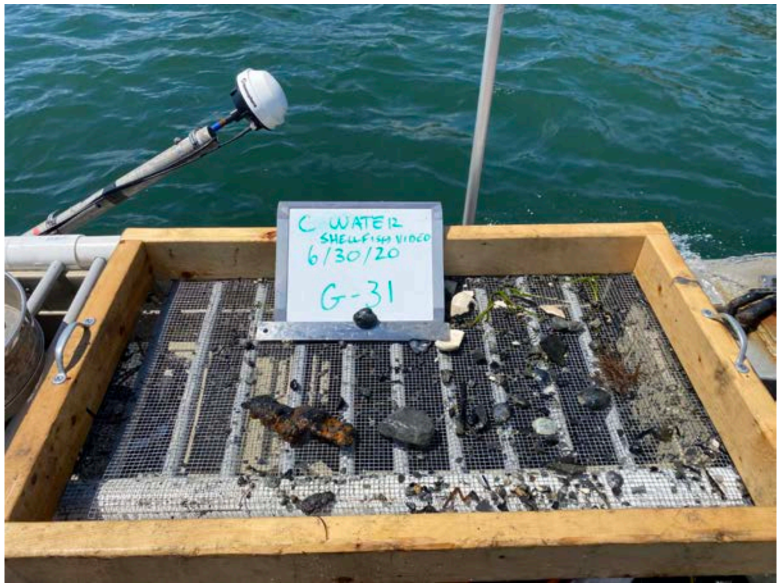
G-28 Sieved   Live eelgrass with some decomposing

G-29 Sieved   Pebbles and cobbles with trace algae

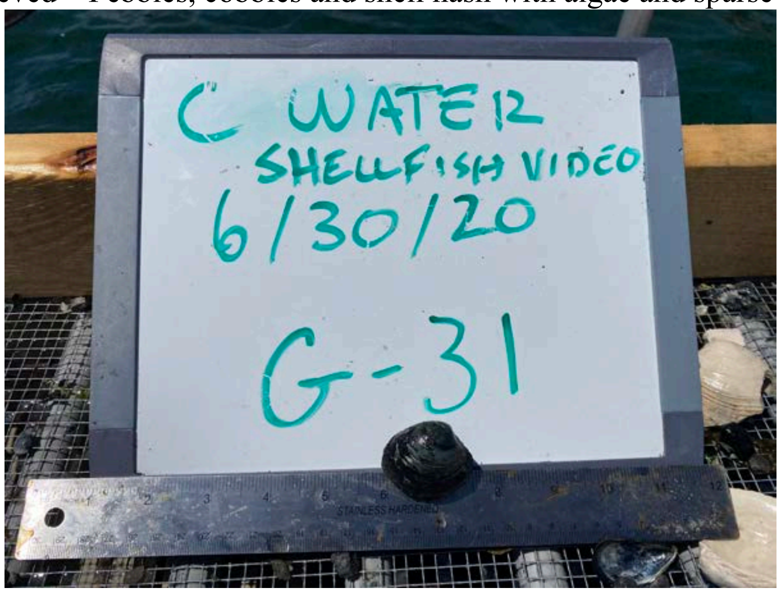


G-30 Sieved   Mostly pebbles with shell hash

Plate 30 Sieved Grab Sample Photographs G-28 through G-30



G-31 Sieved   Pebbles, cobbles and shell hash with algae and sparse eelgrass



G-31 Infauna   Quahog (1) 1.5”

G-32 Sieved   Live eelgrass with trace algae

Plate 31 Sieved Grab Sample and Infauna Photographs G-31and G-32

APPENDIX A

INFAUNA FROM BENTHIC GRABS

(CWB-1C, CWB-2C, CWB-3C, CWB-4C)

Identifications and densities of organisms by Station.

Phylum	Class	Order	Family	Species	Author	CWB-1C	CWB-2C	CWB-3C	CWB-4C	Total
Annelida	Oligochaeta (subclass)	Haplotaxida	Naididae	*Limnodriloides medioporus*	Cook, 1969			2	1	3
Annelida	Oligochaeta (subclass)	Haplotaxida	Naididae	*Limnodriloides* sp. 1	Pierantoni, 1903		7	70	11	88
Annelida	Oligochaeta (subclass)	Haplotaxida	Naididae	Naidinae sp. 1	Ehrenberg, 1828				4	4
Annelida	Oligochaeta (subclass)	Haplotaxida	Naididae	Naidinae spp. juv	Ehrenberg, 1828		16			16
Annelida	Oligochaeta (subclass)	Haplotaxida	Naididae	*Tubificoides apectinatus*	Brinkhurst, 1965		15			15
Annelida	Oligochaeta (subclass)	Haplotaxida	Naididae	*Tubificoides benedii*	(d'Udekem, 1855)		3		3	6
Annelida	Oligochaeta (subclass)	Haplotaxida	Naididae	*Tubificoides intermedius*	(Cook, 1969)		1	56	5	62
Annelida	Oligochaeta (subclass)	Haplotaxida	Naididae	*Tubificoides* sp. 1	Lastočkin, 1937			15	173	188
Annelida	Polychaeta	Eunicida	Lumbrineridae	*Scoletoma tenuis*	(Verrill, 1873)	16				16
Annelida	Polychaeta	Phyllodocida	Glyceridae	*Glycera americana*	Leidy, 1855	5	1	1		7
Annelida	Polychaeta	Phyllodocida	Glyceridae	*Glycera* sp. 1	Lamarck, 1818	1				1
Annelida	Polychaeta	Phyllodocida	Hesionidae	*Oxydromus obscurus*	(Verrill, 1873)		3	7	34	44
Annelida	Polychaeta	Phyllodocida	Nephtyidae	*Nephtys* spp. juv	Cuvier, 1817	1				1
Annelida	Polychaeta	Phyllodocida	Nereididae	*Alitta succinea*	(Leuckart, 1847)		2	8	2	12
Annelida	Polychaeta	Phyllodocida	Nereididae	*Nereis* sp. 1	Linnaeus, 1758	2	1			3
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	*Eumida sanguinea*	(Örsted, 1843)	5	2	6		13
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	*Paranaitis speciosa*	(Webster, 1879)				1	1
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	*Phyllodoce arenae*	Webster, 1879	2				2
Annelida	Polychaeta	Phyllodocida	Polynoidea	*Harmothoe* sp. 1	Kinberg, 1856		2			2
Annelida	Polychaeta	Phyllodocida	Syllidae	*Erinaceusyllis erinaceus*	(Claparède, 1863)			2		2
Annelida	Polychaeta	Phyllodocida	Syllidae	*Exogene verugera*	(Claparède, 1868)	16	20	1		37
Annelida	Polychaeta	Phyllodocida	Syllidae	*Salvatoria clavata*	(Claparède, 1863)			1		1
Annelida	Polychaeta	Phyllodocida	Syllidae	*Sphaerosyllis taylori*	Perkins, 1981	13	2			15
Annelida	Polychaeta	Spionida	Spionidae	*Polydora cornuta*	Bosc, 1802	36		45	25	106
Annelida	Polychaeta	Spionida	Spionidae	*Prionospio heterobranchia*	Moore, 1907	3	8	11	5	27
Annelida	Polychaeta	Spionida	Spionidae	*Spio filicornis*	(Müller, 1776)			5		5
Annelida	Polychaeta	Spionida	Spionidae	*Spiophanes bombyx*	(Claparède, 1870)	3		1		4
Annelida	Polychaeta	Spionida	Spionidae	*Streblospio benedicti*	Webster, 1879	1				1
Annelida	Polychaeta	Terebellida	Ampharetidae	*Ampharete arctica*	Malmgren, 1866	1	9	15		25
Annelida	Polychaeta	Terebellida	Cirratulidae	*Cheatozone setosa*	Malmgren, 1867	2		4	156	162
Annelida	Polychaeta	Terebellida	Pectinariidae	*Pectinaria gouldi*	(Verrill, 1874)			4		4
Annelida	Polychaeta	Terebellida	Terebellidae	*Polycirrus eximius*	(Leidy, 1855)	5		20	32	57

Phylum	Class	Order	Family	Species	Author	CWB-1C	CWB-2C	CWB-3C	CWB-4C	Total
Annelida	Polychaeta		Capitellidae	*Capitella capitata*	(Fabricius, 1780)		34	19	169	222
Annelida	Polychaeta		Capitellidae	*Mediomastus ambiseta*	(Hartman, 1947)	826	8	32	59	925
Annelida	Polychaeta		Capitellidae	*Notomastus* sp. 1	M. Sars, 1851		3	3		6
Annelida	Polychaeta		Eunicidae	*Marphysa sanguinea*	(Montagu, 1813)			1		1
Annelida	Polychaeta		Maldanidae	*Clymenella zonalis*	(Verrill, 1874)	8	2		4	14
Annelida	Polychaeta		Maldanidae	*Maldane sarsi*	Malmgren, 1865			1		1
Annelida	Polychaeta		Orbiniidae	*Leitoscoloplos fragilis*	(Verrill, 1873)	1		2	2	5
Annelida	Polychaeta		Scalibregmatidae	*Scalibregma inflatum*	Rathke, 1843	1				1
Arthropoda	Malacostraca	Amphipoda	Ampeliscidae	*Ampelisca abdita*	Mills, 1964	29			82	111
Arthropoda	Malacostraca	Amphipoda	Corophiidae	*Corophium* spp. juv	Latreille, 1806				1	1
Arthropoda	Malacostraca	Amphipoda	Ischyroceridae	*Ericthonius rubricornis*	(Stimpson, 1853)	7	13	19	4	43
Arthropoda	Malacostraca	Amphipoda	Lysianassidae	*Lysianopsis alba*	Holmes, 1903	2	3	1		6
Arthropoda	Malacostraca	Cumacea	Leuconidae	*Leucon americanus*	Zimmer, 1943				17	17
Arthropoda	Malacostraca	Decapoda	Carcinidae	*Carcinus maenus*	(Linnaeus, 1758)	1			2	3
Arthropoda	Malacostraca	Decapoda	Crangonidae	*Crangon septemspinosa*	Say, 1818			1		1
Arthropoda	Malacostraca	Decapoda	Paguridae	*Pagurus* spp. juv	Fabricius, 1775			1		1
Arthropoda	Malacostraca	Decapoda	Panopeidae	*Panopeus herbstii*	H. Milne Edwards, 1834		4	1		5
Arthropoda	Malacostraca	Isopoda	Janiridae	*Janira alta*	(Stimpson, 1853)			3		3
Cnidaria	Anthozoa	Actiniaria	Edwardsiidae	*Edwardsia elegans*	Verrill, 1869		1			1
Mollusca	Bivalvia	Arcida	Aricidae	*Anadara transversa*	(Say, 1822)	1				1
Mollusca	Bivalvia	Cardiida	Tellinidae	*Ameritella agilis*	(Stimpson, 1857)	2	2		1	5
Mollusca	Bivalvia	Myida	Myidae	*Mya arenaria*	Linnaeus, 1758		1		4	5
Mollusca	Bivalvia	Nuculida	Nuculidae	*Nucula proxima*	Say, 1822		1		2	3
Mollusca	Bivalvia	Solemyida	Solemyidae	*Solemya velum*	Say, 1822	1				1
Mollusca	Bivalvia	Venerida	Veneridae	*Mercenaria mercenaria*	(Linnaeus, 1758)		1	1	1	3
Mollusca	Bivalvia			Bivalvia sp. 1	Linnaeus, 1758		1			1
Mollusca	Gastropoda	Cephalaspidea	Cylichnidae	*Cylichnella oryza*	(Totten, 1835)				18	18
Mollusca	Gastropoda	Cephalaspidea	Retusidae	*Acteocina canaliculata*	(Say, 1826)	3			4	7
Mollusca	Gastropoda	Littorinimorpha	Calyptraeidae	*Crepidula fornicata*	(Linnaeus, 1758)			3		3
Mollusca	Gastropoda	Neogastropoda	Columbellidae	*Astyris lunata*	(Say, 1826)	1	1	1	1	4
Mollusca	Gastropoda			Gastropoda sp. 1	Cuvier, 1795	1	2			3
Nemertea	Hoplonemertea	Monostillifera	Amphiporidae	*Amphiporus angulatus*	(Müller, 1774)	2	5			7
Nemertea	Palaeonemertea		Carinomidae	*Carinomella lactea*	Coe, 1905	9				9
					TOTAL	**1007**	**174**	**363**	**823**	**2367**

Attachment E

Eelgrass Avoidance and Protection

Eelgrass Avoidance and Protection Plan

WOODS HOLE OCEANOGRAPHIC INSTITUTION-CWATER

INTRODUCTION

The Woods Hole Oceanographic Institution ("WHOI") is advancing the Complex for Waterfront Access to Exploration and Research ("CWATER") project to provide a more modern and resilient marine support facility that will serve the institution's needs for the next century. The CWATER project includes replacing the existing 50-yer old pile-supported dock, bulkhead reconstruction, establishing a formal robotic vessel port, dredging proximate to the robotics port, reconfiguring the small boat slips, and constructing a new waterfront building. The project is more fully described, and the proposed layout is depicted, in the Environmental Notification Form ("ENF") (EEA No. 16285).

This Eelgrass Avoidance and Protection Plan ("Plan") describes the strategies and measures proposed to avoid and minimize alteration to nearby eelgrass meadows, and the mitigation proposed for any unavoidable alteration. This Plan was developed in consultation with representatives of the U.S. Environmental Protection Agency ("EPA"), Massachusetts Division of Marine Fisheries ("DMF"), the Falmouth Conservation Commission ("Commission") and the Falmouth Harbormaster.

Project Description

The CWATER Project includes replacing the existing dock with an in-place and in-kind pile supported structure, primarily within its existing footprint. Some pier modifications are proposed and involve reconfiguring the bulkhead near the small boat slips along the Eel Pond entrance channel and the relocation of the large test well towards the southern end of the replacement pier. On the west side, a new dock will be installed to formalize the robotics port used expressly for the deployment and recovery of autonomous vessels. The number and size of the pilings will also be changed, the replacement pier will reduce the number of piles from 232 30-inch diameter piles to 187 48-inch diameter piles.

Dredging at the robotics port is proposed in the footprint of the previously dredged area with a slight extension to the south and a increase in depth from the previously approved dredge depth of -22 feet mean lower low water ("MLLW") to -24 feet MLLW. The total dredge volume is approximately 2,600 cubic yards ('cy") which is comprised of approximately 2,435 cy of riprap and 165 cy of marine sediments. Dredging will be performed by a combination of clamshell and hydraulic equipment, and all materials will be discharged at an authorized upland site. The riprap located in front of the bulkhead will be removed for the installation of the new bulkhead and replaced in-kind.

The project will replace existing buildings on the dock with a new waterfront building that has been designed to support and improve existing port operations. The New Waterfront Building ("NWB") will consist of approximately 45,000 square feet ("sf") of gross floor space. The existing buildings to be replaced collectively total approximately 48,000 sf. The NWB will be constructed entirely landward of the bulkhead directly behind the Smith Building.

Eelgrass Resources in the Project Area

Both the western side of the project area and the northeastern corner, near the entrance to Eel Pond, support eelgrass (*Zostera marina*) meadows as mapped by the Massachusetts Department of Environmental Protection ("MassDEP"). The MassDEP mapped eelgrass meadows are determined by remote sensing techniques. An in-water video survey performed at the pier from June 30 to July 1, 2020 by CR Environmental confirmed the presence of eelgrass, and accurately mapped the eelgrass meadow boundaries. The site-specific mapped effort documented an estimated 5,780 sf meadow on the west side of the Iselin Dock and a 14,940 sf meadow on the eastern side near the Eel Pond channel. Pier replacement construction activities are proposed close to the eelgrass meadows and that work may affect eelgrass during construction (e.g., turbidity) as well as post-construction (from boat shading).

Following are the proposed measures to avoid, minimize, and mitigate potential adverse effects to eelgrass from construction and operation of the CWATER facility.

Avoidance and Minimization of Eelgrass

As recommend by DMF and EPA, a pre-construction in-water eelgrass survey will be performed within 100 feet of the Iselin Pier during the summer or early fall before construction begins to re-delineate the lateral extent of the eelgrass beds proximate to the work zone. The survey will be conducted using single-beam sonar and towed video camera, consistent with the study area and methodology used by CR Environmental for the survey completed for the CWATER project in June 2020.

Based on the results of the pre-construction survey, and prior to the arrival of work vessels, the closest edge of the eelgrass beds will be marked with buoys, or other suitable in-water markers, so the eelgrass limits are clearly visible at the surface. Fixed markers will be offset ten feet from the outer edge of the eelgrass beds at each angle point and at 25-foot intervals in between. Work vessels will be positioned and operated to avoid eelgrass areas, and if unavoidable the incursion will be minimized.

Prior to starting in-water construction activities, marine contractors will deploy silt curtains at the marked perimeter as shown on the attached figure. When installed properly, silt curtains can effectively reduce impact to eelgrass by limiting transport and deposition of suspended sediments in to the meadow, but there is also some risk that movement of the curtains on the harbor bottom may adversely impact the eelgrass. Movement of the silt curtain bottom and anchors can cause bottom scour as the silt curtain moves with tides and currents. For this reason, the silt curtains will be installed no closer than 5 feet from the edge of eelgrass. The silt curtains will be anchored at the bottom to maintain contact with the substrate, and floats will be attached along the top of the curtain to clearly mark the position on the water surface. This installation means that the silt curtain will extend through the full depth of the water column.

For the work on the bulkhead reconfiguration along the Eel Pond entrance channel, a 10-foot minimum width workspace is required for floats and other equipment used by the marine contractors. Therefore, the silt curtain cannot be installed within ten feet of the bulkhead and must be terminated wherever the mapped eelgrass bed is less than ten feet from bulkhead refer to Figure 1.

Work barges, from which cranes will operate, will be positioned to avoid the placement of anchors and spuds in eelgrass beds. Barges and cranes will be sized so that they are able to reach required areas from those positions. The placement of anchors or spuds within mapped eelgrass areas will only be permitted in those circumstances where such placement is necessary to avoid damage to equipment or property (exceptions for emergencies only). Any such emergency anchoring within eelgrass will be documented (date and GPS location of anchoring event). If anchoring does occur within in an eelgrass meadow, then the anchoring site(s) within eelgrass would be added to the quadrat survey plan for subsequent post-construction growing season surveys as described below.

Eelgrass Monitoring Program

The pre-construction survey of eelgrass resources within 100 feet of the dock perimeter will be performed during the summer or early fall and prior to the start of work and arrival of work vessels to provide a baseline against which subsequent monitoring activities will be compared. Annual post-construction monitoring of eelgrass areas will be performed during the same time of year for a period of 3-years to observe and document the overall status of the eelgrass meadows and the recovery of any areas directly affected by in-water construction.

The study area and methodology for both pre- and post-construction monitoring will include all areas evaluated for the eelgrass survey conducted by CR Environmental for the CWATER project in June, 2020. Monitoring metrics will include extent of meadow and plant density, particularly in any area that may be subject to longer term impacts from shading. In addition, stem counts will be performed at eight permanent ½-meter square quadrat stations (two near the bulkhead reconfiguration along the Eel Pond entrance channel, two near the robotics vessel port, and four located in westernmost portion of Great Harbor, far removed from the construction zone, which will serve as reference stations). All data obtained from quadrat stations will be gathered by diver surveys.

Refer to Figure 2 for the limits of the eelgrass extents surveys and quadrat locations.

Proactive Eelgrass Mitigation Strategy

WHOI estimates that the construction of the CWATER project has the potential to alter 500 to 1,500 square feet of eelgrass habitat proximate to the Iselin Marine Facility and proposes to provide proactive mitigation to offset this potential impact. To do so, WHOI proposes to convert traditional boat moorings within eelgrass meadows in Great Harbor to conservation moorings that are designed to prevent anchor chain scour which damages and prevents eelgrass growth around the mooring anchor. Proactive conversions would be completed prior to construction to establish a mitigation credit to offset any observed impacts to eelgrass resulting from construction activities.

.

Proactive mitigation will be based on an assumed alteration of 1,000 square feet of eelgrass habitat, and a 3:1 mitigation ratio which yields 3,000 sf of mitigation area (credit). The West Falmouth Harbor conservation mooring program demonstrated that the average area of mooring scars from traditional tackle measured 82 square meters (882 sf). Assuming the scars from traditional moorings in Great Harbor are similar in size and conversions will result in 50% restoration of eelgrass habitat within those scarred areas, then approximately 440 sf. of eelgrass habitat could be restored per mooring conversion. Thus, WHOI proposes to convert eight moorings to yield approximately 3,520 sf of restored eelgrass habitat (assuming 50% successful restoration). It is understood that additional conversions may be necessary if post-construction monitoring at the Iselin Pier demonstrates more than 1,000 sf of eel grass is lost within 100 feet of the work limits, after the first full growing season post-construction.

The target area for the mooring conversion effort is at the west end of Great Harbor where extensive eelgrass habitat was mapped by DEP in 2019. Mooring owners within this area will be contacted individually to determine their interest in participating, and moorings to be converted will be selected entirely on a volunteer basis, with priority given to those moorings that are determined to be most detrimental to the eelgrass based on a preliminary survey. Secondary priority will be based on the ability to form a cluster of conservation moorings to avoid conflicts arising from adjacent vessels using dissimilar tackle.

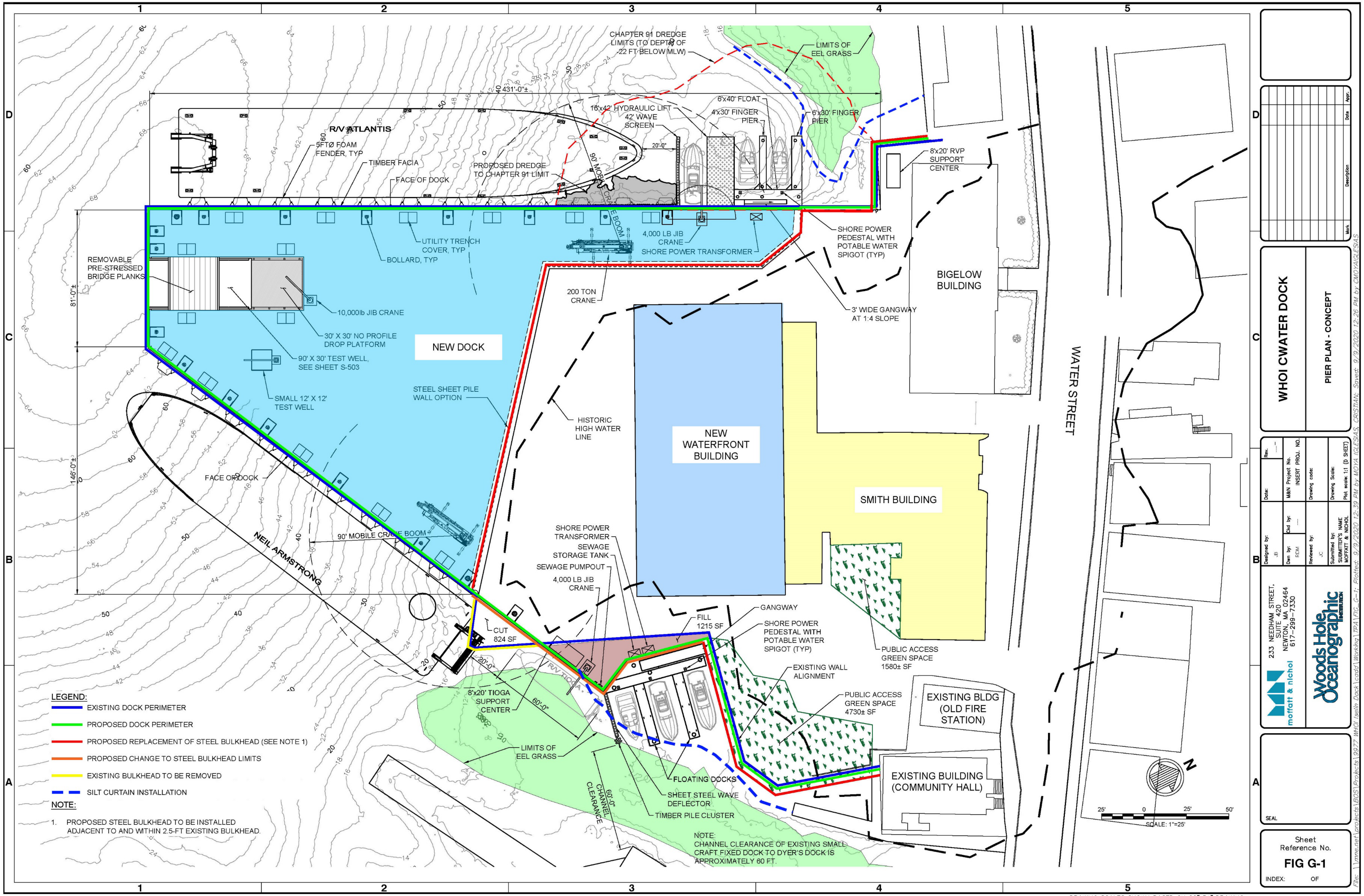
All converted moorings will be monitored prior to conversion and on an annual basis for three years post-conversion to document the results of the proactive mitigation effort. Monitoring and statistical analyses of data will be consistent with that described in *Eelgrass Mitigation for the Massachusetts Port Authority Through Habitat Restoration and Conservation Moorings, 2019 Final Report*, Massachusetts Division of Marine Fisheries, 2019 as summarized below.

Monitoring Protocols: Full monitoring of each mooring will include distance measurements (in meters) from the base of the conservation mooring (mooring shackle) to the first shoot and scar edge along transects in all cardinal and ordinal directions. The scar edge is defined as the point at which the percent cover of eelgrass transitions to 20% or greater. Additionally, shoot counts will be record in eight ¼-meter square quadrats within the scar plus eight ¼-meter square quadrats outside of the scar, the latter to be used as reference measurements. The quadrat locations will be selected using a random number table to select points along each transect. The reference quadrats will be at least 1-meter beyond the original scar edge. Additionally, moorings will be visually inspected to note any fouling or maintenance concerns.

Statistical analyses: Moorings that do not remain conservation moorings for the duration of the 3-year monitoring period will be excluded from the following analyses. The proportion of conservation moorings that were observed dragging on the sediment in each year will be calculated. Mean shoot counts for each mooring will calculated for quadrats collected inside the scar, outside the scar, and in the recovered area of the scar. Means and standard errors for shoot counts inside, outside, and in the recovered area (when applicable) of the scar will be reported for each site. The area of each scar will calculated by totaling the area of each triangular sector defined by points at the mooring base and scar edges.

Determining Need for Additional Eelgrass Mitigation

Through proactive mitigation, WHOI seeks to restore approximately 3,000 square feet of eelgrass habitat in Great Harbor, which will compensate for up to 1,000 square feet of lost eelgrass that may result from Project construction. Post-construction monitoring adjacent to the reconstructed dock will provide data that will be used to document the condition of the eelgrass meadow that is closest to the dock construction. Extant eelgrass meadows adjacent to the pier will be monitored (lateral extent, plant density and stem counts as described above) over a 3-year period. After the first year any documented reduction of eelgrass extent will be quantified and reported. If it is determined that a loss of eelgrass habitat exceeds the amount of restoration provided by the proactive mitigation described above, then WHOI will sponsor and fund additional mooring conversions to yield a net zero loss of eelgrass in the Town of Falmouth. Location(s) for additional conversions will be those that are deemed suitable by DMF and the Town of Falmouth Harbor master and Conservation Commission staff.



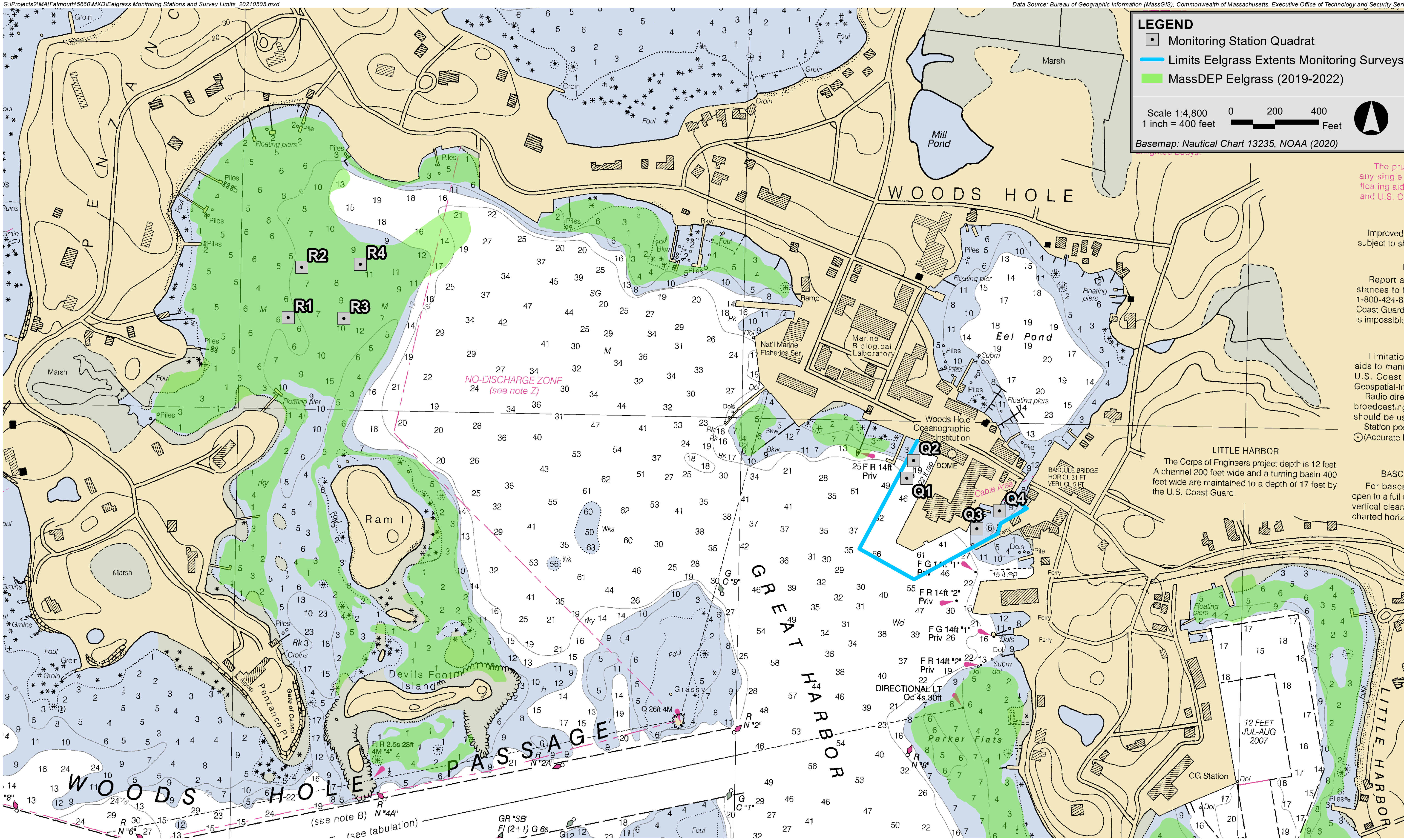
Woods Hole Oceanographic Institution, CWATER Project   Falmouth, Massachusetts

Epsilon ASSOCIATES INC.

Figure 1

Eelgrass Avoidance and Protection-Silt Curtain Placement

Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services



Woods Hole Oceanographic Institution, CWATER Project **Falmouth, Massachusetts**

Epsilon ASSOCIATES INC.

Figure 2

Eelgrass Monitoring Stations and Survey Limits

Attachment F

Variance Request

Attachment F

REQUEST FOR VARIANCE

1.0 INTRODUCTION

Founded in 1930, Woods Hole Oceanographic Institution ("WHOI" or "the Institution") is the largest private, non-profit institution dedicated to ocean science, education and engineering in the world. WHOI employs over 1,000 scientists, engineers, technicians, seafarers and administrators, and hosts over 400 affiliates, including graduate students in a joint Ph.D. program with the Massachusetts Institute of Technology ("MIT"), post-doctoral scholars, undergraduate interns and guest investigators. WHOI has two campuses in Woods Hole: the Quissett Campus and the Woods Hole Village Campus. The Woods Hole Campus includes its working waterfront known as the Iselin Marine Facility. From this base of operations, WHOI scientific crews deploy on ocean research vessels and smaller coastal research vessels, and fabricate and deploy submersibles to the far reaches of the world's oceans seeking answers to the most fundamental and pressing questions about the ocean.

WHOI's Complex for Waterfront Access to Exploration and Research ("CWATER") Project, which involves the replacement the more than 50-year old pier and the existing Iselin Marine Facility, is key to meeting these the Institution's research needs for the next century. CWATER builds upon WHOI's 90-year history of providing the ocean science community access to the sea through the modernization of its water-dependent facilities that support WHOI's mission of research, science and education, while being resilient in the face of climate change, sea level rise and storm events. Moreover, as described below, this Project also underpins the economic vitality of the blue economy on Cape Cod and beyond.

2.0 ECONOMIC IMPORTANCE OF THE ISELIN MARINE FACILITY

The Iselin Marine Facility is a vitally important asset to WHOI and the science community, and generates significant economic activity. WHOI is the recipient of over $200 million federal dollars annually, leads the state in National Science Foundation funding and is the 5th largest recipient of NSF funding nationally. WHOI's operations translate to approximately 3,900 jobs, $186.5 million in wages, $333.7 million value added to Gross Domestic Product, and supports $603.8 million in business revenue annually. The Blue Tech Economy contributes $2.6 billion in earnings and supports nearly 25,000 ocean-related jobs in Massachusetts, four percent of which are with WHOI. Regionally, WHOI is the second largest employer on Cape Cod (after Cape Cod Healthcare), and supports the region in coastal planning, resource management, and habitat protection, while also being a significant contributor to the growing national security R&D base. (source: UMDI economic impact analysis of WHOI, 2019)

WHOI is the largest Marine and Science Technology ("MST") corridor employer in Massachusetts, the MST institution that government and nonprofit organizations collaborate with more than any other, and a leader in federal undersea and defense research contracts. (source: 2019 UMass Dartmouth study funded by the U.S. Economic Development Administration to facilitate development of a Marine and Science Technology corridor in Southeast New England) From 2015-2019, the Iselin Marine Facility created or supported over 1,500 jobs and $236 million of GDP in New England. These findings suggest that every job related directly to the facility created one more job elsewhere in Massachusetts. Similarly, every dollar of operations spending creates an additional $0.50 of business revenues. (source: UMDI economic impact analysis of Iselin Marine Support Facility, 2020) In the past 5 years, the Iselin Marine Facility has contributed over $50M to the local economy. Replacing the Iselin Marine Facility with a modern and resilient port facility will help WHOI maintain its position as a leader in ocean research, bolster the Blue Tech Economy, and will allow the Commonwealth to continue to derive the associated economic benefits.

3.0 PROJECT DESCRIPTION

The Iselin Marine Facility was originally constructed in 1969 and has reached the end of its 50-year design life. Over the course of its lifespan, sections of the concrete deck have undergone repair or replacement, but these efforts are not sustainable and repair activities alone are increasingly unable to keep up with the advancing deterioration of the structure. While these maintenance costs escalate, it is anticipated that the existing dock will be more susceptible to flooding due to sea level rise. In light of these concerns WHOI seeks to replace and rebuild the Iselin Marine Facility and the buildings that are situated upon it at a higher elevation, and the CWATER Project is designed to provide a more modern and resilient marine support facility that will serve the Institution's needs for the next century.

In 2018 WHOI performed an assessment of the facilities currently located at the waterfront and highlighted those programs that are critical to remain at the dock. These include: an expanded number of high bays so that multiple vessels can be worked on at once; dive operations and diver training with expanded locker and operations space; the Ocean Systems Laboratory ("OSL"), which supports unmanned underwater vehicle development; the Advanced Fabrication Lab; flexible laboratory space; Shipboard Scientific Services Group ("SSSG") and Marine Operations office. The proposed three-story New Waterfront Building ("NWB") will be constructed entirely on land[1] and landward of the FEMA VE-Zone.

The primary purpose of the NWB is to replace and right size existing facilities on WHOI's waterfront campus. The Project proposes to remove the existing Iselin Laboratory building, Alvin High Bay, Smith Connector Building and the Flume Building, which collectively total approximately 48,600 square feet ("s.f.") of gross floor area, within an 25,800 s.f. footprint. The NWB will consist of approximately 45,000 square feet of gross floor area within an approximately 18.500 s.f. footprint, and therefore, post-redevelopment conditions result in a decrease of approximately 3,600 square feet of gross floor area and 7,300 s.f. of building footprint, respectively.

The reconstructed dock will replace the existing structure essentially within its existing footprint, but will have some minor modifications that are intended to enhance dock operations, berthing positions, vessel loading/unloading, and navigation. These modifications include accommodations for improved unmanned vessel access on the west side, and reconfiguration of the bulkhead and small boat slips along the Eel Pond entrance channel, and relocation of the large test well to the southern edge of the pier. None of these modifications will result in an increase the intensity of port facility uses.

As part of the Project, WHOI also intends to expand upon previously authorized dredge depths along the dock's west berth where riprap that was placed seaward of the sheet pile bulkhead has slumped into the vessel berthing area. Dredging in this area will extend slightly beyond previously authorized dredge limits and will increase depth to -24 MLLW. This dredging, which estimated to be approximately 166 cubic yards in volume, will affect approximately 1,700 sf of the harbor bottom and will be performed largely within dredge limits previously authorized under the Site's current Chapter 91 license.

[1] The existing Iselin Building is built partly on land and partly on the pier.

4.0 REQUEST FOR VARIANCE FROM PROVISIONS OF FALMOUTH WETLAND REGULATIONS

The CWATER Project meets all performance standards that are prescribed in the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00 *et seq.*) but cannot satisfy certain performance standards established in the Falmouth Wetlands Protection Regulations ("FWR"), specifically:

- The NWB, although being moved further landward from the Federal Emergency Management Agency ("FEMA") mapped VE-Zone boundary cannot be sited in a manner that provides 25-feet of separation from the FEMA mapped VE-Zone as currently mapped. Relief from regulation **FWR 10.38(4)(d)** is therefore requested to allow construction of the NWB within 25 feet of the VE-Zone as established by FEMA.

- The proposed dock replacement and minor alignment modifications will require installing marine infrastructure within fifty feet of eelgrass beds located within the Eel pond entrance channel and in shallow water adjacent to the west edge of the dock. Relief from regulation **FWR 10.16 (1)(h)(5)** is therefore requested to allow for the reconstruction of the Iselin Marine Facility with modifications within fifty feet of eelgrass beds.

Because, the CWATER project cannot satisfy these two performance standards, WHOI respectfully requests that the Falmouth Conservation Commission grant a variance pursuant FWR 10.13 so that an Order of Conditions for the CWATER Project can be issued pursuant to the Falmouth Wetlands Bylaw, Chapter 235 of the Code of Falmouth. Following is a review of the pertinent section of FWR 10.13 to support this request for a variance.

<u>Demonstration of Hardship</u>

Hardship as defined in the FWR 10.04 means: "… *the application of Chapter 235 of the Code of Falmouth to a particular piece of property, evaluated in its totality, owing to the unique characteristics of the property, that is unduly oppressive, arbitrary or confiscatory and would involve substantial economic loss to the Applicant because of the literal enforcement of the Bylaw provided that the Conditions and characteristics of the property are not the result of the actions of the Applicant, or owner, or their agents, predecessors, successors or assignees. No Hardship exists where there is established under the Code of Falmouth a right to transfer development rights.*"

The Iselin Marine Facility includes a pile-supported, bulkhead and solid fill behind the bulkhead and terrestrial landform. The pier and immediate land surface provides a platform for stationary and mobile equipment used for vessel loading and unloading, and the deployment and retrieval of un-manned autonomous vehicles ("UAVs" or "submersibles"). The dock is also occupied by several Institution buildings that are integral to the operation of the dock and provide interior space for vessel maintenance and support, UAV fabrication repair and maintenance, and water-dependent marine research. These buildings are individually known as the Iselin Laboratory, Alvin High Bay, Smith Connector Building, and Flume Building. The most seaward of these buildings, the Iselin Building is located partly on the pile-supported dock, and partly upon the solid fill pier. As a result, reconstruction of the Iselin Dock requires the demolishing and replacing the Iselin Building as well as the other buildings mentioned above.

The Iselin Marine Facility in its current form is approximately 50 years old and pre-dates the FWR. The water dependent uses, plus functional dependency of the buildings and the pier establish unique characteristics of the WHOI Village Campus such that strict application of *Chapter 235 of the Code of Falmouth* and FWR sections 10.28(4)(d) and 10.16 (1)(h)(5) to the CWATER project is unduly oppressive and would involve substantial economic loss to WHOI, the Town of Falmouth, and the Region's blue economy. A significant portion of the existing Iselin Marine Facility is located within the VE-Zone as mapped by FEMA, which extends up and onto the dock surface approximately 30-40 feet from its seaward face as "over wash," refer to FWR 10.38(2)(a)(5). Furthermore, the Iselin Marine Facility is located within fifty feet of mapped eelgrass resources on both sides of the pier, and as a result, the CWATER project will require construction within 50 feet of eelgrass beds.

Due to these constraints, and the unique dependency of the pier and the waterfront buildings strict application of *Chapter 235 of the Falmouth Code* would prevent WHOI from replacing the dock and buildings in a manner that meets the current and future needs of the Institution, as well as the local, national and international scientific communities it serves. Prohibiting the CWATER Project from proceeding as planned would therefore hinder ocean science research causing substantial economic hardship to the Institution, the Cape Cod region and the Commonwealth. This hardship is not the result of the actions of the Applicant, or owner, or their agents, predecessors, successors or assignees, but rather the hardship results from the need for WHOI to maintain a world-class scientific research port at their existing base of operations on the Woods Hole waterfront, the unique existing characteristics of the property and surrounding area, and the performance standards in FWR sections 10.28(4)(d) and 10.16 (1)(h)(5).

Justification for Variance

The CWATER Project satisfies the five standards for issuance of a variance as specified in the Falmouth Wetland Regulation at FWR 10.13 (1) (a) through (e) as discussed below.

(a) *The project does not meet one or more of the performance standards articulated in FWR 10.16 through 10.60.*

Due to its unique site characteristics, the CWATER Project is unable to satisfy performance standards established in the Falmouth Wetland Regulations that prohibit:

i) the reconstruction or substantial alteration of an existing dock within 50 feet of an area of eel grass (FWR 10.16 (1)(h)5), and

ii) the construction of a new structure within 25' feet of a VE-zone as mapped by FEMA (FWR 10.28(4)(d)).

A variance from these two performance standards is therefore requested.

(b) *Mitigating measures are proposed by the Applicant that will allow the project to be conditioned so as to contribute to the protection of the resource areas identified in Chapter 235.*

The CWATER project incorporates appropriate mitigation and can be conditioned so it contributes to the protection of both Land under the Ocean and Land Subject to Coastal Storm Flowage as briefly described below. For more information about the proposed mitigation measures see the Notice of Intent ("NOI") Project Narrative (Attachment A) and the NOI Project Plans (Attachment K)

Land Under the Ocean (Eelgrass Mitigation)

An eelgrass avoidance and protection plan has been prepared in consultation with the Division of Marine Fisheries ("DMF") and the US Environmental Protection Agency ("EPA") and is included as Attachment XX to the NOI. This mitigation plan includes specific measures to be implemented to minimize potential adverse impact to eelgrass areas located in the Project vicinity during construction, including restrictions on construction vessel traffic and anchoring positions as well as use of siltation curtains to minimize impacts related to deposition of suspended sediments from pile driving and bulkhead reconstruction. Proactive mitigation is proposed by the applicant to restore eel grass in the Great Harbor by converting traditional boat moorings with conservation moorings (i.e., a mooring conversion program) during the early stages of the CWATER Project. It also specifies pre- and post-construction eelgrass monitoring requirements, impact assessment, and restoration goals. If, after three years of post-construction monitoring, eel grass impacts are observed that exceed the mitigation provided by the mooring conversion program, then additional mitigation will be provided.

Land Subject to Coastal Storm Flowage

WHOI has embraced the concept that the CWATER Project should be built in an adaptable and forward-looking fashion that anticipates projected sea-level rise ("SLR"). This idea has formed the underpinning for the construction of the new facility. Additionally, engagement with subject matter experts within the Institution coupled with modeling completed by external consultants has provided a clearer understanding of the risks associated with SLR and climate change in Woods Hole as well as reinforcing uncertainty associated with long-range projections. The combined results of these analyses are reflected in the proposed Site elevations, which set the base elevations for both the new dock and building at +2.5 feet for the dock structure and at-grade access to the facility initially, with the ability to raise the pier and increase the first floor elevation an additional 1.5 feet (for a total of +4.0 feet above existing dock and building elevations).

To understand the extent of flooding for the proposed conditions, WHOI retained the Woods Hole Group, Inc. ("WHG") to perform a flood plain analysis to calculate the extent of flooding across the site after the dock is raised by 2.5 feet. The WHG model shows that the AE-Zone elevation will be reduced by one foot to elevation 11 feet North American Vertical Datum of 1988 ("NAVD88") and the VE-Zone boundary will follow along the edge of the dock, and not extend landward from the edge of the dock. Based on this model result, the proposed NWB will be located greater than 25 feet from the future VE-Zone Boundary. Additionally, the CWATER Project promotes resiliency and adaptation to SLR by: (1) locating the NWB further landward from the pier edge than the existing buildings, (2) reducing building footprint on the property to better distribute floodwaters across the site, (3) reducing impervious cover on the property, and (4) including highly efficient mechanical, electrical and plumbing ("MEP") design elements to reduced greenhouse gas emissions (e.g., use of passive solar energy, maximizing sun light to reduce electrical lighting needs, and the use of seawater for heating and cooling).

Thus, the CWATER project will enhance the primary functions of Land Subject to Coastal Storm Flowage, which are storm damage prevention and flood control, and represents a significant improvement over existing conditions.

The project will not create a nuisance.

The CWATER Project will not increase the vessel berthing capacity, traffic or parking requirements, or intensity of use of the Iselin Marine Facility and therefore will not create a nuisance.

The hardship was not created by the applicant or the applicant's agents.

This hardship is not the result of the actions of the Applicant, or owner, or their agents, predecessors, successors or assignees, but rather results from the need for WHOI to maintain a world-class scientific research port at a confined and constrained location at its existing base of operations at Woods Hole. See the discussion of hardship above for additional information.

The resource areas delineated in Chapter 235 will be better protected if the project is allowed than if the project is denied, or the project has an overriding public benefit.

As described above, the CWATER Project has an overriding public benefit. First, WHOI's mission includes conducting novel world leading ocean research, and to educate the next the generation of ocean scientists and engineers, and the dock/port is vitally important to its research and mission. With a changing climate and changing ocean environments conducting research presently and educating the next generation of ocean researchers is an overriding public interest unto itself. The research conducted at WHOI is research that is needed to: help mankind learn how to mitigate global warming, understand changes to the ocean environment, and adapt to a warming planet and the resulting changes to ocean to the coastal environments. Second, WHOI and its Iselin Marine Facility are significant drivers of the regional Cape Cod economy and of the Commonwealth's economy more broadly.

Land Under the Ocean (Eelgrass)

During construction, mitigation measures will be employed to avoid and minimize potential adverse effects to eel grass to the maximum extent practicable. The proposed mooring conversion program as a result of the CWATER will lead to better eel grass protection in Great Harbor than leaving the traditional moorings in place. Thus, through the CWATER Project mitigation program will better protect eel grass resources in the Woods Hole waters.

Land Subject to Coastal Storm Flowage

The raised pier will effectively act as a breakwater and reduce the base flood elevation in the AE Zone by one foot and move the VE Zone boundary to the edge of the pier (i.e. further seaward than current conditions). By these changes, the CWATER Project will enhance the storm damage prevention and flood control functions of LSCSF on the site and immediate environs. Significantly, the project will also reduce the building cover (footprint) on the property which will more effectively dissipate floodwaters across property.

Further, the CWATER project is serving as a catalyst for the Woods Hole Community which is now looking at the SLR issue on a village-wide basis with the various stakeholders starting to work proactively to devise a resiliency plan in conjunction with the Town of Falmouth.

5.0 Variance Procedure

The applicant has prepared this request in compliance with procedures established in FWR 10.13 (2)(a) as demonstrated below. Note, these subsections mirror previous subsections of the FWR, therefore if unique answers are not required the reader is directed to the prior applicable response.

(a) A request for a variance shall be made in writing at the time the Permit Application is filed and shall include, at a minimum, the following information:

This is the written request for a variance, and it is submitted concurrent with the NOI.

1. A description of how the project qualifies for a variance in accordance with FWR 10.13(1); and

Please see responses above to FWR 10.13 (1) (a) through (e)

2. A description of alternatives explored that would allow the project to proceed in Compliance with FWR 10.16 through 10.60 and an explanation of why each is unreasonable or unrealistic; and

Because of the unique characteristics of the site, there are no alternatives, other than the no-build or site relocation alternatives, that would allow the project to proceed in compliance with FWR 10.16 through 10.60. Because the goal of the Project is to maintain WHOI's ocean-going capabilities on the Woods Hole waterfront and reputation as a world class oceanographic research institution, neither the no-build or site relocation are reasonable or realistic.

3. A description of the mitigating measures to be used to contribute to the protection of the Resource area values identified in Chapter 235 of the Code of Falmouth; and

A summary of the proposed mitigation measures for eel grass and LSCSF are presented above in response to FWR 10.13(1)(b). Also see NOI Project Narrative (Attachment A).

4. A description of how the resource areas delineated in Chapter 235 will be better protected if the project is allowed than if the project is denied; or

See response to FWR 10.13(1)(e) above.

5. Evidence that an overriding public interest is associated with the project which justifies waiver of FWR 10.16 through 10.60.

See response to FWR 10.13(1)(e) above.

6.0 Term of Variance Procedure

FWR 10.13 (3) reads as follows: "*If the rights authorized by a variance are not exercised within one year of the date of grant of such variance such rights shall lapse provided, however, that the Commission may extend the time for the exercise of such rights for a period not to exceed six months provided further that the application for any extension be submitted prior to the expiration of such rights.*"

The CWATER Project is a phased project that will be built over an approximately two-year period. Further, several state permits are also required, the issuance of which are dependent upon the issuance of the Order of Conditions ("OOC"), and those permitting processes will take 12- to 18-months. Therefore, project completion will not occur for some 3 to 3½ years after the OOC is issued. Due to these time constraints WHOI respectfully requests relief from the time periods established in in FWR 10.13(3). WHOI requests that the Variance be allowed to run concurrent with the OOC.

Attachment G

Stormwater Management Report

Storm Runoff Analysis
And
Operation and Maintenance Plan

Woods Hole Oceanographic Institute
Falmouth, Massachusetts

Iselin Dock Redevelopment

FEBRUARY 22, 2021

Prepared for: Town of Falmouth
59 Town Hall Square
Falmouth, MA 02540

Prepared by: Moffatt & Nichol

moffatt & nichol

180 Wells Avenue, Suite 302
Newton, MA 02459

(617) 229-7330
www.moffattnichol.com

List of Appendices

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

---

[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☐ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☒ Reduced Impervious Area (Redevelopment Only)

☐ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

- ☐ Credit 1
- ☐ Credit 2
- ☐ Credit 3

☐ Use of "country drainage" versus curb and gutter conveyance and pipe

☐ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☐ Grass Channel

☐ Green Roof

☐ Other (describe): ____________________

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☒ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☐ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☐ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☐ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☒ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☐ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☐ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:
- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☒ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☐ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☐ The BMP is sized (and calculations provided) based on:

- ☐ The ½" or 1" Water Quality Volume or
- ☒ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☒ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☒ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☒ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☒ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☒ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

- ☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

- ☐ The project is ***not*** covered by a NPDES Construction General Permit.
- ☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.
- ☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

- ☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:
  - ☒ Name of the stormwater management system owners;
  - ☒ Party responsible for operation and maintenance;
  - ☒ Schedule for implementation of routine and non-routine maintenance tasks;
  - ☐ Plan showing the location of all stormwater BMPs maintenance access areas;
  - ☒ Description and delineation of public safety features;
  - ☐ Estimated operation and maintenance budget; and
  - ☒ Operation and Maintenance Log Form.
- ☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:
  - ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
  - ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

- ☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;
- ☒ An Illicit Discharge Compliance Statement is attached;
- ☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

1.0 Introduction:

1.1 Project Background

For nearly a century, Woods Hole Oceanographic Institution (WHOI) has been one of the best known and most trusted names in ocean science and exploration. WHOI's scientists and engineers have played roles in many of the discoveries that form the modern understanding of the ocean and how it interacts with other parts of the planet, including human society. Since its founding in 1930, WHOI has had waterfront facilities in Woods Hole (Massachusetts) capable of berthing and supporting the activities of its ocean-going research vessels, as well as those of other research institutions. The current configuration of the Iselin Dock was constructed in 1969 to accommodate an expanding fleet of research vessels. The facility is comprised of test wells, shops, laboratories with flexible high bay space, and facilities activities are responsible for over $35M per year in economic value to the Institution.

1.2 Purpose

The replacement of the aging Iselin Dock provides an opportunity to create a waterfront research facility that anticipates and enables the direction of ocean research for the next century. WHOI has tasked Moffatt & Nichol (M&N) with procuring construction services for the redevelopment of their facilities including this Storm and Runoff analysis report. The limit of work will exceed 1 acre; therefore, this project is subject to the Ten (10) MassDEP Stormwater Management Standards.

1.3 Existing Site Description

The Iselin Dock and Laboratory are situated within WHOI's waterfront facility, which also currently includes several buildings (Smith Facility, Connector Facility, Smith Laboratory, Bigelow Building, Old Fire Station, and Community Hall), and berth facilities for research vessels. The waterfront dock facility includes a pile-supported pier to the south and west and a land-supported deck to the north and east, separated by a bulkhead. The existing pier and deck elevation is approximately 6.0 NAVD88.

The existing stormwater collection and discharge infrastructure on the site consists of catch basins and underground reinforced concrete pipes landward of the bulkhead, with direct discharge into Great Harbor. On the water side of the bulkhead, stormwater drainage is handled via sheet flow across the deck and into the harbor, test pits, and existing scuppers.

1.4 Proposed Conditions

As mentioned above WHOI is redeveloping the current site to accommodate and prepare for the next century of oceanographic research. The proposed improvements for the site include the creation of a new building where the current Iselin Marine Facility is located. This building along with the entire pier will be raised 4.5' above the existing elevations from the existing bulkhead and expanding to all edges on the waterside of the site to an elevation of 10.5 NAVD88. A new access drive will be constructed around the site including more ADA access into current and redeveloped buildings. In addition to the redeveloped building and access drives drainage infrastructure will be upgraded to comply with the MassDEP standards set forth for a redevelopment.

2.0 Stormwater Management Standards

The proposed development has been designed in compliance with the Stormwater Management Regulations issued by the Massachusetts Department of Environmental Protection (MassDEP). The Stormwater Management Regulations include ten (10) standards for stormwater management compliance. The following is a description of how the proposed project will comply with each of the ten (10) Stormwater Management Standards. The proposed project is considered a redevelopment project and therefore is subject to the Standards to the maximum extent possible.

Minimum Standard #1

No new stormwater conveyances may discharge untreated stormwater directly to or cause erosion in wetland or waters of the Commonwealth.

There will be no new untreated stormwater conveyances to wetlands or waters of the Commonwealth associated under this project. The site will be decreasing its stormwater discharge from three (3) outfalls down to two (2) outfalls in the proposed conditions.

Minimum Standard #2

Stormwater management systems must be designed so that the post-development peak discharge rates do not exceed pre-development peak discharge rates.

The proposed redevelopment project directly abuts the Atlantic Ocean and therefore stormwater mitigation is not required. However, the proposed redevelopment conditions do not exceed pre-development conditions under any of the 2, 10 or 100yr storm events.

Autodesk Storm and Sanitary Analysis Modeling (SSA)

The pre- and post-site conditions are analyzed using the Autodesk Storm and Sanitary Analysis (SSA) modelling software. The program models the site hydrology, then through a series of nodes and links routes the water through the proposed drainage system.

The hydrology is modelled using basins with accompanying area, curve numbers, time of concentration and runoff hydrograph inputs, each assigned to a basin within the system. Autodesk Storm and Sanitary Analysis outputs a corresponding hydrograph for each basin using the SCS Unit Hydrograph method and a Type III Storm Distribution.

The hydrology is then applied to the hydraulic data, represented by basins and links. The nodes represent locations in the drainage system where there is storage, a change in link (pipes or channel) characteristics, or where runoff is entering and exiting. The links joining the nodes represent the conveyances, including pipes. The system is analyzed for the selected storm event to determine the flow.

Autodesk Storm and Sanitary uses the equation below to calculate the flow through the drainage system:

$$\Delta s = (Q_{in} - Q_{out})\Delta t$$

Where, $\Delta s =$ Change of Storage for given time step
$Q_{in} =$ Flow entering node at time "t"
$Q_{out} =$ Flow exiting node at time "t"
$\Delta t =$ Time Step as defined in modelling software

This method of analysis accounts for the storage in pipes, and therefore models equilibrium relationships between basins or ponds to properly represent runoff behavior in flat areas. Finally, knowing the pre-development flows, the proposed drainage system can be adjusted as necessary so that the post-development flows meet the design criteria, as specified by the user.

Hydrology

The storm data was provided by NOAA for Barnstable County, Massachusetts. A Type III rainfall distribution type, as specified by the NRCS Urban Hydrology for Small Watersheds – Technical Release (TR)-55, was used for the project. The design storms used in the model as well the rain fall amount are as follows:

Rainfall Return Period (year)	24-Hour Rainfall Amount (inches)
2 year	3.44
10 year	5.02
100 year	7.51

Table 1: NOAA 24hr Rainfall Amounts

Curve numbers were generated using the SCS Runoff Curve Number as described in TR-55. Curve numbers from each drainage basin are calculated based on the hydrologic soil group, cover type, treatment, and the hydrologic condition. Post-development curve numbers consider the proposed change in conditions.

Time of concentration was calculated using the methods described in TR-55. Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or a combination of these flows. Therefore, the travel time for each type of flow was calculated using the equations below and added together to determine the time of concentration.

- Sheet Flow

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}s^{0.4}}$$

Where:

T_t = travel time (hr)
n = Manning's roughness coefficient
L = flow length
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

- Shallow concentrated flow

$$T_t = \frac{L}{60v}$$

Where:

L = length (ft)
v = velocity (ft/sec)

- Channel Flow

$$T_t = \frac{L}{60v}$$

Where:

L = length (ft)
v = velocity (ft/sec)

Manning's equation can be used to estimate average flow velocity. Manning's equation is:

$$V = \frac{1.49r^{2/3}s^{1/2}}{n}$$

Where:

V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to a/p_w
  a = cross sectional flow area (ft^2)
  p_w = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow

Surface runoff hydrographs were developed from storm rainfall data using a dimensionless unit hydrograph, drainage areas, times of concentration (TOC), and NRCS runoff curve numbers. The hydrographs were developed to simulate peak storm runoff flows under existing and proposed conditions for 2, 10 and 100-year storm events. The 24hr values used can be found above in Table 1: NOAA 24hr Rainfall Amounts.

2.1 Existing Watersheds

The following section provides brief descriptions of the existing watershed areas and associated downstream facilities. A summary can be found in *Table 2: Existing Watershed Summary*, directly proceeding the descriptions.

<u>Existing Watershed E1</u>

Includes the eastern access drive, the parking lot behind the Old Fire Station and Community Hall, and the east portions of the Smith Building. Stormwater flows over the roof and access drive to be captured in an existing inlet #4 on the south eastern corner of the parking lot. From there the stormwater outfalls under the pier into Great Harbor via existing Outfall #1.
Area = 0.55 Acres

<u>Existing Watershed E2</u>

Includes the northern half of the Iselin Marine Facility roof, the south-western corner of the Smith Building, and the paved space between the grassed area and the existing buildings. Stormwater runoff flows from the roofs to downspouts, to existing inlet #5, then outfalls into Great Harbor via existing Outfall #3.
Area = 0.27 Acres

<u>Existing Watershed E3</u>

Includes the 2-story brick portion of the Smith Building east of the Iselin Marine Facility, the standalone 1-story wood building with attached woodshed, and the sections of the pier to the east of these structures. Stormwater flows from roof drains, down to the pavement and off the south-eastern corner of the pier via sheet flow.
Area = 0.28 Acres

<u>Existing Watershed E4</u>

Includes the south-western most portion of the pier. Stretching from the south-western most corner, north to the western most corner of the Iselin Marine Facility. Stormwater runoff flows west over the pier and away from the test well via sheet flow.
Area = 0.17 Acres

Existing Watershed E5

Contains the west access drive, the north-western portion of the Smith Building, the south-western corner of the Bigelow Building, and the paved space between the grassed area and the existing buildings. Stormwater flows from the roof to downspouts, to existing inlet #7 and then outfalls into Great Harbor.
Area = 0.25 Acres

Existing Watershed E6

Includes the area around the pier, west of the grassed area and west of the Iselin Marine Facility Building. Stormwater flows across the pavement, over the pier and into Great Harbor via sheet flow.
Area = 0.22 Acres

Existing Watershed E7

Includes a portion of the Smith Building roof and the pavement between the building and grassed area. Stormwater flows from the roof to downspouts located on the western side of the Smith Building, then into two 4” PVC pipes which then junction to another 4” PVC pipe and eventually into existing inlet #6. It ultimately outfalls into the Great Harbor via existing Outfall #3.
Area = 0.09 Acres

Existing Watershed E8

Includes the area from the beginning of the east and west access drives to the opposite side of Water Street, the area between the two access drives, and the portion of Water Street from in front of the Community Hall Building to the in front of the Bigelow Building. Stormwater flows to existing inlets #1,2,3 respectively across the street from the Smith Building, then south to another existing inlet before heading off the site to the east.
Area = 0.37 Acres

Existing Watershed E9

Includes the immediate area around the pier opening in all directions. Stormwater sheet flows towards the center to drain at the pier opening and into Great Harbor via sheet flow.
Area = 0.13 Acres

Existing Watershed E10

Includes the area east of the pier opening and the southern half of the Iselin Marine Facility roof. Stormwater flows from roof drains, down to the pavement and off the south eastern face of the pier and into Great Harbor via sheet flow.
Area = 0.34 Acres

Existing Watershed E11

Includes the southernmost part of the site. This includes the area south east of the test well as well as a portion of the concrete bridge planks south of the pier opening. Stormwater runoff flows over pavement to the edge of the pier and into Great Harbor via sheet flow.
Area = 0.11 Acres

Existing Watershed E12

Includes the grassed area to the south of the Bigelow Building and west of the Smitch Building. Stormwater flows to an existing inlet #9 via existing pipe #14 from the covered parking area and then collects the runoff from the grassed area into existing inlet #10. It is then conveyed via a existing pipe #12 and into Great Harbor via existing Outfall #3.
Area = 0.18 Acres

Existing Watershed E13

Contains the southwestern portion of the Bigelow Building as well as the pavement between the building and the pier. Stormwater flows from the roof to downspouts, to an existing inlet #8 and then outfalls into Great Harbor via existing Outfall #2.
Area = 0.10 Acres

Drainage Basin	Acreage	Time of Concentration (Mins:Seconds)	Curve Number
Basin E1	0.55	10:31	95.05
Basin E2	0.27	07:12	98.00
Basin E3	0.28	07:36	98.00
Basin E4	0.17	05:00	98.00
Basin E5	0.25	08:57	98.00
Basin E6	0.22	05:00	98.00
Basin E7	0.09	05:00	91.00
Basin E8	0.37	05:00	98.00
Basin E9	0.13	05:00	98.00
Basin E10	0.34	07:46	95.76
Basin E11	0.11	05:00	98.00
Basin E12	0.18	14:18	77.84
Basin E13	0.10	05:00	98.00

Table 2: Existing Watershed Summary

2.2 Proposed Watersheds

The following section provides brief descriptions of the proposed watershed areas and associated downstream facilities. A summary can be found in *Table 3: Proposed Watersheds Summary*, directly proceeding the descriptions.

Proposed Watershed P1

Includes the grassed area directly to the north of the Iselin Building and below the 4’ retaining wall. The area drains to proposed Inlet #4, into Manhole #1 and eventually into Great Harbor through proposed Outfall #1 via direct discharge.
Area = 0.02 Acres

Proposed Watershed P2

Includes the entire roof from the redeveloped Iselin Building. The pitch of the roof is sloped such that all runoff is routed to roof drains that are located onto the west face of the building. That runoff then sheet flows away from the building and over the pier into Great Harbor via sheet flow.
Area = 0.50 Acres

Proposed Watershed P3

Includes the access road to the west of the redeveloped Iselin Building. The runoff includes the sheet from the access road as well as the downspouts from the roof. The area sheet flows over the pier and into Great Harbor.
Area = 0.08 Acres

Proposed Watershed P4

Includes the north east parking area by the Old Fire Building. This area is paved and flows into a proposed 24” x 24” Inlet #8. It is then directly in a circular 18” RCP and ultimately into Great Harbor through proposed Outfall #2 via direct discharge.
Area = 0.25 Acres

Proposed Watershed P5

Includes the area directly adjacent to Watershed P10 on the top side of the retaining wall with integral curb as well as a portion of the paved area adjacent to the newly proposed Iselin Building. This area is paved and drains to the proposed 24” x 24” Inlet #7. The inlet then connects into Storm Run #2 and eventually into Great Harbor through proposed Outfall #2 via direct discharge.
Area = 0.02 Acres

Proposed Watershed P6

Includes the paved area and redeveloped access road to the south east of the redeveloped Iselin Building. This area sheet flows over the pier into Great Harbor similar to existing runoff conditions.
Area = 0.28 Acres

Proposed Watershed P7

Includes the grassed area to the north of redeveloped Smith Building. The area is graded to flow to the east and to 6" Wide x 6" Deep Trench Drain #2. The middle of the trench drain includes a junction box which then directs flow into Storm Run #3 and into proposed pipe #9, into proposed manhole #2 where it connects into proposed manhole #3 and conveys via 18" RCP into Great Harbor through proposed Outfall #2 via direct discharge
Area = 0.07 Acres

Proposed Watershed P8

Includes the South West paved area of the pier and a small test well. This paved area sheet flows into Great Harbor similar to existing runoff conditions.
Area = 0.23 Acres

Proposed Watershed P9

Includes the paved area and redeveloped access road to the south and west of the redeveloped Iselin Building. This paved area sheet flows into Great Harbor similar to existing runoff conditions.
Area = 0.56 Acres

Proposed Watershed P10

Includes the grassed area between the newly proposed Iselin building and the redeveloped Smith Building. The Finish Floor elevations of these two buildings differ by approximately 4' and are separated by a stem wall. This area is bordered to the south by the Iselin Building, to the north and west by Smith Building, and to the east by a retaining wall with integral curb. The area drains to the proposed 24" x 24" Area Inlet #6. This inlet then connects to proposed Manhole #3 via a circular 18" RCP and ultimately into Great Harbor through proposed Outfall #2 via direct discharge.
Area = 0.04 Acres

Proposed Watershed P11

Includes half of Water Street and a portion of the redeveloped paved eastern access drive into the site. The flows will be collected via curb and gutter along Water Street and via a reversed crown access road and be directing into the proposed 24”x24” Inlet #5. It then enters into Storm Run #2 and ultimately into Great Harbor through proposed Outfall #2 via direct discharge.
Area = 0.10 Acres

Proposed Watershed P12

Includes the roof area from redeveloped Smith Building which is pitched to drain to the north-west face of the building. This area is then collected into a proposed 6” Wide x 6” Deep Trench Drain #1 which is located between the building and the edge of the paved north-west access drive. It is then conveyed into proposed Manhole #1 via an 18” RCP and ultimately into Great Harbor through Outfall #1 via direct discharge.
Area = 0.22 Acres

Proposed Watershed P13

Includes the grassed area to the West of Smith Building and East of the paved access drive. This area sheet flows into a 6” Wide x 6” Deep trench drain. This trench drain collects the roof are from proposed watershed 12
Area = 0.003 Acres

Proposed Watershed P14

Includes the grassed area to the south of the existing Bigelow Building, and to the north of the proposed retaining wall. The area captures the western downspout from the Bigelow Building as well as the sheet flows from the grassed area. This runoff is collected via the proposed 24” x 24” Inlet #3. The flow then is directed via an 18” RCP ultimately into Great Harbor through Outfall #1 via direct discharge.
Area = 0.08 Acres

Proposed Watershed P15

Includes the grassed area to the south of the existing Bigelow Building, and to the north of the proposed retaining wall. The area captures the eastern downspout from the Bigelow Building and also the sheet flows from the grassed area. This runoff is collected via the proposed 24” x 24” Inlet #2. The flow then is directed via an 18” RCP ultimately into Great Harbor through Outfall #1 via direct discharge.
Area = 0.09 Acres

Proposed Watershed P16

Includes the paved access drive to the north-west of the redeveloped Iselin Building and south of the grassed area adjacent to the existing Bigelow Building. The area sheet flows away from the building and over the retaining wall into the grassed area and into proposed 24” x 24” Inlet #4 and ultimately in Great Harbor through Outfall #1 via direct discharge.
Area = 0.11 Acres

Proposed Watershed P17

Includes half of Water Street and a portion of the redeveloped paved western access drive into the site as well as a portion from the north-west corner of the redeveloped Iselin Building. The flows will be collected via integral curb and gutter that is included in the retaining wall and be directing into the proposed 24”x24” Inlet #1. The flow then is directed via an 18” RCP ultimately into Great Harbor through Outfall #1 via direct discharge.
Area = 0.15 Acres

Drainage Basin	**Acreage**	**Time of Concentration (Mins:Seconds)**	**Curve Number**
Basin P1	0.02	05:00	98.00
Basin P2	0.50	05:43	74.00
Basin P3	0.08	05:00	98.00
Basin P4	0.25	12:03	91.00
Basin P5	0.02	08:56	74.00
Basin P6	0.28	05:00	98.00
Basin P7	0.07	05:00	98.00
Basin P8	0.23	08:25	91.00
Basin P9	0.56	05:00	98.00
Basin P10	0.04	05:00	74.00
Basin P11	0.10	05:00	98.00
Basin P12	0.22	05:00	98.00
Basin P13	0.03	08:15	74.00
Basin P14	0.08	08:54	74.00
Basin P15	0.09	20:54	74.00
Basin P16	0.11	05:00	98.00
Basin P17	0.15	05:00	98.00

Table 3: Proposed Watershed Summary

2.3 Analysis of Redevelopment Results

A summary of the pre- and redevelopment runoff rates (cumulative for all outfalls) is presented in Table 4 below.

Summary of Redevelopment Runoff Rates			
	Peak Flow Rate (cfs)		
	2-yr	10-yr	100-yr
Pre-Development	8.95	13.36	18.47
Redevelopment	7.11	10.81	16.66
Percent Difference	-20.6%	-19.1%	-9.8%

Table 4: Redevelopment Runoff Summary

2.4 Stormwater Mitigation Measures

Minimum Standard #3

Loss of annual recharge to groundwater should be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from the pre-development conditions, based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.

There will be no loss of annual recharge to groundwater as a result of the proposed redevelopment. There will be no increase in overall imperviousness onsite and therefore no recharge will be required.

Minimum Standard #4

For new developments, stormwater management systems must be designed to remove 80% of the average annual load (post-development conditions) of Total Suspended Solids (TSS). It is presumed that this standard is met when:

a. ***Suitable nonstructural practices for source control and pollution prevention are implemented.***
b. ***Stormwater Management BMPs are sized to capture the prescribed runoff volume.***
c. ***Stormwater Management BMPs are maintained as designed.***

In accordance with the manual non-structural practices for source control and pollution prevention will be utilized on site via a long-term pollution prevention plan. These items include: good housekeeping, storing materials and waste products inside or under cover, proper management of deicing chemicals and snow, routine inspections, and maintenance of stormwater BMPS, appropriate spill and response protocols, routine maintenance of lawns and other landscaped areas and the proper operation and management of sanitary sewer related systems. More information regarding the long-term pollution prevention plan can be found in Appendix G.

Although the site is classified as a redevelopment, special attention has been given to adhere to minimum standard #4 to reduce 80% of the average annual load of total suspended solids (TSS). The site is designed to use a set of two (2) Stormwater Management Stormfilters in the peak diversion/linear grate configuration with model numbers SFPD0608/SFLG0608. These devices are a proprietary product from Contech that has been accepted and verified by The New Jersey Corporation for Advanced Technology (NJCAT). See Appendix D for the verification information and Appendix E for the Laboratory Certification. The product utilizes rechargeable, media-filled cartridges to absorb and retain pollutants from runoff including total suspended solids (TSS).

Given the nature of the site there was no ability to implement the typical BMP “process train” due to the site limitations on elevations and surface area. Thusly the linear grate configuration with storm filters have been placed at the last intake into the system to capture all runoff and reduce the maximum amount of TSS possible.

The site is comprised of a total impervious area of 2.60 acres. Not all impervious area is directed into the two (2) onsite proposed stormwater systems, the drainage on the pier just sheet flows into Great Harbor. There is no piping to be located within the piles and therefore the underground storm system will be located inland of the bulkhead. The two (2) Linear Grate Stormfilters will account for 0.48 and 0.59 acres respectively to combine for the total of 1.07 acres. To accommodate to the fullest extent possible, this 1.07 acres of imperviousness will adhere to standard #4.

Stormfilter Linear Grate #1 (Inlet 1) will remove TSS from contributing basins P12, P14, P15, P16 and P17 for a total of 0.48 impervious acres. In accordance with Table 1-A in Appendix D this product can treat 0.549, 0.810 and 1.088 acres for the 12” Low Drop, 18” and the 27” cartridges respectively. Due to the grading limitations the 12” Low Drop configuration has been chosen and therefore with eight (8) total 12” Low Drop Cartridges the structure will reduce TSS by 80% for 0.488 acres which is larger than the required 0.48 acres.

Stormfilter Linear Grate #2 (Inlet 8) will remove TSS from contributing basins P4, P5, P11 and P12 for a total of 0.59 impervious acres. In accordance with Table 1-A in Appendix D this product can treat 0.549, 0.810 and 1.088 acres for the 12” Low Drop, 18” and the 27” cartridges respectively. Due to the grading limitations the 18” Low Drop configuration has been chosen and therefore with seven (7) total 18” Cartridges the structure will reduce TSS by 80% for 0.63 acres which is larger than the required 0.59 acres.

These proprietary stormwater BMPs fully satisfy the requirement for Standard #4, to the fullest extent possible, given the sites classification as a redevelopment.

Minimum Standard #5

Stormwater discharges from areas with higher potential pollutant loads required the use of specific Stormwater Management BMPs. The use of infiltration practices without pretreatment is prohibited.

The proposed redevelopment is not considered to be a Land Use with Higher Potential Pollutant Loads. No infiltration without pretreatment onsite is proposed.

Minimum Standard #6

Stormwater discharges to critical areas must utilize certain Stormwater Management BMPs approved for "critical areas". Critical areas are Outstanding Resource Waters (ORWs), shellfish beds, swimming beaches, cold-water fisheries and recharge areas for public supplies.

The redevelopment is not considered to be located in a critical area. The site does fall into the categories of ORW, shellfish beds, swimming beaches, cold-water fisheries or recharge areas for public supplies.

Minimum Standard #7

Redevelopment of previously developed sites must meet the Stormwater Management Regulations to the maximum extent practicable. However, if it is not practicable to meet all the Standards, new stormwater management systems must be designed to improve existing conditions.

The proposed project is a redevelopment of the Iselin Building and dock and therefore will be defined as a "redevelopment site" However, the project will still meet all MassDEP Stormwater Management to the maximum extent practicable.

Minimum Standard #8

Erosion and sediment controls must be implemented to prevent impacts during construction or land disturbance activities.

Erosion and sediment controls will be implemented in the form of straw wattles or sediment logs located at the downslope and along the perimeter and/or elsewhere required to protect and stabilize earthwork. Inlet protection will be provided to minimize sediment transfer into existing stormwater infrastructure.

Minimum Standard #9

All stormwater management systems must have an operation and maintenance plan to ensure that systems function as designed.

The site will be maintained solely by the owner or the owner's representative. This includes but is not limited to providing permanent stabilization of slopes, maintenances surfaces and thereby preventing excess materials from contacting surface runoff and the minimization of material transport within the drainage system. The proprietary devices will have long term operation and maintenance plans that will require maintenance at a minimum schedule of two (2) times per year in the form of sediment removal and internal chamber cleaning. Refer to the Operation and Maintenance Plan in Appendices E and F for detailed information.

Minimum Standard #10

All illicit discharges to the stormwater management system are prohibited.

The proposed redevelopment project does not discharge to the city stormwater management system. Additionally, the project does not have any illicit discharges. An Illicit Discharge Compliance Certification can be found in Appendix H of this report.

3.0 Siltation Control Procedures

Erosion control measures will be taken onsite to minimize erosion and control sediment transport as much as possible. The downslope areas and perimeter of the site will be protected through the installation of straw wattles or sediment logs and/or as required elsewhere to protect and stabilize earthwork procedures.
All storm drain infrastructure shall be installed early in the construction process to provide control for early runoff onsite. Existing storm drain infrastructure shall be protected with inlet protection during this period.

4.0 Summary and Conclusions

The Woods Hole Oceanographic Institution is a unique site with specific characteristics and hydrologic features that have been carefully studied to develop a comprehensive plan that fully utilized and recognizes these attributes. Significant attention and consideration has been given to proposed management of stormwater runoff from the project site.

Through this study, it has been determined that there will be no adverse impact to any surrounding areas contributed to the redevelopment of the Iselin Dock project for the WHOI. It is also noted that the drainage system has been properly designed to handle the design flow rates while adequately removing the required 80% TSS set forth by Standard #4.

APPENDIX A
LOCUS MAP

PURPOSE: USGS US TOPO MAPS

DATE: 1/29/2021

PRODUCED BY: MOFFATT & NICHOL

APPLICATION BY: MOFFATT AND NICHOL

ISELIN DOCK REDEVELOPMENT

0' 10000' 20000'

1" = 10000'

WOODS HOLE OCEANOGRAPHIC INSTITUTION
86 WATER STREET
WOODS HOLE, MA 02543

LOCUS MAP

SHEET 1 OF 1

File: Q:\BOS\Projects\9977 WHOI Iselin Dock\10 Design and Analysis\30_Civil\Stormwater Management\9977-Locus Map; Plotted: 1/28/2021 2:02 PM by HUSTON, JOSHUA; Saved: 1/21/2021 11:31 AM by JHUSTON

APPENDIX B
AUTOCAD SANITARY AND STORM SEWER ANALYSIS (SSA) CALCULATIONS

Project Description

File Name	9977-00 Existing Conditions - Runoff Analysis.SPF
Description	Woods Hole Oceanographic Institution Iselin Dock Redevelopment Project Existing Conditions Runoff Analysis

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Jan 27, 2021	00:00:00
End Analysis On	Jan 28, 2021	00:00:00
Start Reporting On	Jan 27, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	3
Subbasins	13
Nodes	25
Junctions	6
Outfalls	9
Flow Diversions	0
Inlets	10
Storage Nodes	0
Links	16
Channels	0
Pipes	16
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	2yr - 24hr Storm Event	Intensity	inches	Massachusetts	Barnstable	2	3.44	SCS Type III 24-hr

Subbasin Summary

Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
{Site 1}.E1	0.55	95.05	3.44	2.89	1.59	1.46	0 00:10:31
{Site 1}.E10	0.33	95.76	3.44	2.96	0.99	0.97	0 00:07:46
{Site 1}.E11	0.11	98.00	3.44	3.20	0.36	0.36	0 00:05:00
{Site 1}.E12	0.18	77.84	3.44	1.44	0.26	0.23	0 00:14:18
{Site 1}.E13	0.10	98.00	3.44	3.20	0.32	0.34	0 00:05:00
{Site 1}.E2	0.27	98.00	3.44	3.21	0.86	0.83	0 00:07:12
{Site 1}.E3	0.28	98.00	3.44	3.21	0.89	0.84	0 00:07:36
{Site 1}.E4	0.17	98.00	3.44	3.21	0.55	0.57	0 00:05:00
{Site 1}.E5	0.25	98.00	3.44	3.21	0.81	0.73	0 00:08:57
{Site 1}.E6	0.22	98.00	3.44	3.21	0.71	0.72	0 00:05:00
{Site 1}.E7	0.09	91.00	3.44	2.48	0.23	0.27	0 00:05:00
{Site 1}.E8	0.36	98.00	3.44	3.21	1.17	1.21	0 00:05:00
{Site 1}.E9	0.13	98.00	3.44	3.20	0.40	0.42	0 00:05:00

Subbasin Hydrology

Subbasin : {Site 1}.E1

Input Data

Area (ac) 0.55
Peak Rate Factor 484.00
Weighted Curve Number 95.05
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.19	-	91.00
-	0.34	-	98.00
-	0.01	-	79.00
Composite Area & Weighted CN	0.54		95.05

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft^2)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.28	0.00	0.00
Computed Flow Time (min) :	5.89	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	1130	0.00	0.00
Slope (%) :	4.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	4.07	0.00	0.00
Computed Flow Time (min) :	4.63	0.00	0.00

Total TOC (min) 10.52

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 2.89
Peak Runoff (cfs) 1.46
Weighted Curve Number 95.05
Time of Concentration (days hh:mm:ss) 0 00:10:31

Subbasin : {Site 1}.E2

Input Data

Area (ac) 0.27
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.27	-	98.00
Composite Area & Weighted CN	0.27		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.25	0.00	0.00
Computed Flow Time (min) :	6.74	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	79	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.46	0.00	0.00

Total TOC (min) 7.20

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 0.83
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:07:12

Subbasin : {Site 1}.E3

Input Data

Area (ac) 0.28
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.28	-	98.00
Composite Area & Weighted CN	0.28		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	48	0.00	0.00
Slope (%) :	3.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.52	0.00	0.00
Computed Flow Time (min) :	0.23	0.00	0.00

Total TOC (min) 7.60

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 0.84
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:07:36

Subbasin : {Site 1}.E4

Input Data

Area (ac) 0.17
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.17	-	98.00
Composite Area & Weighted CN	0.17		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	65	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.91	0.00	0.00
Computed Flow Time (min) :	1.19	0.00	0.00

Total TOC (min) 1.19

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 0.57
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:11

Subbasin : {Site 1}.E5

Input Data

Area (ac) 0.25
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.25	-	98.00
Composite Area & Weighted CN	0.25		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	271	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	1.57	0.00	0.00

Total TOC (min) 8.95

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 0.73
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:08:57

Subbasin : {Site 1}.E6

Input Data

Area (ac) 0.22
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.22	-	98.00
Composite Area & Weighted CN	0.22		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	61	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.19	0.00	0.00
Computed Flow Time (min) :	0.86	0.00	0.00

Total TOC (min) 0.86

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 0.72
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:52

Subbasin : {Site 1}.E7

Input Data

Area (ac) 0.09
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.09	-	91.00
Composite Area & Weighted CN	0.09		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.17	0.00	0.00
Computed Flow Time (min) :	4.37	0.00	0.00

Total TOC (min) 4.37

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 2.48
Peak Runoff (cfs) 0.27
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:04:22

Subbasin : {Site 1}.E8

Input Data

Area (ac) 0.36
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.36	-	98.00
Composite Area & Weighted CN	0.36		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	47	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.27	0.00	0.00

Total TOC (min) 1.77

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 1.21
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:46

Subbasin : {Site 1}.E9

Input Data

Area (ac) 0.13
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.13	-	98.00
Composite Area & Weighted CN	0.13		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.85	0.00	0.00
Computed Flow Time (min) :	0.89	0.00	0.00

Total TOC (min) 0.89

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.20
Peak Runoff (cfs) 0.42
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:53

Subbasin : {Site 1}.E10

Input Data

Area (ac) 0.33
Peak Rate Factor 484.00
Weighted Curve Number 95.76
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	91.00
-	0.23	-	98.00
Composite Area & Weighted CN	0.34		95.76

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	69	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.40	0.00	0.00

Total TOC (min) 7.77

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 2.96
Peak Runoff (cfs) 0.97
Weighted Curve Number 95.76
Time of Concentration (days hh:mm:ss) 0 00:07:46

Subbasin : {Site 1}.E11

Input Data

Area (ac) 0.11
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	98.00
Composite Area & Weighted CN	0.11		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	71	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.04	0.00	0.00
Computed Flow Time (min) :	1.14	0.00	0.00

Total TOC (min) 1.14

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.20
Peak Runoff (cfs) 0.36
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:08

Subbasin : {Site 1}.E12

Input Data

Area (ac) 0.18
Peak Rate Factor 484.00
Weighted Curve Number 77.84
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.15	-	74.00
-	0.03	-	98.00
Composite Area & Weighted CN	0.18		77.84

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.40	0.00	0.00
Flow Length (ft) :	63	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.07	0.00	0.00
Computed Flow Time (min) :	14.31	0.00	0.00

Total TOC (min) 14.31

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 1.44
Peak Runoff (cfs) 0.23
Weighted Curve Number 77.84
Time of Concentration (days hh:mm:ss) 0 00:14:19

Subbasin : {Site 1}.E13

Input Data

Area (ac) 0.10
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.10	-	98.00
Composite Area & Weighted CN	0.10		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	65	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.02	0.00	0.00
Computed Flow Time (min) :	1.06	0.00	0.00

Total TOC (min) 1.06

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.20
Peak Runoff (cfs) 0.34
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:04

Inlet Summary

Element ID	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
Exist-Inlet-1	4.50	5.91	1.18	9.03	6.59
Exist-Inlet-10	0.00	6.25	0.00	0.00	6.25
Exist-Inlet-2	2.40	5.97	0.00	0.00	5.97
Exist-Inlet-3	3.60	5.92	0.00	0.00	5.92
Exist-Inlet-4	1.20	3.06	1.46	2.12	4.30
Exist-Inlet-5	1.80	5.30	0.00	0.00	5.30
Exist-Inlet-6	2.90	5.85	0.00	0.00	5.85
Exist-Inlet-7	3.90	6.07	0.70	5.57	6.18
Exist-Inlet-8	3.90	5.00	0.33	2.66	5.05
Exist-Inlet-9	3.30	6.25	0.23	2.70	6.34

Inlet Results

Element ID	Peak Flow (cfs)	Peak Lateral Inflow (cfs)	Time of Max Depth Occurrence (days hh:mm)
Exist-Inlet-1	1.18	1.18	0 12:05
Exist-Inlet-10	0.00	0.00	0 12:15
Exist-Inlet-2	0.00	0.00	0 12:05
Exist-Inlet-3	0.00	0.00	0 00:00
Exist-Inlet-4	1.46	1.46	0 11:09
Exist-Inlet-5	0.00	0.00	0 12:00
Exist-Inlet-6	0.00	0.00	0 12:05
Exist-Inlet-7	0.70	0.70	0 12:10
Exist-Inlet-8	0.33	0.33	0 12:05
Exist-Inlet-9	0.23	0.23	0 00:00

Link Summary

Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Diameter or Height (in)	Manning's Roughness	Peak Flow (cfs)	Design Flow Capacity (cfs)	Peak Flow Velocity (ft/sec)	Peak Flow Depth (ft)
Exist-Pipe-1	Pipe	Exist-Inlet-1	Exist-Inlet-2	52.02	4.50	4.10	0.7700	12.000	0.0230	1.17	1.77	2.41	0.59
Exist-Pipe-10	Pipe	Exist-Inlet-5	Jun-02	7.85	1.80	1.69	1.4000	12.000	0.0150	1.28	3.66	4.24	0.41
Exist-Pipe-11	Pipe	Jun-02	Jun-04	23.16	1.69	1.36	1.4200	12.000	0.0150	1.28	3.69	4.26	0.41
Exist-Pipe-12	Pipe	Jun-04	Jun-03	35.10	1.69	1.20	1.4000	12.000	0.0150	1.28	3.65	4.23	0.41
Exist-Pipe-13	Pipe	Jun-03	Out-03	62.50	1.20	0.50	1.1200	12.000	0.0150	1.48	3.27	4.07	0.47
Exist-Pipe-14	Pipe	Jun-01	Exist-Inlet-9	13.66	3.67	3.60	0.5000	4.000	0.0150	0.00	0.12	0.00	0.00
Exist-Pipe-15	Pipe	Exist-Inlet-9	Exist-Inlet-10	60.73	3.30	2.06	2.0500	10.000	0.0140	0.23	2.91	3.20	0.16
Exist-Pipe-16	Pipe	Exist-Inlet-10	Jun-03	41.33	2.06	1.20	2.0700	10.000	0.0140	0.23	2.93	3.20	0.16
Exist-Pipe-2	Pipe	Exist-Inlet-2	Out-09	88.38	2.40	1.72	0.7700	15.000	0.0140	1.16	5.26	3.45	0.39
Exist-Pipe-3	Pipe	Exist-Inlet-3	Exist-Inlet-2	28.04	3.60	2.50	3.9200	12.000	0.0150	0.00	6.12	0.00	0.00
Exist-Pipe-4	Pipe	Exist-Inlet-4	Out-01	6.24	1.20	1.17	0.5000	4.000	0.0150	0.13	0.12	1.53	0.33
Exist-Pipe-5	Pipe	Exist-Inlet-8	Out-02	5.03	3.90	0.00	77.5300	8.000	0.0150	0.33	9.22	12.45	0.09
Exist-Pipe-6	Pipe	Exist-Inlet-7	Exist-Inlet-6	67.32	3.90	3.00	1.3400	10.000	0.0150	0.70	2.20	3.58	0.32
Exist-Pipe-7	Pipe	Jun-06	Exist-Inlet-6	10.07	6.77	3.50	32.4700	4.000	0.0150	0.26	0.94	9.21	0.12
Exist-Pipe-8	Pipe	Exist-Inlet-6	Exist-Inlet-5	74.98	2.90	1.80	1.4700	10.000	0.0150	0.91	2.30	3.97	0.36
Exist-Pipe-9	Pipe	Jun-05	Exist-Inlet-5	9.30	5.42	4.95	5.0500	4.000	0.0150	0.39	0.37	4.87	0.33

Pipe Input

Element ID	Length (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Manning's Roughness
Exist-Pipe-1	52.02	0.00	4.10	0.40	0.7700	CIRCULAR	12.000	0.0230
Exist-Pipe-10	7.85	0.00	1.69	0.11	1.4000	CIRCULAR	12.000	0.0150
Exist-Pipe-11	23.16	1.69	1.36	0.33	1.4200	CIRCULAR	12.000	0.0150
Exist-Pipe-12	35.10	1.69	1.20	0.49	1.4000	CIRCULAR	12.000	0.0150
Exist-Pipe-13	62.50	1.20	0.50	0.70	1.1200	CIRCULAR	12.000	0.0150
Exist-Pipe-14	13.66	3.67	3.60	0.07	0.5000	CIRCULAR	3.960	0.0150
Exist-Pipe-15	60.73	0.00	2.06	1.25	2.0500	CIRCULAR	9.960	0.0140
Exist-Pipe-16	41.33	2.06	1.20	0.86	2.0700	CIRCULAR	9.960	0.0140
Exist-Pipe-2	88.38	0.00	1.72	0.68	0.7700	CIRCULAR	15.000	0.0140
Exist-Pipe-3	28.04	0.00	2.50	1.10	3.9200	CIRCULAR	12.000	0.0150
Exist-Pipe-4	6.24	0.00	1.17	0.03	0.5000	CIRCULAR	3.960	0.0150
Exist-Pipe-5	5.03	0.00	0.00	3.90	77.5300	CIRCULAR	8.040	0.0150
Exist-Pipe-6	67.32	0.00	3.00	0.90	1.3400	CIRCULAR	9.960	0.0150
Exist-Pipe-7	10.07	6.77	3.50	3.27	32.4700	CIRCULAR	3.960	0.0150
Exist-Pipe-8	74.98	0.00	1.80	1.10	1.4700	CIRCULAR	9.960	0.0150
Exist-Pipe-9	9.30	5.42	4.95	0.47	5.0500	CIRCULAR	3.960	0.0150

Pipe Results

Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio
Exist-Pipe-1	1.17	0 12:05	1.77	0.66	2.41	0.36	0.59	0.59
Exist-Pipe-10	1.28	0 12:10	3.66	0.35	4.24	0.03	0.41	0.41
Exist-Pipe-11	1.28	0 12:10	3.69	0.35	4.26	0.09	0.41	0.41
Exist-Pipe-12	1.28	0 12:10	3.65	0.35	4.23	0.14	0.41	0.41
Exist-Pipe-13	1.48	0 12:10	3.27	0.45	4.07	0.26	0.47	0.47
Exist-Pipe-14	0.00	0 00:00	0.12	0.00	0.00		0.00	0.00
Exist-Pipe-15	0.23	0 12:15	2.91	0.08	3.20	0.32	0.16	0.19
Exist-Pipe-16	0.23	0 12:15	2.93	0.08	3.20	0.22	0.16	0.19
Exist-Pipe-2	1.16	0 12:06	5.26	0.22	3.45	0.43	0.39	0.32
Exist-Pipe-3	0.00	0 00:00	6.12	0.00	0.00		0.00	0.00
Exist-Pipe-4	0.13	0 11:17	0.12	1.08	1.53	0.07	0.33	1.00
Exist-Pipe-5	0.33	0 12:05	9.22	0.04	12.45	0.01	0.09	0.13
Exist-Pipe-6	0.70	0 12:10	2.20	0.32	3.58	0.31	0.32	0.39
Exist-Pipe-7	0.26	0 12:05	0.94	0.28	9.21	0.02	0.12	0.36
Exist-Pipe-8	0.91	0 12:10	2.30	0.39	3.97	0.31	0.36	0.44
Exist-Pipe-9	0.39	0 12:20	0.37	1.06	4.87	0.03	0.33	1.00

Project Description

File Name	9977-00 Existing Conditions - Runoff Analysis.SPF
Description	Woods Hole Oceanographic Institution Iselin Dock Redevelopment Project Existing Conditions Runoff Analysis

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Jan 27, 2021	00:00:00
End Analysis On	Jan 28, 2021	00:00:00
Start Reporting On	Jan 27, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	3
Subbasins	13
Nodes	25
Junctions	6
Outfalls	9
Flow Diversions	0
Inlets	10
Storage Nodes	0
Links	16
Channels	0
Pipes	16
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	10yr - 24hr Storm Event	Intensity	inches	Massachusetts	Barnstable	10	5.02	SCS Type III 24-hr

Subbasin Summary

Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
{Site 1}.E1	0.55	95.05	5.02	4.44	2.44	2.19	0 00:10:31
{Site 1}.E10	0.33	95.76	5.02	4.52	1.51	1.45	0 00:07:46
{Site 1}.E11	0.11	98.00	5.02	4.78	0.53	0.53	0 00:05:00
{Site 1}.E12	0.18	77.84	5.02	2.71	0.50	0.45	0 00:14:18
{Site 1}.E13	0.10	98.00	5.02	4.78	0.48	0.50	0 00:05:00
{Site 1}.E2	0.27	98.00	5.02	4.78	1.28	1.22	0 00:07:12
{Site 1}.E3	0.28	98.00	5.02	4.78	1.33	1.23	0 00:07:36
{Site 1}.E4	0.17	98.00	5.02	4.78	0.83	0.84	0 00:05:00
{Site 1}.E5	0.25	98.00	5.02	4.78	1.21	1.07	0 00:08:57
{Site 1}.E6	0.22	98.00	5.02	4.78	1.05	1.06	0 00:05:00
{Site 1}.E7	0.09	91.00	5.02	4.00	0.37	0.43	0 00:05:00
{Site 1}.E8	0.36	98.00	5.02	4.78	1.74	1.77	0 00:05:00
{Site 1}.E9	0.13	98.00	5.02	4.78	0.60	0.62	0 00:05:00

Subbasin Hydrology

Subbasin : {Site 1}.E1

Input Data

Area (ac) 0.55
Peak Rate Factor 484.00
Weighted Curve Number 95.05
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.19	-	91.00
-	0.34	-	98.00
-	0.01	-	79.00
Composite Area & Weighted CN	0.54		95.05

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.28	0.00	0.00
Computed Flow Time (min) :	5.89	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	1130	0.00	0.00
Slope (%) :	4.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	4.07	0.00	0.00
Computed Flow Time (min) :	4.63	0.00	0.00

Total TOC (min) 10.52

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.44
Peak Runoff (cfs) 2.19
Weighted Curve Number 95.05
Time of Concentration (days hh:mm:ss) 0 00:10:31

Subbasin : {Site 1}.E2

Input Data

Area (ac) 0.27
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.27	-	98.00
Composite Area & Weighted CN	0.27		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.25	0.00	0.00
Computed Flow Time (min) :	6.74	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	79	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.46	0.00	0.00

Total TOC (min) 7.20

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 1.22
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:07:12

Subbasin : {Site 1}.E3

Input Data

Area (ac) 0.28
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.28	-	98.00
Composite Area & Weighted CN	0.28		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	48	0.00	0.00
Slope (%) :	3.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.52	0.00	0.00
Computed Flow Time (min) :	0.23	0.00	0.00

Total TOC (min) 7.60

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 1.23
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:07:36

Subbasin : {Site 1}.E4

Input Data

Area (ac) 0.17
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.17	-	98.00
Composite Area & Weighted CN	0.17		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	65	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.91	0.00	0.00
Computed Flow Time (min) :	1.19	0.00	0.00

Total TOC (min) 1.19

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.84
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:11

Subbasin : {Site 1}.E5

Input Data

Area (ac) 0.25
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.25	-	98.00
Composite Area & Weighted CN	0.25		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	271	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	1.57	0.00	0.00

Total TOC (min) 8.95

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 1.07
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:08:57

Subbasin : {Site 1}.E6

Input Data

Area (ac) 0.22
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.22	-	98.00
Composite Area & Weighted CN	0.22		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	61	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.19	0.00	0.00
Computed Flow Time (min) :	0.86	0.00	0.00

Total TOC (min) 0.86

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 1.06
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:52

Subbasin : {Site 1}.E7

Input Data

Area (ac) 0.09
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.09	-	91.00
Composite Area & Weighted CN	0.09		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.17	0.00	0.00
Computed Flow Time (min) :	4.37	0.00	0.00

Total TOC (min) 4.37

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.00
Peak Runoff (cfs) 0.43
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:04:22

Subbasin : {Site 1}.E8

Input Data

Area (ac) 0.36
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.36	-	98.00
Composite Area & Weighted CN	0.36		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	47	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.27	0.00	0.00

Total TOC (min) 1.77

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 1.77
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:46

Subbasin : {Site 1}.E9

Input Data

Area (ac) 0.13
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.13	-	98.00
Composite Area & Weighted CN	0.13		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.85	0.00	0.00
Computed Flow Time (min) :	0.89	0.00	0.00

Total TOC (min) 0.89

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.62
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:53

Subbasin : {Site 1}.E10

Input Data

Area (ac) 0.33
Peak Rate Factor 484.00
Weighted Curve Number 95.76
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	91.00
-	0.23	-	98.00
Composite Area & Weighted CN	0.34		95.76

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	69	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.40	0.00	0.00

Total TOC (min) 7.77

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.52
Peak Runoff (cfs) 1.45
Weighted Curve Number 95.76
Time of Concentration (days hh:mm:ss) 0 00:07:46

Subbasin : {Site 1}.E11

Input Data

Area (ac) 0.11
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	98.00
Composite Area & Weighted CN	0.11		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	71	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.04	0.00	0.00
Computed Flow Time (min) :	1.14	0.00	0.00

Total TOC (min) 1.14

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.53
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:08

Subbasin : {Site 1}.E12

Input Data

Area (ac) 0.18
Peak Rate Factor 484.00
Weighted Curve Number 77.84
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.15	-	74.00
-	0.03	-	98.00
Composite Area & Weighted CN	0.18		77.84

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.40	0.00	0.00
Flow Length (ft) :	63	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.07	0.00	0.00
Computed Flow Time (min) :	14.31	0.00	0.00

Total TOC (min) 14.31

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 2.71
Peak Runoff (cfs) 0.45
Weighted Curve Number 77.84
Time of Concentration (days hh:mm:ss) 0 00:14:19

Subbasin : {Site 1}.E13

Input Data

Area (ac) 0.10
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.10	-	98.00
Composite Area & Weighted CN	0.10		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	65	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.02	0.00	0.00
Computed Flow Time (min) :	1.06	0.00	0.00

Total TOC (min) 1.06

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.50
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:04

Inlet Summary

Element ID	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
Exist-Inlet-1	4.50	5.91	1.73	11.41	6.64
Exist-Inlet-10	0.00	6.25	0.00	0.00	6.25
Exist-Inlet-2	2.40	5.97	0.00	0.00	5.97
Exist-Inlet-3	3.60	5.92	0.00	0.00	5.92
Exist-Inlet-4	1.20	3.06	2.19	2.48	5.03
Exist-Inlet-5	1.80	5.30	0.00	0.00	5.30
Exist-Inlet-6	2.90	5.85	0.00	0.00	5.85
Exist-Inlet-7	3.90	6.07	1.04	8.05	6.23
Exist-Inlet-8	3.90	5.00	0.49	3.92	5.08
Exist-Inlet-9	3.30	6.25	0.44	5.15	6.43

Inlet Results

Element ID	Peak Flow (cfs)	Peak Lateral Inflow (cfs)	Time of Max Depth Occurrence (days hh:mm)
Exist-Inlet-1	1.73	1.73	0 12:05
Exist-Inlet-10	0.00	0.00	0 12:15
Exist-Inlet-2	0.00	0.00	0 12:05
Exist-Inlet-3	0.00	0.00	0 00:00
Exist-Inlet-4	2.19	2.19	0 10:10
Exist-Inlet-5	0.00	0.00	0 11:52
Exist-Inlet-6	0.00	0.00	0 12:05
Exist-Inlet-7	1.04	1.04	0 12:10
Exist-Inlet-8	0.49	0.49	0 12:05
Exist-Inlet-9	0.44	0.44	0 00:00

Pipe Input

Element ID	Length (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Manning's Roughness
Exist-Pipe-1	52.02	0.00	4.10	0.40	0.7700	CIRCULAR	12.000	0.0230
Exist-Pipe-10	7.85	0.00	1.69	0.11	1.4000	CIRCULAR	12.000	0.0150
Exist-Pipe-11	23.16	1.69	1.36	0.33	1.4200	CIRCULAR	12.000	0.0150
Exist-Pipe-12	35.10	1.69	1.20	0.49	1.4000	CIRCULAR	12.000	0.0150
Exist-Pipe-13	62.50	1.20	0.50	0.70	1.1200	CIRCULAR	12.000	0.0150
Exist-Pipe-14	13.66	3.67	3.60	0.07	0.5000	CIRCULAR	3.960	0.0150
Exist-Pipe-15	60.73	0.00	2.06	1.25	2.0500	CIRCULAR	9.960	0.0140
Exist-Pipe-16	41.33	2.06	1.20	0.86	2.0700	CIRCULAR	9.960	0.0140
Exist-Pipe-2	88.38	0.00	1.72	0.68	0.7700	CIRCULAR	15.000	0.0140
Exist-Pipe-3	28.04	0.00	2.50	1.10	3.9200	CIRCULAR	12.000	0.0150
Exist-Pipe-4	6.24	0.00	1.17	0.03	0.5000	CIRCULAR	3.960	0.0150
Exist-Pipe-5	5.03	0.00	0.00	3.90	77.5300	CIRCULAR	8.040	0.0150
Exist-Pipe-6	67.32	0.00	3.00	0.90	1.3400	CIRCULAR	9.960	0.0150
Exist-Pipe-7	10.07	6.77	3.50	3.27	32.4700	CIRCULAR	3.960	0.0150
Exist-Pipe-8	74.98	0.00	1.80	1.10	1.4700	CIRCULAR	9.960	0.0150
Exist-Pipe-9	9.30	5.42	4.95	0.47	5.0500	CIRCULAR	3.960	0.0150

Pipe Results

Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio
Exist-Pipe-1	1.73	0 12:05	1.77	0.98	2.59	0.33	0.79	0.80
Exist-Pipe-10	1.72	0 12:10	3.66	0.47	4.59	0.03	0.48	0.48
Exist-Pipe-11	1.72	0 12:10	3.69	0.47	4.62	0.08	0.48	0.48
Exist-Pipe-12	1.72	0 12:10	3.65	0.47	4.58	0.13	0.48	0.48
Exist-Pipe-13	2.13	0 12:11	3.27	0.65	4.43	0.24	0.59	0.59
Exist-Pipe-14	0.00	0 00:00	0.12	0.00	0.00		0.00	0.00
Exist-Pipe-15	0.44	0 12:15	2.91	0.15	3.85	0.26	0.22	0.26
Exist-Pipe-16	0.44	0 12:15	2.93	0.15	3.86	0.18	0.22	0.26
Exist-Pipe-2	1.71	0 12:06	5.26	0.32	3.84	0.38	0.48	0.39
Exist-Pipe-3	0.00	0 00:00	6.12	0.00	0.00		0.00	0.00
Exist-Pipe-4	0.13	0 14:30	0.12	1.08	1.53	0.07	0.33	1.00
Exist-Pipe-5	0.49	0 12:05	9.22	0.05	13.99	0.01	0.10	0.16
Exist-Pipe-6	1.02	0 12:10	2.20	0.47	3.98	0.28	0.40	0.48
Exist-Pipe-7	0.41	0 12:05	0.94	0.44	10.41	0.02	0.15	0.46
Exist-Pipe-8	1.35	0 12:10	2.30	0.59	4.39	0.28	0.46	0.55
Exist-Pipe-9	0.40	0 12:27	0.37	1.08	4.87	0.03	0.33	1.00

Link Summary

Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Diameter or Height (in)	Manning's Roughness	Peak Flow (cfs)	Design Flow Capacity (cfs)	Peak Flow Velocity (ft/sec)	Peak Flow Depth (ft)
Exist-Pipe-1	Pipe	Exist-Inlet-1	Exist-Inlet-2	52.02	4.50	4.10	0.7700	12.000	0.0230	1.73	1.77	2.59	0.79
Exist-Pipe-10	Pipe	Exist-Inlet-5	Jun-02	7.85	1.80	1.69	1.4000	12.000	0.0150	1.72	3.66	4.59	0.48
Exist-Pipe-11	Pipe	Jun-02	Jun-04	23.16	1.69	1.36	1.4200	12.000	0.0150	1.72	3.69	4.62	0.48
Exist-Pipe-12	Pipe	Jun-04	Jun-03	35.10	1.69	1.20	1.4000	12.000	0.0150	1.72	3.65	4.58	0.48
Exist-Pipe-13	Pipe	Jun-03	Out-03	62.50	1.20	0.50	1.1200	12.000	0.0150	2.13	3.27	4.43	0.59
Exist-Pipe-14	Pipe	Jun-01	Exist-Inlet-9	13.66	3.67	3.60	0.5000	4.000	0.0150	0.00	0.12	0.00	0.00
Exist-Pipe-15	Pipe	Exist-Inlet-9	Exist-Inlet-10	60.73	3.30	2.06	2.0500	10.000	0.0140	0.44	2.91	3.85	0.22
Exist-Pipe-16	Pipe	Exist-Inlet-10	Jun-03	41.33	2.06	1.20	2.0700	10.000	0.0140	0.44	2.93	3.86	0.22
Exist-Pipe-2	Pipe	Exist-Inlet-2	Out-09	88.38	2.40	1.72	0.7700	15.000	0.0140	1.71	5.26	3.84	0.48
Exist-Pipe-3	Pipe	Exist-Inlet-3	Exist-Inlet-2	28.04	3.60	2.50	3.9200	12.000	0.0150	0.00	6.12	0.00	0.00
Exist-Pipe-4	Pipe	Exist-Inlet-4	Out-01	6.24	1.20	1.17	0.5000	4.000	0.0150	0.13	0.12	1.53	0.33
Exist-Pipe-5	Pipe	Exist-Inlet-8	Out-02	5.03	3.90	0.00	77.5300	8.000	0.0150	0.49	9.22	13.99	0.10
Exist-Pipe-6	Pipe	Exist-Inlet-7	Exist-Inlet-6	67.32	3.90	3.00	1.3400	10.000	0.0150	1.02	2.20	3.98	0.40
Exist-Pipe-7	Pipe	Jun-06	Exist-Inlet-6	10.07	6.77	3.50	32.4700	4.000	0.0150	0.41	0.94	10.41	0.15
Exist-Pipe-8	Pipe	Exist-Inlet-6	Exist-Inlet-5	74.98	2.90	1.80	1.4700	10.000	0.0150	1.35	2.30	4.39	0.46
Exist-Pipe-9	Pipe	Jun-05	Exist-Inlet-5	9.30	5.42	4.95	5.0500	4.000	0.0150	0.40	0.37	4.87	0.33

Project Description

File Name	9977-00 Existing Conditions - Runoff Analysis.SPF
Description	Woods Hole Oceanographic Institution Iselin Dock Redevelopment Project Existing Conditions Runoff Analysis

Project Options

Flow Units	CFS
Elevation Type	Elevation
Hydrology Method	SCS TR-55
Time of Concentration (TOC) Method	SCS TR-55
Link Routing Method	Kinematic Wave
Enable Overflow Ponding at Nodes	YES
Skip Steady State Analysis Time Periods	NO

Analysis Options

Start Analysis On	Jan 27, 2021	00:00:00
End Analysis On	Jan 28, 2021	00:00:00
Start Reporting On	Jan 27, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	3
Subbasins	13
Nodes	25
Junctions	6
Outfalls	9
Flow Diversions	0
Inlets	10
Storage Nodes	0
Links	16
Channels	0
Pipes	16
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	100yr - 24hr Storm Event	Intensity	inches	Massachusetts	Barnstable	100	7.51	SCS Type III 24-hr

Subbasin Summary

Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
{Site 1}.E1	0.55	95.05	7.51	6.92	3.81	3.22	0 00:10:31
{Site 1}.E10	0.33	95.76	7.51	7.00	2.34	2.04	0 00:07:46
{Site 1}.E11	0.11	98.00	7.51	7.27	0.81	0.69	0 00:05:00
{Site 1}.E12	0.18	77.84	7.51	4.92	0.91	0.80	0 00:14:18
{Site 1}.E13	0.10	98.00	7.51	7.27	0.73	0.65	0 00:05:00
{Site 1}.E2	0.27	98.00	7.51	7.27	1.95	1.67	0 00:07:12
{Site 1}.E3	0.28	98.00	7.51	7.27	2.02	1.71	0 00:07:36
{Site 1}.E4	0.17	98.00	7.51	7.27	1.26	1.09	0 00:05:00
{Site 1}.E5	0.25	98.00	7.51	7.27	1.83	1.52	0 00:08:57
{Site 1}.E6	0.22	98.00	7.51	7.27	1.60	1.38	0 00:05:00
{Site 1}.E7	0.09	91.00	7.51	6.44	0.60	0.58	0 00:05:00
{Site 1}.E8	0.36	98.00	7.51	7.27	2.65	2.31	0 00:05:00
{Site 1}.E9	0.13	98.00	7.51	7.27	0.91	0.81	0 00:05:00

Subbasin Hydrology

Subbasin : {Site 1}.E1

Input Data

Area (ac) 0.55
Peak Rate Factor 484.00
Weighted Curve Number 95.05
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.19	-	91.00
-	0.34	-	98.00
-	0.01	-	79.00
Composite Area & Weighted CN	0.54		95.05

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft^2)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.28	0.00	0.00
Computed Flow Time (min) :	5.89	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	1130	0.00	0.00
Slope (%) :	4.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	4.07	0.00	0.00
Computed Flow Time (min) :	4.63	0.00	0.00

Total TOC (min) 10.52

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 6.92
Peak Runoff (cfs) 3.22
Weighted Curve Number 95.05
Time of Concentration (days hh:mm:ss) 0 00:10:31

Subbasin : {Site 1}.E2

Input Data

Area (ac) 0.27
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.27	-	98.00
Composite Area & Weighted CN	0.27		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.25	0.00	0.00
Computed Flow Time (min) :	6.74	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	79	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.46	0.00	0.00

Total TOC (min) 7.20

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 1.67
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:07:12

Subbasin : {Site 1}.E3

Input Data

Area (ac) 0.28
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.28	-	98.00
Composite Area & Weighted CN	0.28		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	48	0.00	0.00
Slope (%) :	3.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.52	0.00	0.00
Computed Flow Time (min) :	0.23	0.00	0.00

Total TOC (min) 7.60

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 1.71
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:07:36

Subbasin : {Site 1}.E4

Input Data

Area (ac) 0.17
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.17	-	98.00
Composite Area & Weighted CN	0.17		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	65	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.91	0.00	0.00
Computed Flow Time (min) :	1.19	0.00	0.00

Total TOC (min) 1.19

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 1.09
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:11

Subbasin : {Site 1}.E5

Input Data

Area (ac) 0.25
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.25	-	98.00
Composite Area & Weighted CN	0.25		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	271	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	1.57	0.00	0.00

Total TOC (min) 8.95

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 1.52
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:08:57

Subbasin : {Site 1}.E6

Input Data

Area (ac) 0.22
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.22	-	98.00
Composite Area & Weighted CN	0.22		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	61	0.00	0.00
Slope (%) :	3.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.19	0.00	0.00
Computed Flow Time (min) :	0.86	0.00	0.00

Total TOC (min) 0.86

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 1.38
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:52

Subbasin : {Site 1}.E7

Input Data

Area (ac) 0.09
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.09	-	91.00
Composite Area & Weighted CN	0.09		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.17	0.00	0.00
Computed Flow Time (min) :	4.37	0.00	0.00

Total TOC (min) 4.37

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 6.44
Peak Runoff (cfs) 0.58
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:04:22

Subbasin : {Site 1}.E8

Input Data

Area (ac) 0.36
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.36	-	98.00
Composite Area & Weighted CN	0.36		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	47	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.27	0.00	0.00

Total TOC (min) 1.77

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 2.31
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:46

Subbasin : {Site 1}.E9

Input Data

Area (ac) 0.13
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.13	-	98.00
Composite Area & Weighted CN	0.13		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.85	0.00	0.00
Computed Flow Time (min) :	0.89	0.00	0.00

Total TOC (min) 0.89

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 0.81
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:53

Subbasin : {Site 1}.E10

Input Data

Area (ac) 0.33
Peak Rate Factor 484.00
Weighted Curve Number 95.76
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	91.00
-	0.23	-	98.00
Composite Area & Weighted CN	0.34		95.76

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.23	0.00	0.00
Computed Flow Time (min) :	7.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	69	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.40	0.00	0.00

Total TOC (min) 7.77

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.00
Peak Runoff (cfs) 2.04
Weighted Curve Number 95.76
Time of Concentration (days hh:mm:ss) 0 00:07:46

Subbasin : {Site 1}.E11

Input Data

Area (ac) 0.11
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	98.00
Composite Area & Weighted CN	0.11		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	71	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.04	0.00	0.00
Computed Flow Time (min) :	1.14	0.00	0.00

Total TOC (min) 1.14

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 0.69
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:08

Subbasin : {Site 1}.E12

Input Data

Area (ac) 0.18
Peak Rate Factor 484.00
Weighted Curve Number 77.84
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.15	-	74.00
-	0.03	-	98.00
Composite Area & Weighted CN	0.18		77.84

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.40	0.00	0.00
Flow Length (ft) :	63	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.07	0.00	0.00
Computed Flow Time (min) :	14.31	0.00	0.00

Total TOC (min) 14.31

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 4.92
Peak Runoff (cfs) 0.80
Weighted Curve Number 77.84
Time of Concentration (days hh:mm:ss) 0 00:14:19

Subbasin : {Site 1}.E13

Input Data

Area (ac) 0.10
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.10	-	98.00
Composite Area & Weighted CN	0.10		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.015	0.00	0.00
Flow Length (ft) :	65	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.02	0.00	0.00
Computed Flow Time (min) :	1.06	0.00	0.00

Total TOC (min) 1.06

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 0.65
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:04

Inlet Summary

Element ID	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
Exist-Inlet-1	4.50	5.91	2.30	13.64	6.69
Exist-Inlet-10	0.00	6.25	0.00	0.00	6.25
Exist-Inlet-2	2.40	5.97	0.00	0.00	5.97
Exist-Inlet-3	3.60	5.92	0.00	0.00	5.92
Exist-Inlet-4	1.20	3.06	3.11	2.75	6.30
Exist-Inlet-5	1.80	5.30	0.00	0.00	5.30
Exist-Inlet-6	2.90	5.85	0.00	0.00	5.85
Exist-Inlet-7	3.90	6.07	1.48	9.84	6.27
Exist-Inlet-8	3.90	5.00	0.65	5.21	5.10
Exist-Inlet-9	3.30	6.25	0.80	9.33	6.57

Inlet Results

Element ID	Peak Flow	Peak Lateral Inflow	Time of Max Depth Occurrence
	(cfs)	(cfs)	(days hh:mm)
Exist-Inlet-1	2.30	2.30	0 12:03
Exist-Inlet-10	0.00	0.00	0 12:15
Exist-Inlet-2	0.00	0.00	0 12:04
Exist-Inlet-3	0.00	0.00	0 00:00
Exist-Inlet-4	3.11	3.11	0 08:46
Exist-Inlet-5	0.00	0.00	0 11:46
Exist-Inlet-6	0.00	0.00	0 12:10
Exist-Inlet-7	1.48	1.48	0 12:10
Exist-Inlet-8	0.65	0.65	0 12:08
Exist-Inlet-9	0.80	0.80	0 00:00

Pipe Input

Element ID	Length (ft)	Inlet Invert Offset (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Manning's Roughness
Exist-Pipe-1	52.02	0.00	4.10	0.40	0.7700	CIRCULAR	12.000	0.0230
Exist-Pipe-10	7.85	0.00	1.69	0.11	1.4000	CIRCULAR	12.000	0.0150
Exist-Pipe-11	23.16	1.69	1.36	0.33	1.4200	CIRCULAR	12.000	0.0150
Exist-Pipe-12	35.10	1.69	1.20	0.49	1.4000	CIRCULAR	12.000	0.0150
Exist-Pipe-13	62.50	1.20	0.50	0.70	1.1200	CIRCULAR	12.000	0.0150
Exist-Pipe-14	13.66	3.67	3.60	0.07	0.5000	CIRCULAR	3.960	0.0150
Exist-Pipe-15	60.73	0.00	2.06	1.25	2.0500	CIRCULAR	9.960	0.0140
Exist-Pipe-16	41.33	2.06	1.20	0.86	2.0700	CIRCULAR	9.960	0.0140
Exist-Pipe-2	88.38	0.00	1.72	0.68	0.7700	CIRCULAR	15.000	0.0140
Exist-Pipe-3	28.04	0.00	2.50	1.10	3.9200	CIRCULAR	12.000	0.0150
Exist-Pipe-4	6.24	0.00	1.17	0.03	0.5000	CIRCULAR	3.960	0.0150
Exist-Pipe-5	5.03	0.00	0.00	3.90	77.5300	CIRCULAR	8.040	0.0150
Exist-Pipe-6	67.32	0.00	3.00	0.90	1.3400	CIRCULAR	9.960	0.0150
Exist-Pipe-7	10.07	6.77	3.50	3.27	32.4700	CIRCULAR	3.960	0.0150
Exist-Pipe-8	74.98	0.00	1.80	1.10	1.4700	CIRCULAR	9.960	0.0150
Exist-Pipe-9	9.30	5.42	4.95	0.47	5.0500	CIRCULAR	3.960	0.0150

Pipe Results

Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio
Exist-Pipe-1	1.89	0 12:13	1.77	1.07	2.68	0.32	1.00	1.00
Exist-Pipe-10	2.41	0 12:10	3.66	0.66	4.97	0.03	0.59	0.59
Exist-Pipe-11	2.41	0 12:10	3.69	0.65	5.00	0.08	0.59	0.59
Exist-Pipe-12	2.41	0 12:10	3.65	0.66	4.96	0.12	0.59	0.59
Exist-Pipe-13	3.09	0 12:11	3.27	0.94	4.73	0.22	0.76	0.77
Exist-Pipe-14	0.00	0 00:00	0.12	0.00	0.00		0.00	0.00
Exist-Pipe-15	0.80	0 12:15	2.91	0.27	4.56	0.22	0.30	0.36
Exist-Pipe-16	0.79	0 12:15	2.93	0.27	4.56	0.15	0.30	0.36
Exist-Pipe-2	1.84	0 12:14	5.26	0.35	3.97	0.37	0.50	0.41
Exist-Pipe-3	0.00	0 00:00	6.12	0.00	0.00		0.00	0.00
Exist-Pipe-4	0.13	0 15:51	0.12	1.08	1.53	0.07	0.33	1.00
Exist-Pipe-5	0.64	0 12:10	9.22	0.07	15.22	0.01	0.12	0.18
Exist-Pipe-6	1.47	0 12:10	2.20	0.67	4.32	0.26	0.50	0.60
Exist-Pipe-7	0.58	0 12:10	0.94	0.62	11.33	0.01	0.19	0.57
Exist-Pipe-8	2.04	0 12:10	2.30	0.89	4.77	0.26	0.61	0.73
Exist-Pipe-9	0.40	0 12:35	0.37	1.07	4.85	0.03	0.33	1.00

Link Summary

Element ID	Element Type	From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Diameter or Height (in)	Manning's Roughness	Peak Flow (cfs)	Design Flow Capacity (cfs)	Peak Flow Velocity (ft/sec)	Peak Flow Depth (ft)
Exist-Pipe-1	Pipe	Exist-Inlet-1	Exist-Inlet-2	52.02	4.50	4.10	0.7700	12.000	0.0230	1.89	1.77	2.68	1.00
Exist-Pipe-10	Pipe	Exist-Inlet-5	Jun-02	7.85	1.80	1.69	1.4000	12.000	0.0150	2.41	3.66	4.97	0.59
Exist-Pipe-11	Pipe	Jun-02	Jun-04	23.16	1.69	1.36	1.4200	12.000	0.0150	2.41	3.69	5.00	0.59
Exist-Pipe-12	Pipe	Jun-04	Jun-03	35.10	1.69	1.20	1.4000	12.000	0.0150	2.41	3.65	4.96	0.59
Exist-Pipe-13	Pipe	Jun-03	Out-03	62.50	1.20	0.50	1.1200	12.000	0.0150	3.09	3.27	4.73	0.76
Exist-Pipe-14	Pipe	Jun-01	Exist-Inlet-9	13.66	3.67	3.60	0.5000	4.000	0.0150	0.00	0.12	0.00	0.00
Exist-Pipe-15	Pipe	Exist-Inlet-9	Exist-Inlet-10	60.73	3.30	2.06	2.0500	10.000	0.0140	0.80	2.91	4.56	0.30
Exist-Pipe-16	Pipe	Exist-Inlet-10	Jun-03	41.33	2.06	1.20	2.0700	10.000	0.0140	0.79	2.93	4.56	0.30
Exist-Pipe-2	Pipe	Exist-Inlet-2	Out-09	88.38	2.40	1.72	0.7700	15.000	0.0140	1.84	5.26	3.97	0.50
Exist-Pipe-3	Pipe	Exist-Inlet-3	Exist-Inlet-2	28.04	3.60	2.50	3.9200	12.000	0.0150	0.00	6.12	0.00	0.00
Exist-Pipe-4	Pipe	Exist-Inlet-4	Out-01	6.24	1.20	1.17	0.5000	4.000	0.0150	0.13	0.12	1.53	0.33
Exist-Pipe-5	Pipe	Exist-Inlet-8	Out-02	5.03	3.90	0.00	77.5300	8.000	0.0150	0.64	9.22	15.22	0.12
Exist-Pipe-6	Pipe	Exist-Inlet-7	Exist-Inlet-6	67.32	3.90	3.00	1.3400	10.000	0.0150	1.47	2.20	4.32	0.50
Exist-Pipe-7	Pipe	Jun-06	Exist-Inlet-6	10.07	6.77	3.50	32.4700	4.000	0.0150	0.58	0.94	11.33	0.19
Exist-Pipe-8	Pipe	Exist-Inlet-6	Exist-Inlet-5	74.98	2.90	1.80	1.4700	10.000	0.0150	2.04	2.30	4.77	0.61
Exist-Pipe-9	Pipe	Jun-05	Exist-Inlet-5	9.30	5.42	4.95	5.0500	4.000	0.0150	0.40	0.37	4.85	0.33

Project Description

File Name .... 9977-00 Proposed Conditions - Runoff Analysis.SPF
Description ....
Woods Hole Oceanographic Institution

Iselin Dock Redevelopment Project

Proposed Conditions Runoff Analysis

Project Options

Flow Units .... CFS
Elevation Type .... Elevation
Hydrology Method .... SCS TR-55
Time of Concentration (TOC) Method .... SCS TR-55
Link Routing Method .... Kinematic Wave
Enable Overflow Ponding at Nodes .... YES
Skip Steady State Analysis Time Periods .... NO

Analysis Options

Start Analysis On	Jan 26, 2021	00:00:00
End Analysis On	Jan 27, 2021	00:00:00
Start Reporting On	Jan 26, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	3
Subbasins..	17
Nodes..	23
Junctions	6
Outfalls	7
Flow Diversions	0
Inlets	8
Storage Nodes	2
Links..	16
Channels	3
Pipes	13
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	2yr - 24hr Storm Event	Intensity	inches	Massachusetts	Barnstable	2	3.44	SCS Type III 24-hr

Subbasin Summary

Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
{Site 1}.P1	0.02	74.00	3.44	1.01	0.02	0.03	0 00:05:43
{Site 1}.P10	0.04	74.00	3.44	1.17	0.05	0.05	0 00:08:56
{Site 1}.P11	0.10	98.00	3.44	3.20	0.31	0.28	0 00:05:00
{Site 1}.P12	0.22	91.00	3.44	2.48	0.54	0.52	0 00:08:25
{Site 1}.P13	0.01	74.00	3.44	0.61	0.00	0.01	0 00:05:00
{Site 1}.P14	0.08	74.00	3.44	1.20	0.10	0.10	0 00:08:15
{Site 1}.P15	0.09	74.00	3.44	1.20	0.11	0.10	0 00:08:54
{Site 1}.P16	0.11	98.00	3.44	3.20	0.35	0.31	0 00:05:00
{Site 1}.P17	0.15	98.00	3.44	3.20	0.48	0.42	0 00:05:00
{Site 1}.P2	0.50	91.00	3.44	2.48	1.25	1.13	0 00:12:03
{Site 1}.P3	0.08	98.00	3.44	3.20	0.26	0.24	0 00:05:00
{Site 1}.P4	0.25	98.00	3.44	3.21	0.80	0.72	0 00:05:00
{Site 1}.P5	0.02	98.00	3.44	3.03	0.07	0.07	0 00:05:00
{Site 1}.P6	0.28	98.00	3.44	3.21	0.90	0.81	0 00:05:00
{Site 1}.P7	0.07	74.00	3.44	1.19	0.08	0.06	0 00:20:54
{Site 1}.P8	0.23	98.00	3.44	3.21	0.72	0.64	0 00:05:00
{Site 1}.P9	0.56	98.00	3.44	3.21	1.80	1.62	0 00:05:00

Subbasin Hydrology

Subbasin : {Site 1}.P1

Input Data

Area (ac) 0.02
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.02	-	74.00
Composite Area & Weighted CN	0.02		74.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft^2)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	20	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	5.72	0.00	0.00

Total TOC (min) 5.72

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 1.01
Peak Runoff (cfs) 0.03
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:05:43

Subbasin : {Site 1}.P2

Input Data

Area (ac) 0.50
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.50	-	91.00
Composite Area & Weighted CN	0.50		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	160	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.22	0.00	0.00
Computed Flow Time (min) :	12.05	0.00	0.00

Total TOC (min) 12.05

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 2.48
Peak Runoff (cfs) 1.13
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:12:03

Subbasin : {Site 1}.P3

Input Data

Area (ac) 0.08
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.08	-	98.00
Composite Area & Weighted CN	0.08		98.00

Time of Concentration

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.20
Peak Runoff (cfs) 0.24
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:00

Subbasin : {Site 1}.P4

Input Data

Area (ac) 0.25
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.25	-	98.00
Composite Area & Weighted CN	0.25		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.22	0.00	0.00
Computed Flow Time (min) :	1.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	25	0.00	0.00
Slope (%) :	2.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.13	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 0.72
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Subbasin : {Site 1}.P5

Input Data

Area (ac) 0.02
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.02	-	98.00
Composite Area & Weighted CN	0.02		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.06	0.00	0.00
Computed Flow Time (min) :	0.79	0.00	0.00

Total TOC (min) 0.79

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.03
Peak Runoff (cfs) 0.07
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:47

Subbasin : {Site 1}.P6

Input Data

Area (ac) 0.28
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.28	-	98.00
Composite Area & Weighted CN	0.28		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.22	0.00	0.00
Computed Flow Time (min) :	1.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	2.50	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.21	0.00	0.00

Total TOC (min) 1.58

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 0.81
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:35

Subbasin : {Site 1}.P7

Input Data

Area (ac) 0.07
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.07	-	74.00
Composite Area & Weighted CN	0.07		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.08	0.00	0.00
Computed Flow Time (min) :	20.71	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	25	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Grassed waterway	Unpaved	Unpaved
Velocity (ft/sec) :	2.12	0.00	0.00
Computed Flow Time (min) :	0.20	0.00	0.00

Total TOC (min) 20.91

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 1.19
Peak Runoff (cfs) 0.06
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:20:55

Subbasin : {Site 1}.P8

Input Data

Area (ac) 0.23
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.23	-	98.00
Composite Area & Weighted CN	0.23		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.95	0.00	0.00
Computed Flow Time (min) :	0.79	0.00	0.00

Total TOC (min) 0.79

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 0.64
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:47

Subbasin : {Site 1}.P9

Input Data

Area (ac) 0.56
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.56	-	98.00
Composite Area & Weighted CN	0.56		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	75	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.44	0.00	0.00

Total TOC (min) 1.93

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.21
Peak Runoff (cfs) 1.62
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:56

Subbasin : {Site 1}.P10

Input Data

Area (ac) 0.04
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.04	-	74.00
Composite Area & Weighted CN	0.04		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	35	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.07	0.00	0.00
Computed Flow Time (min) :	8.94	0.00	0.00

Total TOC (min) 8.94

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 1.17
Peak Runoff (cfs) 0.05
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:56

Subbasin : {Site 1}.P11

Input Data

Area (ac) 0.10
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.10	-	98.00
Composite Area & Weighted CN	0.10		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.20
Peak Runoff (cfs) 0.28
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Subbasin : {Site 1}.P12

Input Data

Area (ac) 0.22
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.22	-	91.00
Composite Area & Weighted CN	0.22		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.20	0.00	0.00
Computed Flow Time (min) :	8.27	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	24	0.00	0.00
Slope (%) :	1.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.49	0.00	0.00
Computed Flow Time (min) :	0.16	0.00	0.00

Total TOC (min) 8.43

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 2.48
Peak Runoff (cfs) 0.52
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:08:26

Subbasin : {Site 1}.P13

Input Data

Area (ac) 0.01
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.00	-	74.00
Composite Area & Weighted CN	0.00		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	2.5	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	0.75	0.00	0.00

Total TOC (min) 0.75

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 0.61
Peak Runoff (cfs) 0.01
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:00:45

Subbasin : {Site 1}.P14

Input Data

Area (ac) 0.08
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.08	-	74.00
Composite Area & Weighted CN	0.08		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.10	0.00	0.00
Computed Flow Time (min) :	8.25	0.00	0.00

Total TOC (min) 8.25

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 1.20
Peak Runoff (cfs) 0.10
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:15

Subbasin : {Site 1}.P15

Input Data

Area (ac) 0.09
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.09	-	74.00
Composite Area & Weighted CN	0.09		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	55	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.10	0.00	0.00
Computed Flow Time (min) :	8.90	0.00	0.00

Total TOC (min) 8.90

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 1.20
Peak Runoff (cfs) 0.10
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:54

Subbasin : {Site 1}.P16

Input Data

Area (ac) 0.11
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	98.00
Composite Area & Weighted CN	0.11		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	70	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.04	0.00	0.00
Computed Flow Time (min) :	1.13	0.00	0.00

Total TOC (min) 1.13

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.20
Peak Runoff (cfs) 0.31
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:08

Subbasin : {Site 1}.P17

Input Data

Area (ac) 0.15
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 2yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.15	-	98.00
Composite Area & Weighted CN	0.15		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.39	0.00	0.00
Computed Flow Time (min) :	1.20	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	70	0.00	0.00
Slope (%) :	3.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.80	0.00	0.00
Computed Flow Time (min) :	0.31	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 3.44
Total Runoff (in) 3.20
Peak Runoff (cfs) 0.42
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Inlet Summary

Element ID	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
Prop-Inlet-2	1.58	6.30	0.10	0.82	6.32
Prop-Inlet-3	1.10	6.30	0.09	0.76	6.32
Prop-Inlet-4	2.32	6.65	0.03	0.25	6.65
Prop-Inlet-5	2.24	6.23	0.28	2.28	6.27
Prop-Inlet-6	2.16	6.50	0.05	0.41	6.51
Prop-Inlet-7	1.83	6.80	0.07	0.60	6.81
Prop-Inlet-8	1.22	7.93	0.72	5.92	8.05
Proposed-Inlet-1	2.50	6.29	0.42	3.49	6.36

Inlet Results

Element ID	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
Prop-Inlet-2	0.10	0.82	6.32	0.02	0 12:10	0.00	0.00
Prop-Inlet-3	0.09	0.76	6.32	0.02	0 12:10	0.00	0.00
Prop-Inlet-4	0.03	0.25	6.65	0.00	0 12:09	0.00	0.00
Prop-Inlet-5	0.28	2.28	6.27	0.04	0 12:09	0.00	0.00
Prop-Inlet-6	0.05	0.41	6.51	0.01	0 12:12	0.00	0.00
Prop-Inlet-7	0.07	0.60	6.81	0.01	0 12:12	0.00	0.00
Prop-Inlet-8	0.72	5.92	8.05	0.12	0 12:10	0.00	0.00
Proposed-Inlet-1	0.42	3.49	6.36	0.07	0 12:09	0.00	0.00

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft²)	Minimum Pipe Cover (in)
1	Prop-Manhole-1	1.92	8.91	6.99	1.92	0.00	8.91	0.00	0.00	0.00
2	Prop-Manhole-2	1.95	6.67	4.72	1.95	0.00	6.67	0.00	0.00	0.00
3	Prop-Manhole-3	1.53	7.98	6.44	1.53	0.00	7.98	0.00	0.00	0.00
4	Prop-TrenchDrain-1End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Prop-TrenchDrain-2A-End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Prop-TrenchDrain-2B-End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Junction Results

Element ID	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
Prop-Manhole-1	0.47	2.36	0.44	0.00	6.54	2.16	0.24	0 12:10	0 00:00	0.00	0.00
Prop-Manhole-2	0.28	2.25	0.30	0.00	4.43	2.15	0.20	0 12:10	0 00:00	0.00	0.00
Prop-Manhole-3	0.39	1.93	0.40	0.00	6.05	1.77	0.24	0 12:10	0 00:00	0.00	0.00
Prop-TrenchDrain-1End	0.50	6.50	6.50	0.00	0.00	6.37	6.37	0 06:06	0 00:00	0.00	0.00
Prop-TrenchDrain-2A-End	0.06	7.00	7.00	0.00	0.00	6.77	6.77	0 11:11	0 00:00	0.00	0.00
Prop-TrenchDrain-2B-End	0.00	6.00	6.00	0.00	0.50	6.00	6.00	0 00:00	0 00:00	0.00	0.00

Pipe Input

Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Manning's Roughness
{9977-00 Proposed Storm Drain}.Prop-Pipe-1	75.51	2.50	2.12	0.38	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-10	28.66	2.16	2.02	0.14	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-11	38.98	1.83	1.63	0.20	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-12	22.63	1.53	1.42	0.11	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-13	44.59	1.22	1.00	0.22	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-2	17.53	5.00	2.02	2.98	17.0000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-3	48.07	1.92	1.68	0.24	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-4	56.66	1.58	1.30	0.28	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-5	19.84	1.10	1.00	0.10	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-6	38.92	2.32	2.12	0.20	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-7	37.44	2.24	2.05	0.19	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-8	14.75	5.50	2.15	3.35	22.7100	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-9	44.53	1.95	1.73	0.22	0.5000	CIRCULAR	18.000	0.0130

Pipe Results

Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)
{9977-00 Proposed Storm Drain}.Prop-Pipe-1	0.42	0 12:10	7.43	0.06	2.32	0.54	0.24	0.16	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-10	0.05	0 12:12	7.42	0.01	1.35	0.35	0.09	0.06	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-11	0.12	0 12:10	7.43	0.02	1.62	0.40	0.13	0.09	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-12	0.39	0 12:10	7.42	0.05	2.22	0.17	0.23	0.16	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-13	1.10	0 12:10	7.43	0.15	3.02	0.25	0.39	0.26	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-2	0.01	0 12:10	43.31	0.00	2.49	0.12	0.02	0.01	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-3	0.46	0 12:10	7.42	0.06	2.36	0.34	0.25	0.17	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-4	0.55	0 12:10	7.42	0.07	2.46	0.38	0.28	0.18	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-5	0.64	0 12:11	7.42	0.09	2.56	0.13	0.30	0.20	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-6	0.03	0 12:10	7.43	0.00	1.34	0.48	0.07	0.05	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-7	0.28	0 12:10	7.42	0.04	2.04	0.31	0.20	0.13	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-8	0.00	0 00:00	50.06	0.00	0.00		0.00	0.00	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-9	0.27	0 12:10	7.43	0.04	2.01	0.37	0.20	0.13	0.00

Project Description

File Name .... 9977-00 Proposed Conditions - Runoff Analysis.SPF
Description ....
Woods Hole Oceanographic Institution

Iselin Dock Redevelopment Project

Proposed Conditions Runoff Analysis

Project Options

Flow Units .... CFS
Elevation Type .... Elevation
Hydrology Method .... SCS TR-55
Time of Concentration (TOC) Method .... SCS TR-55
Link Routing Method .... Kinematic Wave
Enable Overflow Ponding at Nodes .... YES
Skip Steady State Analysis Time Periods .... NO

Analysis Options

Start Analysis On	Jan 26, 2021	00:00:00
End Analysis On	Jan 27, 2021	00:00:00
Start Reporting On	Jan 26, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	3
Subbasins...	17
Nodes...	23
Junctions	6
Outfalls	7
Flow Diversions	0
Inlets	8
Storage Nodes	2
Links...	16
Channels	3
Pipes	13
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	10yr - 24hr Storm Event	Intensity	inches	Massachusetts	Barnstable	10	5.02	SCS Type III 24-hr

Subbasin Summary

Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
{Site 1}.P1	0.02	74.00	5.02	2.32	0.05	0.06	0 00:05:43
{Site 1}.P10	0.04	74.00	5.02	2.37	0.10	0.10	0 00:08:56
{Site 1}.P11	0.10	98.00	5.02	4.78	0.46	0.40	0 00:05:00
{Site 1}.P12	0.22	91.00	5.02	4.00	0.87	0.82	0 00:08:25
{Site 1}.P13	0.01	74.00	5.02	1.65	0.01	0.02	0 00:05:00
{Site 1}.P14	0.08	74.00	5.02	2.38	0.19	0.20	0 00:08:15
{Site 1}.P15	0.09	74.00	5.02	2.38	0.21	0.21	0 00:08:54
{Site 1}.P16	0.11	98.00	5.02	4.78	0.52	0.46	0 00:05:00
{Site 1}.P17	0.15	98.00	5.02	4.78	0.71	0.62	0 00:05:00
{Site 1}.P2	0.50	91.00	5.02	4.00	2.01	1.78	0 00:12:03
{Site 1}.P3	0.08	98.00	5.02	4.78	0.39	0.35	0 00:05:00
{Site 1}.P4	0.25	98.00	5.02	4.78	1.19	1.05	0 00:05:00
{Site 1}.P5	0.02	98.00	5.02	4.73	0.11	0.11	0 00:05:00
{Site 1}.P6	0.28	98.00	5.02	4.78	1.34	1.19	0 00:05:00
{Site 1}.P7	0.07	74.00	5.02	2.37	0.16	0.12	0 00:20:54
{Site 1}.P8	0.23	98.00	5.02	4.78	1.08	0.94	0 00:05:00
{Site 1}.P9	0.56	98.00	5.02	4.78	2.69	2.38	0 00:05:00

Subbasin Hydrology

Subbasin : {Site 1}.P1

Input Data

Area (ac) 0.02
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.02	-	74.00
Composite Area & Weighted CN	0.02		74.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	20	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	5.72	0.00	0.00

Total TOC (min) 5.72

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 2.32
Peak Runoff (cfs) 0.06
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:05:43

Subbasin : {Site 1}.P2

Input Data

Area (ac) 0.50
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.50	-	91.00
Composite Area & Weighted CN	0.50		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	160	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.22	0.00	0.00
Computed Flow Time (min) :	12.05	0.00	0.00

Total TOC (min) 12.05

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.00
Peak Runoff (cfs) 1.78
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:12:03

Subbasin : {Site 1}.P3

Input Data

Area (ac) 0.08
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.08	-	98.00
Composite Area & Weighted CN	0.08		98.00

Time of Concentration

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.35
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:00

Subbasin : {Site 1}.P4

Input Data

Area (ac) 0.25
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.25	-	98.00
Composite Area & Weighted CN	0.25		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.22	0.00	0.00
Computed Flow Time (min) :	1.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	25	0.00	0.00
Slope (%) :	2.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.13	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 1.05
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Subbasin : {Site 1}.P5

Input Data

Area (ac) 0.02
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.02	-	98.00
Composite Area & Weighted CN	0.02		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.06	0.00	0.00
Computed Flow Time (min) :	0.79	0.00	0.00

Total TOC (min) 0.79

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.73
Peak Runoff (cfs) 0.11
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:47

Subbasin : {Site 1}.P6

Input Data

Area (ac) 0.28
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.28	-	98.00
Composite Area & Weighted CN	0.28		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.22	0.00	0.00
Computed Flow Time (min) :	1.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	2.50	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.21	0.00	0.00

Total TOC (min) 1.58

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 1.19
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:35

Subbasin : {Site 1}.P7

Input Data

Area (ac) 0.07
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.07	-	74.00
Composite Area & Weighted CN	0.07		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.08	0.00	0.00
Computed Flow Time (min) :	20.71	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	25	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Grassed waterway	Unpaved	Unpaved
Velocity (ft/sec) :	2.12	0.00	0.00
Computed Flow Time (min) :	0.20	0.00	0.00

Total TOC (min) 20.91

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 2.37
Peak Runoff (cfs) 0.12
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:20:55

Subbasin : {Site 1}.P8

Input Data

Area (ac) 0.23
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.23	-	98.00
Composite Area & Weighted CN	0.23		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.95	0.00	0.00
Computed Flow Time (min) :	0.79	0.00	0.00

Total TOC (min) 0.79

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.94
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:47

Subbasin : {Site 1}.P9

Input Data

Area (ac) 0.56
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.56	-	98.00
Composite Area & Weighted CN	0.56		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	75	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.44	0.00	0.00

Total TOC (min) 1.93

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 2.38
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:56

Subbasin : {Site 1}.P10

Input Data

Area (ac) 0.04
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.04	-	74.00
Composite Area & Weighted CN	0.04		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	35	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.07	0.00	0.00
Computed Flow Time (min) :	8.94	0.00	0.00

Total TOC (min) 8.94

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 2.37
Peak Runoff (cfs) 0.10
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:56

Subbasin : {Site 1}.P11

Input Data

Area (ac) 0.10
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.10	-	98.00
Composite Area & Weighted CN	0.10		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.40
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Subbasin : {Site 1}.P12

Input Data

Area (ac) 0.22
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.22	-	91.00
Composite Area & Weighted CN	0.22		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.20	0.00	0.00
Computed Flow Time (min) :	8.27	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	24	0.00	0.00
Slope (%) :	1.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.49	0.00	0.00
Computed Flow Time (min) :	0.16	0.00	0.00

Total TOC (min) 8.43

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.00
Peak Runoff (cfs) 0.82
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:08:26

Subbasin : {Site 1}.P13

Input Data

Area (ac) 0.01
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.00	-	74.00
Composite Area & Weighted CN	0.00		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	2.5	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	0.75	0.00	0.00

Total TOC (min) 0.75

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 1.65
Peak Runoff (cfs) 0.02
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:00:45

Subbasin : {Site 1}.P14

Input Data

Area (ac) 0.08
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.08	-	74.00
Composite Area & Weighted CN	0.08		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.10	0.00	0.00
Computed Flow Time (min) :	8.25	0.00	0.00

Total TOC (min) 8.25

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 2.38
Peak Runoff (cfs) 0.20
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:15

Subbasin : {Site 1}.P15

Input Data

Area (ac) 0.09
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.09	-	74.00
Composite Area & Weighted CN	0.09		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	55	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.10	0.00	0.00
Computed Flow Time (min) :	8.90	0.00	0.00

Total TOC (min) 8.90

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 2.38
Peak Runoff (cfs) 0.21
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:54

Subbasin : {Site 1}.P16

Input Data

Area (ac) 0.11
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	98.00
Composite Area & Weighted CN	0.11		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	70	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.04	0.00	0.00
Computed Flow Time (min) :	1.13	0.00	0.00

Total TOC (min) 1.13

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.46
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:08

Subbasin : {Site 1}.P17

Input Data

Area (ac) 0.15
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 10yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.15	-	98.00
Composite Area & Weighted CN	0.15		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.39	0.00	0.00
Computed Flow Time (min) :	1.20	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	70	0.00	0.00
Slope (%) :	3.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.80	0.00	0.00
Computed Flow Time (min) :	0.31	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 5.02
Total Runoff (in) 4.78
Peak Runoff (cfs) 0.62
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Inlet Summary

Element ID	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
Prop-Inlet-2	1.58	6.30	0.20	1.65	6.33
Prop-Inlet-3	1.10	6.30	0.18	1.52	6.33
Prop-Inlet-4	2.32	6.65	0.06	0.51	6.66
Prop-Inlet-5	2.24	6.23	0.40	3.34	6.29
Prop-Inlet-6	2.16	6.50	0.10	0.83	6.51
Prop-Inlet-7	1.83	6.80	0.11	0.89	6.82
Prop-Inlet-8	1.22	7.93	1.05	8.49	8.10
Proposed-Inlet-1	2.50	6.29	0.62	5.12	6.39

Inlet Results

Element ID	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
Prop-Inlet-2	0.20	1.65	6.33	0.03	0 12:10	0.00	0.00
Prop-Inlet-3	0.18	1.52	6.33	0.03	0 12:11	0.00	0.00
Prop-Inlet-4	0.06	0.51	6.66	0.01	0 12:10	0.00	0.00
Prop-Inlet-5	0.40	3.34	6.29	0.07	0 12:10	0.00	0.00
Prop-Inlet-6	0.10	0.83	6.51	0.01	0 12:14	0.00	0.00
Prop-Inlet-7	0.11	0.89	6.82	0.02	0 12:15	0.00	0.00
Prop-Inlet-8	1.05	8.49	8.10	0.17	0 12:10	0.00	0.00
Proposed-Inlet-1	0.62	5.12	6.39	0.10	0 12:09	0.00	0.00

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft²)	Minimum Pipe Cover (in)
1	Prop-Manhole-1	1.92	8.91	6.99	1.92	0.00	8.91	0.00	0.00	0.00
2	Prop-Manhole-2	1.95	6.67	4.72	1.95	0.00	6.67	0.00	0.00	0.00
3	Prop-Manhole-3	1.53	7.98	6.44	1.53	0.00	7.98	0.00	0.00	0.00
4	Prop-TrenchDrain-1End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Prop-TrenchDrain-2A-End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Prop-TrenchDrain-2B-End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Junction Results

Element ID	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
Prop-Manhole-1	0.69	2.41	0.49	0.00	6.49	2.17	0.25	0 12:10	0 00:00	0.00	0.00
Prop-Manhole-2	0.40	2.29	0.34	0.00	4.39	2.15	0.20	0 12:10	0 00:00	0.00	0.00
Prop-Manhole-3	0.60	1.97	0.44	0.00	6.01	1.77	0.24	0 12:10	0 00:00	0.00	0.00
Prop-TrenchDrain-1End	0.79	6.50	6.50	0.00	0.00	6.41	6.41	0 04:26	0 00:00	0.00	0.00
Prop-TrenchDrain-2A-End	0.12	7.00	7.00	0.00	0.00	6.80	6.80	0 09:51	0 00:00	0.00	0.00
Prop-TrenchDrain-2B-End	0.00	6.00	6.00	0.00	0.50	6.00	6.00	0 00:00	0 00:00	0.00	0.00

Pipe Input

Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Manning's Roughness
{9977-00 Proposed Storm Drain}.Prop-Pipe-1	75.51	2.50	2.12	0.38	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-10	28.66	2.16	2.02	0.14	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-11	38.98	1.83	1.63	0.20	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-12	22.63	1.53	1.42	0.11	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-13	44.59	1.22	1.00	0.22	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-2	17.53	5.00	2.02	2.98	17.0000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-3	48.07	1.92	1.68	0.24	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-4	56.66	1.58	1.30	0.28	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-5	19.84	1.10	1.00	0.10	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-6	38.92	2.32	2.12	0.20	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-7	37.44	2.24	2.05	0.19	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-8	14.75	5.50	2.15	3.35	22.7100	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-9	44.53	1.95	1.73	0.22	0.5000	CIRCULAR	18.000	0.0130

Pipe Results

Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)
{9977-00 Proposed Storm Drain}.Prop-Pipe-1	0.62	0 12:10	7.43	0.08	2.57	0.49	0.29	0.19	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-10	0.10	0 12:15	7.42	0.01	1.56	0.31	0.12	0.08	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-11	0.20	0 12:10	7.43	0.03	1.84	0.35	0.17	0.11	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-12	0.60	0 12:10	7.42	0.08	2.53	0.15	0.29	0.19	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-13	1.64	0 12:10	7.43	0.22	3.40	0.22	0.48	0.32	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-2	0.02	0 12:10	43.31	0.00	3.14	0.09	0.02	0.02	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-3	0.69	0 12:10	7.42	0.09	2.64	0.30	0.31	0.21	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-4	0.89	0 12:11	7.42	0.12	2.84	0.33	0.35	0.23	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-5	1.07	0 12:10	7.42	0.14	2.99	0.11	0.38	0.26	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-6	0.07	0 12:10	7.43	0.01	1.52	0.43	0.10	0.07	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-7	0.40	0 12:10	7.42	0.05	2.28	0.27	0.24	0.16	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-8	0.00	0 00:00	50.06	0.00	0.00		0.00	0.00	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-9	0.40	0 12:10	7.43	0.05	2.25	0.33	0.24	0.16	0.00

Project Description

File Name .... 9977-00 Proposed Conditions - Runoff Analysis.SPF
Description ....

Woods Hole Oceanographic Institution

Iselin Dock Redevelopment Project

Proposed Conditions Runoff Analysis

Project Options

Flow Units .... CFS
Elevation Type .... Elevation
Hydrology Method .... SCS TR-55
Time of Concentration (TOC) Method .... SCS TR-55
Link Routing Method .... Kinematic Wave
Enable Overflow Ponding at Nodes .... YES
Skip Steady State Analysis Time Periods .... NO

Analysis Options

Start Analysis On	Jan 26, 2021	00:00:00
End Analysis On	Jan 27, 2021	00:00:00
Start Reporting On	Jan 26, 2021	00:00:00
Antecedent Dry Days	0	days
Runoff (Dry Weather) Time Step	0 01:00:00	days hh:mm:ss
Runoff (Wet Weather) Time Step	0 00:05:00	days hh:mm:ss
Reporting Time Step	0 00:05:00	days hh:mm:ss
Routing Time Step	30	seconds

Number of Elements

	Qty
Rain Gages	3
Subbasins...	17
Nodes..	23
Junctions	6
Outfalls	7
Flow Diversions	0
Inlets	8
Storage Nodes	2
Links..	16
Channels	3
Pipes	13
Pumps	0
Orifices	0
Weirs	0
Outlets	0
Pollutants	0
Land Uses	0

Rainfall Details

SN	Rain Gage ID	Data Source	Data Source ID	Rainfall Type	Rain Units	State	County	Return Period (years)	Rainfall Depth (inches)	Rainfall Distribution
1		Time Series	100yr - 24hr Storm Event	Intensity	inches	Massachusetts	Barnstable	100	7.51	SCS Type III 24-hr

Subbasin Summary

Subbasin ID	Area (ac)	Weighted Curve Number	Total Rainfall (in)	Total Runoff (in)	Total Runoff Volume (ac-in)	Peak Runoff (cfs)	Time of Concentration (days hh:mm:ss)
{Site 1}.P1	0.02	74.00	7.51	4.46	0.10	0.12	0 00:05:43
{Site 1}.P10	0.04	74.00	7.51	4.48	0.19	0.20	0 00:08:56
{Site 1}.P11	0.10	98.00	7.51	7.27	0.70	0.61	0 00:05:00
{Site 1}.P12	0.22	91.00	7.51	6.44	1.40	1.28	0 00:08:25
{Site 1}.P13	0.01	74.00	7.51	3.64	0.02	0.03	0 00:05:00
{Site 1}.P14	0.08	74.00	7.51	4.49	0.36	0.37	0 00:08:15
{Site 1}.P15	0.09	74.00	7.51	4.49	0.40	0.39	0 00:08:54
{Site 1}.P16	0.11	98.00	7.51	7.27	0.79	0.69	0 00:05:00
{Site 1}.P17	0.15	98.00	7.51	7.27	1.08	0.93	0 00:05:00
{Site 1}.P2	0.50	91.00	7.51	6.44	3.24	2.79	0 00:12:03
{Site 1}.P3	0.08	98.00	7.51	7.27	0.59	0.53	0 00:05:00
{Site 1}.P4	0.25	98.00	7.51	7.27	1.81	1.58	0 00:05:00
{Site 1}.P5	0.02	98.00	7.51	7.24	0.17	0.16	0 00:05:00
{Site 1}.P6	0.28	98.00	7.51	7.27	2.04	1.78	0 00:05:00
{Site 1}.P7	0.07	74.00	7.51	4.48	0.30	0.22	0 00:20:54
{Site 1}.P8	0.23	98.00	7.51	7.27	1.64	1.42	0 00:05:00
{Site 1}.P9	0.56	98.00	7.51	7.27	4.09	3.56	0 00:05:00

Subbasin Hydrology

Subbasin : {Site 1}.P1

Input Data

Area (ac) 0.02
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.02	-	74.00
Composite Area & Weighted CN	0.02		74.00

Time of Concentration

TOC Method : SCS TR-55

Sheet Flow Equation :

Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

Where :

Tc = Time of Concentration (hr)
n = Manning's roughness
Lf = Flow Length (ft)
P = 2 yr, 24 hr Rainfall (inches)
Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation :

V = 16.1345 * (Sf^0.5) (unpaved surface)
V = 20.3282 * (Sf^0.5) (paved surface)
V = 15.0 * (Sf^0.5) (grassed waterway surface)
V = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
V = 7.0 * (Sf^0.5) (short grass pasture surface)
V = 5.0 * (Sf^0.5) (woodland surface)
V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation :

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where :

Tc = Time of Concentration (hr)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area (ft²)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's roughness

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	20	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	5.72	0.00	0.00

Total TOC (min) 5.72

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 4.46
Peak Runoff (cfs) 0.12
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:05:43

Subbasin : {Site 1}.P2

Input Data

Area (ac) 0.50
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.50	-	91.00
Composite Area & Weighted CN	0.50		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	.11	0.00	0.00
Flow Length (ft) :	160	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.22	0.00	0.00
Computed Flow Time (min) :	12.05	0.00	0.00

Total TOC (min) 12.05

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 6.44
Peak Runoff (cfs) 2.79
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:12:03

Subbasin : {Site 1}.P3

Input Data

Area (ac) 0.08
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.08	-	98.00
Composite Area & Weighted CN	0.08		98.00

Time of Concentration

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 0.53
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:00

Subbasin : {Site 1}.P4

Input Data

Area (ac) 0.25
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.25	-	98.00
Composite Area & Weighted CN	0.25		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.22	0.00	0.00
Computed Flow Time (min) :	1.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	25	0.00	0.00
Slope (%) :	2.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.13	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 1.58
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Subbasin : {Site 1}.P5

Input Data

Area (ac) 0.02
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.02	-	98.00
Composite Area & Weighted CN	0.02		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.06	0.00	0.00
Computed Flow Time (min) :	0.79	0.00	0.00

Total TOC (min) 0.79

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.24
Peak Runoff (cfs) 0.16
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:47

Subbasin : {Site 1}.P6

Input Data

Area (ac) 0.28
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.28	-	98.00
Composite Area & Weighted CN	0.28		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.22	0.00	0.00
Computed Flow Time (min) :	1.37	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	40	0.00	0.00
Slope (%) :	2.50	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.21	0.00	0.00
Computed Flow Time (min) :	0.21	0.00	0.00

Total TOC (min) 1.58

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 1.78
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:35

Subbasin : {Site 1}.P7

Input Data

Area (ac) 0.07
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.07	-	74.00
Composite Area & Weighted CN	0.07		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.08	0.00	0.00
Computed Flow Time (min) :	20.71	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	25	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Grassed waterway	Unpaved	Unpaved
Velocity (ft/sec) :	2.12	0.00	0.00
Computed Flow Time (min) :	0.20	0.00	0.00

Total TOC (min) 20.91

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 4.48
Peak Runoff (cfs) 0.22
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:20:55

Subbasin : {Site 1}.P8

Input Data

Area (ac) 0.23
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.23	-	98.00
Composite Area & Weighted CN	0.23		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	45	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.95	0.00	0.00
Computed Flow Time (min) :	0.79	0.00	0.00

Total TOC (min) 0.79

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 1.42
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:00:47

Subbasin : {Site 1}.P9

Input Data

Area (ac) 0.56
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.56	-	98.00
Composite Area & Weighted CN	0.56		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	75	0.00	0.00
Slope (%) :	2.0	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.87	0.00	0.00
Computed Flow Time (min) :	0.44	0.00	0.00

Total TOC (min) 1.93

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 3.56
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:56

Subbasin : {Site 1}.P10

Input Data

Area (ac) 0.04
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.04	-	74.00
Composite Area & Weighted CN	0.04		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	35	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.07	0.00	0.00
Computed Flow Time (min) :	8.94	0.00	0.00

Total TOC (min) 8.94

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 4.48
Peak Runoff (cfs) 0.20
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:56

Subbasin : {Site 1}.P11

Input Data

Area (ac) 0.10
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.10	-	98.00
Composite Area & Weighted CN	0.10		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.11	0.00	0.00
Computed Flow Time (min) :	1.50	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 0.61
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Subbasin : {Site 1}.P12

Input Data

Area (ac) 0.22
Peak Rate Factor 484.00
Weighted Curve Number 91.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.22	-	91.00
Composite Area & Weighted CN	0.22		91.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.11	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	1.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.20	0.00	0.00
Computed Flow Time (min) :	8.27	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	24	0.00	0.00
Slope (%) :	1.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	2.49	0.00	0.00
Computed Flow Time (min) :	0.16	0.00	0.00

Total TOC (min) 8.43

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 6.44
Peak Runoff (cfs) 1.28
Weighted Curve Number 91.00
Time of Concentration (days hh:mm:ss) 0 00:08:26

Subbasin : {Site 1}.P13

Input Data

Area (ac) 0.01
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.00	-	74.00
Composite Area & Weighted CN	0.00		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	2.5	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.06	0.00	0.00
Computed Flow Time (min) :	0.75	0.00	0.00

Total TOC (min) 0.75

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 3.64
Peak Runoff (cfs) 0.03
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:00:45

Subbasin : {Site 1}.P14

Input Data

Area (ac) 0.08
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.08	-	74.00
Composite Area & Weighted CN	0.08		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	50	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.10	0.00	0.00
Computed Flow Time (min) :	8.25	0.00	0.00

Total TOC (min) 8.25

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 4.49
Peak Runoff (cfs) 0.37
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:15

Subbasin : {Site 1}.P15

Input Data

Area (ac) 0.09
Peak Rate Factor 484.00
Weighted Curve Number 74.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.09	-	74.00
Composite Area & Weighted CN	0.09		74.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.40	0.00	0.00
Flow Length (ft) :	55	0.00	0.00
Slope (%) :	5.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	0.10	0.00	0.00
Computed Flow Time (min) :	8.90	0.00	0.00

Total TOC (min) 8.90

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 4.49
Peak Runoff (cfs) 0.39
Weighted Curve Number 74.00
Time of Concentration (days hh:mm:ss) 0 00:08:54

Subbasin : {Site 1}.P16

Input Data

Area (ac) 0.11
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.11	-	98.00
Composite Area & Weighted CN	0.11		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	70	0.00	0.00
Slope (%) :	2.0	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.04	0.00	0.00
Computed Flow Time (min) :	1.13	0.00	0.00

Total TOC (min) 1.13

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 0.69
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:08

Subbasin : {Site 1}.P17

Input Data

Area (ac) 0.15
Peak Rate Factor 484.00
Weighted Curve Number 98.00
Rain Gage ID 100yr

Composite Curve Number

Soil/Surface Description	Area (acres)	Soil Group	Curve Number
-	0.15	-	98.00
Composite Area & Weighted CN	0.15		98.00

Time of Concentration

Sheet Flow Computations	Subarea A	Subarea B	Subarea C
Manning's Roughness :	0.015	0.00	0.00
Flow Length (ft) :	100	0.00	0.00
Slope (%) :	3.5	0.00	0.00
2 yr, 24 hr Rainfall (in) :	3.44	0.00	0.00
Velocity (ft/sec) :	1.39	0.00	0.00
Computed Flow Time (min) :	1.20	0.00	0.00

Shallow Concentrated Flow Computations	Subarea A	Subarea B	Subarea C
Flow Length (ft) :	70	0.00	0.00
Slope (%) :	3.5	0.00	0.00
Surface Type :	Paved	Unpaved	Unpaved
Velocity (ft/sec) :	3.80	0.00	0.00
Computed Flow Time (min) :	0.31	0.00	0.00

Total TOC (min) 1.50

Subbasin Runoff Results

Total Rainfall (in) 7.51
Total Runoff (in) 7.27
Peak Runoff (cfs) 0.93
Weighted Curve Number 98.00
Time of Concentration (days hh:mm:ss) 0 00:01:30

Inlet Results

Element ID	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)	Max Gutter Water Depth during Peak Flow (ft)	Time of Max Depth Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
Prop-Inlet-2	0.37	3.08	6.36	0.06	0 12:10	0.00	0.00
Prop-Inlet-3	0.35	2.91	6.36	0.06	0 12:11	0.00	0.00
Prop-Inlet-4	0.12	0.96	6.67	0.02	0 12:10	0.00	0.00
Prop-Inlet-5	0.61	5.02	6.32	0.10	0 12:09	0.00	0.00
Prop-Inlet-6	0.19	1.54	6.53	0.03	0 12:09	0.00	0.00
Prop-Inlet-7	0.16	1.34	6.82	0.02	0 12:15	0.00	0.00
Prop-Inlet-8	1.58	10.74	8.15	0.22	0 12:10	0.00	0.00
Proposed-Inlet-1	0.93	7.69	6.44	0.15	0 12:09	0.00	0.00

Inlet Summary

Element ID	Catchbasin Invert Elevation (ft)	Max (Rim) Elevation (ft)	Peak Flow (cfs)	Max Gutter Spread during Peak Flow (ft)	Max Gutter Water Elev. during Peak Flow (ft)
Prop-Inlet-2	1.58	6.30	0.37	3.08	6.36
Prop-Inlet-3	1.10	6.30	0.35	2.91	6.36
Prop-Inlet-4	2.32	6.65	0.12	0.96	6.67
Prop-Inlet-5	2.24	6.23	0.61	5.02	6.32
Prop-Inlet-6	2.16	6.50	0.19	1.54	6.53
Prop-Inlet-7	1.83	6.80	0.16	1.34	6.82
Prop-Inlet-8	1.22	7.93	1.58	10.74	8.15
Proposed-Inlet-1	2.50	6.29	0.93	7.69	6.44

Junction Input

SN	Element ID	Invert Elevation (ft)	Ground/Rim (Max) Elevation (ft)	Ground/Rim (Max) Offset (ft)	Initial Water Elevation (ft)	Initial Water Depth (ft)	Surcharge Elevation (ft)	Surcharge Depth (ft)	Ponded Area (ft²)	Minimum Pipe Cover (in)
1	Prop-Manhole-1	1.92	8.91	6.99	1.92	0.00	8.91	0.00	0.00	0.00
2	Prop-Manhole-2	1.95	6.67	4.72	1.95	0.00	6.67	0.00	0.00	0.00
3	Prop-Manhole-3	1.53	7.98	6.44	1.53	0.00	7.98	0.00	0.00	0.00
4	Prop-TrenchDrain-1End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Prop-TrenchDrain-2A-End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Prop-TrenchDrain-2B-End	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Junction Results

Element ID	Peak Inflow (cfs)	Max HGL Elevation Attained (ft)	Max HGL Depth Attained (ft)	Max Surcharge Depth Attained (ft)	Min Freeboard Attained (ft)	Average HGL Elevation Attained (ft)	Average HGL Depth Attained (ft)	Time of Max HGL Occurrence (days hh:mm)	Time of Peak Flooding Occurrence (days hh:mm)	Total Flooded Volume (ac-in)	Total Time Flooded (min)
Prop-Manhole-1	1.07	2.48	0.56	0.00	6.43	2.19	0.27	0 12:10	0 00:00	0.00	0.00
Prop-Manhole-2	0.60	2.34	0.39	0.00	4.33	2.15	0.20	0 12:10	0 00:00	0.00	0.00
Prop-Manhole-3	0.95	2.02	0.49	0.00	5.96	1.79	0.26	0 12:10	0 00:00	0.00	0.00
Prop-TrenchDrain-1End	1.24	6.50	6.50	0.00	0.00	6.44	6.44	0 03:06	0 00:00	0.00	0.00
Prop-TrenchDrain-2A-End	0.22	7.00	7.00	0.00	0.00	6.83	6.83	0 08:16	0 00:00	0.00	0.00
Prop-TrenchDrain-2B-End	0.00	6.00	6.00	0.00	0.50	6.00	6.00	0 00:00	0 00:00	0.00	0.00

Pipe Input

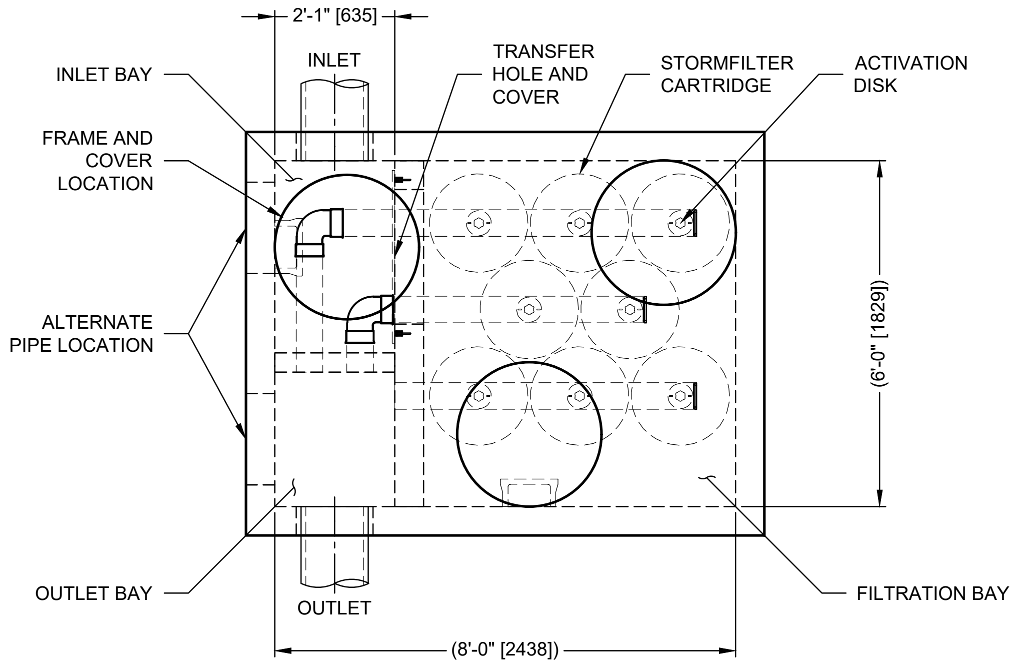
Element ID	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Total Drop (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (in)	Manning's Roughness
{9977-00 Proposed Storm Drain}.Prop-Pipe-1	75.51	2.50	2.12	0.38	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-10	28.66	2.16	2.02	0.14	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-11	38.98	1.83	1.63	0.20	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-12	22.63	1.53	1.42	0.11	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-13	44.59	1.22	1.00	0.22	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-2	17.53	5.00	2.02	2.98	17.0000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-3	48.07	1.92	1.68	0.24	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-4	56.66	1.58	1.30	0.28	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-5	19.84	1.10	1.00	0.10	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-6	38.92	2.32	2.12	0.20	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-7	37.44	2.24	2.05	0.19	0.5000	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-8	14.75	5.50	2.15	3.35	22.7100	CIRCULAR	18.000	0.0130
{9977-00 Proposed Storm Drain}.Prop-Pipe-9	44.53	1.95	1.73	0.22	0.5000	CIRCULAR	18.000	0.0130

Pipe Results

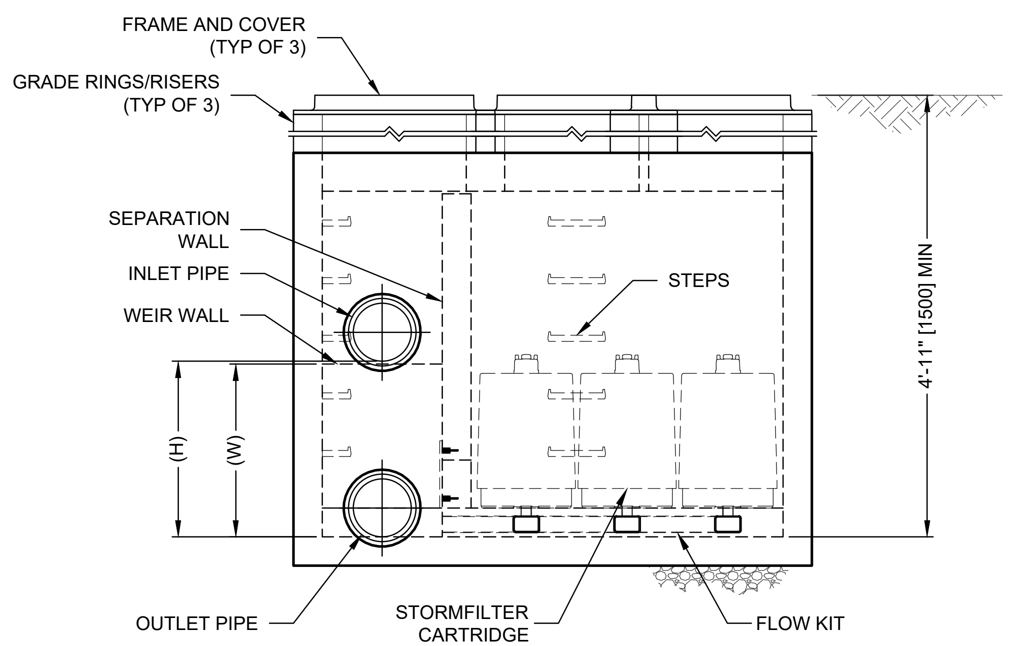
Element ID	Peak Flow (cfs)	Time of Peak Flow Occurrence (days hh:mm)	Design Flow Capacity (cfs)	Peak Flow/ Design Flow Ratio	Peak Flow Velocity (ft/sec)	Travel Time (min)	Peak Flow Depth (ft)	Peak Flow Depth/ Total Depth Ratio	Total Time Surcharged (min)
{9977-00 Proposed Storm Drain}.Prop-Pipe-1	0.92	0 12:10	7.43	0.12	2.88	0.44	0.36	0.24	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-10	0.19	0 12:15	7.42	0.03	1.76	0.27	0.17	0.11	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-11	0.34	0 12:10	7.43	0.05	2.19	0.30	0.22	0.15	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-12	0.95	0 12:10	7.42	0.13	2.89	0.13	0.36	0.24	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-13	2.51	0 12:10	7.43	0.34	3.80	0.20	0.60	0.40	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-2	0.04	0 12:10	43.31	0.00	3.90	0.07	0.03	0.02	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-3	1.07	0 12:10	7.42	0.14	2.99	0.27	0.38	0.26	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-4	1.43	0 12:11	7.42	0.19	3.25	0.29	0.45	0.30	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-5	1.78	0 12:11	7.42	0.24	3.45	0.10	0.50	0.33	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-6	0.12	0 12:10	7.43	0.02	1.64	0.40	0.13	0.09	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-7	0.60	0 12:10	7.42	0.08	2.54	0.25	0.29	0.19	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-8	0.00	0 00:00	50.06	0.00	0.00		0.00	0.00	0.00
{9977-00 Proposed Storm Drain}.Prop-Pipe-9	0.60	0 12:10	7.43	0.08	2.54	0.29	0.29	0.19	0.00

APPENDIX C

CONTECH PROPRIETARY BMP DETAILS



PLAN



ELEVATION

The Stormwater Management
StormFilter®

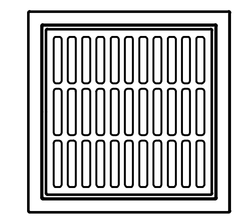
THIS PRODUCT MAY BE PROTECTED BY ONE OR MORE OF THE FOLLOWING U.S. PATENTS: 5,322,629; 5,524,576; 5,707,527; 5,985,157; 6,027,639; 6,649,048; RELATED FOREIGN PATENTS, OR OTHER PATENTS PENDING.

STORMFILTER DESIGN NOTES

- STORMFILTER TREATMENT CAPACITY VARIES BY CARTRIDGE COUNT AND LOCALLY APPROVED SURFACE AREA SPECIFIC FLOW RATE. PEAK CONVEYANCE CAPACITY TO BE DETERMINED BY ENGINEER OF RECORD
- A 6' x 8' [1829 x 2438] PEAK DIVERSION STYLE STORMFILTER IS SHOWN WITH THE MAXIMUM NUMBER OF CARTRIDGES (8) AND IS AVAILABLE IN A LEFT INLET (AS SHOWN) OR A RIGHT INLET CONFIGURATION
- ALL PARTS AND INTERNAL ASSEMBLY PROVIDED BY CONTECH UNLESS NOTED OTHERWISE

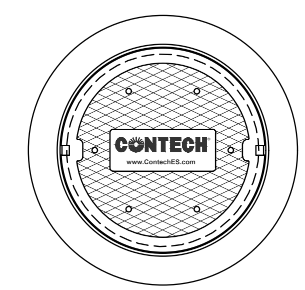
CARTRIDGE SIZE (in. [mm])	27 [686]			18 [457]			LOW DROP		
RECOMMENDED HYDRAULIC DROP (H) (ft. [mm])	3.05 [930]			2.3 [701]			1.8 [549]		
HEIGHT OF WEIR (W) (ft. [mm])	3.00 [914]			2.25 [686]			1.75 [533]		
SPECIFIC FLOW RATE (gpm/sf [L/s/m^2])	2 [1.36]	1.67* [1.13]*	1 [0.68]	2 [1.36]	1.67* [1.13]*	1 [0.68]	2 [1.36]	1.67* [1.13]*	1 [0.68]
CARTRIDGE FLOW RATE (gpm [L/s])	22.5 [1.42]	18.79 [1.19]	11.25 [0.71]	15 [0.95]	12.53 [0.79]	7.5 [0.47]	10 [0.63]	8.35 [0.53]	5 [0.32]

* 1.67 gpm/sf [1.13 L/s/m^2] SPECIFIC FLOW RATE IS APPROVED WITH PHOSPHOSORB® (PSORB) MEDIA ONLY



FRAME AND GRATE

(24" SQUARE)
(NOT TO SCALE)



FRAME AND COVER

(30" ROUND)
(NOT TO SCALE)

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID	
WATER QUALITY FLOW RATE (cfs [L/s])	
PEAK FLOW RATE (cfs [L/s])	
RETURN PERIOD OF PEAK FLOW (yrs)	
CARTRIDGE FLOW RATE	
CARTRIDGE SIZE (27, 18, LOW DROP (LD))	
MEDIA TYPE (PERLITE, ZPG, PSORB)	
NUMBER OF CARTRIDGES REQUIRED	
INLET BAY RIM ELEVATION	
FILTER BAY RIM ELEVATION	

PIPE DATA:	INVERT	MATERIAL	DIAMETER
INLET PIPE 1			
INLET PIPE 2			
OUTLET PIPE			

NOTES/SPECIAL REQUIREMENTS:

PERFORMANCE SPECIFICATION

FILTER CARTRIDGES SHALL BE MEDIA-FILLED, PASSIVE, SIPHON ACTUATED, RADIAL FLOW, AND SELF CLEANING. **RADIAL MEDIA DEPTH SHALL BE 7" [178].** FILTER MEDIA CONTACT TIME SHALL BE AT LEAST **37 SECONDS**. SPECIFIC FLOW RATE SHALL BE **2 GPM/SF [1.36 L/s/m^2] (MAXIMUM)**. SPECIFIC FLOW RATE IS THE MEASURE OF THE FLOW (GPM) DIVIDED BY THE MEDIA SURFACE CONTACT AREA (SF). MEDIA VOLUMETRIC FLOW RATE SHALL BE **6 GPM/CF [13.39 L/s/m^3] OF MEDIA (MAXIMUM).**

GENERAL NOTES

1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. ALTERNATE DIMENSIONS ARE IN MILLIMETERS [mm] UNLESS NOTED OTHERWISE.
4. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH REPRESENTATIVE. www.ContechES.com
5. STORMFILTER WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING. CONTRACTOR TO CONFIRM STRUCTURE MEETS REQUIREMENTS OF PROJECT.
6. STRUCTURE SHALL MEET AASHTO HS20 LOAD RATING, ASSUMING EARTH COVER OF 0' - 10' [3048] AND GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION. CASTINGS SHALL MEET AASHTO M306 AND BE CAST WITH THE CONTECH LOGO.

INSTALLATION NOTES

A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE STORMFILTER STRUCTURE.
C. CONTRACTOR TO INSTALL JOINT SEALANT BETWEEN ALL SECTIONS AND ASSEMBLE STRUCTURE.
D. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH OUTLET PIPE INVERT WITH OUTLET BAY FLOOR.
E. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO PROTECT CARTRIDGES FROM CONSTRUCTION-RELATED EROSION RUNOFF.
F. CONTRACTOR TO REMOVE THE TRANSFER OPENING COVER WHEN THE SYSTEM IS BROUGHT ONLINE.

CONTECH®
ENGINEERED SOLUTIONS LLC
www.ContechES.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-338-1122 513-645-7000 513-645-7993 FAX

SFPD0608 (6' x 8')
PEAK DIVERSION STORMFILTER
STANDARD DETAIL

I:\COMMON\CAD\TREATMENT\10 STORMFILTER\40 STANDARD DRAWINGS\SFPD\STANDARD\IN PROCESS\DWG\SFPD0608-DTL.DWG 10/20/2020 3:06 PM

APPENDIX D

STORMWATER MANAGEMENT STORMFILTER NJCAT VERIFICATION

NJCAT TECHNOLOGY VERIFICATION

Stormwater Management StormFilter®
(StormFilter) With Perlite Media

Contech Engineered Solutions LLC

November, 2016

TABLE OF CONTENTS

List of Figures

List of Tables

1. Description of Technology

The Stormwater Management StormFilter® (StormFilter) is a manufactured treatment device that is provided by Contech Engineered Solutions LLC (Contech). The StormFilter improves the quality of stormwater runoff before it enters receiving waterways through the use of its customizable filter media, which removes non-point source pollutants. As illustrated in **Figure 1**, the StormFilter is typically comprised of a vault or manhole structure that houses rechargeable, media-filled filter cartridges. Stormwater entering the system percolates through these media-filled cartridges, which trap particulates and remove pollutants. Once filtered through the media, the treated stormwater is discharged through an outlet pipe to a storm sewer system or receiving water.

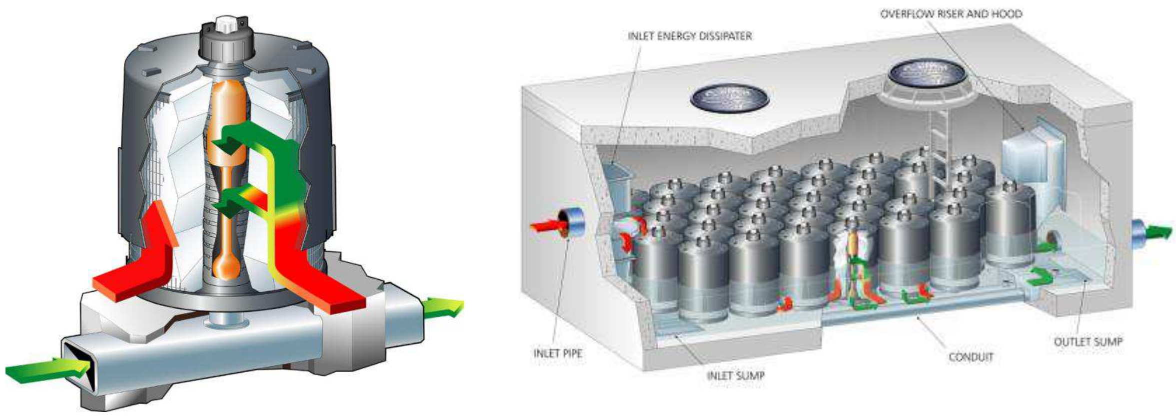


Figure 1 Individual StormFilter Cartridge (Left) and Typical Vault StormFilter Installation (Right)

Depending on the treatment requirements and expected pollutant characteristics at an individual site, the per cartridge filtration flow rate and driving head can be adjusted. The flow rate is individually controlled for each cartridge by a restrictor disc located at the connection point between the cartridge and the underdrain manifold. Driving head is managed by positioning of the inlet, outlet, and overflow elevations. The StormFilter is typically designed so that the restrictor disc passes the design treatment rate once the water surface reaches the shoulder of the cartridge which is equivalent to the cartridge height. Since the StormFilter uses a restrictor disc to restrict treatment flows below the hydraulic capacity of the media the system typically operates under consistent driving head for the useful life of the media. Site specific head constraints are also addressed by three different cartridge heights (low drop (effective height of 12 inches), 18, and 27 inches) which operate on the same principal and surface area specific loading rates. The StormFilter requires a minimum of 1.8 ft, 2.3 ft and 3.05 ft of drop between inlet invert and outlet invert to accommodate the low drop, 18 and 27 inch cartridges, respectively, without backing up flow into the upstream piping during operation. When site conditions limit the amount of drop available across the StormFilter then flow is typically backed up into the upstream piping during operation to ensure sufficient driving head is provided. If desirable the StormFilter can be designed to operate under additional driving head.

The StormFilter is offered in multiple configurations including plastic, steel, and concrete catch basins; and precast concrete manholes, and vaults. Other configurations include panel vaults, CON/SPAN®, box culverts, and curb inlets. The filter cartridges operate consistently and act independently regardless of housing which enables linear scaling.

The StormFilter cartridge can house different types of media including perlite, zeolite, granular activated carbon (GAC), CSF® leaf media, MetalRx™, PhosphoSorb® or various media blends such as ZPG™ (perlite, zeolite and GAC). All of the media use processes associated with depth filtration to remove solids. Some media configurations also provide additional treatment mechanisms such as cation exchange, and/or adsorption, chelation, and precipitation. This verification is specific to perlite media.

2. Laboratory Testing

The test program was conducted at Contech's Portland, Oregon laboratory under the direct supervision of Scott A. Wells, Ph.D. and Associates. Scott A. Wells and Associates provide environmental consulting services focusing on water quality and hydrodynamic models of hydraulic structures, rivers, reservoirs, and estuary systems. All particle size distribution (PSD) analysis and all water quality samples collected during this testing process were analyzed by Apex Labs, 12232 S.W. Garden Place, Tigard, OR 97223, an independent analytical testing facility.

Laboratory testing was done in accordance with the New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device (January, 2013) (NJDEP Filtration Protocol). Prior to starting the performance testing program, a quality assurance project plan (QAPP) was submitted to and approved by the New Jersey Corporation for Advanced Technology (NJCAT).

2.1 Test Setup

The laboratory test used a full-scale, 18-inch StormFilter cartridge filled with perlite media that was installed in a test tank in a manner consistent with commercial installations and meeting the criteria established in the NJDEP Filtration Protocol. An illustration of the test apparatus is shown in **Figure 2**. The test tank floor dimension is 3 ft^2, which is equivalent to the least amount of floor surface area per cartridge in a typical commercial installation.

A Zoeller M76 submersible pump delivered water from a source water storage tank to the test unit through PVC piping that included energy dissipation at the points of discharge to deliver water to the test tank in a manner consistent with commercial installations. The flow rate was controlled with a globe valve and monitored with a Seametrics EX810P flow meter and a Seametrics FT420 flow computer, and FlowInspector software. Sediment was dry-fed from a hopper and auger assembly (Acrison 170-M15) through a 2-inch diameter port located upstream of the test unit.

Effluent from the StormFilter was directed into an effluent water tank equipped with a submersible pump. The effluent passed through a particulate filter before being recycled back to the source water tank (see **Figure 3**). As needed, potable water was brought into the source water tank to supply make-up water.

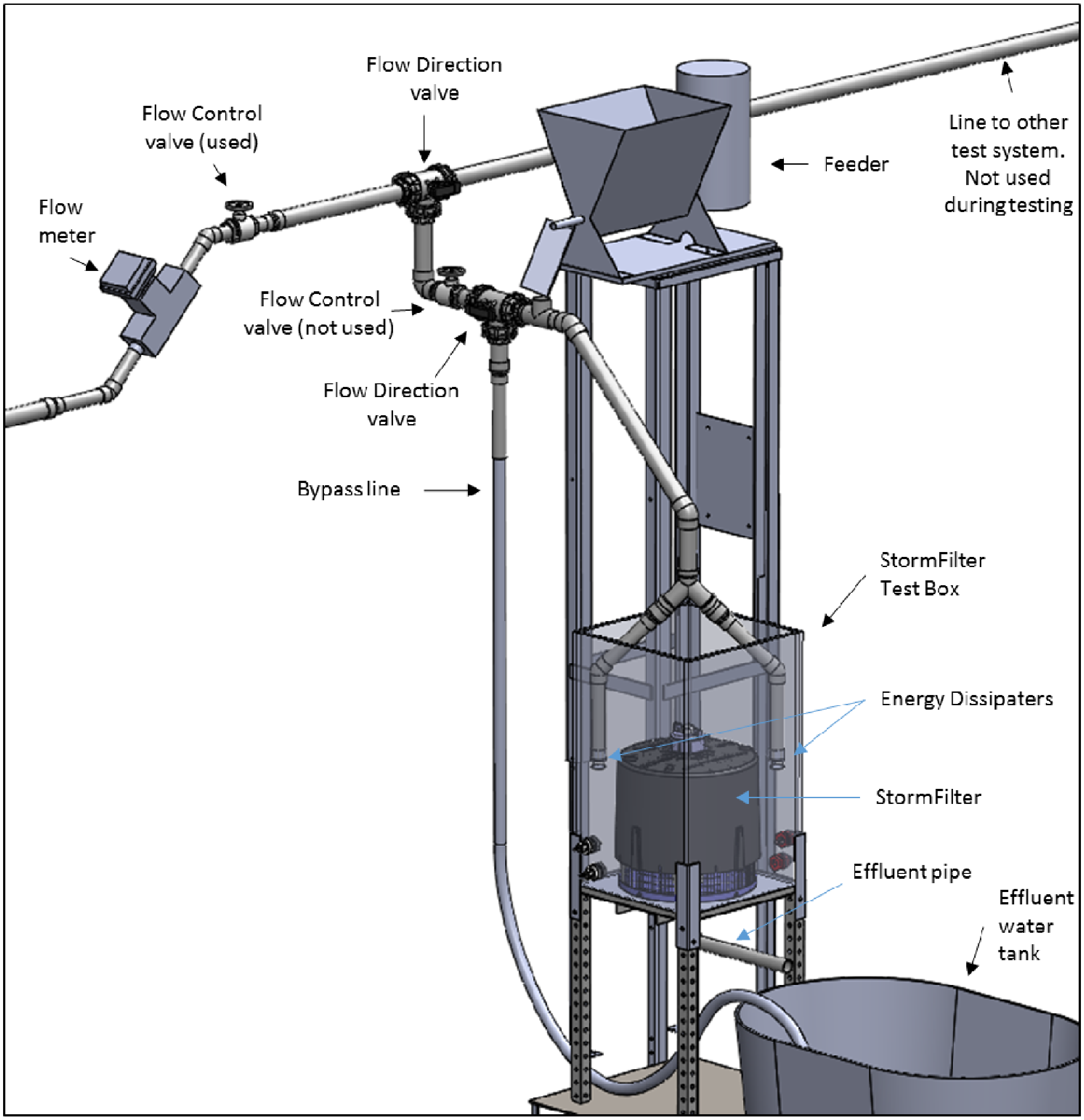


Figure 2 Graphic of StormFilter Test Apparatus

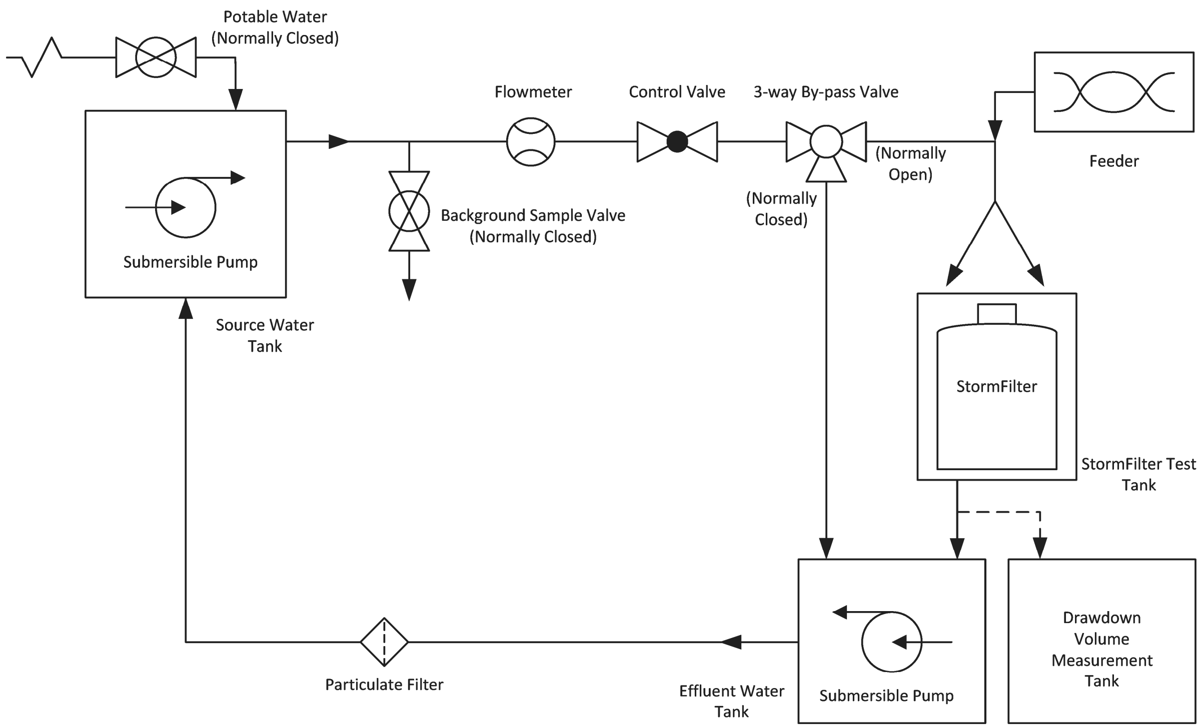


Figure 3 Schematic of StormFilter Laboratory Test Setup

2.2 Test Sediment

Sediment used for solids removal efficiency testing was high-purity silica (SiO_2 99.8%) material with a PSD consisting of approximately 55% sand, 40% silt, and 5% clay. A large batch of sediment meeting the NJDEP Filtration Protocol PSD criteria was purchased and stored in 50 lb. bags. Three of the 50 lb. bags were set aside and utilized for this testing. The sediment PSD in the three bags was verified by a randomized sample collection routine. First, the bags of sediment were mixed by rolling the bags several times both end over end in both directions on the laboratory floor. Each bag had a numbered six-section grid overlaid on it. The Microsoft Excel randomizer function was used to select one grid section from each bag. A subsample (three level tablespoons) was selected from the appropriate section of each bag. The subsamples were mixed together to create one sample. The grid section selection and subsample collection was repeated two more times for a total of three composite samples which were submitted for PSD analyses. Finally, after completion of the PSD sampling process the bags were then mixed into a single container and set aside for the verification testing.

The three composite PSD samples were sent to Apex Labs for PSD analysis in accordance with ASTM D422-63 (reapproved 2007). The mean of the three PSD samples was calculated and plotted as a single representative PSD curve. This representative curve is plotted alongside the "Test Sediment PSD" curve specified in section 5, subsection B of the NJDEP Filtration Protocol in Section 4.1. Sediment sampling for PSD analysis was conducted in-house with oversight from Scott Wells, Ph.D. and Associates.

2.3 Removal Efficiency Testing Procedure

Removal efficiency (RE) testing was performed at a target influent sediment concentration of 200 mg/L (±10%). The StormFilter was tested at a maximum treatment flow rate (MTFR) of 15 gallons per minute (gpm) which for the 18” cartridge is equivalent to a surface area specific loading rate of 2.12 gpm/ft^2 of filter media surface area. Three water temperature readings were taken per trial to verify the water did not exceed 80 degrees Fahrenheit.

Removal efficiency testing was carried out according to the “Effluent Grab Sampling Method,” as described in section 5G of the NJDEP Filtration Protocol. Prior to each test, the flow rate was stabilized while being routed through a bypass line. Once the flow rate was stabilized, the bypass valve was turned to direct flow to the test tank, and feeding of the dry sediment commenced, initiating the testing procedure. The feeder delivered sediment into the flow stream at a rate calculated to yield a target concentration of 200 mg/L (±10%).

Sediment feed rate, background, effluent, and drawdown samples were collected via grab sampling, see **Table 1**. Three sediment feed samples were collected per trial including one sample at the start of dosing, one in the middle of the trial and one toward the end of dosing to allow for 3 residence times to pass before drawdown began. Sediment feed rate samples were collected from the injection point using a clean container and collected for one minute.

Background water quality samples were collected from a 1/4 inch valved sample port (**Figure 3**) in the water supply line located upstream of the test sediment injection point. Background samples were taken in correspondence with the odd-numbered effluent samples (first, third, and fifth).

Five effluent water quality samples were collected during each test run by sampling the free outflow from the discharge pipe. The first effluent sample collection time was scheduled at 7 minutes and the four subsequent effluent samples were scheduled at 6 to 7 minute intervals thereafter. Once the test sediment feed was diverted for measurement, the next effluent sample was collected after a minimum of three detention times had passed. During the first removal efficiency test run (test 1), 7 drawdown samples were collected spanning the entire drawdown time. The two samples collected nearest the correct evenly-spaced drawdown times were sent to Apex lab for TSS analysis and the remaining 5 samples were discarded. Once the appropriate drawdown sample times had been established using the total drawdown time from the first test those same sample times were applied to subsequent test runs. To address changing drawdown times as sediment accumulated in the test box, actual drawdown time data collected from each test was used to predict the drawdown sampling times for the following test. Tests and drawdown were considered complete when the effluent flow slowed to a drip, allowing the next test to begin. Although not included in the total drawdown volume, it is estimated that less than 1 liter of water remains in the test tank after test completion.

The drawdown volume was determined by diverting the effluent to a calibrated drawdown capture tank at the same time the influent was shut off. As the influent flow was shut off, a 4-inch PVC open pipe channel was placed under the effluent pipe to direct the discharge to the drawdown capture tank. Drawdown samples were collected by moving the diversion pipe aside and capturing the effluent directly in the sample container. After the test was completed, the volume drained from the system was measured and used in the removal efficiency calculation.

Table 1 Test Run Sampling Plan

Scheduled Time (min:sec)	Sample or Reading				
	Sediment Feed Rate	Effluent TSS	Background TSS	Drawdown TSS	Additional Actions
0:00					Start sediment feed and introduce influent flow to test tank
1:00	X				
7:00		X	X		
13:00		X			
14:00	X				
20:00		X	X		
26:00		X			
27:00	X				
33:00		X	X		
34:00					Stop sediment feed and divert influent flow from test tank. Divert drawdown flow to drawdown capture tank
TBD*				X	
TBD*				X	
TBD**					End of test run

** Times for drawdown TSS samples were determined before each trial, using the previous trial's drawdown duration to determine appropriate spacing*

*** The end of a test run is the time at which the drawdown effluent stream transitions to a drip. The end time varied from trial to trial.*

Flow rate readings were logged every 15 seconds using a Seametrics DL76 data logger and accessed using Seametrics FlowInspector software. The flow meter was calibrated in accordance with the manufacturer's instructions before testing began and the calibration was verified with manual flow measurements (timed bucket method). The entire calibration process was completed in the presence of the third-party observer. A sight tube manometer connected to the test tank was used to take head measurements. Head readings were taken at the beginning and end of each test run, during sample collection, when water temperature was taken and at three minute intervals between sampling (**Table 2**). The driving head readings had an accuracy of ±0.0625 inches.

Table 2 Water Surface Elevation and Temperature Sampling Times

Time (min:sec)	Measurement
0:00	WSE
1:00	WSE
4:00	WSE
7:00	WSE
9:00	Temperature
10:00	WSE
13:00	WSE
14:00	WSE
17:00	WSE
18:00	Temperature
20:00	WSE
23:00	WSE
26:00	WSE
27:00	WSE
28:00	Temperature
30:00	WSE
33:00	WSE
34:00	WSE
37:00	WSE
40:00	WSE
43:00	WSE
46:00	WSE
49:00	WSE
52:00	WSE
55:00 ***	WSE
58:00 ***	WSE
61:00 ***	WSE
64:00 ***	WSE
67:00 ***	WSE
70:00 ***	WSE
73:00 ***	WSE
76:00 ***	WSE
79:00 ***	WSE
TBD *	WSE with drawdown sample
TBD *	WSE with drawdown sample
TBD **	WSE at end of trial
TBD **	Drawdown volume at end of trial

Time (min:sec)	Measurement

**** These measurements may be unnecessary if the drawdown flow has already slowed to a drip and the trial is over*

Following each test, all sediment feed rate samples were weighed in-house on a calibrated balance. The resultant mass of each sample was divided by the duration required to obtain the sample in order to establish the sediment feed rate and ultimately determine the influent concentration. Scott Wells, Ph.D. and Associates oversaw all in-house measurements and calculations. Effluent, background and drawdown samples were sent to Apex labs for TSS analysis in accordance with ASTM D3977-97 (re-approved 2007). The procedure was repeated for 10 test runs and each test had a sediment feed time of 34 minutes, with three 1-minute sample collections, for a total of 31 minutes of sediment injection.

2.4 Sediment Mass Loading Capacity Testing Procedure

Sediment mass load capacity testing of the StormFilter was conducted in accordance with the NJDEP Filtration Protocol. After performing the removal efficiency evaluation, additional tests were conducted using a target influent TSS concentration of 200 mg/L until trial 46 at which time the loading concentration was increased to 400 mg/L (±10%). Samples were collected in the same manner as the TSS removal efficiency testing.

Background, effluent and drawdown samples from the sediment mass load trials were transported to the third party analytical laboratory (Apex Labs) for TSS analysis in accordance with ASTM D3977-97 (re-approved 2007).

2.5 Scour Testing

No scour testing was conducted, since the StormFilter is only offered for off-line installation at this time.

3. Performance Claims

Per the NJDEP verification procedure, the following are the performance claims for the StormFilter based on the results of the laboratory testing conducted.

Total Suspended Solids (TSS) Removal Efficiency

Based on the laboratory testing conducted in accordance with the NJDEP Filter Protocol, the Stormwater Management StormFilter® (StormFilter) achieved greater than 80% removal efficiency of suspended solids. In accordance with the NJDEP Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from NJCAT (January, 2013) (NJDEP Verification Procedure) the TSS removal efficiency is rounded down to 80%.

Maximum Treatment Flow Rate (MTFR)

For all the commercially available model sizes, the hydraulic loading rate used to calculate the MTFR is 2.12 gpm/ft^2 of filter media surface area. This results in an MTFR of 10, 15 and 22.5 gpm for each low drop (effective height is 12 inches), 18 and 27-inch tall filter cartridge respectively.

Effective treatment/Sedimentation Area

The single 18-inch cartridge StormFilter test unit had an effective sedimentation area (horizontal footprint) of 3 ft^2. All commercially available StormFilter models have a minimum of 3 ft^2 of effective (horizontal) sedimentation area per 18" filter cartridge. This is equivalent to 0.42 ft^2 of sedimentation area per square foot of filtration surface area.

Detention Time and Wet Volume

Detention time of the StormFilter will vary with model size and configuration. The detention time of the 18-inch single cartridge test unit was 1 minute and 20 seconds. Since the test unit represents the smallest allowable ratio of effective sedimentation area per filter cartridge and the surface area specific hydraulic loading rate of all cartridges remains constant at 2.12 gpm/ft^2 of media surface area the detention time for commercially available units will be the same or longer than the detention time of the tested unit.

The StormFilter does not maintain a permanent wet volume. The operational wet volume for the test unit was approximately 20 gallons. The system drains down between each storm event.

Effective Filtration Treatment Area

The effective filtration treatment area of the 18" StormFilter cartridge used during the testing is 7.07 ft^2.

Sediment Mass Load Capacity

The sediment mass loading capacity varies with the StormFilter model size, the number of cartridges and the size of cartridges installed. Based on the laboratory testing results, the 18 inch StormFilter cartridge has a mass loading capacity of 54.5 lbs. This is equivalent to a sediment mass loading capacity of 7.71 lbs/ft^2 of filter surface area.

Maximum Allowable Inflow Drainage Area

Based on the NJDEP requirement to determine maximum allowable inflow area using 600 lbs of sediment per acre annually and the tested sediment mass loading capacity for the StormFilter of 54.5 lbs per 18-inch cartridge (7.71 lbs/ft^2 of filter surface area), the StormFilter has a maximum allowable inflow drainage area of 0.09 acres per 18-inch cartridge. This is equivalent to a maximum allowable inflow drainage area of 0.061 acres for each low drop (12 inch) cartridge and 0.136 acres for each 27-inch cartridge.

4. Supporting Documentation

The NJDEP Procedure (NJDEP, 2013a) for obtaining verification of a stormwater manufactured treatment device (MTD) from the New Jersey Corporation for Advanced Technology (NJCAT) requires that "copies of the laboratory test reports, including all collected and measured data; all data from performance evaluation test runs; spreadsheets containing original data from all performance test runs; all pertinent calculations; etc." be included in this section. This was discussed with NJDEP and it was agreed that as long as such documentation could be made available by NJCAT upon request that it would not be prudent or necessary to include all this information in this verification report. This information was provided to NJCAT and is available upon request.

4.1 Test Sediment PSD Analysis

The PSD's of the three randomly collected sediment samples are shown in **Table 3** and plotted in **Figure 4**. The test sediment met or exceeded the NJDEP PSD sediment specifications across the entire distribution. The average median particle size (d_{50}) of the three samples is ~70 microns.

Table 3 Sediment Particle Size Distribution Analysis on Contech Test Sediment

NJDEP Sediment Specifications			Contech Test Sediment						
			Sample 1		Sample 2		Sample 3		
Particle size (um)	Percent Finer	Allowable error Percent Finer	Particle size (um)	Percent Finer	Particle size (um)	Percent Finer	Particle size (um)	Percent Finer	Percent Finer Mean
1000	100	98	1000.0	98.2	1000	98.16	1000	98.3	98.2
500	95	93	500.0	96.0	500	95.78	500	95.8	95.9
250	90	88	250.0	90.8	250	90.59	250	90.8	90.7
150	75	73	150.0	76.3	150	76.11	150	76.4	76.3
100	60	58	106.0	65.1	106	65.15	106	65.1	65.1
75	50	48	75.0	51.6	75	51.34	75	51.2	51.4
50	45	43	63.0	48.5	63	48.2	63	48.3	48.3
20	35	33	53.0	46.3	53	45.87	53	46.0	46.0
8	20	18	44.7	42.9	45	41.5	45	41.0	41.8
5	10	8	31.9	40.1	33	38.59	32	39.1	39.1
2	5	3	22.8	36.3	23	34.7	23	37.2	36.1
			16.4	33.4	17	30.82	16	32.5	32.0
			12.2	27.7	12	26.93	12	27.7	27.5
			8.7	24.0	9	21.16	9	22.2	22.4
			6.3	17.4	6	17.37	6	16.6	17.1
			5.2	14.6	5	14.6	5	14.8	14.7
			4.5	13.0	5	12.71	5	13.1	12.9
			3.2	10.7	3	11.21	3	10.9	10.9

2.6	8.5	3	8.83	3	8.6	8.7
1.3	5.1	1	4.69	1	5.2	5.0

*Linear interpolation was used to determine percent finer results when particle sizes differed from sample to sample.

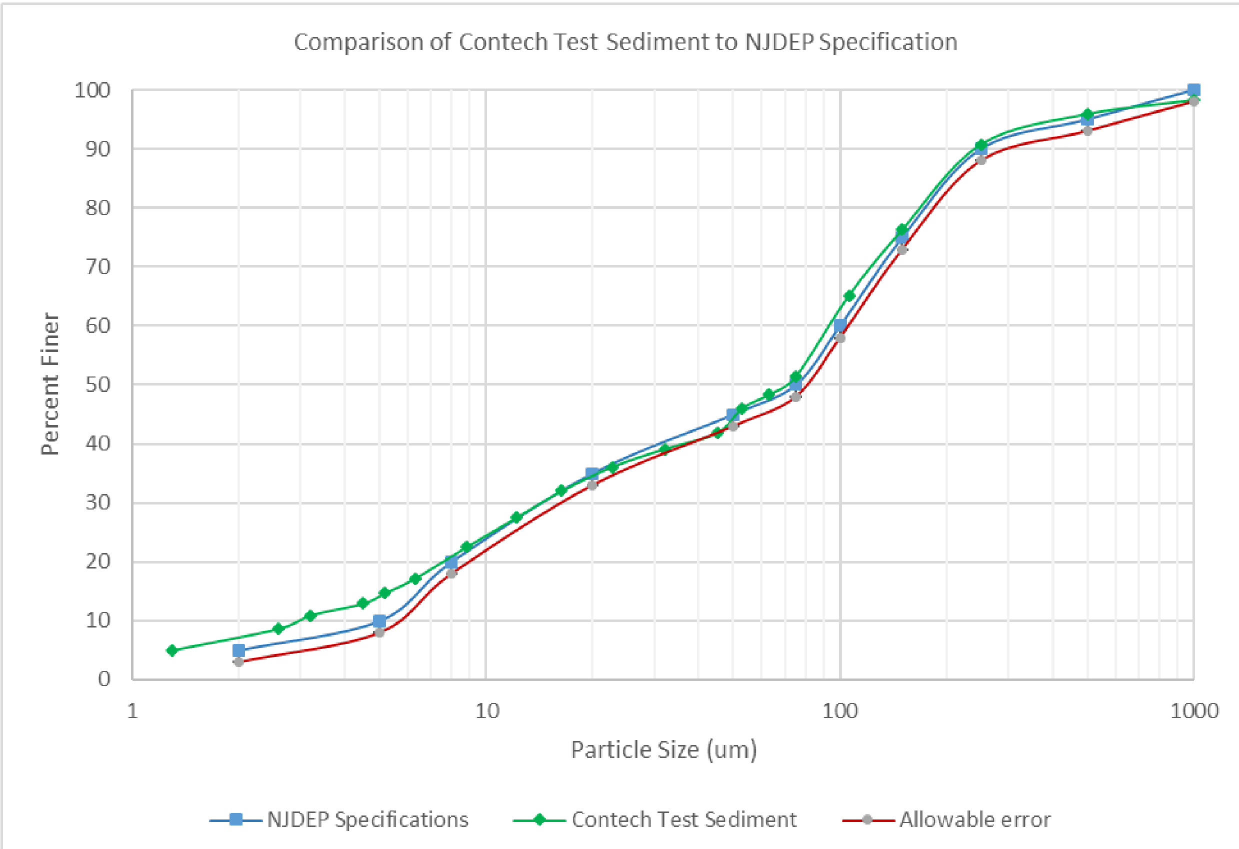


Figure 4 Comparison of Contech Test Sediment to NJDEP PSD Specification

4.2 Removal Efficiency (RE) Testing

Ten (10) test runs were completed as part of the removal efficiency testing following the procedures detailed in Section 2.0 of this report. The results from all 10 runs were used to calculate the average removal efficiency of the 18-inch StormFilter test system. Average removal efficiency and RE for each trial is listed in **Table 8** and shown in **Figure 5**.

Test Water Flow Rate, Temperature and Driving Head

The target flow rate for each test run was 15.0 gpm. The average flow rate during each test run was within ±10% of the target, with a maximum coefficient of variation (COV) of 0.01. The highest test water temperature measured during any test run was 74.6 °F, which is below the maximum allowed 80°F. Reported driving head measurements represent the distance from the crown of the effluent pipe to the water surface elevation. The system did not exceed the maximum available driving head for the test unit of 27.6 inches during any of the test runs. As intended, the system operated at relatively consistent driving head throughout the test process. Summary flow data, water temperature, driving head and QA/QC compliance results are summarized in **Table 4**. Average flow rate and maximum driving head are shown graphically in **Figure 6** and **Figure 7**.

Table 4 Removal Efficiency Water Flow Rate, Temperature and Driving Head

Test Run	Average Flow Rate (gpm)	Flow Rate COV	Maximum Water Temperature (°F)	Maximum Driving Head (in)	QA/QC Compliant (YES/NO)	
-	**Target: 15.0 gpm**	-	**≤ 80 °F**	-	-	***Target or QA/QC Requirement***
1	14.9	0.01	73.7	23.7	YES	
2	15.0	0.01	73.5	23.8	YES	
3	14.9	0.01	73.9	23.7	YES	
4	14.9	0.01	74.2	23.6	YES	
5	14.9	0.01	74.1	23.8	YES	
6	15.0	0.01	74.6	24.0	YES	
7	15.0	0.01	74.5	23.7	YES	
8	14.9	0.01	74.2	23.5	YES	
9	14.9	0.01	74.2	23.4	YES	
10	15.0	0.01	74.2	23.9	YES	

Sediment Feed Rate and Influent Concentration

Sediment was fed into the test water stream at a rate calculated to yield a target influent concentration of 200 mg/L. Three feed rate samples were collected per trial to verify the sediment delivery rate and resulting influent concentration. All sediment feed rate samples were collected in clean sampling containers over an interval of 1 minute. Average influent TSS was calculated using **Equation 1** and **Equation 2**. During all test runs, influent TSS was maintained within ±10% of target, with a maximum COV of 0.03. The total sediment injection time during each run was 31 minutes, exceeding the minimum test length requirement of 30 minutes. Sediment feed rates, resulting influent TSS and QA/QC compliance results are summarized in **Table 5**.

Equation 1: Average Feed Rate

Average Feed Rate (g/min) = Sediment Moisture Correction Factor x Average Measured Feed Rate (g/min)

Equation 2: Average Influent TSS

$$Average\ Influent\ TSS\ \left(\frac{mg}{L}\right) = \frac{Average\ Feed\ Rate\ \left(\frac{g}{min}\right) \times \frac{1000\ mg}{g}}{Average\ Water\ Flow\ Rate\ \left(\frac{gal}{min}\right) \times \frac{3.785\ L}{gal}}$$

Table 5 Removal Efficiency Sediment Feed Rate and Influent Concentration

Test Run	Sediment Injection Time (min)	Average Feed Rate (g/min)	Feed Rate COV	Feed Rate Sampling Duration (min)	Average Influent TSS (mg/L)	Minimum Influent TSS (mg/L)	Maximum Influent TSS (mg/L)	QA/QC Compliant (YES/NO)	
-	≥ 30 min	Target: 11.4 g/min	≤ 0.1	≤ 1 min	Target: 200 mg/L	≥ -10% of Target: 180 mg/L	≤ +10% of Target: 220 mg/L	-	*Target or QA/QC Requirement*
1	31.0	11.5	0.02	1.0	203	198	205	YES	
2	31.0	11.9	0.02	1.0	210	206	213	YES	
3	31.0	11.7	0.01	1.0	207	204	210	YES	
4	31.0	12.0	0.02	1.0	213	209	216	YES	
5	31.0	12.0	0.01	1.0	212	210	216	YES	
6	31.0	11.8	0.03	1.0	208	203	213	YES	
7	31.0	12.0	0.02	1.0	212	208	215	YES	
8	31.0	11.5	0.01	1.0	203	202	205	YES	
9	31.0	11.7	0.01	1.0	206	203	208	YES	
10	31.0	11.8	0.03	1.0	207	202	213	YES	

Drawdown Sampling and Duration

Drawdown TSS sampling and drawdown volume quantification were performed to determine the amount of influent mass that exited the system during the drawdown period. Drawdown TSS sampling times were determined using the drawdown duration from the previous trial. Sampling times and drawdown durations are presented in **Table 6**.

Table 6 Removal Efficiency Testing Drawdown Duration and Drawdown Sampling Times

Test Run	Drawdown Duration (min from pump shutoff)	Drawdown TSS Sample 1 Time (min from pump shutoff)	Drawdown TSS Sample 2 Time (min from pump shutoff)
1	38	12	21
2	34	13	25
3	30	11	23
4	27	10	20
5	26	10	20
6	26	9	17
7	26	9	18
8	26	9	17
9	26	9	17
10	26	9	17

Background, Effluent and Drawdown TSS

Background, effluent and drawdown TSS samples were collected in clean 1-liter bottles, with each sample exceeding the minimum required 500 mL sample volume. With the exception of test run 10, effluent and drawdown TSS samples were collected no less than three residence times, or 4 total minutes after the sediment injection stream was interrupted for feed rate sampling. During test run 10, an effluent sample was collected 5 seconds early; as this was such a small error in timing, no data from this test run was excluded from calculations. Background TSS samples were taken with odd numbered effluent TSS samples as required by the NJDEP Filtration Protocol. The highest measured background TSS was 4 mg/L, which is below the maximum allowed concentration of 20 mg/L. Average effluent TSS and average drawdown TSS values were adjusted for background levels using **Equation 3** and **Equation 4,** respectively. Background TSS, effluent TSS, drawdown TSS and QA/QC compliance results are presented in **Table 7**.

Equation 3: Average Adjusted Effluent TSS

$$Average\ Adjusted\ Effluent\ TSS\left(\frac{mg}{L}\right) = Average\ Effluent\ TSS\ \left(\frac{mg}{L}\right) - Average\ Background\ TSS\ \left(\frac{mg}{L}\right)$$

Equation 4: Average Adjusted Drawdown TSS

$$Average\ Adjusted\ Drawdown\ TSS\ \left(\frac{mg}{L}\right) = Average\ Drawdown\ TSS\ \left(\frac{mg}{L}\right) - Average\ Background\ TSS\ \left(\frac{mg}{L}\right)$$

Table 7 Removal Efficiency Background, Effluent and Drawdown TSS

Test Run	Average Background TSS (mg/L)	Maximum Background TSS (mg/L)	Minimum Background Sample Volume (mL)	Average Adjusted Effluent TSS (mg/L)	Minimum Effluent Sample Volume (mL)	Average Adjusted Drawdown TSS (mg/L)	Minimum Drawdown Sample Volume (mL)	QA/QC Compliant (YES/NO)	
-	-	≤ 20 mg/L	≥ 500 mL	-	≥ 500 mL	-	≥ 500 mL	-	*Target or QA/QC Requirement*
1	2	3	740	38	930	20	590	YES	
2	2	2	790	35	820	8	580	YES	
3	3	3	770	41	880	8	580	YES	
4	2	2	730	37	870	8	600	YES	
5	2	2	700	36	910	6	560	YES	
6	2	3	720	38	830	10	540	YES	
7	2	2	720	38	780	11	545	YES	
8	2	3	750	36	850	9	550	YES	
9	3	3	780	35	880	8	580	YES	
10	3	4	740	36	850	9	560	YES	

Removal Efficiency (RE) Results

Average RE at the end of the test run 10 was 83%. **Equation 5** through **Equation 7** were used to calculate RE for each test run. Sediment mass loading per trial and mass captured per trial were calculated using **Equation 8** and **Equation 9**, respectively. Cumulative sediment mass loading and cumulative mass captured by the StormFilter were calculated by summing the mass loading per trial and mass captured per trial values. The total mass loading for the removal efficiency test runs was 8.0 lbs and the mass captured by the system was 6.7 lbs. The summary of RE results is reported in **Table 8**.

Equation 5: Influent Volume

$$Influent\ Volume\ (L) = Sediment\ Injection\ Time\ (min) \times Average\ Flow\ Rate\ \left(\frac{gal}{min}\right) \times \frac{3.785\ L}{gal}$$

Equation 6: Effluent Volume

$$Effluent\ Volume\ (L) = Influent\ Volume\ (L) - Drawdown\ Volume\ (L)$$

Equation 7: Removal Efficiency (RE)

$$\boldsymbol{RE}\ (\%) = (\mathbf{100\%}) \times \frac{\left[\begin{matrix}\boldsymbol{Average\ Influent\ TSS}\ \left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right) \\ \times \boldsymbol{Influent\ Volume}\ (\boldsymbol{L})\end{matrix}\right] - \left[\begin{matrix}\boldsymbol{Average\ Adjusted\ Effluent\ TSS}\ \left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right) \\ \times \boldsymbol{Effluent\ Volume}\ (\boldsymbol{L})\end{matrix}\right] - \left[\begin{matrix}\boldsymbol{Average\ Adjusted\ Drawdown\ TSS}\ \left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right) \\ \times \boldsymbol{Drawdown\ Volume}\ (\boldsymbol{L})\end{matrix}\right]}{\left[\begin{matrix}\boldsymbol{Average\ Influent\ TSS}\ \left(\frac{\boldsymbol{mg}}{\boldsymbol{L}}\right) \\ \times \boldsymbol{Influent\ Volume}\ (\boldsymbol{L})\end{matrix}\right]}$$

Equation 8: Sediment Mass Loading per Trial

$$\mathit{Sediment\ Mass\ Loading\ per\ Trial}\ (lb) = \mathit{Average\ Influent\ TSS}\left(\frac{mg}{L}\right) \times \mathit{Influent\ Volume}\ (L) \times \frac{2.20\text{E-}6\ mg}{lb}$$

Equation 9: Mass Captured per Trial

$$\mathit{Mass\ Captured\ per\ Trial}\ (lb) = \frac{\mathit{Sediment\ Mass\ Loading\ per\ Trial}\ (lb) \times RE\ (\%)}{(100\%)}$$

Table 8 Removal Efficiency Results

Test Run	Average Influent TSS (mg/L)	Average Adjusted Effluent TSS (mg/L)	Average Adjusted Drawdown TSS (mg/L)	Influent Volume (L)	Effluent Volume (L)	Drawdown Volume (L)	Mass Loading (lb)	Mass Captured (lb)	Trial Removal Efficiency (%)	Average Removal Efficiency (%)
1	203	38	20	1751	1673	78	0.8	0.6	82%	82%
2	210	35	8	1758	1677	81	1.6	1.3	84%	83%
3	207	41	8	1745	1666	79	2.4	2.0	81%	82%
4	213	37	8	1753	1674	79	3.2	2.6	83%	83%
5	212	36	6	1754	1679	75	4.0	3.3	84%	83%
6	208	38	10	1757	1678	79	4.8	4.0	82%	83%
7	212	38	11	1758	1679	79	5.6	4.7	82%	83%
8	203	36	9	1753	1674	79	6.4	5.3	83%	83%
9	206	35	8	1754	1675	79	7.2	6.0	84%	83%
10	207	36	9	1766	1686	79	8.0	6.7	83%	83%

4.3 Sediment Mass Loading Capacity

Mass loading capacity testing was conducted as a continuation of removal efficiency (RE) testing. Mass loading test runs were conducted using identical testing procedures and targets as those used in the RE runs, the only change was to increase the target influent concentration to 400 mg/L after test run 45. Testing concluded after 67 test runs, 57 of which were completed during mass loading and 10 during RE testing. The system did not occlude or reach maximum driving head during the test process, but the average removal efficiency (on a mass basis) dropped below 80% so testing was suspended and deemed complete at trial 66 as per the QAPP and protocol. The mass loading test data and QA/QC compliance results are summarized in **Table 9** through **Table 13**.

Test Water Flow Rate, Temperature and Driving Head

The average flow rate during each test run was within ±10% of the target 15 gpm and the maximum observed COV was 0.01 (excluding test run 14, see Section 4.4 for discussion). The test water temperature remained below the maximum allowed 80°F during all runs and the maximum available driving head was not reached or exceed at any time. During test run 15, driving head readings were not taken with drawdown TSS samples. The missing data points do not affect any computations, (including maximum driving head), so all data for test run 15 is included in calculations. Test run 29 did not include a driving head measurement at the scheduled time of 10 minutes, which caused the measurement spacing to exceed the maximum 5-minute interval. The driving head readings prior to and following the missing measurement show the driving head remained consistent and indicate that the system was not operating at or near the maximum design driving head, so all data from test run 29 is included in reported results.

Table 9 includes summary flow data, water temperature and driving head results. Average flow rate and maximum driving head are also shown in **Figure 6** and **Figure 7**.

Table 9 Sediment Mass Loading Trial Flow Rate, Temperature and Driving Head

Test Run	Average Flow Rate (gpm)	Flow Rate COV	Maximum Water Temperature (°F)	Maximum Driving Head (in)	QA/QC Compliant (YES/NO)
-	Target: 15.0 gpm	-	≤ 80 °F	-	-
11	15.0	0.01	71.1	23.8	YES
12	15.0	0.01	70.5	24.2	YES
13	15.0	0.01	71.6	23.9	YES
14	14.9	0.07	70.5	23.7	NO*
15	14.8	0.01	71.4	23.0	NO
16	14.9	0.01	71.1	23.6	YES
17	14.9	0.01	71.1	23.7	YES
18	14.9	0.01	71.2	23.6	YES
19	15.0	0.01	71.3	23.9	YES
20	15.0	0.01	71.6	23.7	YES
21	15.0	0.01	71.4	23.7	YES
22	14.9	0.01	72.1	23.5	YES
23	14.9	0.01	71.2	23.6	YES
24	15.0	0.01	71.4	24.0	YES
25	15.0	0.01	71.8	23.7	YES
26	15.0	0.01	71.0	23.6	YES
27	15.0	0.01	71.4	23.7	YES
28	14.9	0.01	71.4	23.4	YES
29	15.0	0.01	71.9	23.7	NO
30	15.0	0.01	71.8	24.0	YES
31	15.0	0.01	71.0	23.7	YES
32	15.0	0.01	71.4	23.7	YES
33	15.0	0.01	71.1	23.8	YES
34	15.0	0.01	71.3	24.3	YES
35	15.0	0.01	71.0	23.9	YES

Test Run	Average Flow Rate (gpm)	Flow Rate COV	Maximum Water Temperature (°F)	Maximum Driving Head (in)	QA/QC Compliant (YES/NO)
36	15.0	0.01	73.6	23.7	YES
37	15.0	0.01	73.0	24.0	YES
38	15.0	0.01	72.9	23.8	YES
39	15.0	0.01	73.0	23.6	YES
40	14.9	0.01	73.1	23.5	YES
41	15.0	0.01	72.7	23.7	YES
42	15.0	0.01	72.2	23.7	YES
43	15.0	0.01	71.0	23.7	YES
44	15.0	0.01	71.4	23.8	YES
45	15.0	0.01	71.1	24.3	YES
46	14.9	0.01	73.0	23.4	YES
47	14.9	0.01	72.1	23.6	YES
48	15.0	0.01	72.1	23.8	YES
49	14.9	0.01	71.6	23.4	YES
50	15.0	0.01	72.2	23.6	YES
51	14.9	0.01	72.4	23.4	YES
52	14.9	0.01	72.6	23.7	YES
53	15.0	0.01	72.4	23.5	YES
54	15.0	0.01	72.5	23.5	YES
55	14.9	0.01	72.5	23.5	YES
56	15.0	0.01	72.9	23.7	YES
57	15.0	0.01	72.4	23.7	YES
58	15.0	0.01	72.2	23.7	YES
59	15.0	0.01	71.2	23.7	YES
60	15.0	0.01	71.3	23.7	YES
61	15.0	0.01	71.4	23.7	YES
62	15.0	0.01	71.7	23.7	YES
63	15.0	0.01	72.4	23.7	YES
64	15.0	0.01	71.9	23.5	YES
65	15.0	0.01	72.1	23.7	YES
66	15.0	0.01	72.1	23.6	YES
67	15.0	0.01	72.5	23.4	YES

See Section 4.4 for discussion

Sediment Feed Rate and Influent Concentration

During test runs 11 through 45, sediment was introduced at a target feed rate of 11.4 g/min to yield a 200 mg/L influent concentration. All feed rates and resulting influent concentrations during these trials were within ±10% of target, with a maximum COV of 0.05. The target feed rate was increased to 22.7 g/min for test runs 46 through 67 in order to provide a 400 mg/L influent concentration. Feed rates during runs 46 through 67 were also within ±10% of target and the maximum COV was 0.04. The influent TSS data for test run 27 was excluded from calculations (see Section 4.4 for discussion). **Table 10** shows the feed rate data, influent concentration data and QA/QC results for all mass loading test runs.

Table 10 Sediment Mass Loading Sediment Feed Rate and Influent Concentration

Test Run	Sediment Injection Time (min)	Average Feed Rate (g/min)	Feed Rate COV	Maximum Feed Rate Sampling Duration (min)	Average Influent TSS (mg/L)	Minimum Influent TSS (mg/L)	Maximum Influent TSS (mg/L)	QA/QC Compliant (YES/NO)
-	≥ 30 min	Target: 11.4 or 22.7 g/min	≤ 0.1	≤ 1 min	Target: 200 or 400 mg/L	≥ -10% of Target	≤ +10% of Target	-
11	31.0	11.3	0.02	1.0	200	196	205	YES
12	31.0	11.9	0.01	1.0	209	206	212	YES
13	31.0	12.0	0.01	1.0	211	210	213	YES
14	31.0	11.7	0.02	1.0	206	203	212	YES
15	31.0	11.7	0.01	1.0	209	205	210	YES
16	31.0	11.4	0.01	1.0	202	200	205	YES
17	31.0	11.7	0.01	1.0	206	203	209	YES
18	31.0	11.5	0.01	1.0	203	202	205	YES
19	31.0	11.6	0.01	1.0	204	202	206	YES
20	31.0	11.9	0.01	1.0	210	208	212	YES
21	31.0	11.3	0.05	1.0	199	192	210	YES
22	31.0	11.6	0.03	1.0	206	198	211	YES
23	31.0	11.5	0.01	1.0	203	202	204	YES
24	31.0	11.7	0.01	1.0	206	204	207	YES
25	31.0	11.5	0.02	1.0	203	197	206	YES
26	31.0	11.6	0.02	1.0	204	201	210	YES
27	31.0	11.8	0.04	1.0	208	198	215	NO*
28	31.0	11.2	0.02	1.0	199	195	200	YES
29	31.0	11.3	0.03	1.0	199	192	203	YES
30	31.0	11.5	0.01	1.0	202	199	204	YES
31	31.0	11.3	0.01	1.0	200	198	201	YES
32	31.0	11.5	0.01	1.0	202	201	203	YES
33	31.0	11.6	0.02	1.0	204	201	208	YES
34	31.0	11.4	0.02	1.0	200	196	204	YES
35	31.0	11.2	0.02	1.0	198	194	201	YES
36	31.0	11.6	0.01	1.0	204	203	206	YES
37	31.0	11.5	0.01	1.0	203	202	204	YES

Test Run	Sediment Injection Time (min)	Average Feed Rate (g/min)	Feed Rate COV	Maximum Feed Rate Sampling Duration (min)	Average Influent TSS (mg/L)	Minimum Influent TSS (mg/L)	Maximum Influent TSS (mg/L)	QA/QC Compliant (YES/NO)
38	31.0	11.5	0.02	1.0	202	201	206	YES
39	31.0	11.5	0.02	1.0	203	199	208	YES
40	31.0	11.5	0.01	1.0	203	201	205	YES
41	31.0	11.3	0.01	1.0	199	196	201	YES
42	31.0	11.3	0.03	1.0	199	195	206	YES
43	31.0	11.4	0.01	1.0	200	199	202	YES
44	31.0	11.5	0.01	1.0	203	201	206	YES
45	31.0	11.5	0.01	1.0	202	201	202	YES
46	31.0	22.6	0.02	1.0	401	395	410	YES
47	31.0	22.7	0.02	1.0	402	398	410	YES
48	31.0	22.7	0.00	1.0	401	399	403	YES
49	31.0	22.4	0.01	1.0	396	393	398	YES
50	31.0	23.3	0.01	1.0	412	410	415	YES
51	31.0	22.4	0.01	1.0	396	394	400	YES
52	31.0	22.4	0.02	1.0	396	389	405	YES
53	31.0	22.8	0.02	1.0	403	393	411	YES
54	31.0	22.8	0.01	1.0	403	399	408	YES
55	31.0	22.6	0.02	1.0	400	394	408	YES
56	31.0	22.7	0.01	1.0	400	395	405	YES
57	31.0	22.9	0.02	1.0	403	399	411	YES
58	31.0	23.1	0.02	1.0	407	398	417	YES
59	31.0	22.4	0.01	1.0	395	389	400	YES
60	31.0	22.9	0.01	1.0	404	401	408	YES
61	31.0	23.3	0.03	1.0	410	401	422	YES
62	31.0	22.6	0.03	1.0	398	388	411	YES
63	31.0	22.8	0.02	1.0	401	394	410	YES
64	31.0	22.8	0.03	1.0	402	389	412	YES
65	31.0	22.9	0.01	1.0	403	402	407	YES
66	31.0	22.8	0.02	1.0	402	395	409	YES
67	31.0	23.0	0.01	1.0	405	402	409	YES

***See Section 4.4 for discussion**

Drawdown Sampling and Duration

Drawdown TSS sampling times and drawdown durations are presented in **Table 11**. Sampling times were determined prior to each test run using the drawdown duration from the previous trial.

Table 11 Sediment Mass Loading Drawdown Sampling Times

Test Run	Drawdown Duration (min from pump shutoff)	Drawdown TSS Sample 1 Time (min from pump shutoff)	Drawdown TSS Sample 2 Time (min from pump shutoff)
11	24	9	17
12	27	8	16
13	26	9	19
14	26	9	17
15	24	9	17
16	25	8	16
17	25	8	16
18	24	8	17
19	25	8	16
20	25	8	16
21	23	8	16
22	24	8	16
23	23	8	16
24	24	8	15
25	23	8	16
26	22	8	15
27	23	7	15
28	21	8	15
29	22	7	14
30	21	7	14
31	20	7	14
32	21	7	14
33	21	7	14
34	21	7	14
35	21	7	14
36	21	7	14
37	20	7	14
38	21	7	13
39	20	7	14

Test Run	Drawdown Duration (min from pump shutoff)	Drawdown TSS Sample 1 Time (min from pump shutoff)	Drawdown TSS Sample 2 Time (min from pump shutoff)
40	21	7	14
41	20	7	14
42	19	7	13
43	18	6	12
44	19	6	12
45	18	6	13
46	18	6	12
47	18	6	12
48	19	6	12
49	19	6	13
50	17	6	12
51	18	6	11
52	16	6	12
53	17	5	10
54	17	6	11
55	15	6	11
56	15	5	10
57	16	5	10
58	15	5	10
59	16	5	10
60	15	5	11
61	10	5	(not sampled)
62	16	5	10
63	15	5	11
64	15	5	10
65	15	5	10
66	15	5	10
67	15	5	10

Background, Effluent and Drawdown TSS

Background, effluent and drawdown TSS samples were collected in clean 1-liter bottles and all samples exceeded the minimum required volume. Effluent and drawdown TSS samples were taken no less than three residence times (4 minutes) after the sediment injection stream was interrupted for feed rate sampling. Background TSS samples were taken concurrently with odd numbered effluent samples. The highest background TSS level was 9 mg/L, which is below the allowable concentration of 20 mg/L. Data from test run 61 was excluded from calculations (see Section 4.4 for discussion).

Table 12 Sediment Mass Loading Background, Effluent and Drawdown TSS

Test Run	Average Background TSS (mg/L)	Maximum Background TSS (mg/L)	Minimum Background Sample Volume (mL)	Average Adjusted Effluent TSS (mg/L)	Minimum Effluent Sample Volume (mL)	Average Adjusted Drawdown TSS (mg/L)	Minimum Drawdown Sample Volume (mL)	QA/QC Compliant (YES/NO)
-	-	≤ 20 mg/L	≥ 500 mL	-	≥ 500 mL	-	≥ 500 mL	-
11	2	2	750	37	900	11	560	YES
12	2	2	720	36	820	12	580	YES
13	2	3	740	41	880	11	540	YES
14	2	2	710	38	900	11	510	YES
15	2	3	850	36	880	10	570	YES
16	2	2	840	36	850	11	600	YES
17	2	2	590	40	770	12	670	YES
18	3	4	500	35	600	13	690	YES
19	3	3	625	37	600	10	680	YES
20	3	3	750	36	535	10	670	YES
21	3	4	640	40	700	12	700	YES
22	3	3	700	41	610	12	670	YES
23	3	4	680	37	570	12	680	YES
24	3	3	680	39	570	14	610	YES
25	3	4	640	37	730	11	690	YES
26	3	3	600	40	540	14	660	YES
27	3	3	640	29	790	8	680	YES
28	2	3	640	38	690	14	660	YES
29	4	4	730	38	550	14	660	YES
30	4	4	730	38	630	12	660	YES
31	3	4	680	42	750	19	690	YES
32	3	3	700	43	650	18	710	YES
33	5	5	620	43	720	15	690	YES

Test Run	Average Background TSS (mg/L)	Maximum Background TSS (mg/L)	Minimum Background Sample Volume (mL)	Average Adjusted Effluent TSS (mg/L)	Minimum Effluent Sample Volume (mL)	Average Adjusted Drawdown TSS (mg/L)	Minimum Drawdown Sample Volume (mL)	QA/QC Compliant (YES/NO)
34	5	5	670	40	670	14	680	YES
35	4	4	600	44	720	18	680	YES
36	4	4	670	43	860	20	600	YES
37	5	5	690	43	890	16	590	YES
38	5	6	750	41	840	19	600	YES
39	6	6	680	35	870	15	610	YES
40	6	7	720	40	870	15	570	YES
41	4	4	690	43	890	21	630	YES
42	3	3	720	45	870	22	610	YES
43	3	3	690	41	760	17	740	YES
44	3	4	700	40	780	16	620	YES
45	4	4	670	47	850	24	610	YES
46	2	2	720	79	630	31	660	YES
47	2	2	720	82	660	35	660	YES
48	2	3	685	86	791	37	630	YES
49	3	5	640	87	660	38	670	YES
50	2	2	720	86	670	45	670	YES
51	4	4	650	88	770	48	700	YES
52	4	4	740	90	650	56	690	YES
53	4	4	680	92	700	62	690	YES
54	5	6	770	90	690	50	670	YES
55	4	4	700	86	660	53	660	YES
56	2	2	730	89	830	50	670	YES
57	2	3	770	89	830	40	650	YES
58	3	3	760	90	910	67	640	YES
59	3	4	740	93	890	65	670	YES
60	3	3	690	88	860	58	640	YES
61	2	2	730	91	900	58	555	NO*
62	2	2	750	87	900	51	610	YES
63	3	3	770	88	860	56	600	YES
64	3	3	710	91	860	62	630	YES
65	4	4	740	89	890	63	630	YES
66	4	4	780	89	850	82	560	YES
67	4	4	770	95	680	67	740	YES

See Section 4.4 for discussion

Mass Loading Results

The total influent mass loaded at the conclusion of the testing process (Trial 66) was 68.1 lbs and the total mass captured by the StormFilter was 54.5 lbs. There was an average of 3-3.5 inches of sediment on the bottom of the test tank after testing. No maintenance was performed on the test system during the entire testing program. The average TSS RE (on a mass basis) was 80% after all testing was complete. The RE results were excluded from test runs 14, 27 and 61 due to equipment issues and one sampling error (see Section 4.4 for discussion), so the average TSS RE from the trial before and following trials 14, 27 and 61 was used to determine the mass captured. **Table 13** and **Figure 5** summarize the removal efficiency and mass loading results.

Table 13 Sediment Mass Loading Results

Test Run	Average Influent TSS (mg/L)	Average Adjusted Effluent TSS (mg/L)	Average Adjusted Drawdown TSS (mg/L)	Influent Volume (L)	Effluent Volume (L)	Drawdown Volume (L)	Mass Loadin g (lb.)	Mass Captured (lb.)	Trial Removal Efficienc y (%)	Average Removal Efficiency by Mass (%)
11	200	37	11	1758	1681	77	8.8	7.3	81.8%	82.8%
12	209	36	12	1756	1674	82	9.6	8.0	83.4%	82.8%
13	211	41	11	1758	1677	81	10.4	8.6	81.3%	82.7%
14	206	38	11	1754	1674	79	11.2	9.3	*82.2%***	82.7%
15	209	36	10	1738	1663	75	12.0	9.9	83.2%	82.7%
16	202	36	11	1750	1671	79	12.8	10.6	82.6%	82.7%
17	206	40	12	1753	1672	81	13.6	11.2	81.3%	82.6%
18	203	35	13	1750	1670	79	14.4	11.9	83.2%	82.6%
19	204	37	10	1760	1678	82	15.2	12.5	82.4%	82.6%
20	210	36	10	1757	1677	80	16.0	13.2	83.6%	82.7%
21	199	40	12	1757	1679	77	16.8	13.8	80.7%	82.6%
22	206	41	12	1749	1669	79	17.5	14.5	80.9%	82.5%
23	203	37	12	1749	1673	76	18.3	15.1	82.3%	82.5%
24	206	39	14	1763	1682	81	19.1	15.8	81.8%	82.5%
25	203	37	11	1758	1679	79	19.9	16.4	82.1%	82.5%
26	204	40	14	1758	1679	79	20.7	17.1	80.8%	82.4%
27	208	29	8	1756	1679	77	21.5	17.7	*81.2%***	82.3%
28	199	38	14	1748	1671	77	22.3	18.3	81.5%	82.3%
29	199	38	14	1756	1675	80	23.0	19.0	81.6%	82.3%
30	202	38	12	1761	1679	81	23.8	19.6	82.0%	82.3%
31	200	42	19	1754	1678	76	24.6	20.2	79.3%	82.2%
32	202	43	18	1757	1680	77	25.4	20.8	79.1%	82.1%
33	204	43	15	1758	1678	80	26.2	21.5	79.8%	82.0%
34	200	40	14	1759	1680	78	26.9	22.1	80.6%	82.0%

Test Run	Average Influent TSS (mg/L)	Average Adjusted Effluent TSS (mg/L)	Average Adjusted Drawdown TSS (mg/L)	Influent Volume (L)	Effluent Volume (L)	Drawdown Volume (L)	Mass Loading (lb.)	Mass Captured (lb.)	Trial Removal Efficiency (%)	Average Removal Efficiency by Mass (%)
35	198	44	18	1760	1680	79	27.7	22.7	78.1%	81.9%
36	204	43	20	1758	1678	80	28.5	23.3	79.5%	81.8%
37	203	43	16	1762	1682	80	29.3	23.9	79.4%	81.7%
38	202	41	19	1762	1683	79	30.1	24.6	80.0%	81.7%
39	203	35	15	1760	1682	78	30.8	25.2	83.3%	81.7%
40	203	40	15	1754	1676	78	31.6	25.8	80.9%	81.7%
41	199	43	21	1758	1677	80	32.4	26.4	78.7%	81.6%
42	199	45	22	1762	1683	79	33.2	27.0	77.9%	81.6%
43	200	41	17	1761	1682	79	33.9	27.7	80.1%	81.5%
44	203	40	16	1759	1679	80	34.7	28.3	80.9%	81.5%
45	202	47	24	1760	1681	79	35.5	28.9	77.4%	81.4%
46	401	79	31	1747	1672	75	37.1	30.2	80.8%	81.4%
47	402	82	35	1754	1678	76	38.6	31.4	80.2%	81.3%
48	401	86	37	1754	1677	78	40.2	32.6	79.2%	81.3%
49	396	87	38	1753	1676	76	41.7	33.8	78.5%	81.2%
50	412	86	45	1754	1678	76	43.3	35.1	79.6%	81.1%
51	396	88	48	1752	1677	75	44.8	36.3	78.3%	81.0%
52	396	90	56	1754	1679	75	46.3	37.5	77.6%	80.9%
53	403	92	62	1757	1681	75	47.9	38.7	77.4%	80.8%
54	403	90	50	1757	1681	75	49.4	39.9	78.1%	80.7%
55	400	86	53	1754	1679	75	51.0	41.1	78.8%	80.6%
56	400	89	50	1759	1684	75	52.5	42.3	78.2%	80.6%
57	403	89	40	1757	1680	76	54.1	43.5	78.5%	80.5%
58	407	90	67	1760	1684	75	55.7	44.8	78.2%	80.4%
59	395	93	65	1759	1682	76	57.2	45.9	76.9%	80.3%
60	404	88	58	1756	1683	73	58.7	47.2	78.5%	80.3%
61	410	91	58	1762	1687	76	60.3	48.4	*78.5%***	80.2%
62	398	87	51	1755	1680	75	61.9	49.6	78.6%	80.2%
63	401	88	56	1763	1690	72	63.4	50.8	78.3%	80.2%
64	402	91	62	1759	1685	73	65.0	52.1	77.6%	80.1%
65	403	89	63	1759	1686	73	66.5	53.3	78.2%	80.1%
66	402	89	82	1759	1686	73	68.1	54.5	77.8%	80.0%
67	405	95	67	1756	1686	70	69.7	55.7	76.9%	79.9%

See Section 4.4 for discussion

***** RE value assigned using the average of the trial immediately before and following this trial***

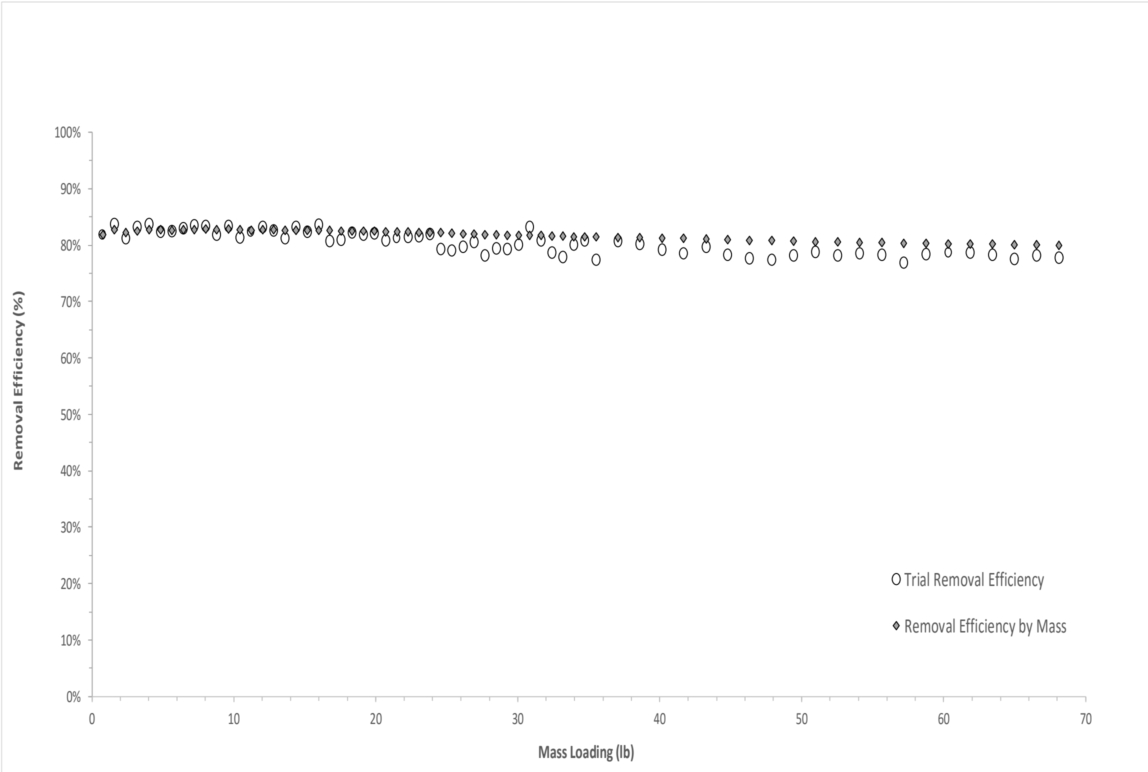


Figure 5 Average Removal Efficiency (by mass) and Trial Removal Efficiency vs. Sediment Mass Loading

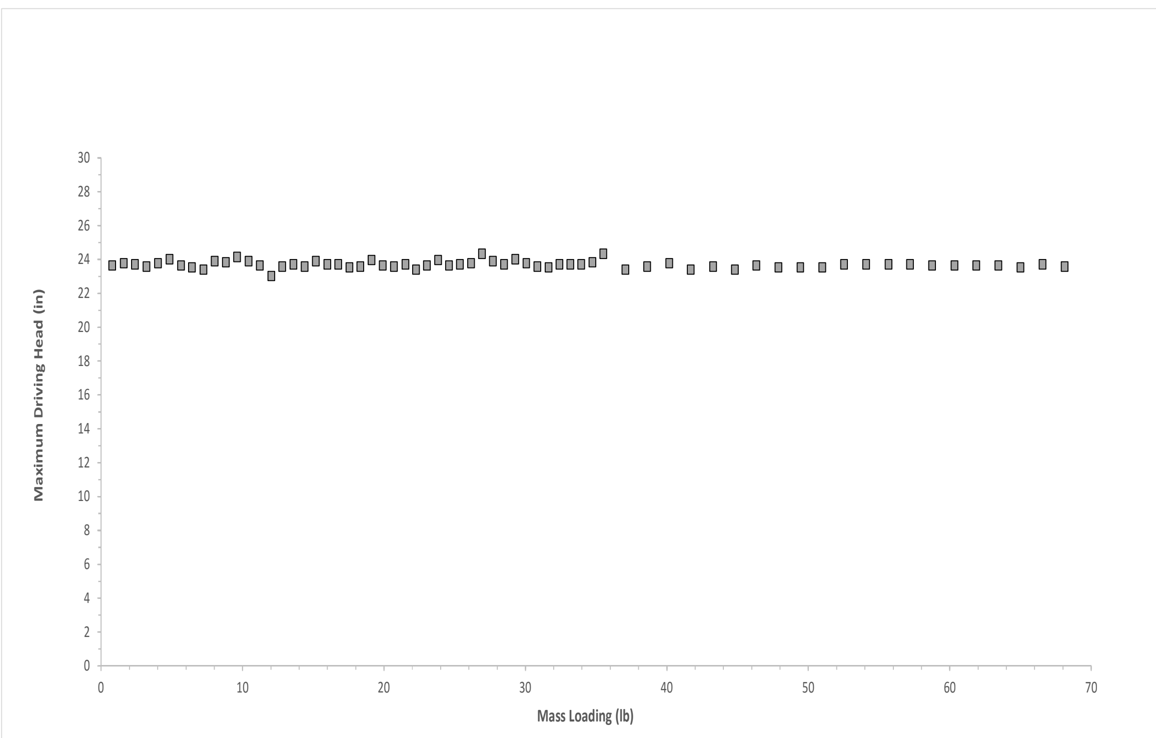


Figure 6 Maximum Driving Head vs. Sediment Mass Loading

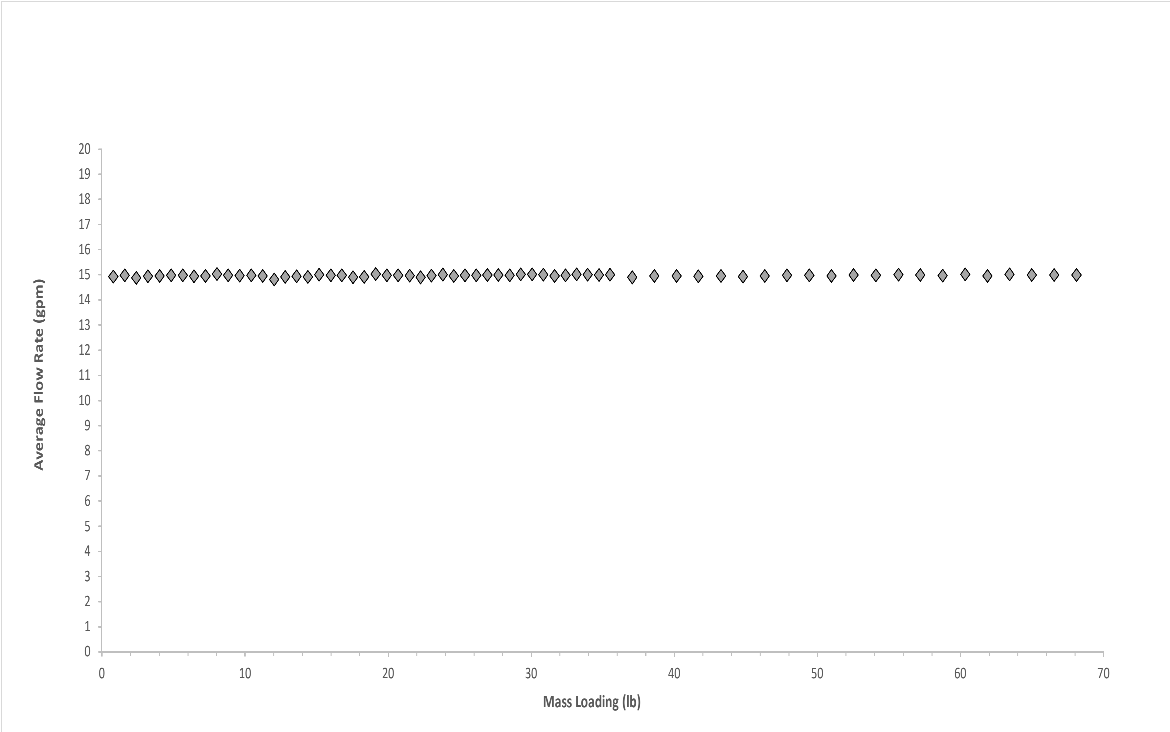


Figure 7 Average Flow Rate vs. Sediment Mass Loading

4.4 Excluded Results

The RE results of test runs 14, 27 and 61 were excluded to either sample collection or equipment errors. As required, all data collected during these trials are disclosed in **Table 4** through **Table 13**. During test run 14, the data logger battery failed, which compromised the flow rate data for that trial. Test run 27 showed correct sediment feed rates, but an equipment setup error prevented the sediment from being injected at a constant influent dosing of 200 mg/L over the entirety of the trial. It was verified that a portion of sediment intended for (but not injected during) run 27 entered the test box during the start of test run (28). The drawdown period of test run 61 was shorter than anticipated because the cartridge float valve did not fully close. As a result of the shorter duration, the second drawdown TSS sample could not be collected before the test run concluded.

The mass captured calculation (**Equation 9)** uses individual test run RE values and could not be performed for test runs 14, 27 and 61 with the stated data exclusions. Instead, the average removal efficiency from the trial immediately prior to and proceeding the impacted trials was substituted for the purpose of calculating the mass captured. This approach is consistent with the policy established by NJDEP and NJCAT.

5. Design Limitations

Required Soil Characteristics

The StormFilter is suitable for installation in all types of soils.
Slope

The StormFilter is recommended to be installed at 0% slope. Steep pipe slopes (>25 degrees) may present a fabrication or installation challenge and are likely to create inlet velocities that even at low flows may cause excess turbulence or resuspension of settled pollutants. However, due to the wide variety of configurations available for both the structure and the internal components, the StormFilter may be able to accommodate pipes with such aggressive slopes with minimal impact to the overall system performance. Inlet configurations such as the catch basin can be designed to accommodate sloping surface grades. Contech's engineering team should be consulted during the design process with questions relative to slope.

Maximum Flow Rate

The maximum treatment flow rate for the StormFilter is a function of model size and the number and size of the filter cartridges contained in the unit. The StormFilter is rated for a hydraulic loading rate of 2.12 gpm/ft^2 of filter media surface area.

Maintenance Requirements

As is true of all stormwater best management practices, maintenance requirements for each individual StormFilter installation will be influenced by site specific pollutant loading. Detailed maintenance information is provided in **Section 6**.

Driving Head

The amount of driving head required for normal operation of the StormFilter is typically fixed and dependent on the cartridge height. The minimum drop required across a StormFilter system is typically 1.8 ft, 2.3 ft and 3.05 ft for the low drop, 18 and 27-inch tall cartridges respectively. When site conditions limit the amount of drop available across the StormFilter then flow is typically backed up into the upstream piping during operation to ensure sufficient driving head is provided. The StormFilter can be designed to accommodate much higher drop/driving head where applicable.

Installation Limitations

The StormFilter is subject to few installation limitations. Contech's engineering team works with the site design engineer and support is provided to the contractor to ensure each unit is properly designed and installed given the unique conditions of each site.

Configurations

The StormFilter is typically comprised of a vault or manhole structure that house the rechargeable, media-filled filter cartridges. The StormFilter is also offered in plastic, steel, and concrete catch basins. Other configurations include panel vaults, CON/SPAN®, box culverts, and curb inlets. The filter cartridges operate consistently and act independently, regardless of housing, which enables linear scaling.

Structural Load Limitations

Most StormFilter configurations are designed for H-20 traffic loading. Contech's engineering team ensures that the configuration is appropriate for the site specific loading conditions during the design process.

Pre-treatment Requirements

The StormFilter does not require additional pretreatment. If desirable, pretreatment may be provided upstream of the StormFilter to reduce the pollutant load reaching the filter media and extend the useful life of the cartridges. However, all sediment capacity and maintenance recommendations assume no additional pretreatment is provided.

Limitations in Tailwater

Tailwater has the potential to impact the operation of the StormFilter. Any applications where the StormFilter will be subject to tailwater conditions should be reviewed with Contech's engineering team to evaluate the potential impact on proper functionality and performance.

Depth to Seasonal High Water Table

The operation and performance of the StormFilter is not typically impacted by high ground water since the unit is fully contained in a vault, manhole or other closed structure. Contech's engineering team is available to consult on the need for water tightness and/or concerns related to buoyancy.

6. Maintenance

Maintenance Procedures

Although there are many effective maintenance options, Contech believes the following procedure to be efficient, using common equipment and existing maintenance protocols. The following two-step procedure is recommended and can also be found at: http://www.conteches.com/DesktopModules/Bring2mind/DMX/Download.aspx?EntryId=2813&PortalId=0&DownloadMethod=attachment.

1. Inspection - vault interior to determine the need for maintenance.
2. Maintenance - cartridge replacement and sediment removal

Inspection and Maintenance

At least one scheduled inspection should take place per year, followed by maintenance if necessary. First, an inspection should be performed before the winter season. During the inspection, the need for maintenance should be determined. If disposal during maintenance will be required, samples of the accumulated sediments and filtration media should be collected.

Second, if necessary, maintenance (replacement of the filter cartridges and removal of accumulated sediments) should be performed during periods of dry weather. In addition to these two activities, it is important to check the condition of the StormFilter unit after major storms for potential damage caused by high flows and for high sediment accumulation that may be caused by localized erosion in the drainage area. It may be necessary to adjust the inspection/ maintenance schedule depending on the actual operating conditions encountered by the system. In general, inspection activities can be conducted at any time, and maintenance should occur, if warranted, during dryer months in late summer to early fall.

Maintenance Frequency

The primary factor for determining frequency of maintenance for the StormFilter is sediment loading. A properly functioning system will remove solids from water by trapping particulates in the porous structure of the filter media inside the cartridges. The flow through the system will naturally decrease as more and more particulates are trapped. Eventually the flow through the cartridges will be low enough to require replacement. It may be possible to extend the usable span of the cartridges by removing sediment from upstream trapping devices on a routine, as-needed basis in order to prevent material from being re-suspended and discharged to the StormFilter treatment system.

The average maintenance lifecycle is approximately 1-5 years. Site conditions greatly influence maintenance requirements. StormFilter units located in areas with erosion or active construction may need to be inspected and maintained more often than those with fully stabilized surface conditions.

Regulatory requirements or a chemical spill can shift maintenance timing as well. The maintenance frequency may be adjusted as additional monitoring information becomes available during the inspection program. Areas that consistently develop problems should be inspected more frequently than areas that experience fewer problems, particularly after major storms. Ultimately, inspection and maintenance activities should be scheduled based on the historic records and characteristics of an individual StormFilter system or site. It is recommended that the site owner develop a database to properly manage StormFilter inspection and maintenance programs.

Inspection Procedures

The primary goal of an inspection is to assess the condition of the cartridges relative to the level of visual sediment loading as it relates to decreased treatment capacity. It may be desirable to conduct this inspection during a storm to observe the relative flow through the filter cartridges. If the submerged cartridges are severely plugged, then large amounts of sediments will typically be present and very little flow will be discharged from the drainage pipes. If this is the case, then maintenance is warranted and the cartridges need to be replaced.

Warning: In the case of a spill, the worker should abort inspection activities until the proper guidance is obtained. Notify the local hazard control agency and Contech Engineered Solutions immediately.

Important: Inspection should be performed by a person who is familiar with the operation and configuration of the StormFilter treatment unit.

To conduct an inspection:

1. If applicable, set up safety equipment to protect and notify surrounding vehicle and pedestrian traffic.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.
3. Open the access portals to the vault and allow the system to vent.
4. Without entering the vault, visually inspect the inside of the unit, and note accumulations of liquids and solids.
5. Be sure to record the level of sediment build-up on the floor of the vault, in the forebay, and on top of the cartridges. If flow is occurring, note the flow of water per drainage pipe. Record all observations. Digital pictures are valuable for historical documentation.
6. Close and fasten the access portals.
7. Remove safety equipment.
8. If appropriate, make notes about the local drainage area relative to ongoing construction, erosion problems, or high loading of other materials to the system.
9. Discuss conditions that suggest maintenance and make decision as to whether or not maintenance is needed.

Maintenance Decision Tree

The need for maintenance is typically based on results of the inspection. The following Maintenance Decision Tree should be used as a general guide. (Other factors, such as regulatory requirements, may need to be considered).

1. Sediment loading on the vault floor.
   - If >4” of accumulated sediment, maintenance is required.

2. Sediment loading on top of the cartridge.
   - If >1/4” of accumulation, maintenance is required. (Note that this indicator is not always applicable to volume StormFilter designs)

3. Submerged cartridges.
   - If >4” of static water above cartridge bottom for more than 24 hours after end of rain event, maintenance is required. (Catch basins have standing water in the cartridge bay.)

4. Plugged media.

- If pore space between media granules is absent, maintenance is required.

5. Bypass condition.
    - If inspection is conducted during an average rain fall event and StormFilter remains in bypass condition (water over the internal outlet baffle wall or submerged cartridges), maintenance is required.

6. Hazardous material release.
    - If hazardous material release (automotive fluids or other) is reported, maintenance is required.

7. Pronounced scum line.
    - If pronounced scum line (≥ 1/4” thick) is present above top cap, maintenance is required.

Maintenance

Depending on the configuration of the particular system, maintenance personnel will be required to enter the vault to perform the maintenance.

Important: If vault entry is required, OSHA rules for confined space entry must be followed.

Filter cartridge replacement should occur during dry weather. It may be necessary to plug the filter inlet pipe if base flows is occurring.

Replacement cartridges can be delivered to the site or customers facility. Information concerning how to obtain the replacement cartridges is available from Contech Engineered Solutions.

Warning: In the case of a spill, the maintenance personnel should abort maintenance activities until the proper guidance is obtained. Notify the local hazard control agency and Contech Engineered Solutions immediately.

To conduct cartridge replacement and sediment removal maintenance:

1. If applicable, set up safety equipment to protect maintenance personnel and pedestrians from site hazards.

2. Visually inspect the external condition of the unit and take notes concerning defects and/or problems.

3. Open the doors (access portals) to the vault and allow the system to vent.

4. Without entering the vault, give the inside of the unit, including components, a general condition inspection.

5. Make notes about the external and internal condition of the vault. Give particular attention to recording the level of sediment build-up on the floor of the vault, in the forebay, and on top of the internal components.

6. Using appropriate equipment offload the replacement cartridges (up to 150 lbs. each) and set aside.

7. Remove used cartridges from the vault using one of the following methods:

Method 1

1. This activity will require that maintenance personnel enter the vault to remove the cartridges from the under drain manifold and place them under the vault opening for lifting (removal). Disconnect each filter cartridge from the underdrain connector by rotating counterclockwise 1/4 of a turn. Roll the loose cartridge, on edge, to a convenient spot beneath the vault access.

   Using appropriate hoisting equipment, attach a cable from the boom, crane, or tripod to the loose cartridge. Contact Contech Engineered Solutions for suggested attachment devices.

2. Remove the used cartridges (up to 250 lbs. each) from the vault.

   Important: Care must be used to avoid damaging the cartridges during removal and installation. The cost of repairing components damaged during maintenance will be the responsibility of the owner.

3. Set the used cartridge aside or load onto the hauling truck.

4. Continue steps 1 through 3 until all cartridges have been removed.

Method 2

1. This activity will require that maintenance personnel enter the vault to remove the cartridges from the under drain manifold and place them under the vault opening for lifting (removal). Disconnect each filter cartridge from the underdrain connector by rotating counterclockwise 1/4 of a turn. Roll the loose cartridge, on edge, to a convenient spot beneath the vault access.

2. Unscrew the cartridge cap.

3. Remove the cartridge hood and float.

4. At location under structure access, tip the cartridge on its side.

5. Empty the cartridge onto the vault floor. Reassemble the empty cartridge.

6. Set the empty, used cartridge aside or load onto the hauling truck.

7. Continue steps 1 through 5 until all cartridges have been removed.

8. Remove accumulated sediment from the floor of the vault and from the forebay. This can most effectively be accomplished by use of a vacuum truck.

9. Once the sediments are removed, assess the condition of the vault and the condition of the connectors.

10. Using the vacuum truck boom, crane, or tripod, lower and install the new cartridges. Once again, take care not to damage connections.

11. Close and fasten the door.

12. Remove safety equipment.

13. Finally, dispose of the accumulated materials in accordance with applicable regulations. Make arrangements to return the used empty cartridges to Contech Engineered Solutions.

Related Maintenance Activities - Performed on an As-needed Basis

StormFilter units are often just one of many structures in a more comprehensive stormwater drainage and treatment system. In order for maintenance of the StormFilter to be successful, it is imperative that all other components be properly maintained. The maintenance/repair of upstream facilities should be carried out prior to StormFilter maintenance activities. In addition to considering upstream facilities, it is also important to correct any problems identified in the drainage area. Drainage area concerns may include: erosion problems, heavy oil loading, and discharges of inappropriate materials.

Material Disposal

The accumulated sediment found in stormwater treatment and conveyance systems must be handled and disposed of in accordance with regulatory protocols. It is possible for sediments to contain measurable concentrations of heavy metals and organic chemicals (such as pesticides and petroleum products). Areas with the greatest potential for high pollutant loading include industrial areas and heavily traveled roads.

Sediments and water must be disposed of in accordance with all applicable waste disposal regulations. When scheduling maintenance, consideration must be made for the disposal of solid and liquid wastes. This typically requires coordination with a local landfill for solid waste disposal. For liquid waste disposal a number of options are available including a municipal vacuum truck decant facility, local waste water treatment plant or on-site treatment and discharge.

7. Statements

The following signed statements from the manufacturer (Contech Engineered Solutions, LLC), third-party observer (Scott A. Wells and Associates) and NJCAT are required to complete the NJCAT verification process.

In addition, it should be noted that this report has been subjected to public review (e.g. stormwater industry) and all comments and concerns have been satisfactorily addressed.

Contech Engineered Solutions LLC
71 US Route 1, Suite F
Scarborough, Maine 04074
Phone: (207) 885-9830
Fax: (207) 885-9825
www.ContechES.com

8/25/2016

Dr. Richard Magee
Technical Director
New Jersey Corporation for Advanced Technology
c/o Center for Environmental Systems
Stevens Institute of Technology
One Castle Point on Hudson
Hoboken, NJ 07030

RE: 2016 Verification of the Stormwater Management StormFilter® (StormFilter)

Dr. Magee,
This correspondence is being sent to you in accordance with the "*Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology*" (Process Document) dated January 25, 2013. Specifically, the process document requires that manufacturers submit a signed statement confirming that all of the procedures and requirements identified in the aforementioned process document and the accompanying NJDEP Filter Laboratory Testing Protocol have been met. We believe that the testing executed at Contech's laboratory in Portland, Oregon on the StormFilter during the summer of 2016 under the direct supervision of Dr. Scott Wells, Ph.D. and Associates was conducted in full compliance with all applicable protocol and process criteria. Additionally, we believe that all of the required documentation of the testing and resulting performance calculations has been provided within the submittal accompanying this correspondence.

Please do not hesitate to contact me with any additional questions related to this matter.

RE:

Respectfully,

Derek M. Berg
Director – Stormwater Regulatory Management – East
CONTECH Engineered Solutions LLC
71 US Route 1, Suite F | Scarborough, ME 04074
T: 207.885.6174 F: 207.885.9825
DBerg@conteches.com
www.ContechES.com

Scott A. Wells and Associates
Environmental Engineering and Modeling
2382 SW Cedar Street
Portland, OR 97205 USA

September 7, 2016

Deborah Beck
Contech Engineered Solutions LLC
11815 NE Glenn Widing Dr.
Portland, OR 97220

Re: NJCAT Technology Verification of Stormwater Management Stormfilter

Dear Deborah:

NJCAT technology verification testing of the Contech Stormwater Management Stormfilter were overseen by Scott A. Wells and Associates during June-July, 2016 at the Contech Portland, Oregon laboratory. Except for the effluent, background, and drawdown sample TSS analysis which was conducted by an outside laboratory, all phases of the test were observed. This included sediment particle size distribution sampling, calibration of the flow meter, weighing of the sediment feed rate samples, and in-house calculations. The frequency of water surface elevation measurements, temperature measurements, sediment feed rate sampling, background sampling, effluent sampling, and drawdown sampling reported for the test were also observed and are reported accurately. The test used applicable NJCAT protocol and that their report accurately reflects the testing observed by Scott A. Wells and Associates.

Truly,

Scott A. Wells, P.E., Ph.D. Christopher J. Berger, P. E., Ph.D.

503-935-6379
drswells@outlook.com

Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030-0000

November 15, 2016

Titus Magnanao
NJDEP
Division of Water Quality
Bureau of Non-Point Pollution Control
401-02B
PO Box 420
Trenton, NJ 08625-0420

Dear Mr. Magnanao,

Based on my review, evaluation and assessment of the testing conducted on the Contech Stormwater Management StormFilter® (StormFilter) under the direct supervision of Scott A. Wells, Ph.D. and Associates, the test protocol requirements contained in the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" (NJDEP Filter Protocol, January 2013) were met or exceeded. Specifically:

Test Sediment Feed

Sediment used for solids removal efficiency testing was high-purity silica (SiO_2 99.8%) material with a PSD consisting of approximately 55% sand, 40% silt, and 5% clay. Three composite PSD samples were sent to Apex Labs, Tigard, OR, an independent analytical testing laboratory. The sediment was found to meet the NJDEP particle size specification and was acceptable for use.

Removal Efficiency Testing

Sixty-seven (67) removal efficiency testing runs were completed in accordance with the NJDEP test protocol. Fifty-seven (57) of the 67 test runs were conducted during mass loading and 10 during RE testing. The target flow rate and influent sediment concentration were 15 gpm and 200 mg/L (increased to 400 mg/L after run 45) respectively. The system did not occlude or reach maximum driving head during the test process, but the average removal efficiency (on a mass basis) dropped below 80% after run 66 so testing was suspended and deemed complete as per the QAPP and protocol. The StormFilter demonstrated an average sediment removal efficiency on a mass basis of 80% over the course of the 66 test runs.

Sediment Mass Loading Capacity

Mass loading capacity testing was conducted as a continuation of removal efficiency (RE) testing. Mass loading test runs were conducted using identical testing procedures and targets as those used in the RE runs, the only change was to increase the target influent concentration to 400 mg/L after test run 45. Testing concluded after 67 test runs.

The total influent mass loaded through run 66 was 68.1 lbs and the total mass captured by the StormFilter was 54.5 lbs. This is equivalent to a sediment mass loading capacity of 7.71 lbs/ft^2 of filter surface area.

No maintenance was performed on the test system during the entire testing program.

Scour Testing

The StormFilter is designed for off-line installation. Consequently, scour testing is not required.

Sincerely,

Richard S. Magee, Sc.D., P.E., BCEE

8. References

ASTM D422-63. *Standard Test Method for Particle-Size Analysis of Soils.*

ASTM D3977-97. *Standard Test Methods for Determining Concentrations in Water Samples*.

Contech Engineered Solutions, LLC 2016. *Quality Assurance Project Plan for Verification of the Stormwater Management StormFilter®.* Prepared by Contech Engineered Solutions. May, 2016.

Contech Engineered Solutions, LLC 2016. *NJCAT Technology Verification: StormFilter*. Prepared by Contech Engineered Solutions. August 2016.

NJDEP 2013a. *New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology.* Trenton, NJ. January 25, 2013.

NJDEP 2013b. *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device.* Trenton, NJ. January 25, 2013.

VERIFICATION APPENDIX

Introduction

- Manufacturer – Contech Engineered Solutions LLC, 9025 Centre Pointe Drive, West Chester, OH 45069. *General Phone*: 800-338-1122. *Website*: http://www.conteches.com/

- MTD - The Stormwater Management StormFilter® (StormFilter) available cartridge heights and their verified capacities as well as standard models are shown in **Table A-1 and A-2.** Additional models are available when designed per the applicable capacities and conditions of this verification.

- TSS Removal Rate – 80%

- Media - Perlite

- Off-line installation

Detailed Specification

- NJDEP sizing tables and physical dimensions of StormFilter verified models are attached (**Table A-1)**. These Sizing Tables are valid for NJ following NJDEP Water Quality Design Storm Event of 1.25" in 2 hours (NJAC 7:8-5.5(a)).
- Maximum inflow drainage area
    - For flow through designs, the maximum inflow drainage area is typically governed by the maximum treatment flow rate of each model as presented in **Table A-1 and Table A-2**.
    - When installed downstream of a detention system that reduces the release rate for the water quality storm the maximum inflow drainage area is often governed by the mass capture capacity. These capacities are expressed as the maximum treatable area in **Table A-1 and Table A-2**

- The flow rate is individually controlled for each cartridge by a restrictor disc located at the connection point between the cartridge and the underdrain manifold. Driving head is managed by positioning of the inlet, outlet, and overflow elevations. The StormFilter is typically designed so that the restrictor disc passes the design treatment rate once the water surface reaches the shoulder of the cartridge which is equivalent to the cartridge height. Since the StormFilter uses a restrictor disc to restrict treatment flows below the hydraulic capacity of the media the system typically operates under consistent driving head for the useful life of the media. Site specific head constraints are also addressed by three different cartridge heights (low drop (effective height of 12 inches), 18, and 27 inches) which operate on the same principal and surface area specific loading rates. The StormFilter requires a minimum of 1.8 ft, 2.3 ft and 3.05 ft of drop between inlet invert and outlet invert to accommodate the low drop, 18 and 27 inch cartridges, respectively, without backing up flow into the upstream piping during operation. When site conditions limit the amount of drop available across the StormFilter then flow is typically backed up into the upstream piping during operation to ensure sufficient driving head is provided. If desirable the StormFilter can be designed to operate under additional driving head.

- The drain down flow is regulated by a drain down orifice, sized so that a clean filter drains down in approximately 25 minutes.
- StormFilter Inspection and Maintenance Procedures can be found at: http://www.conteches.com/DesktopModules/Bring2mind/DMX/Download.aspx?EntryId=2813&PortalId=0&DownloadMethod=attachment.

- This certification does not extend to the enhanced removal rates under NJAC 7:8-5.5 through the addition of settling chambers (such as hydrodynamic separators) or media filtration practices (such as a sand filter).

Table A-1 Common StormFilter Model Sizes and New Jersey Treatment Capacities

Common StormFilter Model Sizes and New Jersey Treatment Capacities											
Configuration	Model Size	Max. # Cartridges (Low Drop & 18")	Sedimentation Area (ft^2)	Min. Sedimentation Area Per Cartridge[1] (ft^2)	MTFR Low Drop (12") Cartridge (gpm)	MTFR 18" Cartridge (gpm)	Max. # of 27" Cartridges	MTFR 27" Cartridge[2] (gpm)	Max. Treatable Area Low Drop (12") Cartridge (acre)	Max. Treatable Area 18" Cartridge (acre)	Max. Treatable Area 27" Cartridge (acre)
CATCHBASIN STEEL	SFCB1	1	4.00	4.00	10.0	15.0	0	N/A	0.061	0.090	N/A
	SFCB2	2	8.00	4.00	20.0	30.0	1	22.5	0.122	0.180	0.136
	SFCB3	3	11.33	3.78	30.0	45.0	2	45.0	0.183	0.270	0.272
	SFCB4	4	14.67	3.67	40.0	60.0	3	67.5	0.244	0.360	0.408
MANHOLE	SFMH48	3	12.56	4.19	30.0	45.0	2	45.0	0.183	0.270	0.272
	SFMH60	4	19.63	4.91	40.0	60.0	4	90.0	0.244	0.360	0.544
	SFMH72	7	28.27	4.04	70.0	105.0	6	135.0	0.427	0.630	0.816
	SFMH96	14	50.26	3.59	140.0	210.0	11	247.5	0.854	1.260	1.496
VAULT	SF0806	11	48.00	4.36	110.0	165.0	10	225.0	0.671	0.990	1.360
	SF0811	26	88.00	3.38	260.0	390.0	19	427.5	1.586	2.340	2.584
	SF0814	34	112.00	3.29	340.0	510.0	24	540.0	2.074	3.060	3.264
	SF0816	39	128.00	3.28	390.0	585.0	28	630.0	2.379	3.510	3.808
	SF0818	44	144.00	3.27	440.0	660.0	32	720.0	2.684	3.960	4.352
	SF0820	51	160.00	3.14	510.0	765.0	35	787.5	3.111	4.590	4.760
	SF0822	56	176.00	3.14	560.0	840.0	39	877.5	3.416	5.040	5.304
	SF0824	61	192.00	3.15	610.0	915.0	42	945.0	3.721	5.490	5.712
LINEAR GRATE	SFLG0408	4	23.33	5.83	40.0	60.0	4	90.0	0.244	0.360	0.544
	SFLG0608	9	38.67	4.30	90.0	135.0	8	180.0	0.549	0.810	1.088
	SFLG0610	11	49.67	4.52	110.0	165.0	10	225.0	0.671	0.990	1.360
	SFLG0612	15	60.67	4.04	150.0	225.0	13	292.5	0.915	1.350	1.768
	SFLG0614	18	71.67	3.98	180.0	270.0	15	337.5	1.098	1.620	2.040
	SFLG0616	21	82.67	3.94	210.0	315.0	18	405.0	1.281	1.890	2.448
	SFLG0618	24	90.67	3.78	240.0	360.0	20	450.0	1.464	2.160	2.720
	SFLG0816	25	110.67	4.43	250.0	375.0	24	540.0	1.525	2.250	3.264
	SFLG0818	29	121.29	4.18	290.0	435.0	26	585.0	1.769	2.610	3.536
PEAK DIVERSION	SFPD0806	8	34.28	4.28	80.0	120.0	7	157.5	0.488	0.720	0.952
	SFPD0612	11	55.58	5.05	110.0	165.0	11	247.5	0.671	0.990	1.496
	SFPD0811	18	68.83	3.82	180.0	270.0	15	337.5	1.098	1.620	2.040
	SFPD0814	25	92.83	3.71	250.0	375.0	20	450.0	1.525	2.250	2.720
	SFPD0816	33	108.83	3.30	330.0	495.0	24	540.0	2.013	2.970	3.264
	SFPD0818	38	124.83	3.29	380.0	570.0	27	607.5	2.318	3.420	3.672
	SFPD0820	43	140.83	3.28	430.0	645.0	31	697.5	2.623	3.870	4.216
	SFPD0822	48	156.83	3.27	480.0	720.0	34	765.0	2.928	4.320	4.624
	SFPD0824	55	172.83	3.14	550.0	825.0	38	855.0	3.355	4.950	5.168

1 - Sedimentation Area shown references maximum # cartridges column.

2 - MTFR 27" Cartridges uses reduced maximum cartridge count associated with maintaining 4.50 sqft/cartridge sedimentation area lower limit.

NOTE: ADDITIONAL SIZES AND CONFIGURATIONS AVAILABLE, CONSULT CONTECH FOR ASSISTANCE

Table A-2 StormFilter Cartridge Heights and New Jersey Treatment Capacities

StormFilter Cartridge Heights and New Jersey Treatment Capacities				
StormFilter Cartridge Height	**Filtration Surface Area (ft^2)**	**MTFR* (GPM)**	**Mass Capture Capacity (lbs)**	**Maximum Allowable Inflow Area (acres)**
Low Drop (12")	4.71	10	36.3	0.061
18"	7.07	15	54.5	0.09
27"	10.61	22.5	81.8	0.136
*2.12 gpm/ft^2 of filter surface				

APPENDIX E
STORMWATER MANAGEMENT STORMFILTER MTD LABORATORY CERTIFICAION

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Bureau of Nonpoint Pollution Control
Division of Water Quality
Mail Code 401-02B
Post Office Box 420
Trenton, New Jersey 08625-0420
609-633-7021 Fax: 609-777-0432
http://www.state.nj.us/dep/dwq/bnpc_home.htm

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

December 14, 2016

Derek M. Berg
Director - Stormwater Regulatory Management - East
Contech Engineered Solutions LLC
71 US Route 1, Suite F
Scarborough, ME 04074

Re: MTD Laboratory Certification
Stormwater Management StormFilter® (StormFilter) by Contech Engineered Solutions LLC
Off-line Installation

TSS Removal Rate 80%

Dear Mr. Berg:

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7(c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). Contech Engineered Solutions LLC has requested a Laboratory Certification for the StormFilter System.

This project falls under the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology" dated January 25, 2013. The applicable protocol is the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" dated January 25, 2013.

NJCAT verification documents submitted to the NJDEP indicate that the requirements of the aforementioned protocol have been met or exceeded. The NJCAT letter also included a recommended certification TSS removal rate and the required maintenance plan. The NJCAT Verification Report with the Verification Appendix for this device is published online at http://www.njcat.org/verification-process/technology-verification-database.html.

The NJDEP certifies the use of the StormFilter System by Contech Engineered Solutions LLC at a TSS removal rate of 80%, when designed, operated and maintained in accordance with the information provided in the Verification Appendix and subject to the following conditions:

1. The maximum treatment flow rate (MTFR) for the manufactured treatment device (MTD) is calculated using the New Jersey Water Quality Design Storm (1.25 inches in 2 hrs) in N.J.A.C. 7:8-5.5. The MTFR is calculated based on a verified loading rate of 2.12 gpm/sf of effective filtration treatment area.

2. The StormFilter System shall be installed using the same configuration as the unit tested by NJCAT, and sized in accordance with the criteria specified in item 6 below.

3. This device cannot be used in series with another MTD or a media filter (such as a sand filter), to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.

4. Additional design criteria for MTDs can be found in Chapter 9.6 of the New Jersey Stormwater Best Management Practices (NJ Stormwater BMP) Manual which can be found on-line at www.njstormwater.org.

5. The maintenance plan for a site using this device shall incorporate, at a minimum, the maintenance requirements for the StormFilter, which is attached to this document. However, it is recommended to review the maintenance website at http://www.conteches.com/DesktopModules/Bring2mind/DMX/Download.aspx?EntryId=2813&PortalId=0&DownloadMethod=attachment for any changes to the maintenance requirements.

6. Sizing Requirements:

   The example below demonstrates the sizing procedure for a StormFilter System.

   Example: A 0.25 acre impervious site is to be treated to 80% TSS removal using a StormFilter System. The impervious site runoff (Q) based on the New Jersey Water Quality Design Storm was determined to be 0.79 cfs or 354.58 gpm.

   The calculation of the minimum number of cartridges for use in the StormFilter System is based upon both the MTFR and the maximum inflow drainage area. It is necessary to calculate the required cartridges using both methods and to rely on the method that results in the highest minimum number of cartridges determined by the two methods.

   Inflow Drainage Area Evaluation:

   The drainage area to the StormFilter System in this example is 0.25 acres. Based upon the information in Table 1 below, the following minimum number of cartridges are required in a StormFilter System to treat the impervious area without exceeding the maximum drainage area:

1. Five (5) 12” cartridges,
2. Three (3) 18” cartridges, or
3. Two (2) 27” cartridges

Maximum Treatment Flow Rate (MTFR) Evaluation:

The site runoff (Q) was determined based on the following:

time of concentration = 10 minutes
i=3.2 in/hr (page 5-8, Fig. 5-3 of the NJ Stormwater BMP Manual)
c=0.99 (runoff coefficient for impervious)
Q=ciA=0.99x3.2x0.25=0.79 cfs=0.79x448.83 gpm=354.58 gpm

Based on a flow rate of 354.58 gpm, the following minimum number of cartridges are required in a StormFilter System to treat the impervious area without exceeding the MTFR:

1. Thirty-six (36) 12” cartridges,
2. Twenty-four (24) 18” cartridges, or
3. Sixteen (16) 27” cartridges

The MTFR Evaluation results will be used since that method results in the higher minimum number of cartridges determined by the two methods.

The sizing table corresponding to the available system models are noted below:

TABLE 1 STORMFILTER CARTRIDGE HEIGHTS AND NEW JERSEY TREATMENT CAPACITIES

StormFilter Cartridge Heights and New Jersey Treatment Capacities				
StormFilter Cartridge Height	**Filtration Surface Area (sq.ft)**	**MTFR[1] (GPM)**	**Mass Capture Capacity (lbs)**	**Maximum Allowable Inflow Area[2] (acres)**
Low Drop (12")	4.71	10	36.3	0.061
18"	7.07	15	54.5	0.09
27"	10.61	22.5	81.8	0.136

Notes:
1. *MTFR calculated based on 4.72x10-3 cfs/sf (2.12 gpm/sf) of effective filtration treatment area.*
2. *Based upon the equation found in the NJDEP Filter Protocol Maximum Inflow Drainage Area (acres) = weight of TSS before 10% loss in MTFR (lbs)/600 lbs/acre of drainage area annually.*

Be advised a detailed maintenance plan is mandatory for any project with a Stormwater BMP subject to the Stormwater Management Rules, N.J.A.C. 7:8. The plan must include all of the items identified in Stormwater Management Rules, N.J.A.C. 7:8-5.8. Such items include, but are not limited to, the list of indication of problems in the system, and training of maintenance personnel. Additional information can be found in Chapter 8: Maintenance and Retrofit of Stormwater Management Measures.

If you have any questions regarding the above information, please contact Shashi Nayak of my office at (609) 633-7021.

Sincerely,

James J. Murphy, Chief
Bureau of Nonpoint Pollution Control

Attachment: Maintenance Plan

cc: Chron File
Richard Magee, NJCAT
Vince Mazzei, NJDEP - DLUR
Ravi Patraju, NJDEP - BES
Gabriel Mahon, NJDEP - BNPC
Shashi Nayak, NJDEP - BNPC

CONTECH® ENGINEERED SOLUTIONS

StormFilter Inspection and Maintenance Procedures

The Stormwater Management StormFilter®

Maintenance Guidelines

The primary purpose of the Stormwater Management StormFilter® is to filter and prevent pollutants from entering our waterways. Like any effective filtration system, periodically these pollutants must be removed to restore the StormFilter to its full efficiency and effectiveness.

Maintenance requirements and frequency are dependent on the pollutant load characteristics of each site. Maintenance activities may be required in the event of a chemical spill or due to excessive sediment loading from site erosion or extreme storms. It is a good practice to inspect the system after major storm events.

Maintenance Procedures

Although there are many effective maintenance options, we believe the following procedure to be efficient, using common equipment and existing maintenance protocols. The following two-step procedure is recommended::

1. **Inspection**
   - Inspection of the vault interior to determine the need for maintenance.
2. **Maintenance**
   - Cartridge replacement
   - Sediment removal

Inspection and Maintenance Timing

At least one scheduled inspection should take place per year with maintenance following as warranted.

First, an inspection should be done before the winter season. During the inspection the need for maintenance should be determined and, if disposal during maintenance will be required, samples of the accumulated sediments and media should be obtained.

Second, if warranted, a maintenance (replacement of the filter cartridges and removal of accumulated sediments) should be performed during periods of dry weather.

In addition to these two activities, it is important to check the condition of the StormFilter unit after major storms for potential damage caused by high flows and for high sediment accumulation that may be caused by localized erosion in the drainage area. It may be necessary to adjust the inspection/maintenance schedule depending on the actual operating conditions encountered by the system. In general, inspection activities can be conducted at any time, and maintenance should occur, if warranted, during dryer months in late summer to early fall.

Maintenance Frequency

The primary factor for determining frequency of maintenance for the StormFilter is sediment loading.

A properly functioning system will remove solids from water by trapping particulates in the porous structure of the filter media inside the cartridges. The flow through the system will naturally decrease as more and more particulates are trapped. Eventually the flow through the cartridges will be low enough to require replacement. It may be possible to extend the usable span of the cartridges by removing sediment from upstream trapping devices on a routine as-needed basis, in order to prevent material from being re-suspended and discharged to the StormFilter treatment system.

The average maintenance lifecycle is approximately 1-5 years. Site conditions greatly influence maintenance requirements. StormFilter units located in areas with erosion or active construction may need to be inspected and maintained more often than those with fully stabilized surface conditions.

Regulatory requirements or a chemical spill can shift maintenance timing as well. The maintenance frequency may be adjusted as additional monitoring information becomes available during the inspection program. Areas that develop known problems should be inspected more frequently than areas that demonstrate no problems, particularly after major storms. Ultimately, inspection and maintenance activities should be scheduled based on the historic records and characteristics of an individual StormFilter system or site. It is recommended that the site owner develop a database to properly manage StormFilter inspection and maintenance programs..

Inspection Procedures

The primary goal of an inspection is to assess the condition of the cartridges relative to the level of visual sediment loading as it relates to decreased treatment capacity. It may be desirable to conduct this inspection during a storm to observe the relative flow through the filter cartridges. If the submerged cartridges are severely plugged, then typically large amounts of sediments will be present and very little flow will be discharged from the drainage pipes. If this is the case, then maintenance is warranted and the cartridges need to be replaced.

Warning: In the case of a spill, the worker should abort inspection activities until the proper guidance is obtained. Notify the local hazard control agency and Contech Engineered Solutions immediately.

To conduct an inspection:

Important: Inspection should be performed by a person who is familiar with the operation and configuration of the StormFilter treatment unit.

1. If applicable, set up safety equipment to protect and notify surrounding vehicle and pedestrian traffic.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.
3. Open the access portals to the vault and allow the system vent.
4. Without entering the vault, visually inspect the inside of the unit, and note accumulations of liquids and solids.
5. Be sure to record the level of sediment build-up on the floor of the vault, in the forebay, and on top of the cartridges. If flow is occurring, note the flow of water per drainage pipe. Record all observations. Digital pictures are valuable for historical documentation.
6. Close and fasten the access portals.
7. Remove safety equipment.
8. If appropriate, make notes about the local drainage area relative to ongoing construction, erosion problems, or high loading of other materials to the system.
9. Discuss conditions that suggest maintenance and make decision as to weather or not maintenance is needed.

Maintenance Decision Tree

The need for maintenance is typically based on results of the inspection. The following Maintenance Decision Tree should be used as a general guide. (Other factors, such as Regulatory Requirements, may need to be considered)

1. Sediment loading on the vault floor.
   a. If >4" of accumulated sediment, maintenance is required.
2. Sediment loading on top of the cartridge.
   a. If >1/4" of accumulation, maintenance is required.
3. Submerged cartridges.
   a. If >4" of static water above cartridge bottom for more than 24 hours after end of rain event, maintenance is required. (Catch basins have standing water in the cartridge bay.)
4. Plugged media.
   a. If pore space between media granules is absent, maintenance is required.
5. Bypass condition.
   a. If inspection is conducted during an average rain fall event and StormFilter remains in bypass condition (water over the internal outlet baffle wall or submerged cartridges), maintenance is required.
6. Hazardous material release.
   a. If hazardous material release (automotive fluids or other) is reported, maintenance is required.
7. Pronounced scum line.
   a. If pronounced scum line (say ≥ 1/4" thick) is present above top cap, maintenance is required.

Maintenance

Depending on the configuration of the particular system, maintenance personnel will be required to enter the vault to perform the maintenance.

Important: If vault entry is required, OSHA rules for confined space entry must be followed.

Filter cartridge replacement should occur during dry weather. It may be necessary to plug the filter inlet pipe if base flows is occurring.

Replacement cartridges can be delivered to the site or customers facility. Information concerning how to obtain the replacement cartridges is available from Contech Engineered Solutions.

Warning: In the case of a spill, the maintenance personnel should abort maintenance activities until the proper guidance is obtained. Notify the local hazard control agency and Contech Engineered Solutions immediately.

To conduct cartridge replacement and sediment removal maintenance:

1. If applicable, set up safety equipment to protect maintenance personnel and pedestrians from site hazards.
2. Visually inspect the external condition of the unit and take notes concerning defects/problems.
3. Open the doors (access portals) to the vault and allow the system to vent.
4. Without entering the vault, give the inside of the unit, including components, a general condition inspection.
5. Make notes about the external and internal condition of the vault. Give particular attention to recording the level of sediment build-up on the floor of the vault, in the forebay, and on top of the internal components.
6. Using appropriate equipment offload the replacement cartridges (up to 150 lbs. each) and set aside.
7. Remove used cartridges from the vault using one of the following methods:

Method 1:

A. This activity will require that maintenance personnel enter the vault to remove the cartridges from the under drain manifold and place them under the vault opening for lifting (removal). Disconnect each filter cartridge from the underdrain connector by rotating counterclockwise 1/4 of a turn. Roll the loose cartridge, on edge, to a convenient spot beneath the vault access.

   Using appropriate hoisting equipment, attach a cable from the boom, crane, or tripod to the loose cartridge. Contact Contech Engineered Solutions for suggested attachment devices.

B. Remove the used cartridges (up to 250 lbs. each) from the vault.

Important: Care must be used to avoid damaging the cartridges during removal and installation. The cost of repairing components damaged during maintenance will be the responsibility of the owner.

C. Set the used cartridge aside or load onto the hauling truck.

D. Continue steps a through c until all cartridges have been removed.

Method 2:

A. This activity will require that maintenance personnel enter the vault to remove the cartridges from the under drain manifold and place them under the vault opening for lifting (removal). Disconnect each filter cartridge from the underdrain connector by rotating counterclockwise 1/4 of a turn. Roll the loose cartridge, on edge, to a convenient spot beneath the vault access.

B. Unscrew the cartridge cap.

C. Remove the cartridge hood and float.

D. At location under structure access, tip the cartridge on its side.

E. Empty the cartridge onto the vault floor. Reassemble the empty cartridge.

F. Set the empty, used cartridge aside or load onto the hauling truck.

G. Continue steps a through e until all cartridges have been removed.

8. Remove accumulated sediment from the floor of the vault and from the forebay. This can most effectively be accomplished by use of a vacuum truck.
9. Once the sediments are removed, assess the condition of the vault and the condition of the connectors.
10. Using the vacuum truck boom, crane, or tripod, lower and install the new cartridges. Once again, take care not to damage connections.
11. Close and fasten the door.
12. Remove safety equipment.
13. Finally, dispose of the accumulated materials in accordance with applicable regulations. Make arrangements to return the used **empty** cartridges to Contech Engineered Solutions.

Material Disposal

The accumulated sediment found in stormwater treatment and conveyance systems must be handled and disposed of in accordance with regulatory protocols. It is possible for sediments to contain measurable concentrations of heavy metals and organic chemicals (such as pesticides and petroleum products). Areas with the greatest potential for high pollutant loading include industrial areas and heavily traveled roads.

Sediments and water must be disposed of in accordance with all applicable waste disposal regulations. When scheduling maintenance, consideration must be made for the disposal of solid and liquid wastes. This typically requires coordination with a local landfill for solid waste disposal. For liquid waste disposal a number of options are available including a municipal vacuum truck decant facility, local waste water treatment plant or on-site treatment and discharge.

Related Maintenance Activities - Performed on an as-needed basis

StormFilter units are often just one of many structures in a more comprehensive stormwater drainage and treatment system.

In order for maintenance of the StormFilter to be successful, it is imperative that all other components be properly maintained. The maintenance/repair of upstream facilities should be carried out prior to StormFilter maintenance activities.

In addition to considering upstream facilities, it is also important to correct any problems identified in the drainage area. Drainage area concerns may include: erosion problems, heavy oil loading, and discharges of inappropriate materials.

Inspection Report

Date: Personnel:

Location:________________________ System Size: ____

System Type: Vault ☐ Cast-In-Place ☐ Linear Catch Basin ☐ Manhole ☐ Other ☐

Sediment Thickness in Forebay: ____________________________________ Date: ____________

Sediment Depth on Vault Floor: ____

Structural Damage: ____

Estimated Flow from Drainage Pipes (if available):____

Cartridges Submerged: Yes ☐ No ☐ Depth of Standing Water:____________________________

StormFilter Maintenance Activities (check off if done and give description)

☐ Trash and Debris Removal: ____

☐ Minor Structural Repairs: ____

☐ Drainage Area Report ____

Excessive Oil Loading: Yes ☐ No ☐ Source: ______________________________

Sediment Accumulation on Pavement: Yes ☐ No ☐ Source: ______________________________

Erosion of Landscaped Areas: Yes ☐ No ☐ Source: ______________________________

Items Needing Further Work: ____

Owners should contact the local public works department and inquire about how the department disposes of their street waste residuals.

Other Comments:

____

____

____

____

____

____

____

____

Review the condition reports from the previous inspection visits.

StormFilter Maintenance Report

Date: ______________________ Personnel: ______________________

Location: ______________________ System Size: ______________________

System Type: Vault ☐ Cast-In-Place ☐ Linear Catch Basin ☐ Manhole ☐ Other ☐

List Safety Procedures and Equipment Used: ______________________

____

____

System Observations

Months in Service:

Oil in Forebay (if present): Yes ☐ No ☐

Sediment Depth in Forebay (if present): ______________________

Sediment Depth on Vault Floor: ______________________

Structural Damage: ______________________

Drainage Area Report

Excessive Oil Loading: Yes ☐ No ☐ Source: ______________________

Sediment Accumulation on Pavement: Yes ☐ No ☐ Source: ______________________

Erosion of Landscaped Areas: Yes ☐ No ☐ Source: ______________________

StormFilter Cartridge Replacement Maintenance Activities

Remove Trash and Debris: Yes ☐ No ☐ Details: ______________________

Replace Cartridges: Yes ☐ No ☐ Details: ______________________

Sediment Removed: Yes ☐ No ☐ Details: ______________________

Quantity of Sediment Removed (estimate?):

Minor Structural Repairs: Yes ☐ No ☐ Details: ______________________

Residuals (debris, sediment) Disposal Methods: ______________________

Notes:

____

____

____

____

____

____

____

RECYCLED PAPER

CONTECH ENGINEERED SOLUTIONS

800-338-1122

www.ContechES.com

Contech Engineered Solutions LLC provides site solutions for the civil engineering industry. Contech's portfolio includes bridges, drainage, sanitary sewer, stormwater and earth stabilization products. For information on other Contech division offerings, visit contech-cpi.com or call 800.338.1122.

Support

- Drawings and specifications are available at www.conteches.com.
- Site-specific design support is available from our engineers.

800.338.1122

www.conteches.com

APPENDIX F
OPERATION AND MAINTENANCE PLAN

Operation and Maintenance Plan

Owner & Responsible Party:

Woods Hole Oceanographic Institute

Falmouth, Massachusetts

Date:

I. Short Term Maintenance Program During Construction - Responsible Party: Site Contractor

- Contractor shall refer to Site Plans Dated XX/XX/21, prepared by Moffatt & Nichol for additional information.

- Site contractor shall provide Falmouth Engineering Department a 24-hour emergency contact (name and number) prior to start of construction.

- Care shall be taken at all times to control erosion and sediment movement by the use of compaction of disturbed areas and the use of straw wattles as shown on the plan. Other than erosion, no pollutant discharges are expected during construction.

- The contractor shall ensure that all runoff is collected in the appropriate structures as they are constructed, and that uncontrolled runoff is kept to a minimum.

- During construction the straw wattles, must be inspected every week and rain events greater than 1”. Repair and replace as necessary, and remove any sediment buildup behind the devices.

- After installation of the drainage control devices and temporary erosion protection, weekly inspections are required to ensure they are operating as designed and to determine maintenance/cleaning requirements. Structures are to be cleaned either by hand, or mechanical means. Refer to following schedule.

- Sweeping of tracked soils on public way to be performed weekly, or as necessary. Additional crushed stone to be placed within the filter berm as required to prevent tracking of soils offsite.

- If storm events occur after the side slopes and other areas that are to be stabilized have been planted, but prior to seed germination, then re-grading and replanting of those areas may be required.

- Upon completion of the drainage facilities and the successful establishment and stabilization of soils and vegetation, any sediment buildup within each BMP structure is to be removed. A final inspection shall be performed by the P.E. and a report issued to the Falmouth Engineering Department.

- Contractor shall maintain a weekly log of inspections using template below. Logs shall be made available to municipal representatives at request.

- In the event of a fuel spill immediately contact the Falmouth Fire Department (508-548-2325).

- Contractor shall clean all drainage and stormwater control structures at completion of construction.

Maintenance Schedule during Construction

Sediment Control	Inspection	Maintenance Thresholds	Maintenance Action
Erosion control sediment logs, straw wattles	Weekly and after large storm events (more than 0.5-in of rainfall in 24-hour period).	If integrity of the system is compromised.	Restore the integrity of the system and/or clean sediment out.
Area Drains and Outlet Control Structures	Weekly and after large storm events (more than1.0-inches of rainfall in 24-hour period).	If the sump is 1/3 full with sediment.	Clean sediment out.
Seeded areas	Weekly and after large storm events (more than1.0-inches of rainfall in 24-hour period).	When sediment is greater than 2-inches in depth, vegetation is not taking.	Remove sediment by non-intrusive means (non-mechanical), repair vegetation.
Adjacent Roadways and Parking Areas	Weekly and after large storm events (more than1.0-inches of rainfall in 24-hour period).	If sediment is greater than 1/2 an inch in any area of the paved surface.	Sweep/clean sediment.
Contech Cascade Hydrodynamic Separators	After initial instillation and after weekly after large storm events (more than 1.0inches of rainfall in a 24-hr period)	When the sediment reached 50% of the maximum storage volume	Use of a vacuum truck to remove sediment in the chamber during dry weather conditions. As well as washing areas outside of the center chamber and slanted skirt to remove pollutants build up

Short Term Maintenance Program

Responsible Party: Site Contractor

WEEKLY INSPECTION SCHEDULE AND EVALUATION CHECKLIST

Best Management Practices	Current Conditions and Minimum Maintenance / Repairs, If Necessary	Completed Maintenance/ Repair (i.e. date, contractor, tasks complete, etc.)
Catch Basins/Trench Drains		
Straw Wattles/Sediment Logs		
Soil Tracked Offsite		
Overall Site Condition		

Inspected By: ____ Date: _________________________

APPENDIX G

LONG-TERM POLLUTION PREVENTION PLAN

Long Term Maintenance Program After Construction

Responsible Party: Owner

After construction, the owner, shall be the responsible party for maintenance as outlined below:

Town of Falmouth

59 Town Hall Square

Falmouth, MA 02540

Long Term Maintenance Schedule after Construction

Task	Inspection	Maintenance Threshold	Maintenance Action
Parking lot/paved areas sweeping and debris	Four times a year	At a minimum every spring and after leaves have falling, otherwise as needed.	Sweep and pave areas by hand or street sweeper. Pick up miscellaneous litter.
Landscaping	Twice a year late spring and early fall.	Inspect for dead plantings and stabilized slopes.	Replace dead landscape plantings, re-seed and fertilize as needed. Provide temporary slope stabilization as needed.
Area Drains, and Outlet Control Structures	Twice a year – spring and fall	If the sump is 1/3 full with sediment.	Clean sediment out.
Contech Cascade Hydrodynamic Separators	At minimum twice per year	When the sediment level reaches 50% of the maximum storage volume	Use of a vacuum truck to remove sediment in the chamber during dry weather conditions. As well as washing areas outside of the center chamber and slanted skirt to remove pollutants build up

APPENDIX H
ILLICIT DISCHARGE COMPLIANCE CERTIFICATION

ILLICIT DISCHARGE COMPLIANCE CERTIFICATION

Property:

Project: Woods Hole

The undersigned, Joseph Choi, P.E., a professionally licensed civil engineer with the firm of Moffatt & Nichol located in Newton, Massachusetts, hereby makes this certification as required under Standard #10 of the MassDEP Stormwater Management Standards.

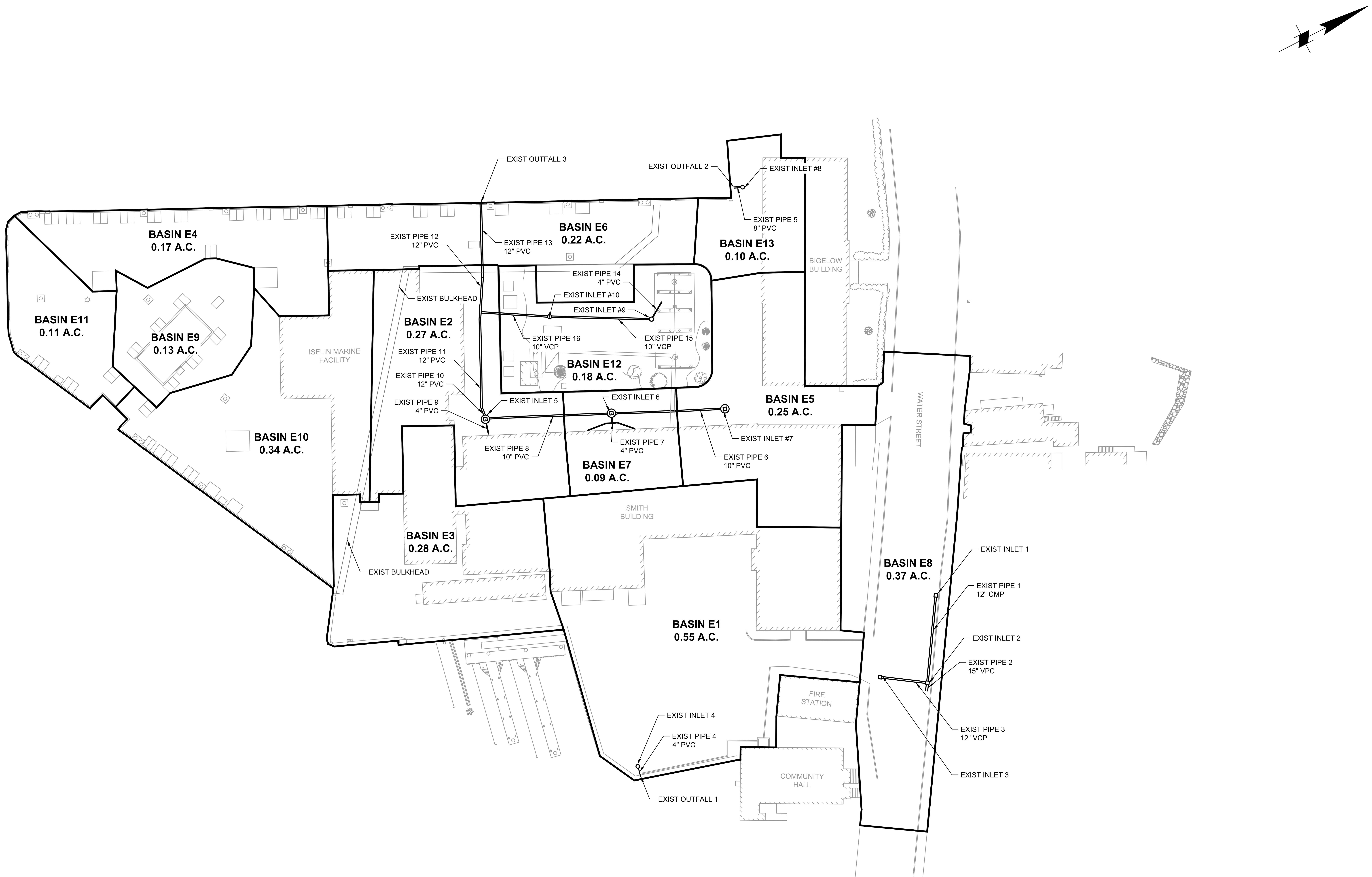
In connection with the above referenced matter, I do hereby certify to the best of my knowledge and belief, as of the date set forth above, that there are no illicit sewage discharges to the existing or proposed site stormwater management system.

MOFFATT & NICHOL

Date as of: _____________ By: ___________________________

Joseph Choi, P.E.

APPENDIX I
EXISTING CONDITIONS WATERSHED MAP



moffatt & nichol

30' 0 30' 60'

SCALE: 1" = 30'

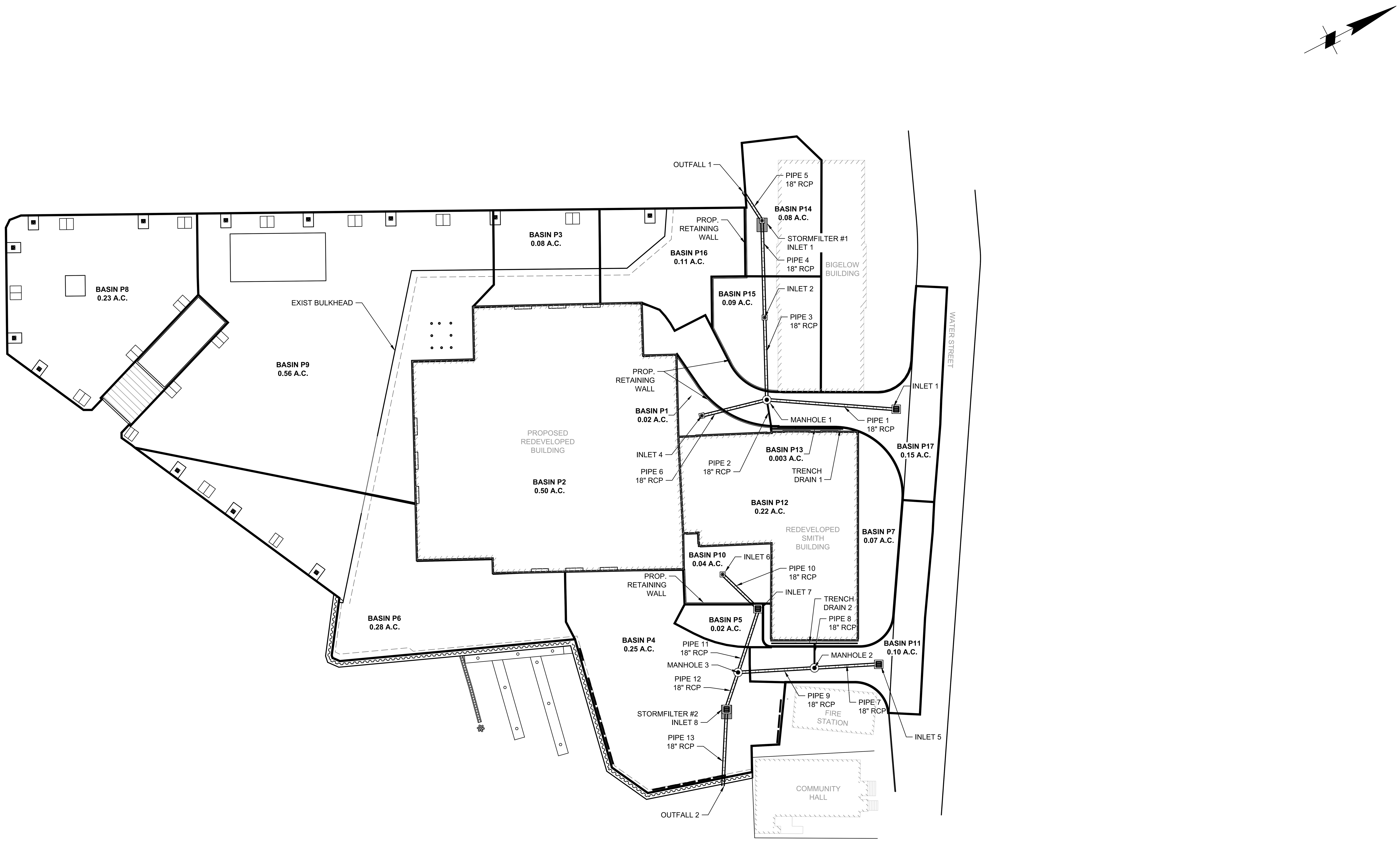
APPENDIX I - EXISTING CONDITIONS WATERSHED MAP

WOODS HOLE ISELIN DOCK

FEBRUARY 22, 2021

APPENDIX J

PROPOSED CONDITIONS WATERSHED MAP



moffatt & nichol

30' 0 30' 60'

SCALE: 1" = 30'

APPENDIX J - PROPOSED CONDITIONS WATERSHED MAP

WOODS HOLE ISELIN DOCK

FEBRUARY 22, 2021

Attachment H

Chapter 91 License #5153

Form WD 54

2M-10-61-931508

19172

The Commonwealth of Massachusetts

No. 5153.

Whereas, the Woods Hole Oceanographic Institution------------------------

of Falmouth-----------, **in the County of** Barnstable----------- **and Commonwealth aforesaid, has applied to the Department of Public Works for license to** construct a concrete pier, wooden small boat dock, steel sheeting to hold fill, fender piling, and to dredge and install riprap and to fill in Great Harbor, at its property in the town of Falmouth,---
and has submitted plans of the same; and whereas due notice of said application, and of the time and place fixed for a hearing thereon, has been given, as required by law, to the Selectmen------------------**of the** town-----------**of** Falmouth----------------;

Now said Department, having heard all parties desiring to be heard, and having fully considered said application, hereby, subject to the approval of the Governor ~~and Council~~, authorizes and licenses the said---

Woods Hole Oceanographic Institution-------, **subject to the provisions of the ninety-first chapter of the General Laws, and of all laws which are or may be in force applicable thereto, to** construct and maintain a concrete pier, timber piers, steel sheet piling bulkhead, fender piles, and to dredge, fill and place riprap in Great Harbor, at its property in the town of Falmouth, in conformity with the accompanying plan No. 5153 (three sheets).

Existing pier structures of the licensee may be removed as shown on said plans.

BOOK 1351 PAGE 407

A steel sheet piling bulkhead may be constructed on lines described as follows: beginning at a point marked "F" in the existing stone retaining wall at the southeasterly side of the premises of the licensee adjoining the Eel Pond Channel, so-called, thence running about southwesterly in said retaining wall to a point marked "G" which is the corner of said retaining wall a distance of 12.5 feet; thence turning and running more westerly to point "H" a distance of 18 feet; thence turning and running about northwesterly to point "J" a distance of 80 feet; thence turning and running about southwesterly a distance of 97.5 feet to point "K" in the present steel bulkhead of the licensee at a distance of 45 feet, more or less, from the most southerly corner thereof; all in the location shown on said plans.

The area enclosed by existing steel sheet piling, by the existing retaining wall and by the steel sheet piling bulkhead authorized hereby may be filled solid as shown on said plans.

A steel sheet piling bulkhead may be constructed on lines described as follows: beginning at a point marked "L" in said existing steel sheet piling bulkhead at a distance of 120 feet northwesterly from said most southerly corner thereof, thence running about northwesterly more westerly 12.5 feet to point "M"; thence turning and running about northwesterly 90 feet to point "N"; thence turning and running about northeasterly 130 feet to point "O"; thence turning and running about northerly 47 feet to point "P"; thence turning and running about northwesterly 19.5 feet to point "Q"; thence turning and running about northeasterly 21.5 feet to point "R"; thence turning and running about northwesterly 33.5 feet to point "S"; thence turning and running about northeasterly 32 feet to point "T" in the existing retaining structure of the northwesterly abutter at a distance of about 2 feet from the property line; all in the location shown on said plans.

The area enclosed by the existing retaining structures and the steel sheet piling bulkhead authorized last preceding may be filled solid as shown on said plans.

A steel and concrete pier incorporating a slip 96 feet long and 20 feet wide with a removable bridge therein may be constructed extending into tidewater from the existing and proposed steel sheet piling bulkheads of the licensee within lines described as follows: beginning at point "Q" in the bulkhead authorized hereby; thence running southwesterly in a line slightly westerly of a line perpendicular to Main Street 414 feet to point "U"; thence turning and running southeasterly 80 feet to point "V"; thence turning and running about northeasterly, more easterly 240 feet to point "W" in the existing steel sheet piling bulkhead at a distance of 34 feet from its most southerly corner; thence turning and running in the steel sheet piling bulkhead authorized hereby through points "L", "M", "N", "O", "P", to "Q" the point of beginning; all in the location shown on said plans.

Extending southeasterly off the section of bulkhead between points "J" and "K" pile and timber piers may be built, one with a length of 60 feet from said steel sheet piling bulkhead and one with a length of 48 feet, each having a width of 7 feet, and a line of steel sheet piling constituting a wave breaker may extend a distance of 38 feet from said bulkhead with a 6 pile dolphin at its southeasterly end, in the locations shown on said plans.

A band of timber platform may be built running along said bulkhead from the corner at point "J" to said wave breaker with a width of 4 feet, in the location shown on said plans.

Two 3 inch P.V.C. intake pipes may be installed running 48 feet, more or less, under the deck of said pier thence extending vertically into tidewater attached to a single pile, in the location shown on said plans and in accordance with the details there indicated.

Dredging may be performed to a depth of 10 feet below mean low water in an area extending southeasterly off the sheet piling along the southeasterly side of the premises of the licensee and into the Eel Pond Channel, and to a depth of 22 feet at mean low water in an area extending northwesterly off the pier and sheet piling along the northwesterly side of the premises of the licensee, in the locations shown on said plans.

Riprap may be placed on the dredge slope at 1½ vertical to 1 horizontal under the pier authorized hereby along the section of new bulkhead, as shown on said plans.

The work authorized hereby shall be performed in the locations shown on said plans numbered 5153 and in accordance with the details there indicated and as indicated in more detail on construction plans on file in the office of the Department of Public Works, Division of Waterways.

All distances given in the hereinbefore descriptions are more or less.

The dredged material may be deposited as fill in the areas authorized hereby to be filled and shall otherwise be deposited above the mean high water line in such location as will insure against its return into tidewater or shall tow same to sea and deposit it in such location as may be assigned by the United States Corps of Engineers.

Said transportation and dumping shall be subject to the provisions of Section 52 through 56 of Chapter 91 of the General Laws.

The dredging authorized hereby shall be performed without interference with the free passage of vessels and any shoaling of adjacent areas resulting therefrom shall be removed by and at the expense of the licensee.

This license is granted upon the express condition that the licensee shall provide navigational lights at the two outboard corners of the pier authorized hereby which shall be visible to passenger vessels operating in Woods Hole Great Harbor and which shall conform to requirements of the United States Coast Guard.

Nothing in this license shall be construed as authorizing encroachment on property not owned or controlled by the licensee except with the consent of the owner or owners thereof.

This license is granted subject to all applicable Federal, State, County and Municipal laws, ordinances and regulations, and upon the further express condition that use by boats or otherwise of the structures hereby licensed shall involve no discharge of sewage or other polluting matter into the adjacent tidewaters except in strict conformity with the requirements of the local and State health departments, and upon the further express condition that any other authorizations necessitated due to the provisions hereof shall be secured prior to the commencement of any work under this license.-----------------------------

The plan of said work, numbered------------5 1 5 3,------------ is on file in the office of said Department, and duplicate of said plan accompanies this License, and is to be referred to as a part hereof.

~~The amount of tide-water displaced by the work hereby authorized shall be ascertained~~ by said Department, and compensation ~~therefor shall be made~~ by the said

~~heirs, successors~~

~~and assigns, by paying into the treasury of the Commonwealth~~

cents for each cubic ~~yard so displaced, being the amount hereby assessed by said Department.~~

Nothing in this License shall be so construed as to impair the legal rights of any person.

This License shall be void unless the same and the accompanying plan are recorded within one year from the date hereof, in the Registry--------of Deeds for the -------- ~~District of the~~ County of Barnstable.

In Witness Whereof, said Department of Public Works have hereunto set their hands this--------twenty-sixth---------- day of-----------October,-------------in the year nineteen hundred and sixty-six.

Edward J. Ribb
Charles A. Burke
Robert S. Foster

Department of Public Works

JCS

Anthony C. Fusaelli
John W. Barner

THE COMMONWEALTH OF MASSACHUSETTS

~~This license is approved in consideration of the payment into the treasury of the Commonwealth by the said~~
~~of the further sum of~~

~~the amount determined by the Governor and council as a just and equitable charge for rights and privileges hereby granted in land of the Commonwealth.~~

BOSTON, NOV 3 1966

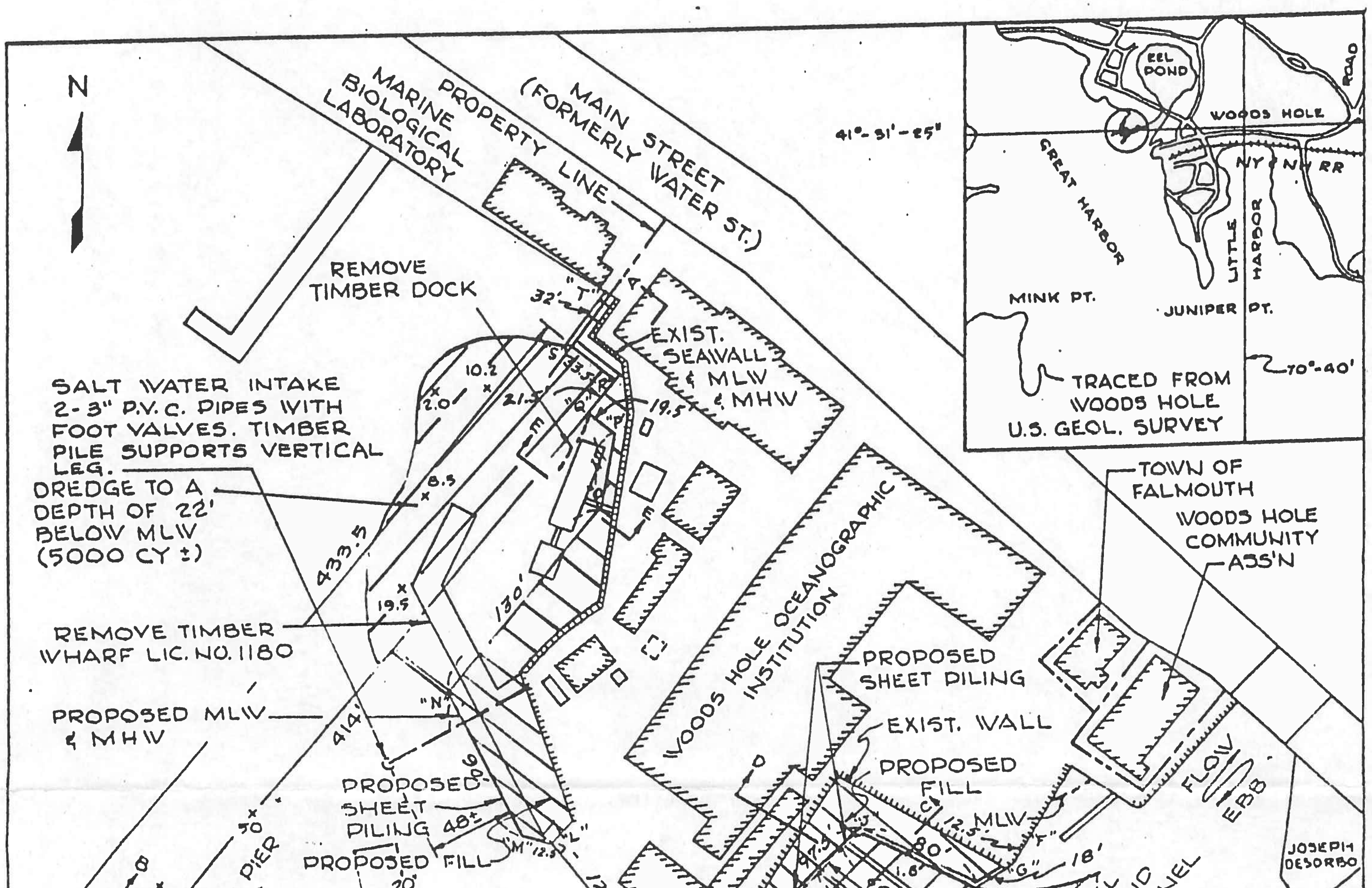
Approved by the Governor. ~~and Council.~~

John A. Volpe

Governor ~~Executive Secretary.~~

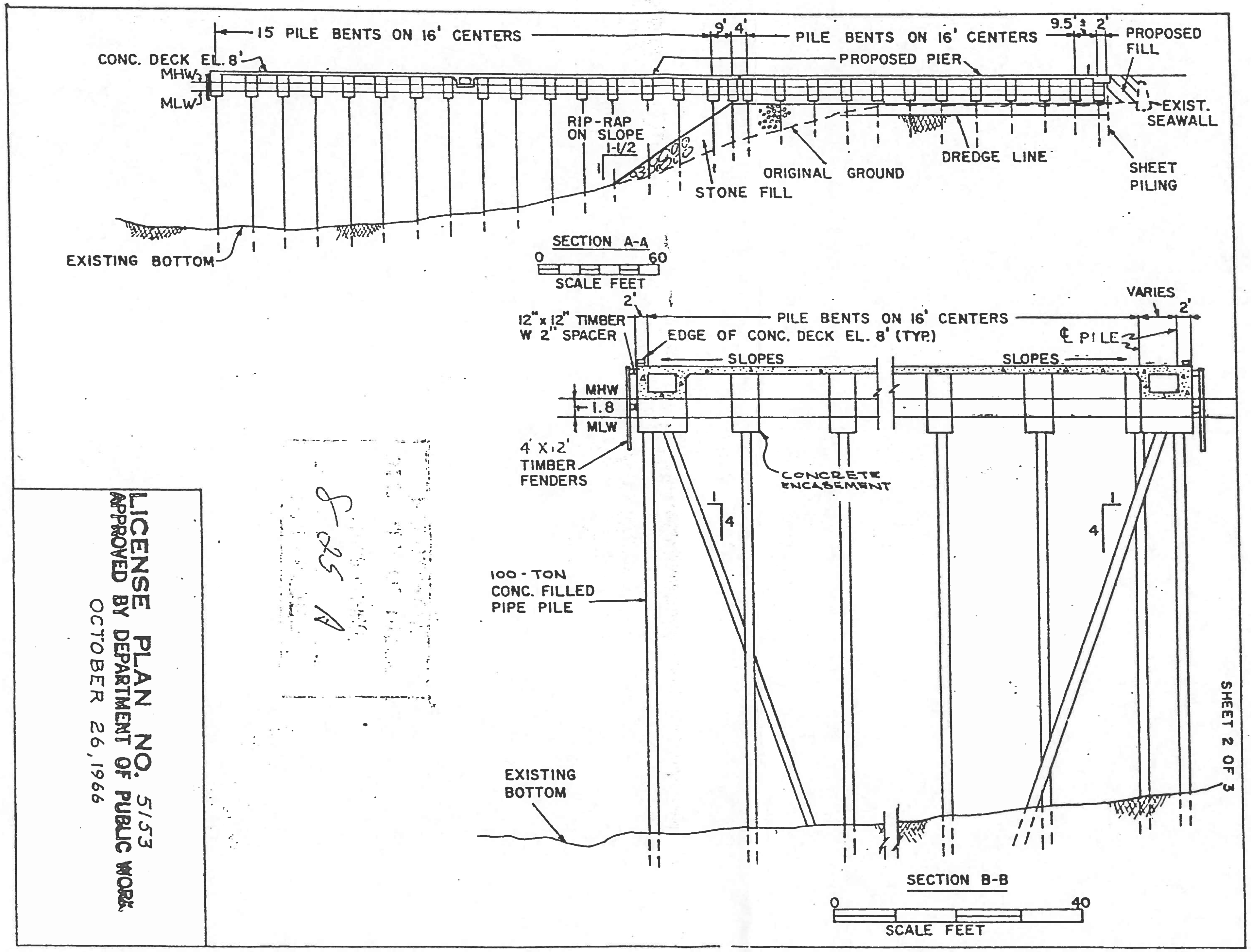
REC'D NOV 9 - 1966 AND RECORDED

206-139



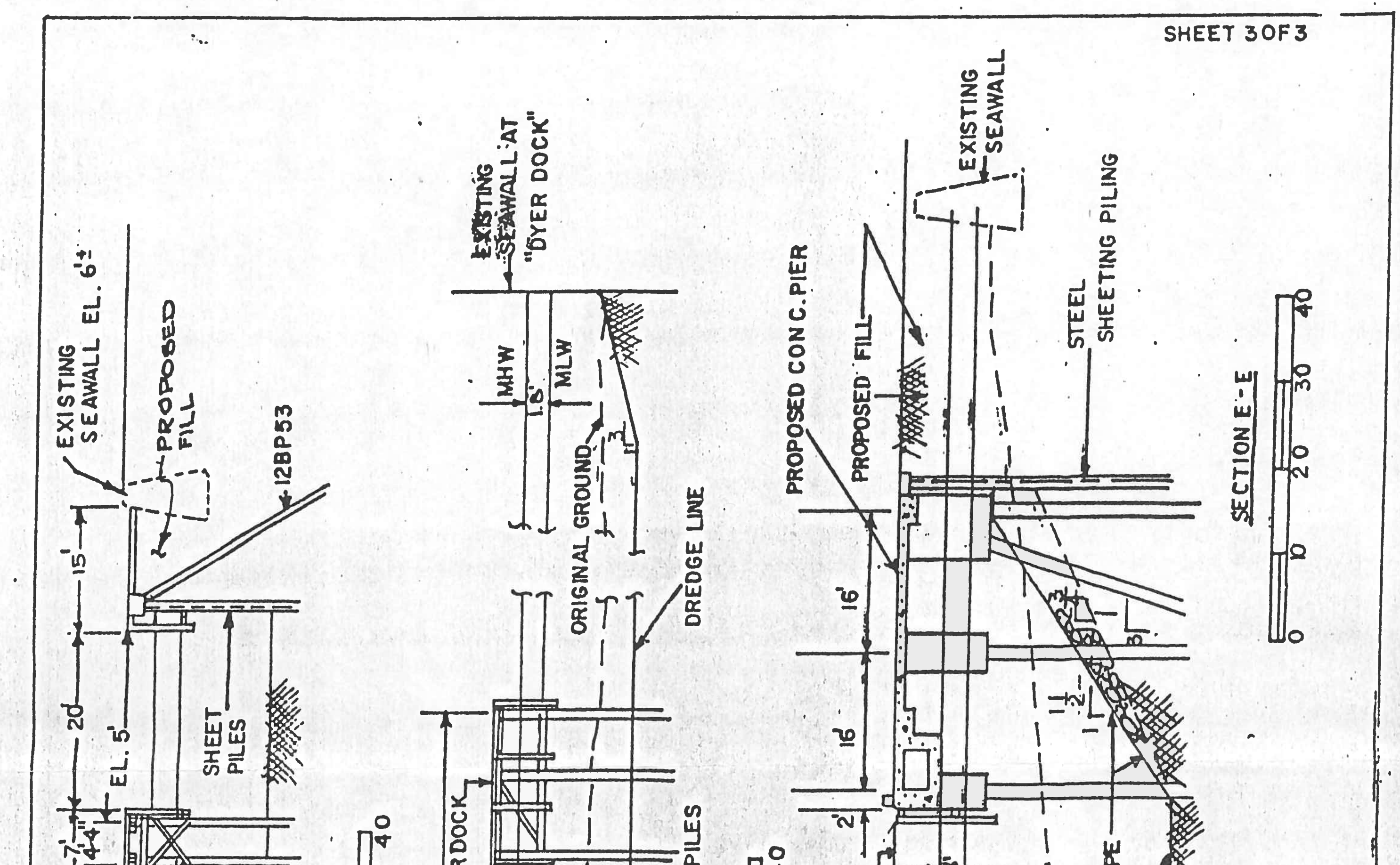
PLAN BOOK 408 PAGE 139

206-141



LICENSE PLAN NO. 5153
APPROVED BY DEPARTMENT OF PUBLIC WORK
OCTOBER 26, 1966

206-141



Public Book 206 - Page 141

Attachment I

Abutter Notification

Notification to Abutters

Under The Massachusetts Wetland Protection Act & Town of Falmouth Wetlands Bylaw

In accordance with the second paragraph of Massachusetts General Laws Chapter 131, Section 40 and the Town of Falmouth Wetlands Protection Bylaw you are hereby notified of the following:

a) The name of the applicant is: **Woods Hole Oceanographic Institution.**

b) The applicant has **filed a Notice of Intent ("NOI") application with the Falmouth Conservation Commission for the proposed replacement of the existing Iselin Marine Facility.**

c) The address of the lot where the activity is proposed is **86 Water Street, Falmouth (Woods Hole), MA 02543.**

d) The work proposed includes **the replacement of the existing Iselin Marine Facility. The proposed work will involve impacts to Land Under the Ocean, Land Subject to Tidal Action, Land Containing Shellfish, Coastal Bank, and Land Subject to Coastal Storm Flowage.**

e) Copies of the Notice of Intent may be examined at the **Falmouth Conservation Commission, 59 Town Hall Square, Falmouth, MA 02540. Call (508) 495-7445.**

f) Applicant's representative's phone number: **(978) 461-6256 (Jack Vaccaro).**

g) The hearing date is scheduled for **August 25, 2021.** Additional information regarding the time and place of the public hearing may be obtained by calling the Falmouth Conservation Commission office at **(508) 495-7445.**

h) Person sending this notification (applicant, representative or other)

   Name: Epsilon Associates, Inc. (Attn. Jack Vaccaro)
   Address: 3 Mill & Main Place, Suite 250
   Town: Maynard   State: MA   Zip: 01754
   Telephone: (978) 461-6256

RECEIVED
MAY 4 2021
Board of Assessors, Town of Falmouth

Town of Falmouth Assessing Department

59 Town Hall Square, Falmouth MA 02540
Telephone: 508-495-7380
Fax: 508-495-7384

REQUEST OF CERTIFIED ABUTTERS LIST

Name of person requesting abutters list: Sean Scannell, Epsilon Associates, Inc.

Address of person requesting abutters list: 3 Mill & Main Place, Suite 250
Maynard, MA 01754

Phone: (978) 461-6299

Abutters to (subject property): Map 49A Section 02 Parcel 000K Lot 001
Map______ Section______ Parcel______ Lot______
Map______ Section______ Parcel______ Lot______

Lot size of subject property: 2.8 acres

Location of subject property: 86 Water Street, Falmouth (Woods Hole), MA 02543

Check one:

______ Direct abutters (includes properties across street)

______ Direct abutters in local Historic District (includes properties across the street) within 100"

______ Immediate abutters (includes only properties with a common property line)

______ Immediate abutters plus churches and schools within 500'

______ Properties within 300'

______ Properties within 300' or abutters abutter to abutter whichever is closest

X Properties within 100'

______ Other (specify)____________________

Fee. $25.00 Total $25.00 Ck # 44271 JL

EMAIL sscannell@epsilonassociates.com

86 WATER ST

CERTIFIED

Bruce Cabral
Assistant Assessor
Town of Falmouth, MA
May 6, 2021

77 WATER ST 49A 01 002 000
77 WATER ST ASSOCIATES LLC LUC: 326
77 WATER ST
WOODS HOLE, MA 02543

68 WATER ST 49A 02 000M 000
WOODS HOLE COMMUNITY ASSOC LUC: 954
PO BOX 327
WOODS HOLE, MA 02543-0327

89 WATER ST 49A 01 004 000
EEL POND PLACE LLC LUC: 031
531 S MAIN ST
CENTERVILLE, MA 02632

93 WATER ST 49A 01 005 000
WOODS HOLE OCEANOGRAPHIC INST LUC: 943
GENERAL ACCOUNTING OFFICE
569 WOODS HOLE RD
ATTN: NANCY SHEA
WOODS HOLE, MA 02543

87 WATER ST 49A 01 003 000
EEL POND REALTY LLC LUC: 325
87 WATER ST
C/O WOODS HOLE MARKET
WOODS HOLE, MA 02543

44 WATER ST 51A 01 002 000
WOODS HOLE OCEANOGRAPHIC INST LUC: 943
GENERAL ACCOUNTING OFFICE
569 WOODS HOLE RD
ATTN: NANCY SHEA
WOODS HOLE, MA 02543

72 WATER ST 49A 02 000L 000
FALMOUTH TOWN OF LUC: 930
59 TOWN HALL SQ
FALMOUTH, MA 02540-2761

86 WATER ST 49A 02 000K 001
WOODS HOLE OCEANOGRAPHIC INST LUC: 943
GENERAL ACCOUNTING OFFICE
569 WOODS HOLE RD
ATTN: NANCY SHEA
WOODS HOLE, MA 02543

66 WATER ST 49A 02 000N 000
FALMOUTH TOWN OF LUC: 980
59 TOWN HALL SQ
FALMOUTH, MA 02540-2761

56 WATER ST 51A 01 001 000
FISHMONGERS CAFE INC LUC: 326
PO BOX 674
WOODS HOLE, MA 02543

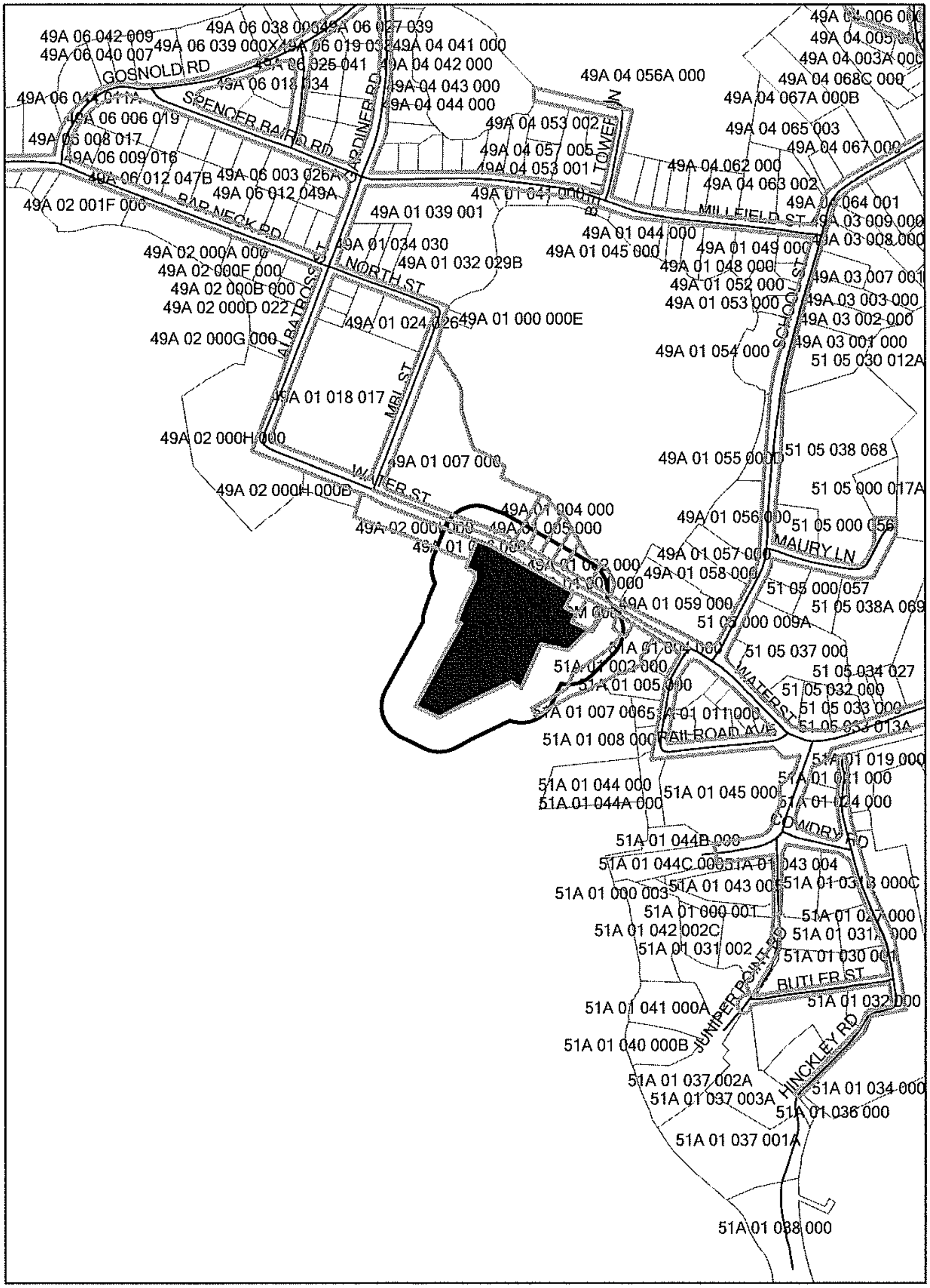
71 WATER ST 49A 01 001 000
HANNON TRUSTEE BARRY T LUC: 326
BRAYDEN RLTY TRUST
305 WEST ST
BRAINTREE, MA 02184

137 WATER ST 49A 01 007 000
MARINE BIOLOGICAL LABORATORY LUC: 943
7 MBL ST
WOODS HOLE, MA 02543

100 WATER ST 49A 02 000I 000
MARINE BIOLOGICAL LABORATORY LUC: 943
7 MBL ST
WOODS HOLE, MA 02543

97 WATER ST 49A 01 006 000
PINKYS MARINA II LLC LUC: 031
137 HAWKS HILL RD
NEW CANAAN, CT 06840

86 WATER ST



GOSNOLD RD
SPENCER BAIRD RD
GARDINER RD
BAR NECK RD
ALBATROSS ST
NORTH ST
MBL ST
WATER ST
MILLFIELD ST
SCHOOL ST
MAURY LN
RAILROAD AVE
COWDRY RD
BUTLER ST
JUNIPER POINT RD
HINCKLEY RD
49A 04 056A 000
49A 01 039 001
49A 01 032 029B
49A 01 000 000E
49A 01 018 017
49A 02 000H 000
49A 01 007 000
49A 02 000H 000B
49A 01 054 000
49A 01 055 000D
51A 01 008 000
51A 01 045 000
51A 01 044 000
51A 01 044A 000
51A 01 041 000A
51A 01 040 000B
51A 01 037 002A
51A 01 037 003A
51A 01 037 001A
51A 01 038 000

Attachment J

Filing Fee Information

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

NOI Wetland Fee Transmittal Form

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A. Applicant Information

1. Location of Project:

86 Water Street	Falmouth
a. Street Address	b. City/Town
43770	$962.50
c. Check number	d. Fee amount

2. Applicant Mailing Address:

a. First Name		b. Last Name	
Woods Hole Oceanographic Institution			
c. Organization			
569 Woods Hole Road			
d. Mailing Address			
Falmouth (Woods Hole)		MA	02543
e. City/Town		f. State	g. Zip Code
h. Phone Number	i. Fax Number	j. Email Address	

3. Property Owner (if different):

a. First Name		b. Last Name	
c. Organization			
d. Mailing Address			
e. City/Town		f. State	g. Zip Code
h. Phone Number	i. Fax Number	j. Email Address	

To calculate filing fees, refer to the category fee list and examples in the instructions for filling out WPA Form 3 (Notice of Intent).

B. Fees

Fee should be calculated using the following process & worksheet. ***Please see Instructions before filling out worksheet.***

Step 1/Type of Activity: Describe each type of activity that will occur in wetland resource area and buffer zone.

Step 2/Number of Activities: Identify the number of each type of activity.

Step 3/Individual Activity Fee: Identify each activity fee from the six project categories listed in the instructions.

Step 4/Subtotal Activity Fee: Multiply the number of activities (identified in Step 2) times the fee per category (identified in Step 3) to reach a subtotal fee amount. Note: If any of these activities are in a Riverfront Area in addition to another Resource Area or the Buffer Zone, the fee per activity should be multiplied by 1.5 and then added to the subtotal amount.

Step 5/Total Project Fee: Determine the total project fee by adding the subtotal amounts from Step 4.

Step 6/Fee Payments: To calculate the state share of the fee, divide the total fee in half and subtract $12.50. To calculate the city/town share of the fee, divide the total fee in half and add $12.50.

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
NOI Wetland Fee Transmittal Form
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

B. Fees (continued)

Step 1/Type of Activity	Step 2/Number of Activities	Step 3/Individual Activity Fee	Step 4/Subtotal Activity Fee
Category 2J	1	$500.00	$500.00
Category 4H	1	$1,450.00	$1,450.00

Step 5/Total Project Fee: $1,950.00

Step 6/Fee Payments:

Total Project Fee:	$1,950.00 a. Total Fee from Step 5
State share of filing Fee:	$962.50 b. 1/2 Total Fee **less** $12.50
City/Town share of filling Fee:	$987.50 c. 1/2 Total Fee **plus** $12.50

C. Submittal Requirements

a.) Complete pages 1 and 2 and send with a check or money order for the state share of the fee, payable to the Commonwealth of Massachusetts.

Department of Environmental Protection
Box 4062
Boston, MA 02211

b.) **To the Conservation Commission:** Send the Notice of Intent or Abbreviated Notice of Intent; a **copy** of this form; and the city/town fee payment.

To MassDEP Regional Office (see Instructions): Send a copy of the Notice of Intent or Abbreviated Notice of Intent; a **copy** of this form; and a **copy** of the state fee payment. (E-filers of Notices of Intent may submit these electronically.)

CASH ONLY IF ALL CheckLock™ SECURITY FEATURES LISTED ON BACK INDICATE NO TAMPERING OR COPYING

EPSILON ASSOCIATES, INC.
3 MILL & MAIN PLACE
STE 250
MAYNARD, MA 01754

Middlesex Savings Bank
CONCORD, MA 01742
53-7122/2113

43770

5/17/2021

PAY TO THE ORDER OF Commonwealth of Massachusetts $ **962.50

Nine Hundred Sixty-Two and 50/100**DOLLARS

PROTECTED AGAINST FRAUD

PINK ICON DISAPPEARS WITH HEAT

Commonwealth of Massachusetts
P.O. Box 419272
Boston, MA 02441-9272

MEMO

MP

[redacted]

CASH ONLY IF ALL CheckLock™ SECURITY FEATURES LISTED ON BACK INDICATE NO TAMPERING OR COPYING

EPSILON ASSOCIATES, INC.
3 MILL & MAIN PLACE
STE 250
MAYNARD, MA 01754

Middlesex Savings Bank
CONCORD, MA 01742
53-7122/2113

43771

5/17/2021

PAY TO THE ORDER OF Town of Falmouth $ **987.50

Nine Hundred Eighty-Seven and 50/100**DOLLARS

PROTECTED AGAINST FRAUD

PINK ICON DISAPPEARS WITH HEAT

Town of Falmouth
59 Town Hall Square
Falmouth, MA 025400

MEMO

MP

[redacted]

CASH ONLY IF ALL CheckLock™ SECURITY FEATURES LISTED ON BACK INDICATE NO TAMPERING OR COPYING

EPSILON ASSOCIATES, INC.
3 MILL & MAIN PLACE
STE 250
MAYNARD, MA 01754

Middlesex Savings Bank
CONCORD, MA 01742
53-7122/2113

43772

5/17/2021

PAY TO THE ORDER OF Town of Falmouth $ **566.00

Five Hundred Sixty-Six and 00/100**DOLLARS

PROTECTED AGAINST FRAUD

PINK ICON DISAPPEARS WITH HEAT

Town of Falmouth
59 Town Hall Square
Falmouth, MA 025400

MEMO

MP

[redacted]

FALMOUTH CONSERVATION COMMISSION
59 Town Hall Square, Falmouth, Massachusetts 02540
(508) 495-7445 FAX (508) 495 -7449

Filing Fee Schedule (effective January 1, 2019)

Administrative Review (AR)	$50.00
Request for Determination of Applicability (RDA)	$100.00 + $16.00 = $116.00
RDA Resource Area Confirmation	$250.00
Notice of Intent (NOI)	
• Category 1 (single family –additions, pool, etc)	$100.00 + $16.00 = $116.00
• Category 1(a) (single family – Construction, including raze/rebuild)	$200.00 + $16.00 = $216.00
• Category 2 (Commercial/Other Conservation)	$300 + $16.00 = $316.00
• Category 3 (Coastal Projects – Including docks, dredging and seawall/revetments)	$550.00 + $16.00 = $566.00
• Category 4 (Road Crossings)	$450.00 + $16.00 = $466.00
• Category 5 (All other not included)	$2.50/linear foot
Continuance Fees	
• For review of revised plans	$75.00
• For additional site visit	$50.00
Amended Order of Conditions	$100.00 + $16.00 = $116.00
Extension Permit	$100.00
Certificate of Compliance Fees	
• First Request	$50.00
• Second Request	$100.00
• Third Request	$150.00
• Search Fee	$17.74 per hour
ANRAD	$2.00/linear foot
Application after the Fact	Double the listed fee
Re-Issuance of a Permit	$25.00
Advertising Fee	$16.00
Administrative Review (AR)	$50.00

General Information

1. Permit fees shall be calculated by the Commission according to the schedule below. The fees shown include the $16.00 advertising fee, (subject to change). Fees should be made payable to the Town of Falmouth
2. Please be advised that the following reflect the Falmouth Wetlands Bylaw fee only, additional fees associated with the Massachusetts Wetlands Protection Act (WPA) may also apply.
3. No Certificate of Compliance shall be issued under the Falmouth Wetlands Bylaw if any required fee has not been paid to the town.
4. Permit fees are payable at the time of the application and are non-refundable.

Attachment K

Project Plans

Woods Hole Oceanographic INSTITUTION

86 WATER STREET - WOODS HOLE , MA 02543

CWATER PROJECT
ISELIN DOCK REPLACEMENT
30% STRUCTURAL DESIGN PACKAGE

VICINITY MAP

LOCATION MAP

DRAWING INDEX	
DRAWING NUMBER	DRAWING TITLE
GENERAL	
G-001	COVER SHEET
G-101	EXISTING CONDITIONS PLAN
G-102	OVERALL SITE PLAN
G-103	MOORING ARRANGEMENT PLAN - 1
G-104	MOORING ARRANGEMENT PLAN - 2
DEMOLITION	
SD101	OVERALL STRUCTURAL DEMOLITION PLAN
SD102	STRUCTURAL DOCK FRAMING DEMOLITION PLAN
SD301	EXISTING DOCK LONGITUDINAL SECTION
SD302	EXISTING DOCK CROSS SECTION
STRUCTURAL	
S-001	STRUCTURAL GENERAL NOTES
S-101	ISELIN DOCK DECK PLAN
S-102	ALTERNATIVE 1 DOCK FRAMING PLAN HYDRAULIC LIFT WITH PILE CAPITALS
S-102A	ALTERNATIVE 2 DOCK FRAMING PLAN CONCRETE DECK OVERLAY WITH LINEAR PILE CAPS
S-103	SMALL CRAFT FLOATING DOCK PLAN
S-104	ROBOTICS VEHICLE FLOATING DOCK PLAN
S-201	ISELIN DOCK ELEVATIONS (1 OF 2)
S-202	ISELIN DOCK ELEVATIONS (2 OF 2)
S-301	ISELIN DOCK LONGITUDINAL SECTION
S-302	ISELIN DOCK TRANSVERSE SECTION
S-303	BULKHEAD WALL CROSS SECTIONS
S-501	ALTERNATIVE 1 DOCK HYDRAULIC LIFT WITH PILE CAPITALS TYPICAL DETAILS
S-501A	ALTERNATIVE 2 DOCK CONCRETE DECK OVERLAY WITH LINEAR PILE CAPS TYPICAL DETAILS
S-502	PILE SCHEDULE
S-503	ISELIN DOCK TYPICAL DETAILS
S-504	TEST WELL DETAILS
S-505	FLOATING DOCK TYPICAL SECTION AND ELEVATION
S-506	FLOATING DOCK TYPICAL DETAILS
S-507	ALUMINUM GANGWAY TYPICAL DETAILS
S-508	WAVE SCREEN TYPICAL DETAILS
S-509	JIB CRANE DETAILS

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

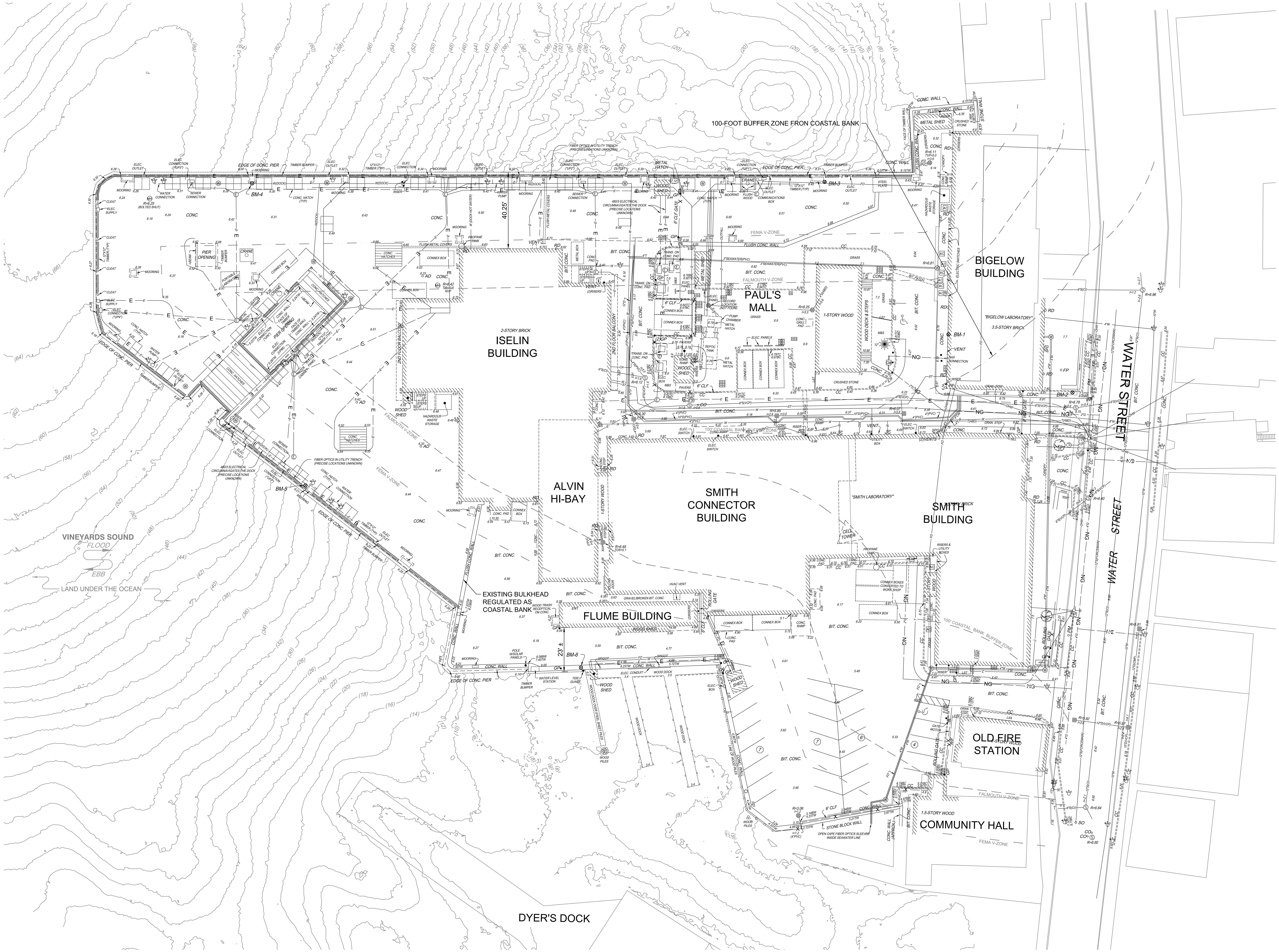
COVER SHEET

Drawing Scale

Project Number

Date Issued
05/12/2021

G-001



moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

EXISTING CONDITIONS PLAN

Drawing Scale

Project Number

Date Issued
05/12/2021

G-101

1 G-101 EXISTING CONDITIONS PLAN
SCALE: 1" = 20'

NOTE:

1. BATHYMETRIC DATA SHOWN WAS GATHERED ON DECEMBER 14, 2017 BY STEELE ASSOCIATES MARINE CONSULTANTS, LLC. HORIZONTAL DATUM IS MASSACHUSETTS STATE PLANE MAINLAND ZONE, NAD 83. VERTICAL DATUM WAS ORIGINALLY MEAN LOWER LOW WATER, 1983-2001 TIDAL EPOCH, AND WAS CONVERTED TO NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) FOR THIS PLAN SET.
2. TOPOGRAPHIC DATA SHOWN IS BASED ON SURVEY PERFORMED BY FELDMAN SURVEY IN 2020. HORIZONTAL DATUM IS MASSACHUSETTS STATE PLANE MAINLAND ZONE, NAD 83. VERTICAL DATUM IS NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).

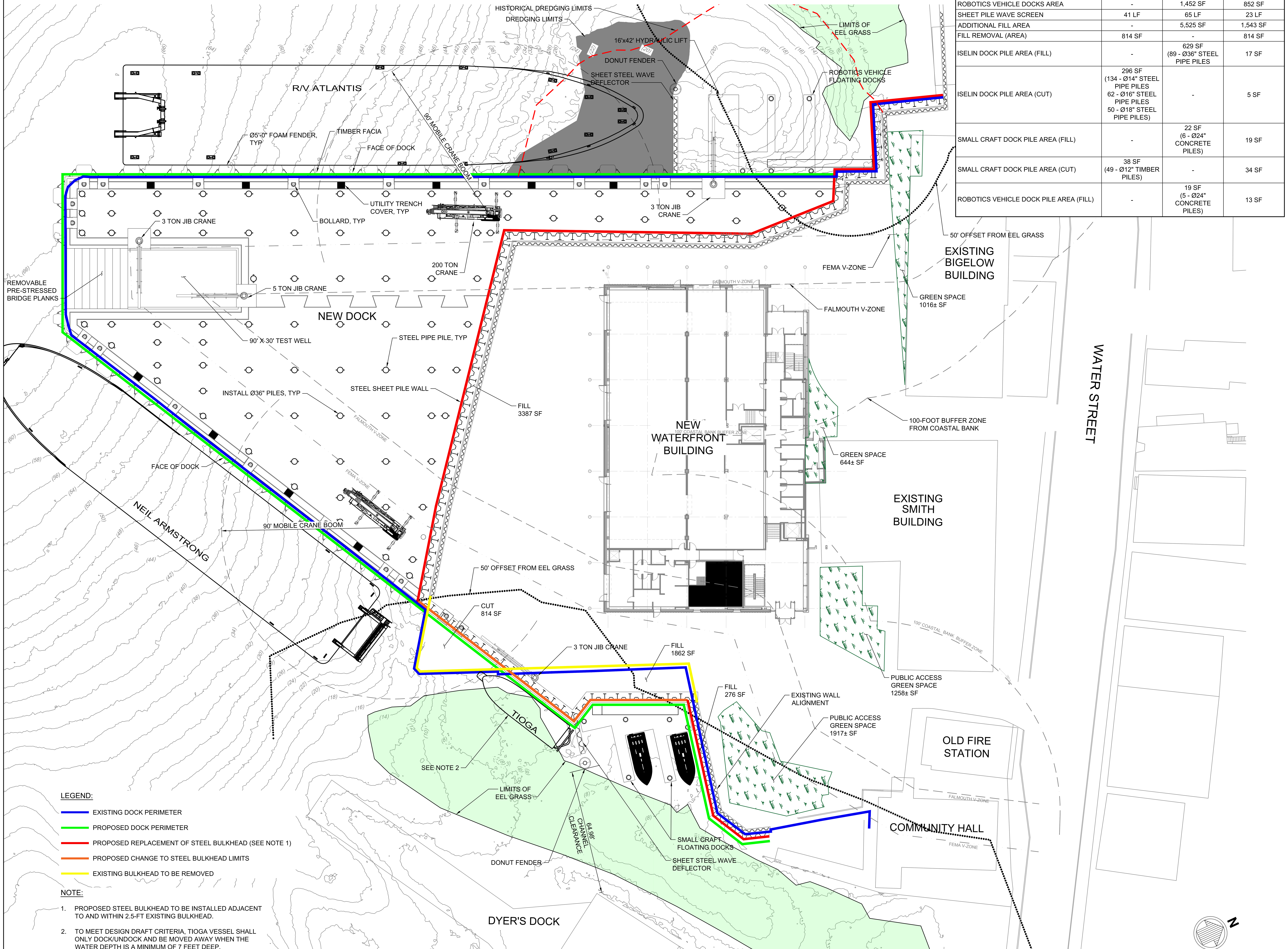
20' 0' 20' 40'
SCALE: 1"=20'

VESSEL STATISTICS AND DREDGE DATA

VESSEL NAME	LOA	BEAM	DWT	DRAFT	UNDERKEEL CLEARANCE	NAVD88 - MLW	MIN REQUIRED ELEV. (NAVD88)	DESIGN DREDGE ELEV. (NAVD88)	DREDGE VOLUME	DREDGE VOLUME WITHIN 50 FT OF EEL GRASS	DREDGE AREA	DREDGE AREA WITHIN 50 FT OF EEL GRASS
R/V ATLANTIS	274 FT	52.5 FT	3,510 LONG TONS	-19 FT	-2 FT	-1.22 FT	-22.22 FT	-23.00 FT	420 CY	30 CY	4,850 SF	310 SF
R/V NEIL ARMSTRONG	238 FT	50 FT	3,204 LONG TONS	-15 FT	-2 FT	-1.22 FT	-18.22 FT	-19.00 FT	-	-	-	-
R/V TIOGA	60 FT	17 FT	53 LONG TONS	-5 FT	-2 FT	-1.22 FT	-8.22 FT	-9.00 FT	-	-	-	-

DOCK DATA

DESCRIPTION	EXISTING	PROPOSED	WITHIN 50 FT OF EEL GRASS
ISELIN DOCK AREA	38,580 SF	38,055 SF	811 SF
BULKHEAD WALL ADDITION	-	830 LF	445 LF
BULKHEAD WALL REMOVAL	203 LF	-	150 LF
SMALL CRAFT BOAT DOCK AREA	914 SF	1,108 SF	1,090 SF
ROBOTICS VEHICLE DOCKS AREA	-	1,452 SF	852 SF
SHEET PILE WAVE SCREEN	41 LF	65 LF	23 LF
ADDITIONAL FILL AREA	-	5,525 SF	1,543 SF
FILL REMOVAL (AREA)	814 SF	-	814 SF
ISELIN DOCK PILE AREA (FILL)	-	629 SF (89 - Ø36" STEEL PIPE PILES	17 SF
ISELIN DOCK PILE AREA (CUT)	296 SF (134 - Ø14" STEEL PIPE PILES 62 - Ø16" STEEL PIPE PILES 50 - Ø18" STEEL PIPE PILES)	-	5 SF
SMALL CRAFT DOCK PILE AREA (FILL)	-	22 SF (6 - Ø24" CONCRETE PILES)	19 SF
SMALL CRAFT DOCK PILE AREA (CUT)	38 SF (49 - Ø12" TIMBER PILES)	-	34 SF
ROBOTICS VEHICLE DOCK PILE AREA (FILL)	-	19 SF (5 - Ø24" CONCRETE PILES)	13 SF



LEGEND:

- EXISTING DOCK PERIMETER
- PROPOSED DOCK PERIMETER
- PROPOSED REPLACEMENT OF STEEL BULKHEAD (SEE NOTE 1)
- PROPOSED CHANGE TO STEEL BULKHEAD LIMITS
- EXISTING BULKHEAD TO BE REMOVED

NOTE:

1. PROPOSED STEEL BULKHEAD TO BE INSTALLED ADJACENT TO AND WITHIN 2.5-FT EXISTING BULKHEAD.
2. TO MEET DESIGN DRAFT CRITERIA, TIOGA VESSEL SHALL ONLY DOCK/UNDOCK AND BE MOVED AWAY WHEN THE WATER DEPTH IS A MINIMUM OF 7 FEET DEEP.

1 G-102 OVERALL SITE PLAN
SCALE: 1" = 20'

20' 0' 20' 40'
SCALE: 1"=20'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

OVERALL SITE PLAN

Drawing Scale

Project Number

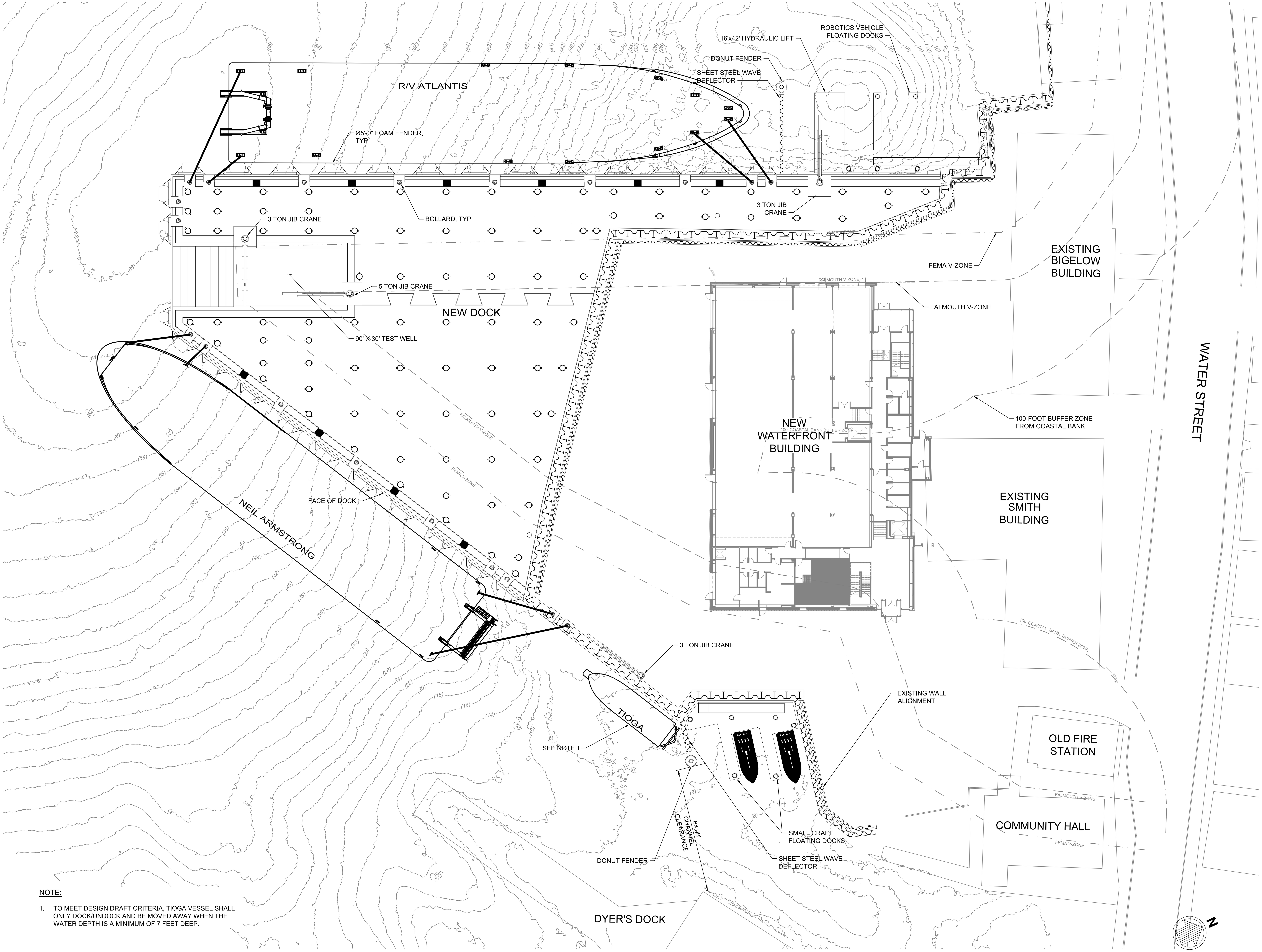
Date Issued
05/12/2021

G-102

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106



NOTE:

1. TO MEET DESIGN DRAFT CRITERIA, TIOGA VESSEL SHALL ONLY DOCK/UNDOCK AND BE MOVED AWAY WHEN THE WATER DEPTH IS A MINIMUM OF 7 FEET DEEP.

1 / G-103 OVERALL SITE PLAN
SCALE: 1" = 20'

SCALE: 1"=20'

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
A	5/28/21	NOI SUBMISSION

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

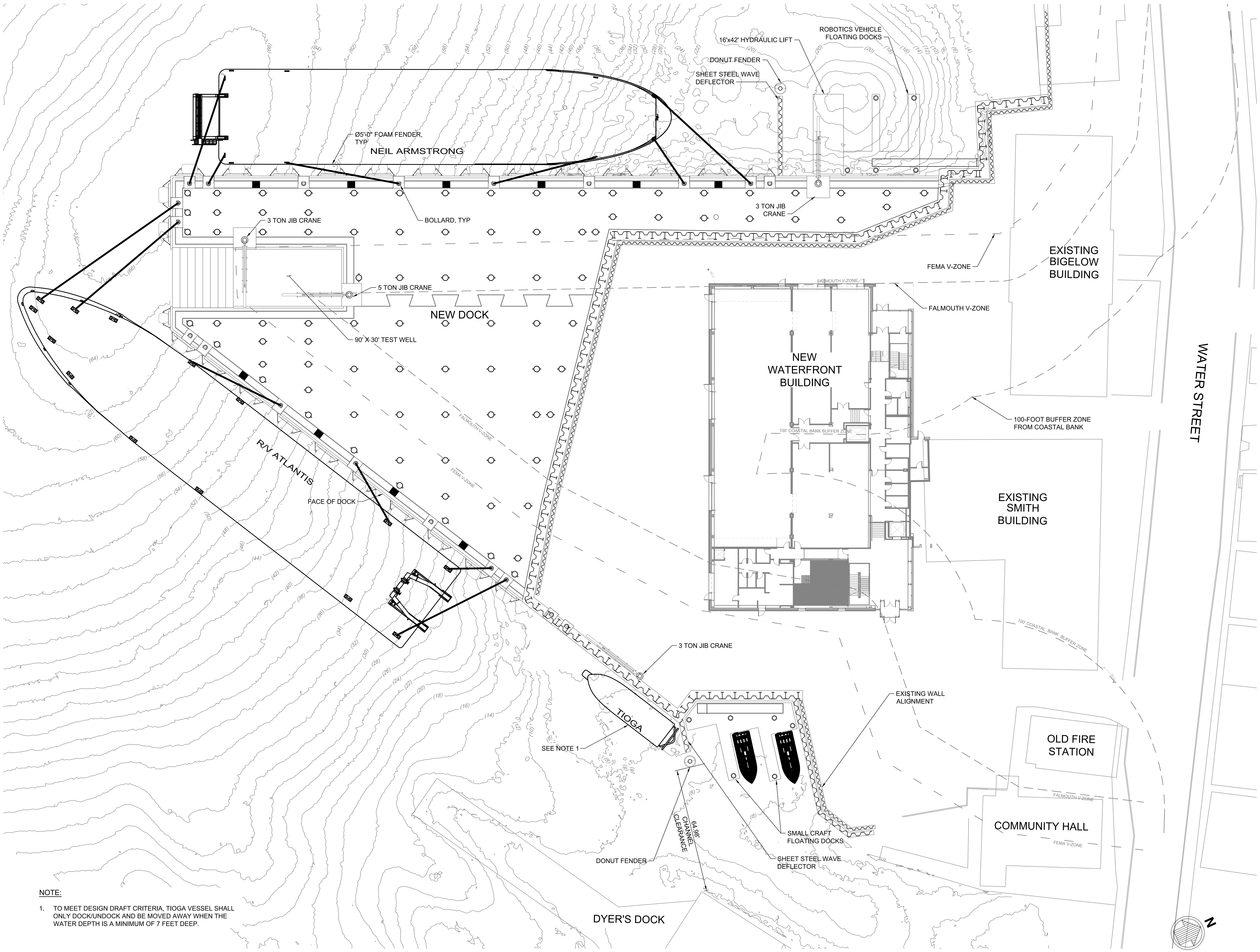
MOORING ARRANGEMENT PLAN - 1

Drawing Scale

Project Number

Date Issued
05/12/2021

G-103



NOTE:

1. TO MEET DESIGN DRAFT CRITERIA, TIOGA VESSEL SHALL ONLY DOCK/UNDOCK AND BE MOVED AWAY WHEN THE WATER DEPTH IS A MINIMUM OF 7 FEET DEEP.

1 G-104 OVERALL SITE PLAN
SCALE: 1" = 20'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
A	5/28/21	NOI SUBMISSION

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

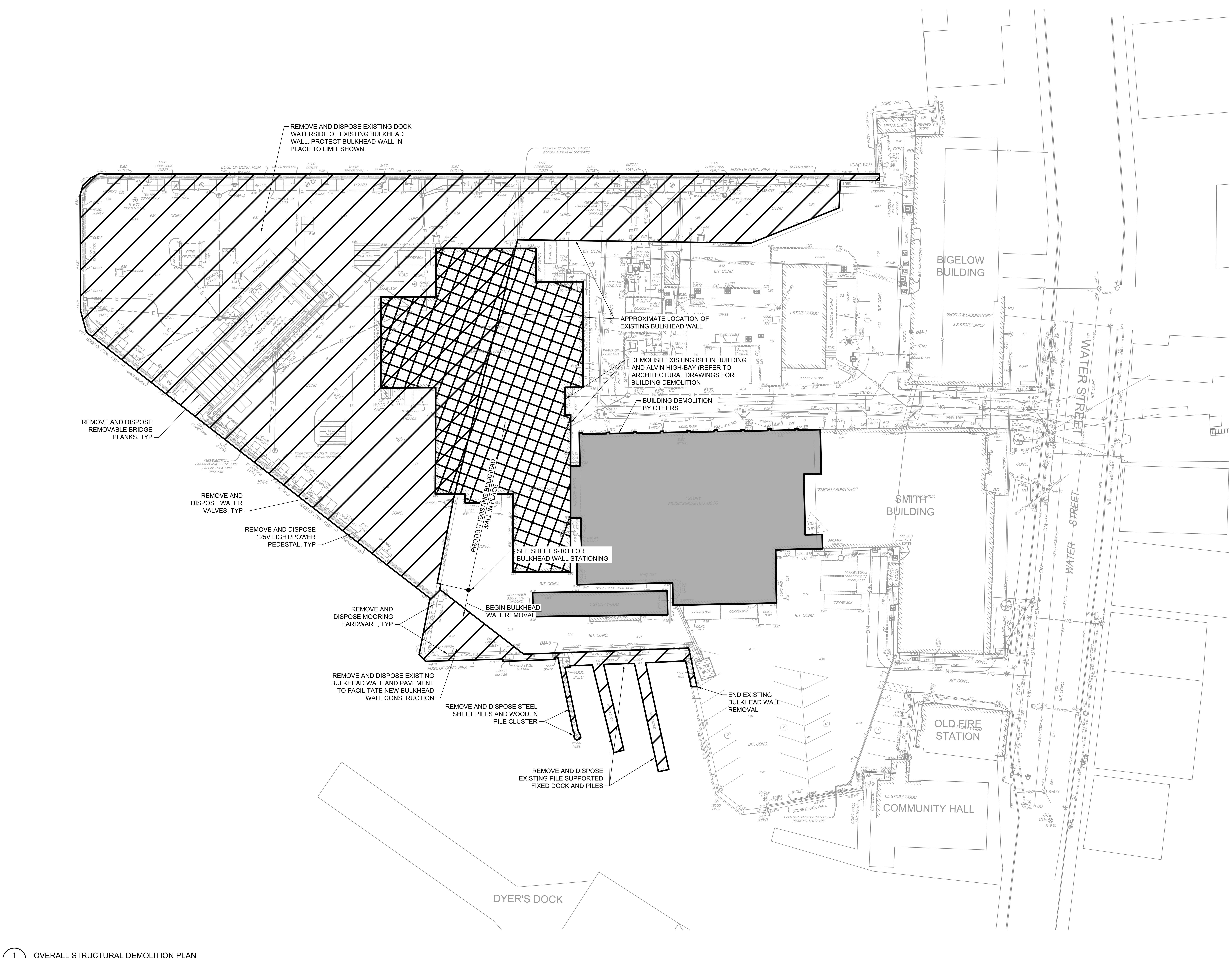
MOORING ARRANGEMENT PLAN - 2

Drawing Scale

Project Number

Date Issued
05/12/2021

G-104



1 SD101 OVERALL STRUCTURAL DEMOLITION PLAN
SCALE: 1" = 20'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

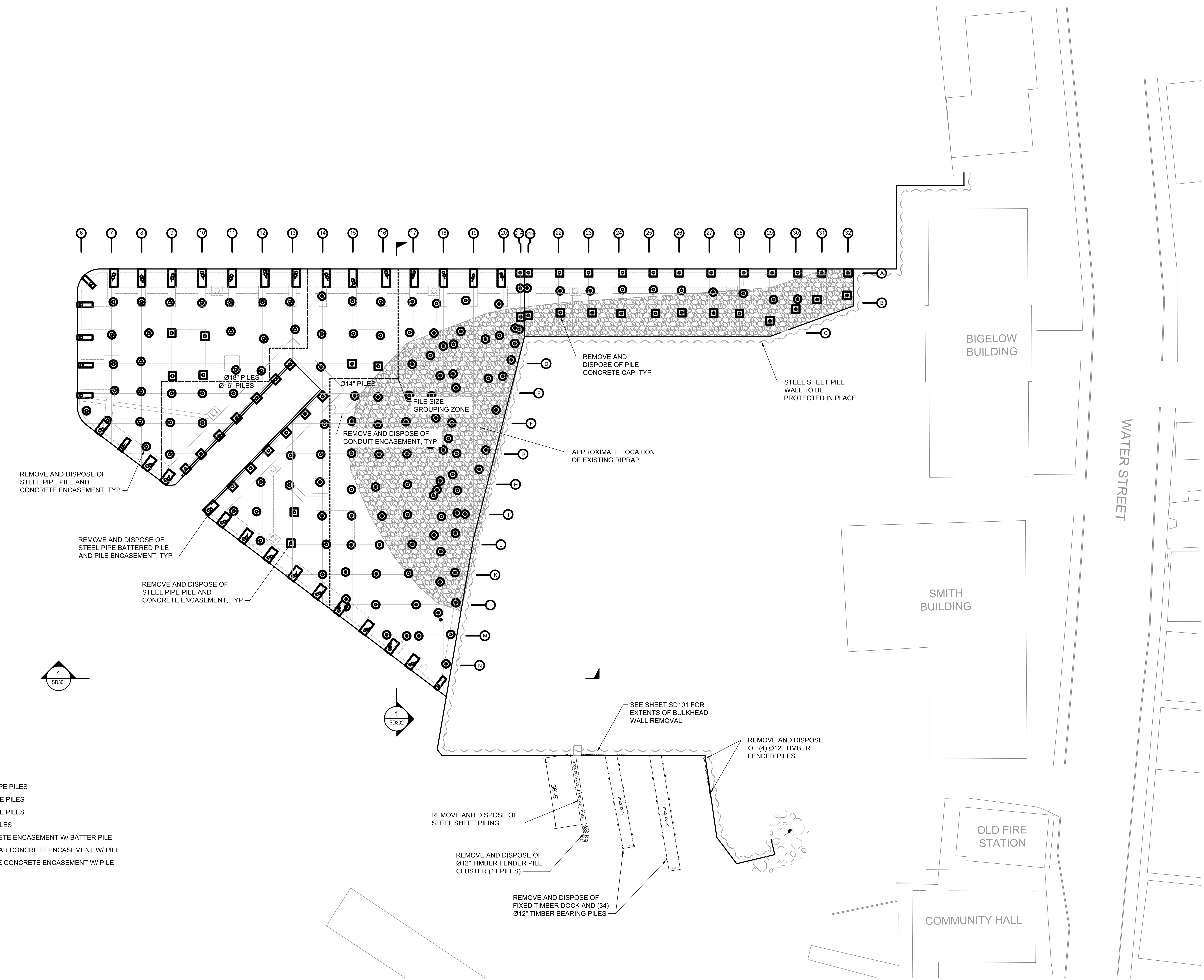
OVERALL STRUCTURAL DEMOLITION PLAN

Drawing Scale

Project Number

Date Issued
05/12/2021

SD101



REMOVE:

134 - Ø14" STEEL PIPE PILES
62 - Ø16" STEEL PIPE PILES
50 - Ø18" STEEL PIPE PILES
49 - Ø12" TIMBER PILES
34 - CONCRETE ENCASEMENT W/ BATTER PILE
138 - CIRCULAR CONCRETE ENCASEMENT W/ PILE
47 - SQUARE CONCRETE ENCASEMENT W/ PILE

1 SD102 STRUCTURAL DOCK FRAMING DEMOLITION PLAN
SCALE: 1" = 20'

NOTE
1. PILE SIZE VARIES FROM 14" TO 18" IN DIAMETER.

20' 0' 20' 40'
SCALE: 1"=20'

moffatt & nichol
Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

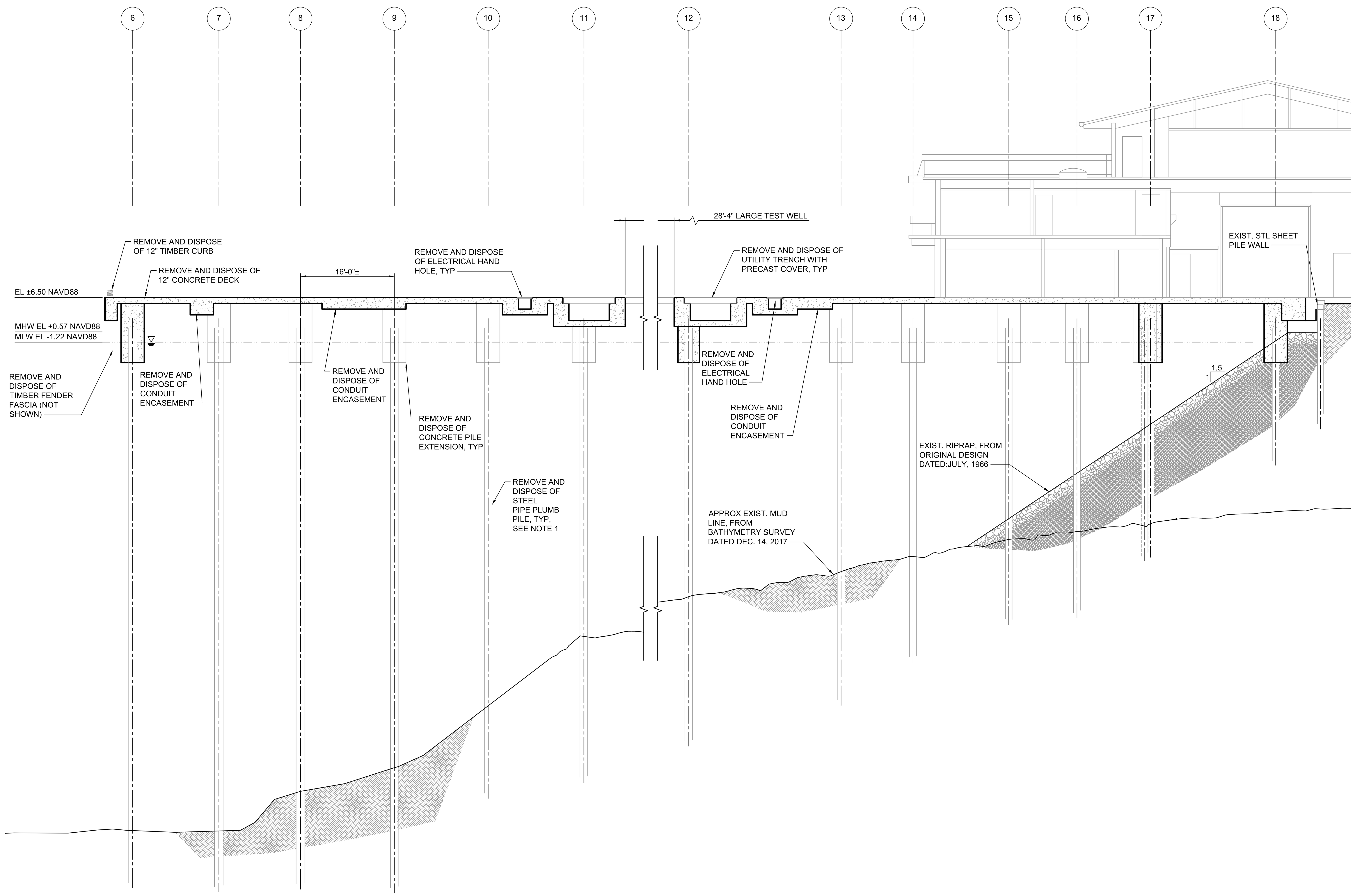
STRUCTURAL DOCK FRAMING DEMOLITION PLAN

Drawing Scale

Project Number

Date Issued
05/12/2021

SD102



1 SD102 EXISTING DOCK LONGITUDINAL SECTION
SCALE: 1/8" = 1'-0"

NOTE

1. PILE SIZE VARIES FROM 14" TO 18" IN DIAMETER.

8'-0" 0'-0" 8'-0" 16'-0"
SCALE: 1/8"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

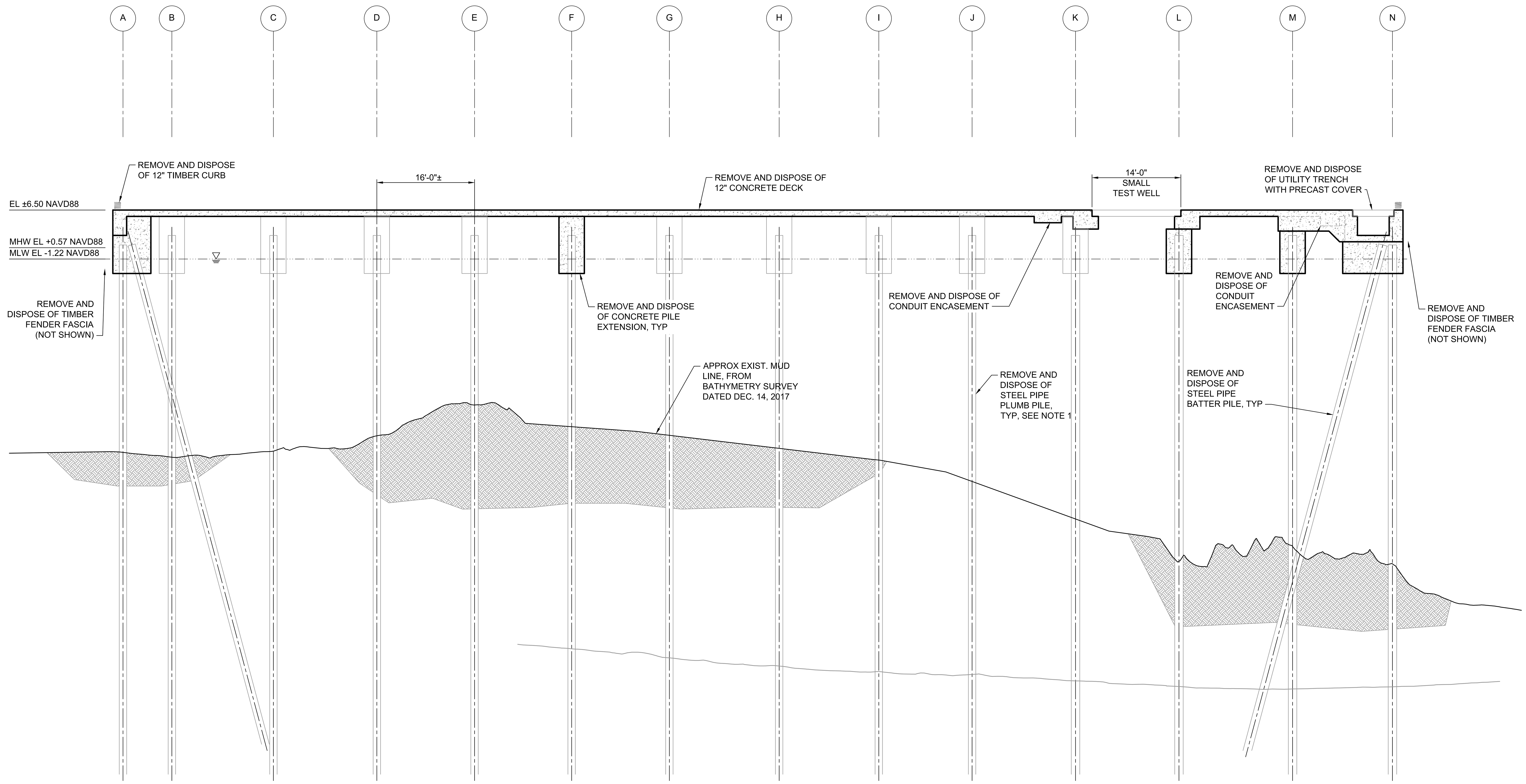
EXISTING DOCK LONGITUDINAL SECTION

Drawing Scale

Project Number

Date Issued
05/12/2021

SD301



1 SD102 EXISTING DOCK CROSS SECTION
SCALE: 1/8" = 1'-0"

NOTE

1. PILE SIZE VARIES FROM 14" TO 18" IN DIAMETER.

8'-0" 0'-0" 8'-0" 16'-0"
SCALE: 1/8"=1'-0"

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

EXISTING DOCK CROSS SECTION

Drawing Scale

Project Number

Date Issued
05/12/2021

SD302

DESIGN CRITERIA

1. VERTICAL DESIGN LOADS

   A. DEAD LOAD: THE PIER SELF WEIGHT AND ALL SUPERIMPOSED LOADS TRANSMITTED BY ANY PERMANENTLY ATTACHED EQUIPMENT AND APPURTENANCES.

   B. LIVE LOAD: 800 PSF UNIFORM LIVE LOAD, WHEN COMBINED WITH OPERATIONAL MOORING LOADS.
   100 PSF UNIFORM LIVE LOAD, WHEN COMBINED WITH EXTREME MOORING LOADS.

   C. VEHICLE LOAD: MAX CRANE OUTRIGGER POINT LOADING OF 203 KIP FOR SINGLE OUTRIGGER; ASSOCIATED WITH 200 TON CRANE (CRANE MANUFACTURER GROVE MODEL NO. GMK5180).

   D. SNOWLOAD: 25 PSF UNIFORM GROUND SNOW.

2. WAVE DESIGN CRITERIA:

   100 YEAR EVENT:
   (EXTREME) Hs = 5.3 FEET
   Tp = 4.3 SECONDS
   50 YEAR EVENT:
   (OPERATIONAL) Hs = 4.8 FEET
   Tp = 4.0 SECONDS

   Hs = SIGNIFICANT WAVE HEIGHT
   Tp = PEAK SPECTRAL PERIOD

3. ATMOSPHERIC ICE LOADS: 1.0 IN THICKNESS, 50 MPH GUST SPEED, IN ACCORDANCE WITH ASCE 7-10.

4. WIND LOADS:

   100 YEAR EVENT:
   (EXTREME) 140 MPH, BASED ON 3-SECOND GUST, RISK CATEGORY II, EXPOSURE D

   50 YEAR EVENT:
   (OPERATIONAL) 105 MPH, BASED ON 3-SECOND GUST, RISK CATEGORY II, EXPOSURE D

5. CURRENT LOADS: 1.0 FT/S

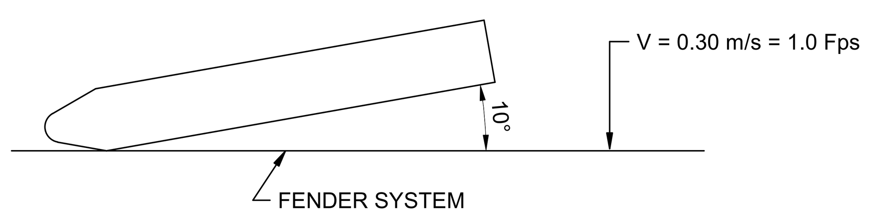
6. SEISMIC DESIGN CRITERIA:
   THE PIER STRUCTURE SHALL BE DESIGNED TO RESIST APPLICABLE EARTHQUAKE MOTIONS IN ACCORDANCE WITH ASCE 7-10 CODE FOR THE FALMOUTH, MA AREA.

   A. SEISMIC DESIGN CATEGORY = B
   B. SPECTRAL RESPONSE ACCELERATIONS:
   C. Ss = 0.169g
   D. S1 = 0.049g
   E. SITE CLASS = D
   F. RESPONSE MODIFICATION FACTOR R = 3.0

7. MOORING HARDWARE CAPACITY:

   A. BOLLARDS: 100 TON, MAX LINE PULL, MOORING SERVICE TYPE IV FOR DESIGN VESSEL AS PER NAVFAC UFC 4-159-03 TABLE 3-5

8. BERTHING DESIGN LOADS:



   V = THE SHIP APPROACH VELOCITY PERPENDICULAR TO THE FENDER LINE.

   10° MAXIMUM BERTHING APPROACH ANGLE
   ABNORMAL BERTHING FACTOR = 1.6

   DESIGN VESSEL DATA:
   VESSEL DESIGNATION: R/V ATLANTIS
   LOA = 274 FT
   BEAM = 52.5 FT
   DRAFT = 19 FT
   DWT = 3,510 LONG-TONS

   VESSEL DESIGNATION: R/V NEIL ARMSTRONG
   BEAM = 50 FT
   DRAFT = 15 FT

DESIGN CODES & REFERENCES

A. MASSACHUSETTS STATE BUILDING CODE, 780 CMR, 9TH EDITION

B. IBC - 2015 (INTERNATIONAL BUILDING CODE)

C. ASCE 7-10 (AMERICAN SOCIETY OF CIVIL ENGINEERS)

D. UFC 4-152-01, 2017 DESIGN: PIERS AND WHARVES (UNIFIED FACILITIES CRITERIA)

E. ACI 318-14, 2011 (AMERICAN CONCRETE INSTITUTE)

F. AISC-LRFD-14th EDITION (AMERICAN INSTITUTE OF STEEL CONSTRUCTION)

G. AWS D1.1 2010 STRUCTURAL WELDING CODE - STEEL (AMERICAN WELDING SOCIETY)

H. NDS-2015 (NATIONAL DESIGN SPECIFICATIONS FOR WOOD CONSTRUCTION)

I. API-1995 (AMERICAN PETROLEUM INSTITUTE) RECOMMENDED PRACTICE, 2nd EDITION, FOR PLANNING, DESIGNING, AND CONSTRUCTING STRUCTURES AND PIPELINES FOR ARCTIC CONDITIONS.

TIMBER CONSTRUCTION

1. ALL TIMBER CONSTRUCTION SHALL CONFORM TO THE RECOMMENDATIONS OF THE NDS AND AMERICAN INSTITUTE OF TIMBER CONSTRUCTION.

2. BOLTS AND NUTS SHALL CONFORM TO ASTM A 307 GALV, UNO.

3. WASHERS SHALL BE GALVANIZED OGEE AND SHALL CONFORM TO ASTM A 48.

4. ALL TIMBER SHALL CONFORM TO SOUTHERN PINE NO. 1 AND BTR, IN ACCORDANCE WITH SOUTERN PINE INSPECTION BUREAU (SPIB) GRADING RULES AND THERE SHALL BE NO LOOSE KNOTS OR OTHER DEFECTS, GRADE S4S.

5. ALL TIMBER SHALL BE PRESSURE TREATED WITH ACQ (ALKALINE COPPER QUATERNARY) TO A MINIMUM NET RETENTION VALUE OF 0.60 LBS/FT³.

6. ALL HOLES SHALL BE PREDRILLED AS REQUIRED ACCORDING TO THE REQUIREMENTS OF THE NDS.

CONCRETE AND REINFORCING STEEL

1. ALL CONCRETE WORK SHALL BE PERFORMED IN ACCORDANCE WITH ACI 318 UNLESS NOTED OTHERWISE . ALL DETAILING, FABRICATION, AND ERECTION OF REINFORCING STEEL SHALL CONFORM TO THE ACI MANUAL OF STANDARD PRACTICE FOR DETAILING REINFORCED CONCRETE STRUCTURES, ACI 315, AND ACI SP66.

2. ALL CONCRETE SHALL BE NORMAL WEIGHT CONCRETE (145 PCF).

3. MATERIALS SHALL CONFORM TO THE FOLLOWING, UNLESS NOTED OTHERWISE:

   A. CONCRETE: (28 DAY STRENGTH)

      a. CAST-IN-PLACE CONCRETE .... 5000 PSI
      b. CEMENTITIOUS GROUT (UNO) .... 7000 PSI
      c. PRECAST CONCRETE .... 5000 PSI

   B. REINFORCING:

      a. REINFORCING STEEL AND DOWELS FOR CONCRETE, ... MMFX CHROMEX GRADE 60 OR GRADE 70 (UNO)
      b. REINFORCING STEEL, WELDABLE .... ASTM A 706 GRADE 60

4. PROVIDE CALCIUM NITRITE IN THE PRECAST CONCRETE PANELS, BENT CAP, AND EDGE BEAM FOR CHLORIDE ION PROTECTION AS PER SPECIFICATIONS.

5. CHAMFER ALL EXPOSED EXTERNAL CORNERS OF CONCRETE WITH 45°, 3/4 IN CHAMFERS, UNLESS NOTED OTHERWISE.

6. THE CONCRETE CLEAR COVER FOR THE REINFORCING SHALL BE 3 INCHES, UNLESS NOTED OTHERWISE.

7. ALL CONSTRUCTION JOINTS BETWEEN CAST-IN-PLACE AND/OR PRECAST CONCRETE SHALL BE BONDED WITH AN EPOXY BONDING AGENT, EXCEPT TOP SURFACE OF PRECAST SLAB WHERE SHEAR TIES ARE EXTENDED. PRECAST BONDING SURFACES SHALL HAVE A ROUGHENED SURFACE OF 1/4 INCH AMPLITUDE, TYP.

8. SHEAR KEYS BETWEEN PRECAST PANELS SHALL BE FILLED WITH 5000 PSI CONCRETE WITH A MAX 3/8" AGGREGATE PRIOR TO PLACING CONCRETE TOPPING.

9. ALL CONCRETE SURFACES SHALL HAVE A BROOMED FINISH (UNO). ALL REINFORCING BAR SPLICES SHALL BE CLASS "B" TENSION LAP SPLICES IN ACCORDANCE WITH ACI 318, CHAPTER 12, UNLESS NOTED OTHERWISE.

LAP SPLICES OF REINFORCING BARS F'c = 5000 PSI			
BAR SIZE	LAP CLASS	TOP BARS	OTHER BARS
#3	B	22"	17"
#4	B	29"	23"
#5	B	36"	28"
#6	B	43"	34"
#7	B	63"	49"
#8	B	72"	56"
#9	B	81"	63"
#10	B	90"	69"

10. SPLICING SHALL OCCUR @ 1/3 POINTS OF THE SPAN PER ACI 318 CHAPTER 21. SPLICING OVER JOINTS IS NOT PERMITTED.

11. PER ACI 318, CHAPTER 21, ALL LONGITUDINAL REINFORCING SPLICE LOCATIONS ALONG THE BENT CAP SHALL BE CONFINED WITH STIRRUPS SPACED NO LESS THAN 4" O.C.

12. TERMINATE ALL LONGITUDINAL TOP BARS ALONG BENT CAPS WITH A STANDARD 90° OR 180° HOOK OR TERMINATOR.

13. LIFTING INSERTS SHALL BE PROVIDED IN ALL APPLICABLE PRECAST MEMBERS TO FACILITATE LIFTING AND SUPPORTING MEMBERS DURING ERECTION. ADDITIONAL REINFORCING STEEL SHALL BE PROVIDED AS NECESSARY TO PREVENT CRACKING DURING HANDLING, DELIVERY, AND ERECTION.

STRUCTURAL AND MISCELLANEOUS METALS

1. ALL STEEL WORK SHALL BE PERFORMED IN ACCORDANCE WITH THE AISC SPECIFICATIONS FOR THE DESIGN, FABRICATION, AND ERECTION OF STRUCTURAL STEEL FOR BUILDINGS (LRFD).

2. ALL WELDING SHALL CONFORM TO AWS D1.1.

3. STEEL MATERIALS SHALL CONFORM TO THE FOLLOWING, UNLESS NOTED OTHERWISE:

   A. STRUCTURAL CARBON STEEL (PIPE PILE) .... ASTM A 572, GRADE 50
   B. STRUCTURAL TUBING .... ASTM A 500, GRADE B, GALV
   C. ANCHOR BOLTS .... ASTM A 193-B7, GRADE 125, GALV
   D. MISC PLATES, BARS, AND SHAPES .... ASTM A 572, GRADE 50, GALV
   E. THREADED FASTENERS / ANCHOR RODS .... ASTM A 36, GALV
   F. MOORING HARDWARE .... MANUFACTURERS RECOMMENDATION
   G. MOORING HARDWARE ANCHOR BOLTS .... MANUFACTURERS RECOMMENDATION
   H. STEEL SHEET PILE .... REFER TO BULKHEAD WALL NOTES, SHEET S-303 AND WAVE SCREEN NOTES, SHEET S-508

4. ALL HARDWARE SHALL BE GALVANIZED BY THE HOT-DIPPED PROCESS IN ACCORDANCE WITH THE REQUIREMENTS OF ASTM A 123 AND/OR A 153, AS APPLICABLE, AFTER FABRICATION, UNLESS NOTED OTHERWISE.

5. HIGH-PERFORMANCE COATING SYSTEM. ALL STEEL PIPE PILES SHALL BE COATED WITH A CORROSION PROTECTION SYSTEM THAT MEETS THE FOLLOWING REQUIREMENTS:

   A. SURFACE PREPARATION AND COATING

      a. SURFACE PREPARATION OF STEEL: SSPC-SP10/NACE 2 (SEVERE EXPOSURE).
      b. BOTTOM COAT: FAST CLAD ER, B62 SERIES EPOXY AMINE AT 25.0 MILS DFT. BOTTOM COAT TO BE APPLIED IN THE SHOP.
      c. TOP COAT: SHER-LOXANE 800 SERIES POLYSILOXANE AT 5.0 MILS DFT. TOP COAT TO BE APPLIED IN THE SHOP.

   B. COLOR

      a. THE ENGINEER WILL SELECT COLOR FROM THE MANUFACTURERS FULL RANGE OF COLOR PRIOR TO APPLICATION.

   C. APPLICATION LENGTH

      a. APPLY COATING FOR EXPOSED LENGTH OF PILE ABOVE MUDLINE OR TOP 80FT OF PILE, WHICHEVER IS GREATER.

6. IN ADDITION TO THE HIGH PERFORMANCE COATING SYSTEM, ALL STEEL PIPE PILES SHALL BE WRAPPED WITH A MARINE GRADE PILING TAPE AND HDPE PILE JACKET SYSTEM. SYSTEM SHALL COMPOSE OF A BASE LAYER OF EPOXY ADHESIVE, DENSO PASTE S105 ADHESIVE, FOLLOWED BY A LAYER OF DENSO MARINE PILING TAPE, AS MANUFACTURED BY DENSOMARINE OR APPROVED EQUAL. IN ADDITION, PROVIDE AN HDPE PILE JACKET AROUND PILE COATING AND PILING TAPE SYSTEM AFTER INSTALLATION AS SHOWN ON THE DRAWINGS. PILE TAPE AND JACKET SYSTEM SHALL BE APPLIED OVER A MINIMUM TOP OF PILE TO 5FT BELOW THE DESIGN LOW WATER ELEVATION, OR TOP 10FT OF PILE, WHICHEVER IS GREATER. FINAL EXTERIOR COLOR TO BE SELECTED BY ENGINEER FROM MANUFACTURERS FULL RANGE OF COLOR PRIOR TO FABRICATION.

7. FIELD TREAT DAMAGED GALVANIZED FINISH WITH TWO COATS OF HIGH ZINC DUST OXIDE PAINT, COLD GALVANIZING COMPOUNDS, OR APPROVED EQUAL CONFORMING TO THE REQUIREMENTS OF ASTM A 780. IN ADDITION, ALL EXPOSED THREADED SURFACES SHALL BE PAINTED WITH TWO COATS OF HIGH ZINC DUST OXIDE PAINT AFTER INSTALLATION OF UNIT.

8. MOORING HARDWARE ON PIER SHALL BE PAINTED PER SPECIFICATIONS AND MANUFACTURERS RECOMMENDATION.

DESIGN WATER LEVELS

1. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) AS ELEVATION 0.00'.

2. THE PRESENT-DAY TIDAL AND WATER LEVEL DATUMS ARE SUMMARIZED IN THE TABLE BELOW. THE DESIGN ACCOUNTS FOR SEA LEVEL CHANGE USING THE FOLLOWING OFFSETS TO THE PRESENT-DAY WATER LEVELS:

   A. FOR A DECK ELEVATION OF +6.500', USE WATER LEVELS AS REPORTED IN THE TABLE.

   B. FOR A DECK ELEVATION OF +9.000', CONSIDER A RANGE OF WATER LEVELS BETWEEN 0 AND 2 FEET HIGHER THAN THE VALUES REPORTED IN THE TABLE (OTHER THAN DESIGN HIGH WATER).

   C. FOR A DECK ELEVATION OF +10.500', CONSIDER A RANGE OF WATER LEVELS BETWEEN 2 AND 4 FEET HIGHER THAN THE VALUES REPORTED IN THE TABLE (OTHER THAN DESIGN HIGH WATER).

   TABLE: TIDAL AND WATER LEVEL DATUMS FOR PRESENT-DAY CONDITIONS

DATUM	ELEVATION (FEET, NAVD88)
DESIGN HIGH WATER (100-YEAR FLOOD)	10.4
HIGHEST ASTRONOMICAL TIDE (HAT)	2.13
MEAN HIGHER HIGH WATER (MHHW)	1.11
MEAN HIGH WATER (MHW)	0.83
MEAN SEA LEVEL (MSL)	-0.11
MEAN LOW WATER (MLW)	-0.96
MEAN LOWER LOW WATER (MLLW)	-1.09

   NOTE: ALL ELEVATIONS HAVE BEEN CORRECTED TO REFLECT A BEST-ESTIMATE OF MEAN SEA LEVEL IN 2020.

3. TIDAL DATA IS NOT GUARANTEED TO REPRESENT CONDITIONS WHICH MAY OCCUR DURING CONSTRUCTION. ACTUAL WATER LEVELS MAY VARY FROM LEVELS INDICATED. THE CONTRACTOR IS RESPONSIBLE THEIR OWN ESTIMATES OF WATER LEVELS WHICH MAY OCCUR DURING CONSTRUCTION. VARIATION OF TIDAL LEVELS FROM THOSE INDICATED SHALL NOT BE CONSIDERED AS A CLAIM FOR ADDITIONAL COMPENSATION OR DELAY OF WORK.

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

STRUCTURAL GENERAL NOTES

Drawing Scale

Project Number
0000-XX

Date Issued
05/14/2021

S-001

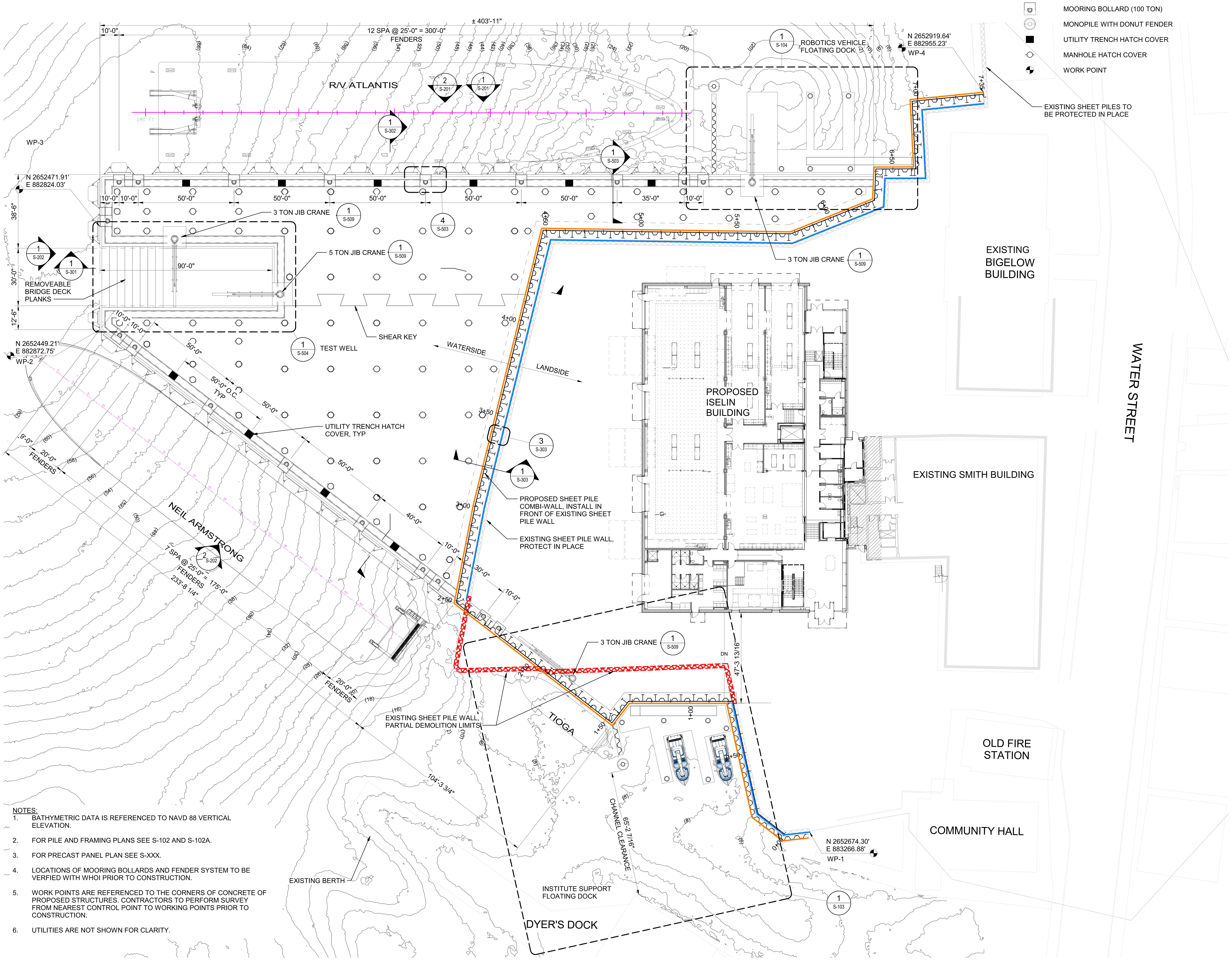
VESSEL STATISTICS

VESSEL NAME	LOA	BEAM	DRAFT	DWT
R/V ATLANTIS	274 FT	52.5 FT	19 FT	3,510 LONG TONS
R/V NEIL ARMSTRONG	238 FT	50 FT	15 FT	3,204 LONG TONS

NOTE:
VESSELS MAY BERTH ON EITHER SIDE OF WHARF. LOCATIONS OF SHIPS SHOW FOR SCHEMATIC PURPOSES ONLY.

LEGEND

- EXISTING BULKHEAD WALL LAYOUT (PROTECT IN PLACE)
- EXISTING BULKHEAD WALL LAYOUT (DEMOLISH)
- PROPOSED BULKHEAD WALL LAYOUT
- FOAM FENDER (5 FT DIA)
- MOORING BOLLARD (100 TON)
- MONOPILE WITH DONUT FENDER
- UTILITY TRENCH HATCH COVER
- MANHOLE HATCH COVER
- WORK POINT



NOTES:
1. BATHYMETRIC DATA IS REFERENCED TO NAVD 88 VERTICAL ELEVATION.
2. FOR PILE AND FRAMING PLANS SEE S-102 AND S-102A.
3. FOR PRECAST PANEL PLAN SEE S-XXX.
4. LOCATIONS OF MOORING BOLLARDS AND FENDER SYSTEM TO BE VERFIED WITH WHOI PRIOR TO CONSTRUCTION.
5. WORK POINTS ARE REFERENCED TO THE CORNERS OF CONCRETE OF PROPOSED STRUCTURES. CONTRACTORS TO PERFORM SURVEY FROM NEAREST CONTROL POINT TO WORKING POINTS PRIOR TO CONSTRUCTION.
6. UTILITIES ARE NOT SHOWN FOR CLARITY.

1 SITE PLAN
S-201 1" = 20'-0"

20' 0'-0" 20' 40'
SCALE: 1"=20'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

ISELIN DOCK DECK PLAN

Drawing Scale
1" = 20'-0"

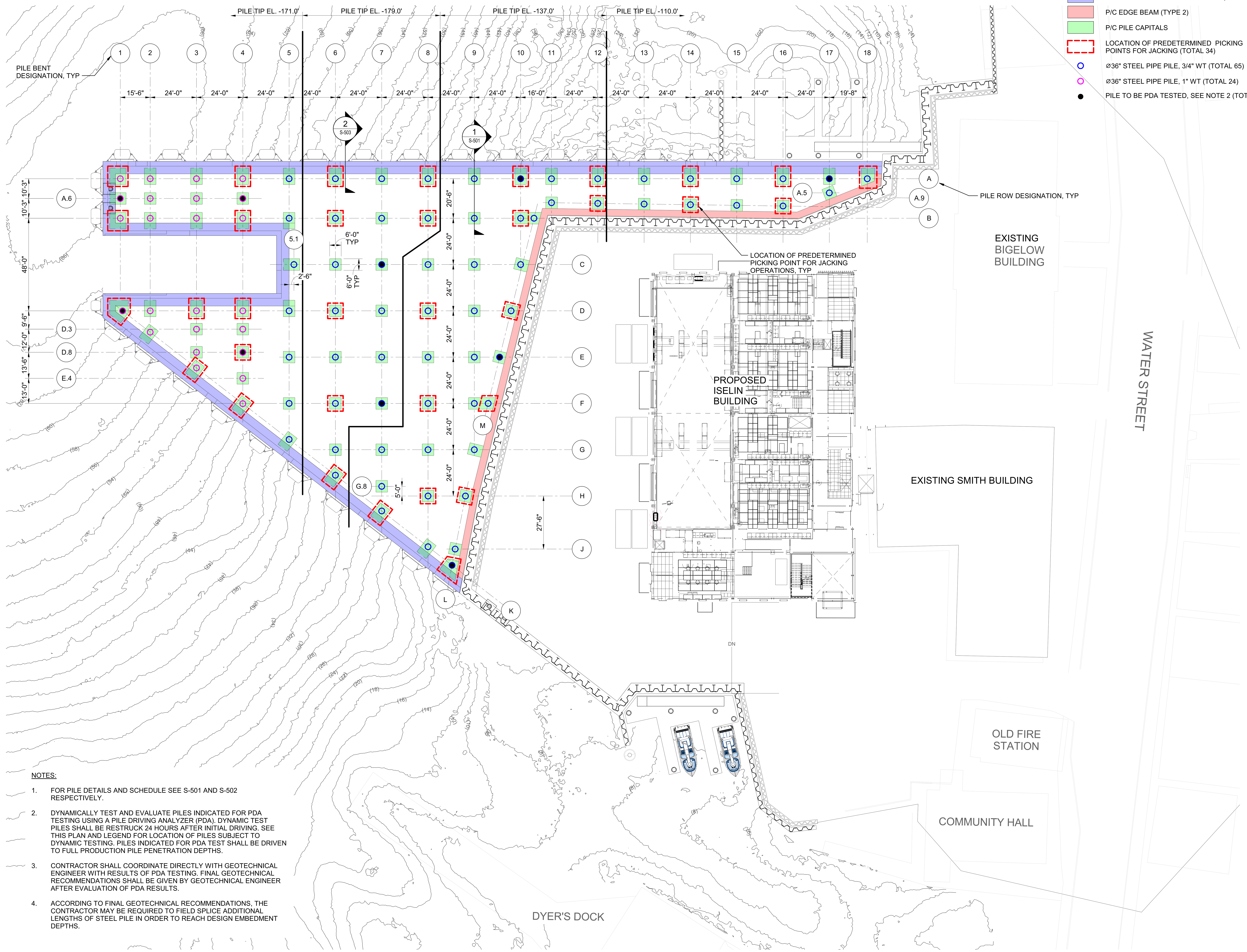
Project Number
0000-XX

Date Issued
05/14/2021

S-101

LEGEND

- P/C EDGE BEAM AND UTIL TRENCH (TYPE 1)
- P/C EDGE BEAM (TYPE 2)
- P/C PILE CAPITALS
- LOCATION OF PREDETERMINED PICKING POINTS FOR JACKING (TOTAL 34)
- Ø36" STEEL PIPE PILE, 3/4" WT (TOTAL 65)
- Ø36" STEEL PIPE PILE, 1" WT (TOTAL 24)
- PILE TO BE PDA TESTED, SEE NOTE 2 (TOTAL 10)



NOTES:

1. FOR PILE DETAILS AND SCHEDULE SEE S-501 AND S-502 RESPECTIVELY.
2. DYNAMICALLY TEST AND EVALUATE PILES INDICATED FOR PDA TESTING USING A PILE DRIVING ANALYZER (PDA). DYNAMIC TEST PILES SHALL BE RESTRUCK 24 HOURS AFTER INITIAL DRIVING. SEE THIS PLAN AND LEGEND FOR LOCATION OF PILES SUBJECT TO DYNAMIC TESTING. PILES INDICATED FOR PDA TEST SHALL BE DRIVEN TO FULL PRODUCTION PILE PENETRATION DEPTHS.
3. CONTRACTOR SHALL COORDINATE DIRECTLY WITH GEOTECHNICAL ENGINEER WITH RESULTS OF PDA TESTING. FINAL GEOTECHNICAL RECOMMENDATIONS SHALL BE GIVEN BY GEOTECHNICAL ENGINEER AFTER EVALUATION OF PDA RESULTS.
4. ACCORDING TO FINAL GEOTECHNICAL RECOMMENDATIONS, THE CONTRACTOR MAY BE REQUIRED TO FIELD SPLICE ADDITIONAL LENGTHS OF STEEL PILE IN ORDER TO REACH DESIGN EMBEDMENT DEPTHS.

1 / S-201 ALTERNATIVE 1 WHARF FRAMING PLAN HYDRAULIC LIFT WITH PILE CAPITALS
1" = 20'-0"

20' 0'-0" 20' 40'
SCALE: 1"=20'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

NOT FOR CONSTRUCTION

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

ALTERNATIVE 1 DOCK FRAMING PLAN HYDRAULIC LIFT WITH PILE CAPITALS

Drawing Scale: As indicated

Project Number: 0000-XX

Date Issued: 05/14/2021

S-102

LEGEND

(blue fill)	P/C EDGE BEAM AND UTIL TRENCH (TYPE 1)
(red fill)	P/C EDGE BEAM (TYPE 2)
(green fill)	P/C PILE BENT CAPS
○ (blue)	Ø36" STEEL PIPE PILE, 3/4" WT (TOTAL 65)
○ (magenta)	Ø36" STEEL PIPE PILE, 1" WT (TOTAL 24)
●	PILE TO BE PDA TESTED, SEE NOTE 2 (TOTAL 10)

NOTES:

1. FOR PILE DETAILS AND SCHEDULE SEE S-501A AND S-502 RESPECTIVELY.
2. DYNAMICALLY TEST AND EVALUATE PILES INDICATED FOR PDA TESTING USING A PILE DRIVING ANALYZER (PDA). DYNAMIC TEST PILES SHALL BE RESTRUCK 24 HOURS AFTER INITIAL DRIVING. SEE THIS PLAN AND LEGEND FOR LOCATION OF PILES SUBJECT TO DYNAMIC TESTING. PILES INDICATED FOR PDA TEST SHALL BE DRIVEN TO FULL PRODUCTION PILE PENETRATION DEPTHS.
3. CONTRACTOR SHALL COORDINATE DIRECTLY WITH GEOTECHNICAL ENGINEER WITH RESULTS OF PDA TESTING. FINAL GEOTECHNICAL RECOMMENDATIONS SHALL BE GIVEN BY GEOTECHNICAL ENGINEER AFTER EVALUATION OF PDA RESULTS.
4. ACCORDING TO FINAL GEOTECHNICAL RECOMMENDATIONS, THE CONTRACTOR MAY BE REQUIRED TO FIELD SPLICE ADDITIONAL LENGTHS OF STEEL PILE IN ORDER TO REACH DESIGN EMBEDMENT DEPTHS.

1 / S-201 ALTERNATIVE 2 WHARF FRAMING PLAN CONCRETE DECK OVERLAY WITH LINEAR PILE CAPS
1" = 20'-0"

20' 0'-0" 20' 40'
SCALE: 1"=20'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

NOT FOR CONSTRUCTION

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

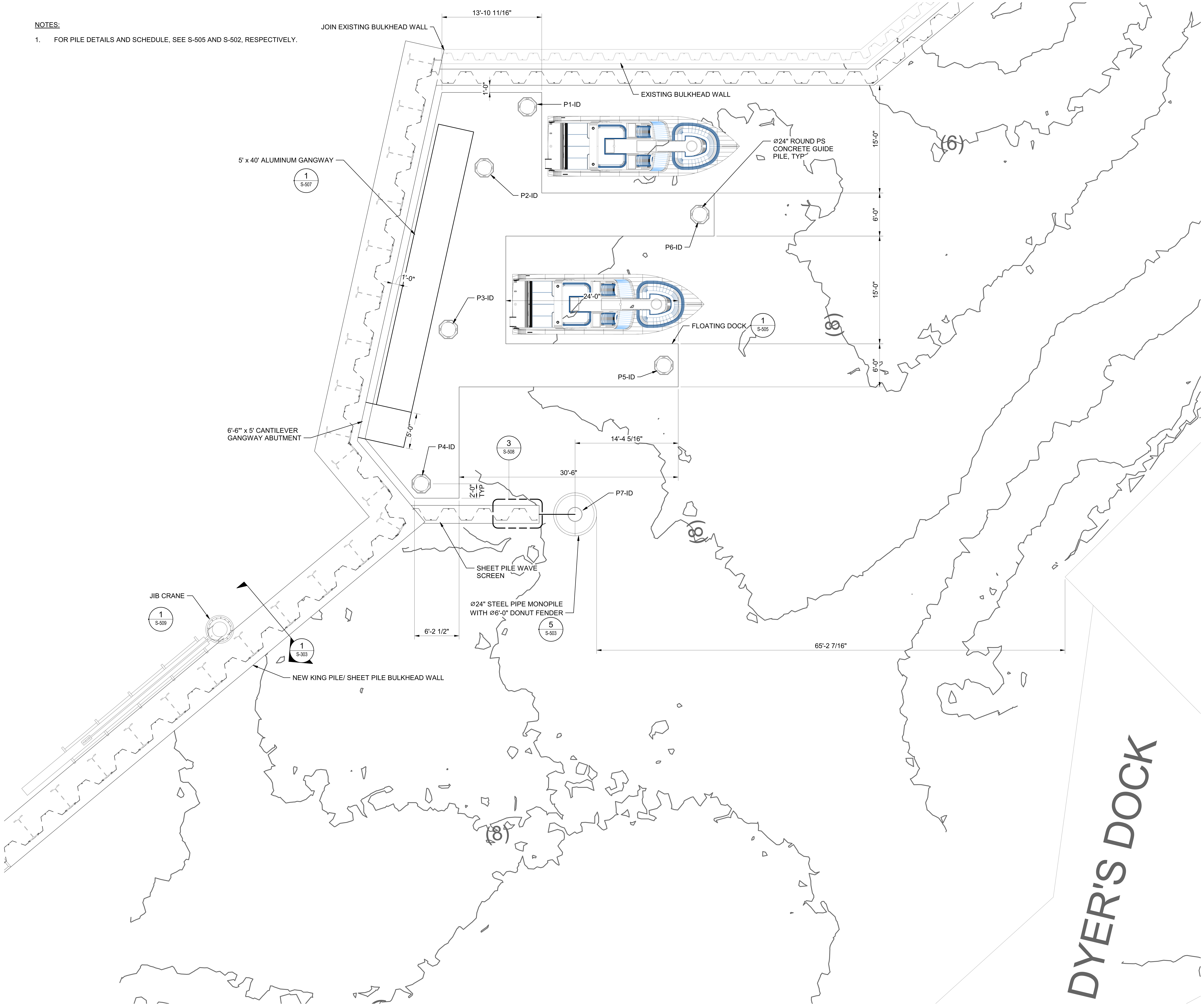
ALTERNATIVE 2 DOCK FRAMING PLAN CONCRETE DECK OVERLAY WITH LINEAR PILE CAPS

Drawing Scale	As indicated
Project Number	0000-XX
Date Issued	05/14/2021

S-102A

NOTES:

1. FOR PILE DETAILS AND SCHEDULE, SEE S-505 AND S-502, RESPECTIVELY.



1 S-101 SMALL CRAFT FLOATING DOCK PLAN
3/16" = 1'-0"

4'-0" 0'-0" 4'-0" 8'-0"
SCALE: 1/4"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

SMALL CRAFT FLOATING DOCK PLAN

Drawing Scale
3/16" = 1'-0"

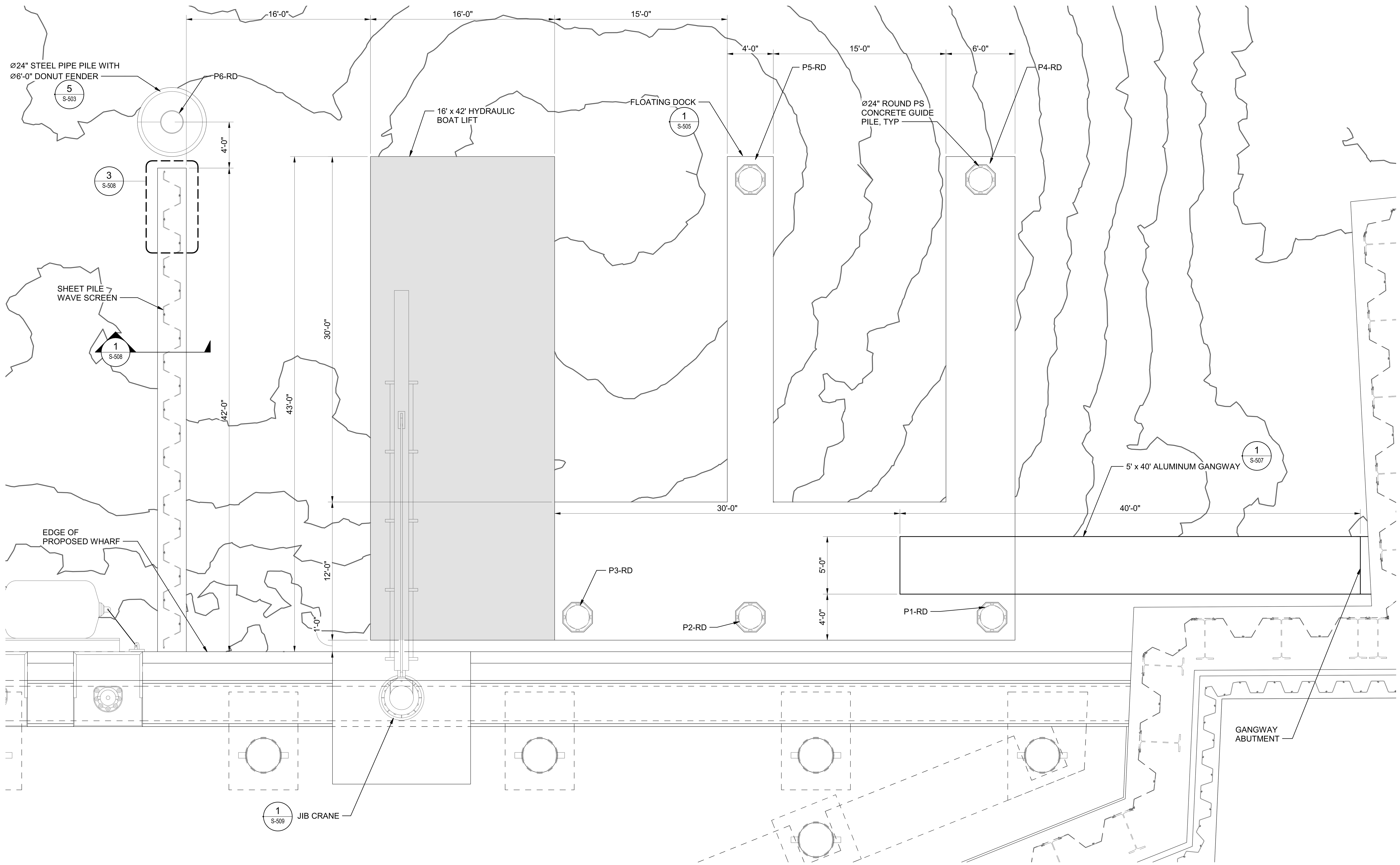
Project Number
0000-XX

Date Issued
05/14/2021

S-103

NOTES:

1. FOR PILE DETAILS AND SCHEDULE, SEE S-505 AND S-502, RESPECTIVELY.



1 S-101 ROBOTICS VEHICLE FLOATING DOCK PLAN
1/4" = 1'-0"

4'-0" 0'-0" 4'-0" 8'-0"
SCALE: 1/4"=1'-0"

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

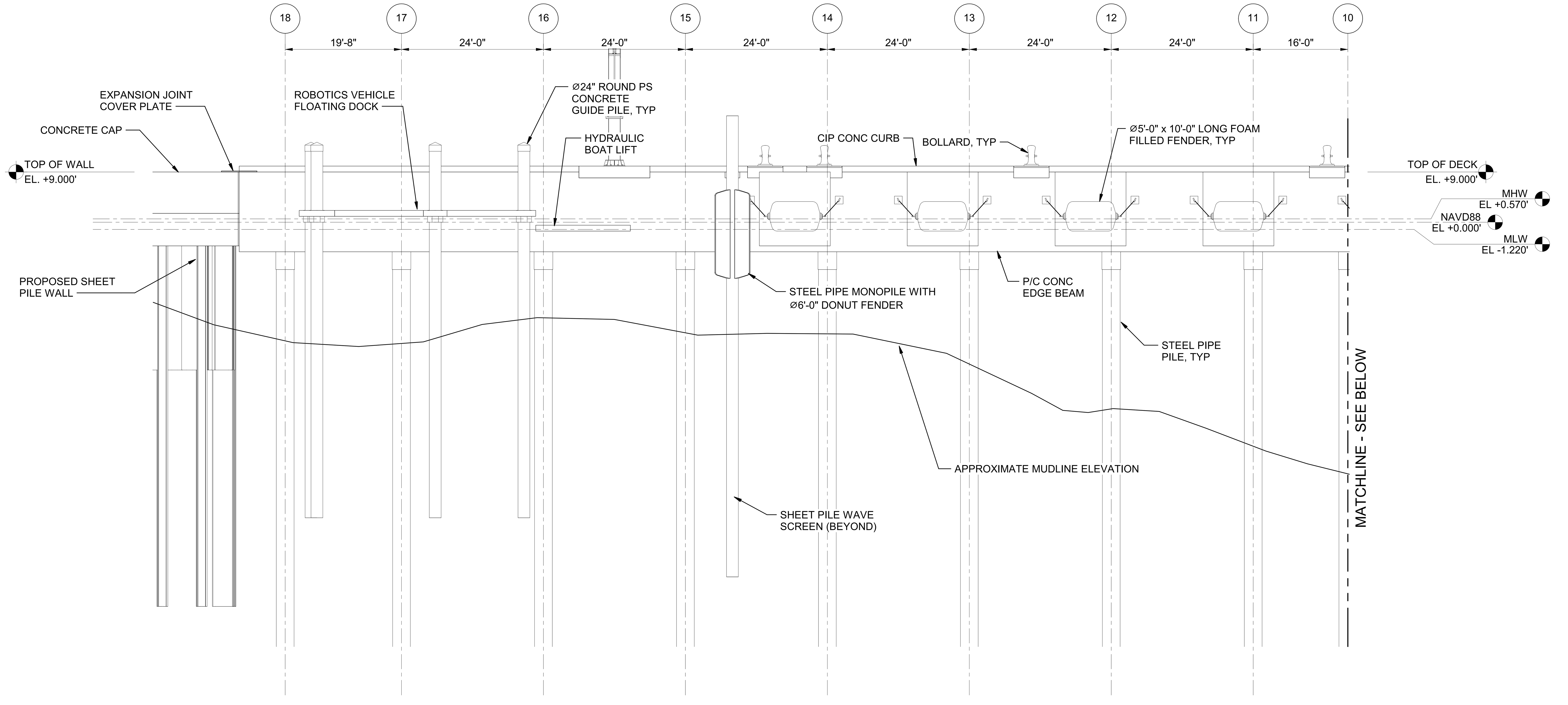
ROBOTICS VEHICLE FLOATING DOCK PLAN

Drawing Scale
1/4" = 1'-0"

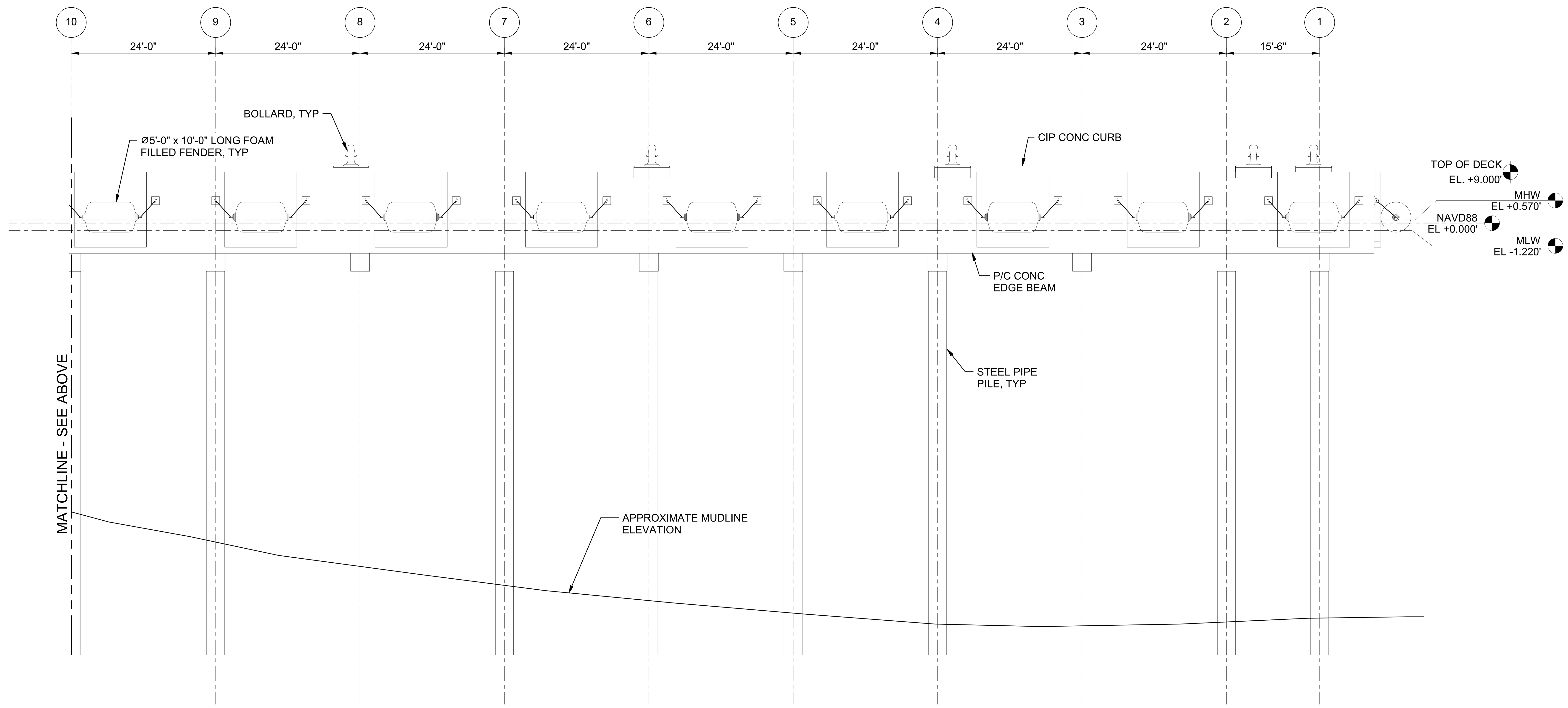
Project Number
0000-XX

Date Issued
05/14/2021

S-104



1 S-101 ELEVATION LOOKING EAST - 1
1" = 10'-0"



2 S-101 ELEVATION LOOKING EAST - 2
1" = 10'-0"

10' 0'-0" 10' 20'
SCALE: 1"=10'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

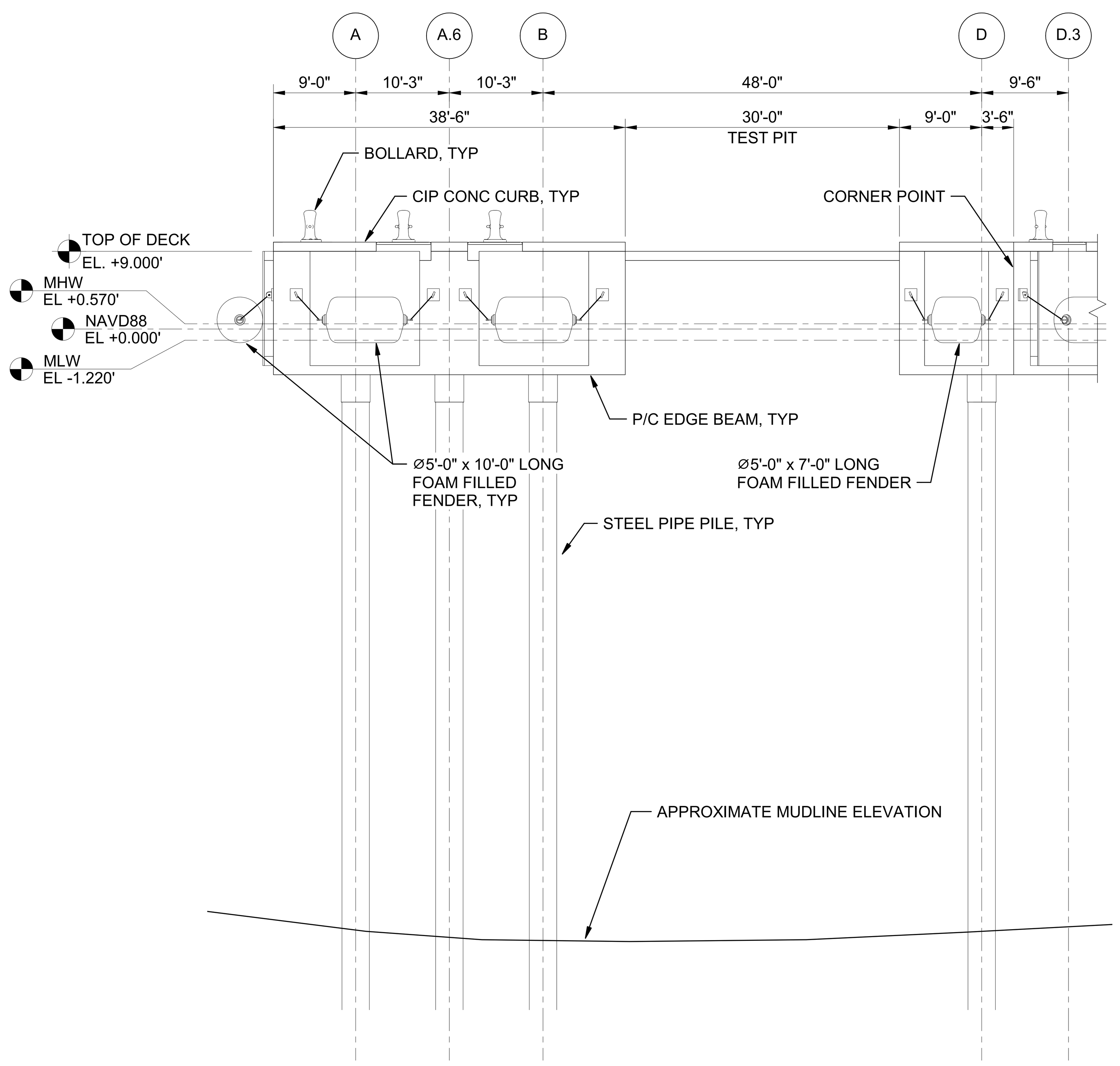
ISELIN DOCK ELEVATIONS (1 OF 2)

Drawing Scale
1" = 10'-0"

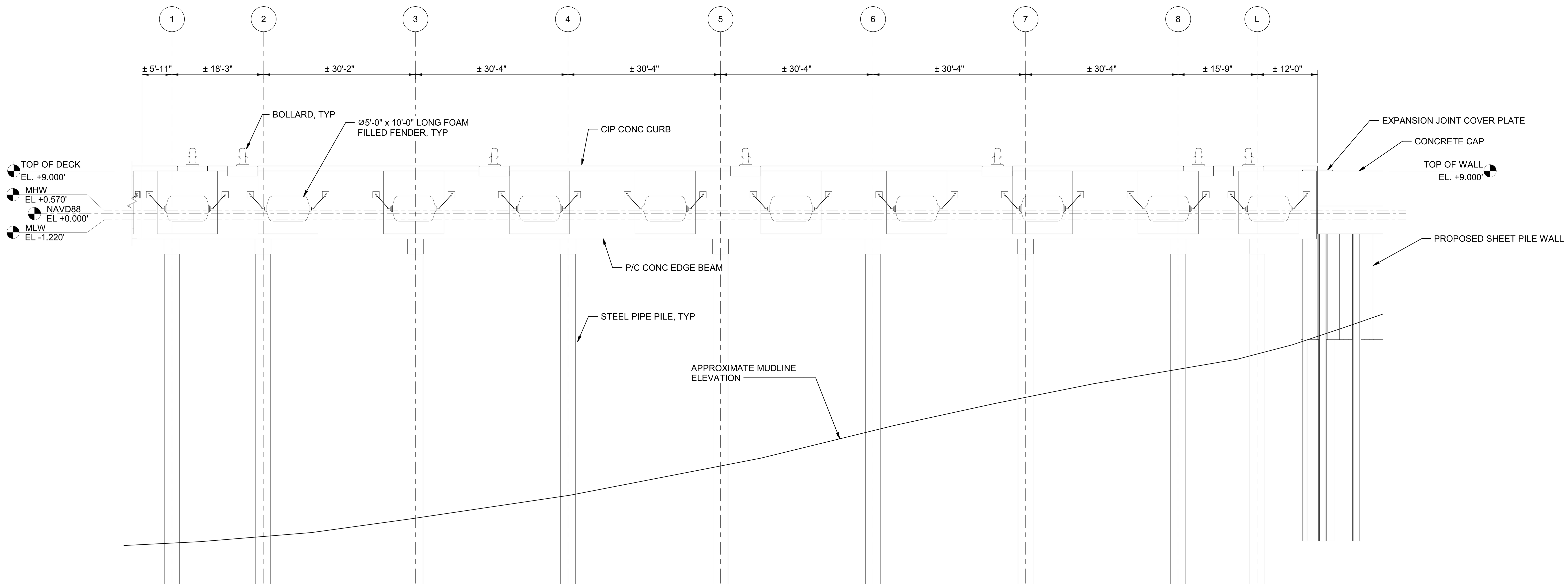
Project Number
0000-XX

Date Issued
05/14/2021

S-201



1
S-101
ELEVATION LOOKING NORTH
1" = 10'-0"



2
S-101
ELEVATION LOOKING NORTH-WEST
1" = 10'-0"

10' 0'-0" 10' 20'
SCALE: 1"=10'

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

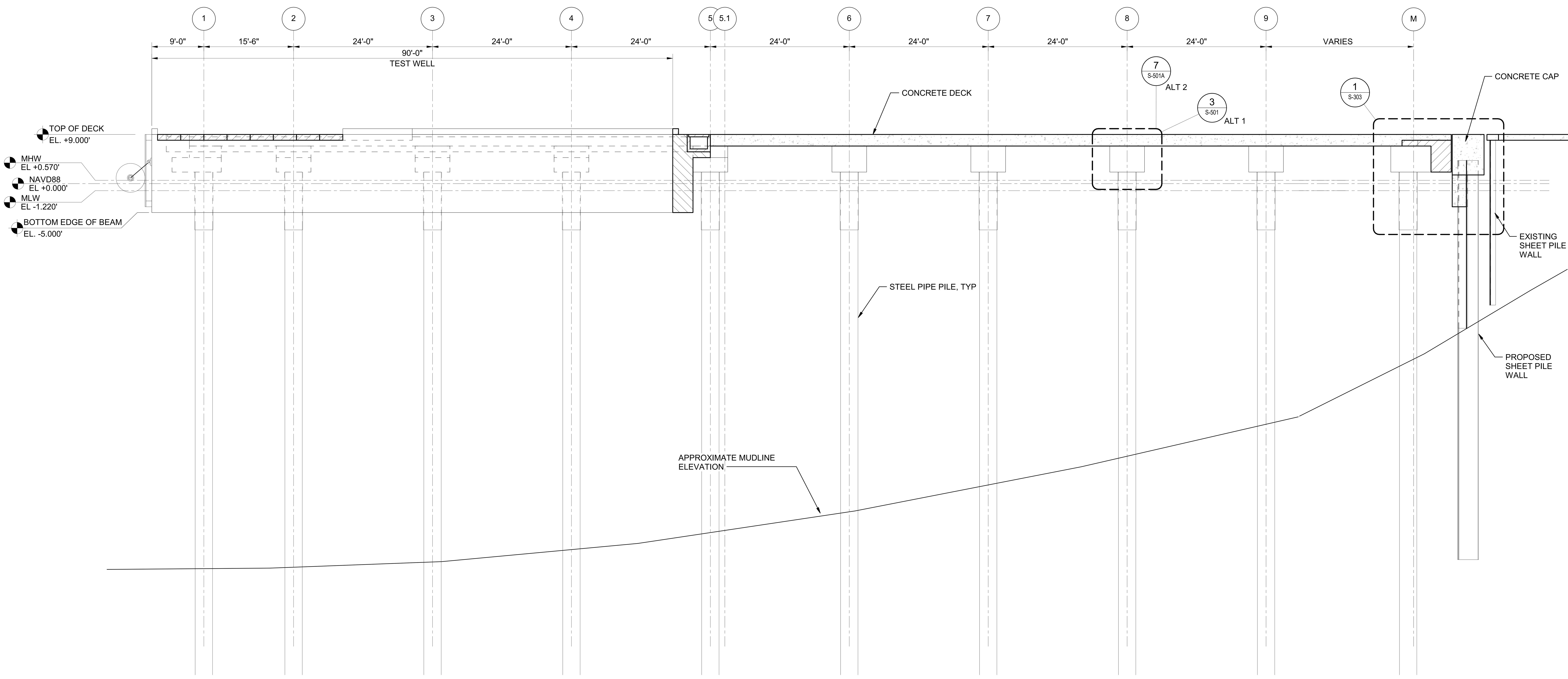
ISELIN DOCK ELEVATIONS (2 OF 2)

Drawing Scale
1" = 10'-0"

Project Number
0000-XX

Date Issued
05/14/2021

S-202



1
S-101
LONGITUDINAL SECTION
1/8" = 1'-0"

8'-0" 0'-0" 8'-0" 16'-0"
SCALE: 1/8"=1'-0"

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

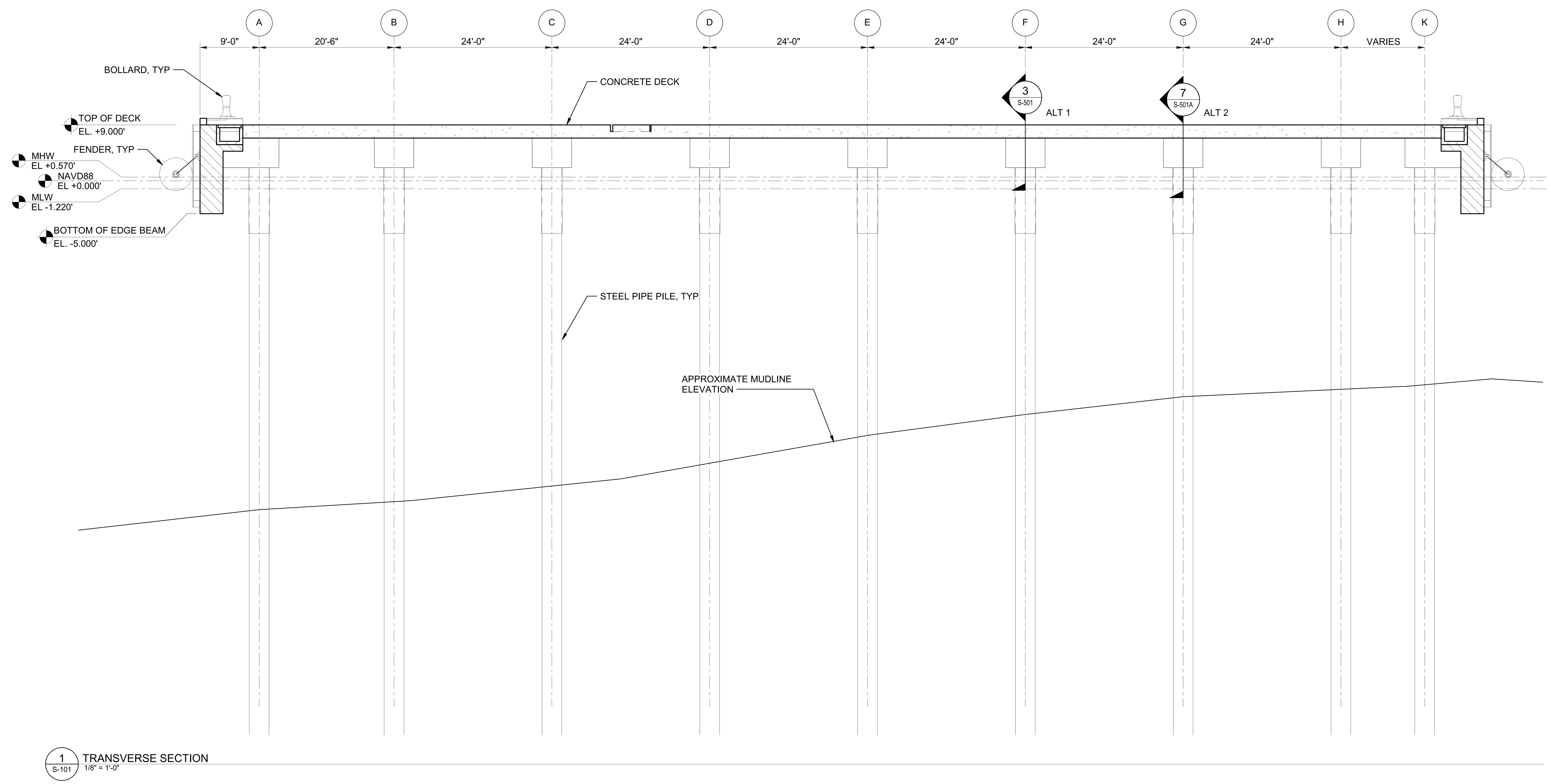
ISELIN DOCK LONGITUDINAL SECTION

Drawing Scale
1/8" = 1'-0"

Project Number
0000-XX

Date Issued
05/14/2021

S-301



1
S-101
TRANSVERSE SECTION
1/8" = 1'-0"

8'-0" 0'-0" 8'-0" 16'-0"
SCALE: 1/8"=1'-0"

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

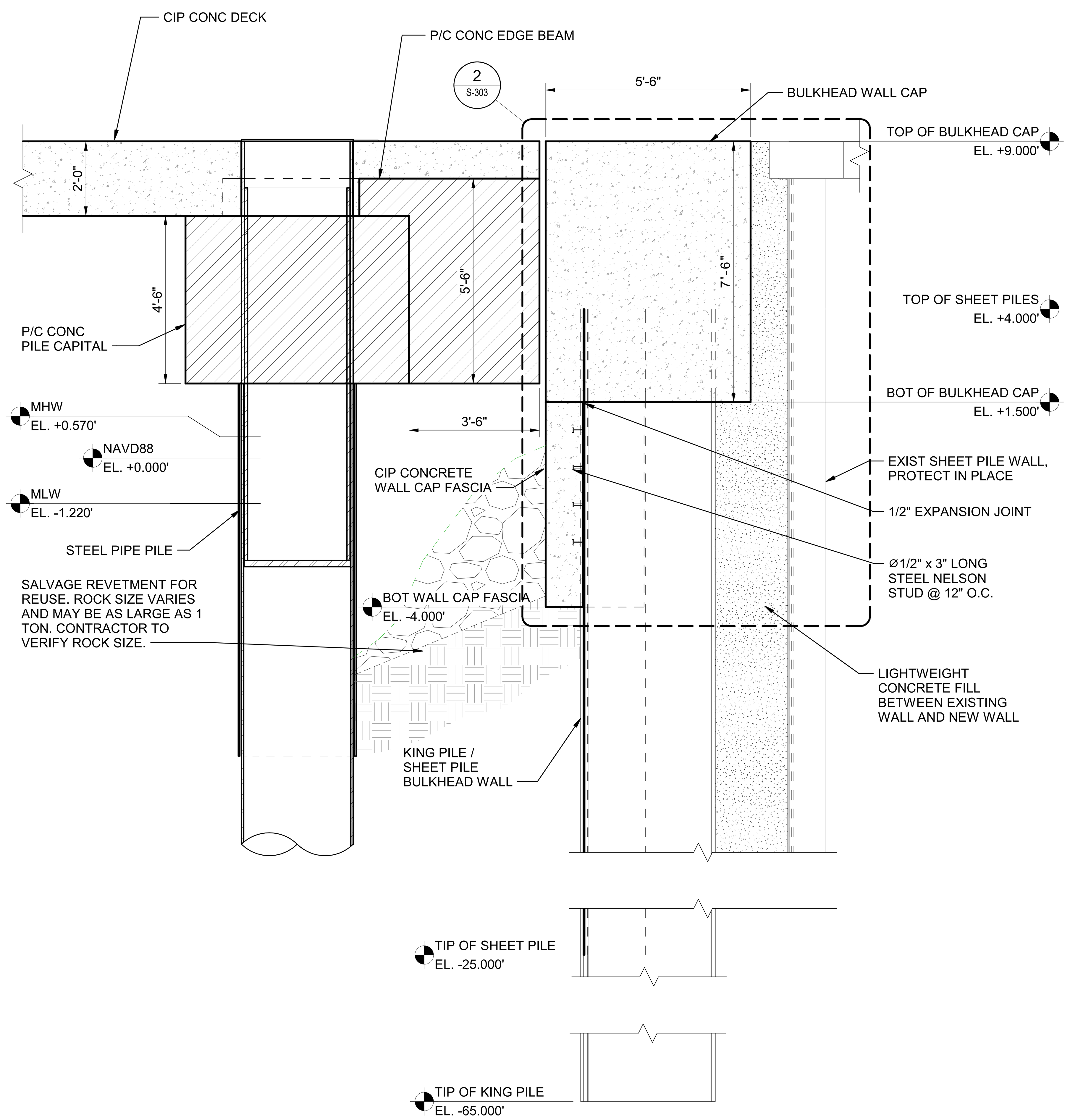
WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

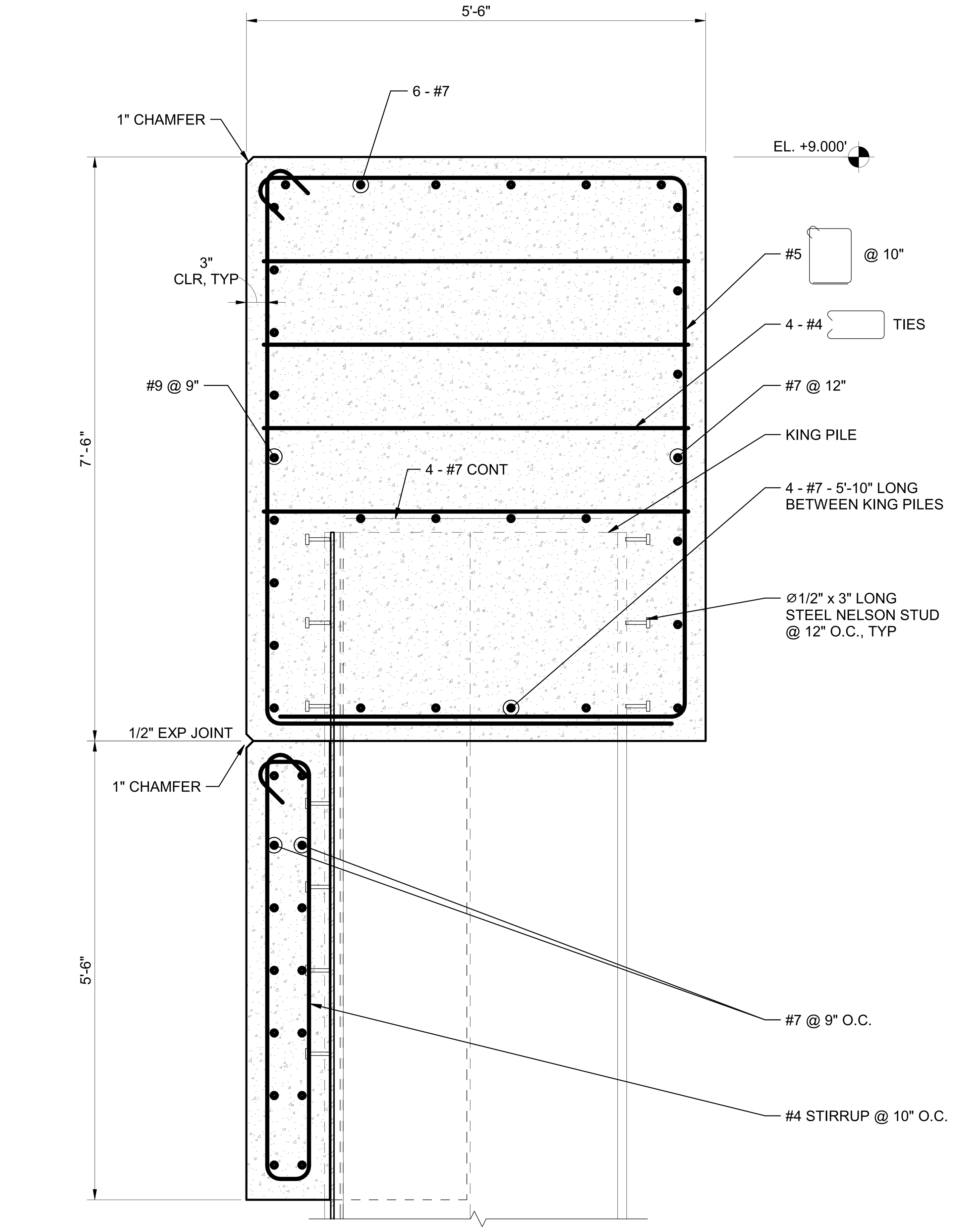
ISELIN DOCK TRANSVERSE SECTION

Drawing Scale 1/8" = 1'-0"	
Project Number 0000-XX	
Date Issued 05/14/2021	

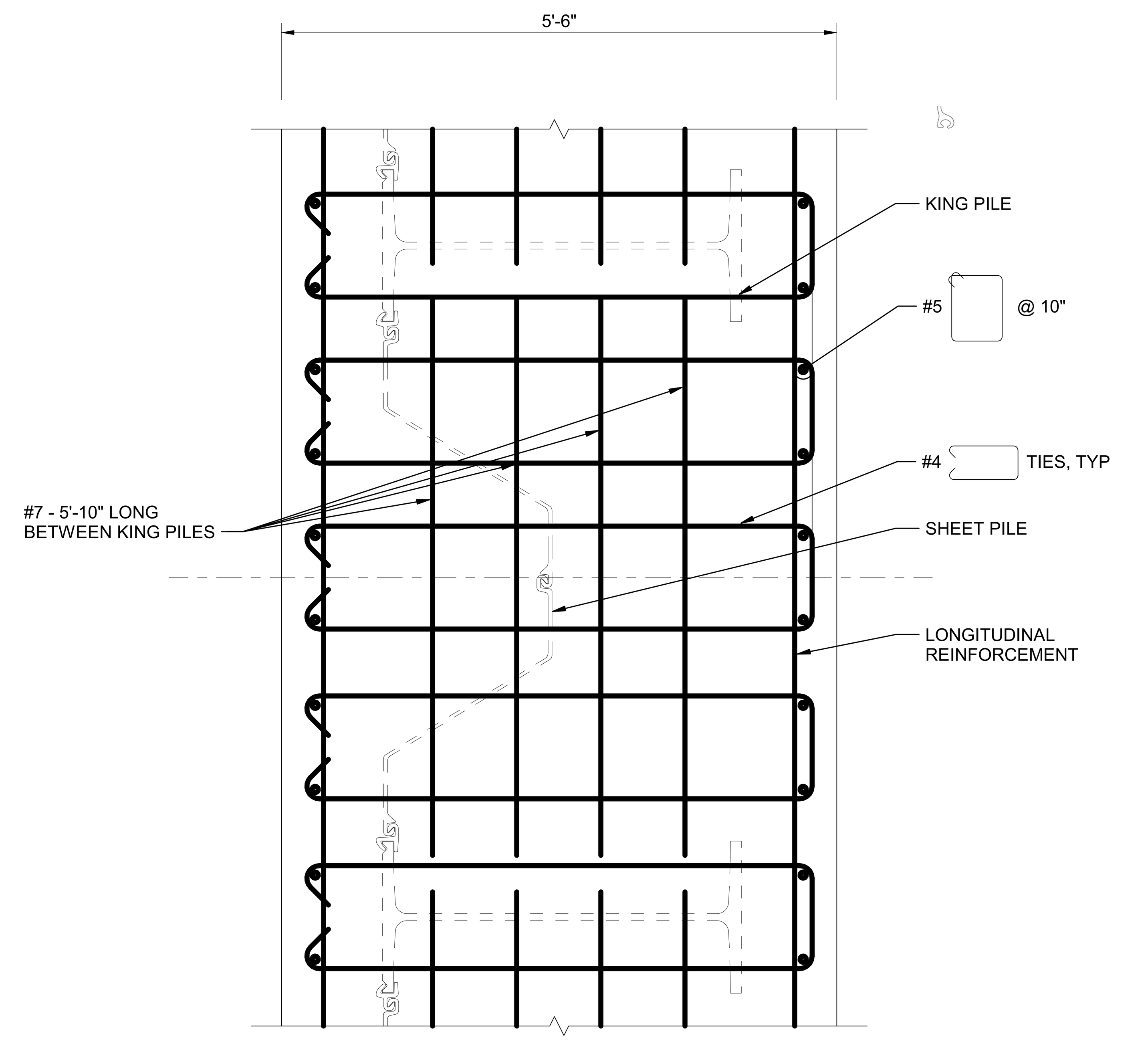
S-302



1 S-101 BULKHEAD WALL SECTION
1/2" = 1'-0"



2 S-303 BULKHEAD WALL PILE CAP DETAIL
1" = 1'-0"



3 S-101 BULKHEAD WALL TYPICAL PLAN VIEW
1" = 1'-0"

NOTES:

1. STEEL SHEET PILING SYSTEM SPECIFICATIONS:
   A. BASIS OF DESIGN: THE DESIGN AND LAYOUT SHOWN IS BASED ON THE HZM/AZ STEEL WALL SYSTEM BY ARCELORMITTAL, OR APPROVED EQUAL. THE CONTRACTOR SHALL PROVIDE A SYSTEM THAT MEETS THE REQUIREMENTS DESCRIBED BELOW.
   B. SHEET PILES AND KING PILES SHALL BE:
      1. ASTM A 690 STEEL, GRADE 50
   C. COMBI-WALL (STA 0+77.39' - STA 7+25.28')
      1. PRODUCT MODEL NO. (KING PILES) HZ-1180-C
      2. PRODUCT MODEL NO. (SHEET PILES) .... AZ 28-750
      3. MINIMUM FLANGE THICKNESS (KING PILES) .... 1.38 in.
      4. MINIMUM FLANGE THICKNESS (SHEET PILES) .... 0.472 in.
      5. COMBINED SECTION MODULUS .... 241.6 in.^{3}/LF
2. CORROSION REQUIREMENTS:
   A. PROVIDE FLANGE AND WEB THICKNESS TO ACCOMODATE THE FOLLOWING CORROSION RATES:
      1. EXPOSED TO SEAWATER AND ABOVE ELEVATION 0.0 MLLW
         i. 0.09 mm/YEAR
      2. EXPOSED TO SEAWATER AND BELOW ELEVATION 0.0 MLLW
         ii. 0.05 mm/YEAR
   B. COMBI-WALL DESIGN LIFE = 100 YEARS. ACCOMODATE CORROSION RATES i AND ii, AND NO PERFORATION ALLOWED AT RATE i BOTH FACES.
   C. CORROSION PROTECTION SYSTEM
      1. PROVIDE EPOXY MASTIC COATING SYSTEM APPLIED OVER FULL LENGTH OF SHEET PILE SYSTEM. SEE SPECIFICATIONS.

1'-0" 0'-0" 1'-0" 2'-0"
SCALE: 1"=1'-0"

2'-0" 0'-0" 2'-0" 4'-0"
SCALE: 1/2"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

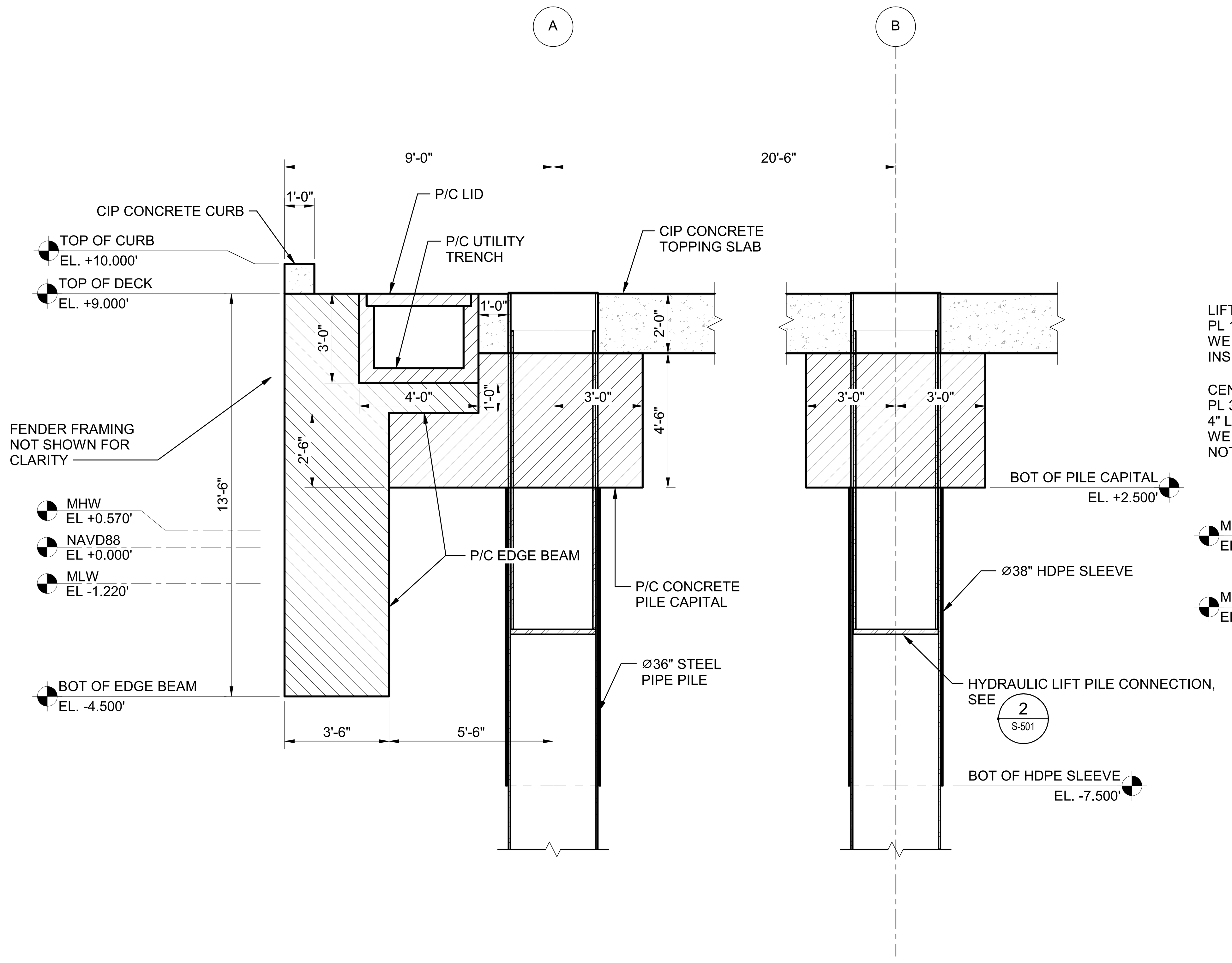
BULKHEAD WALL CROSS SECTIONS

Drawing Scale
As indicated

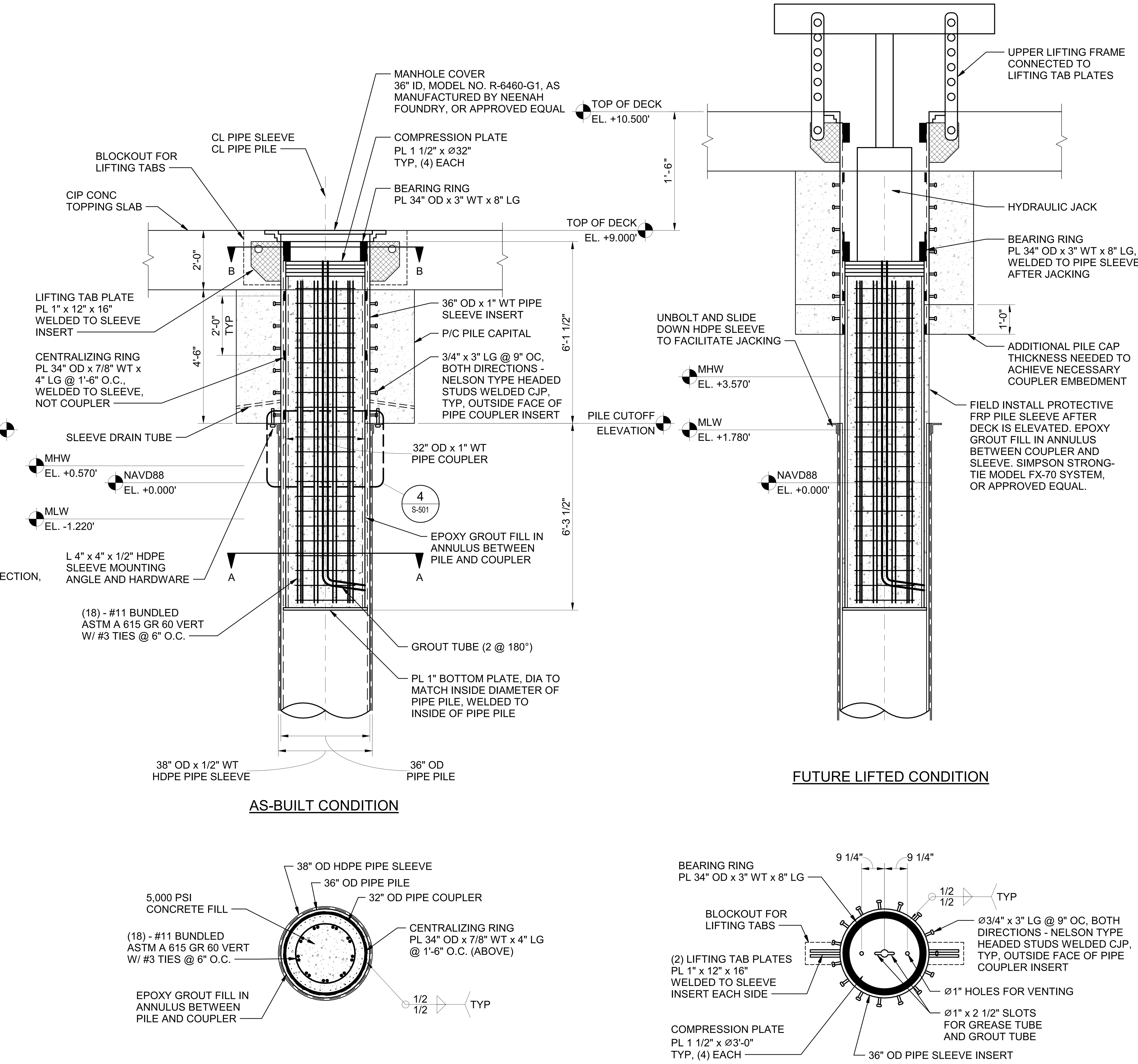
Project Number
0000-XX

Date Issued
05/14/2021

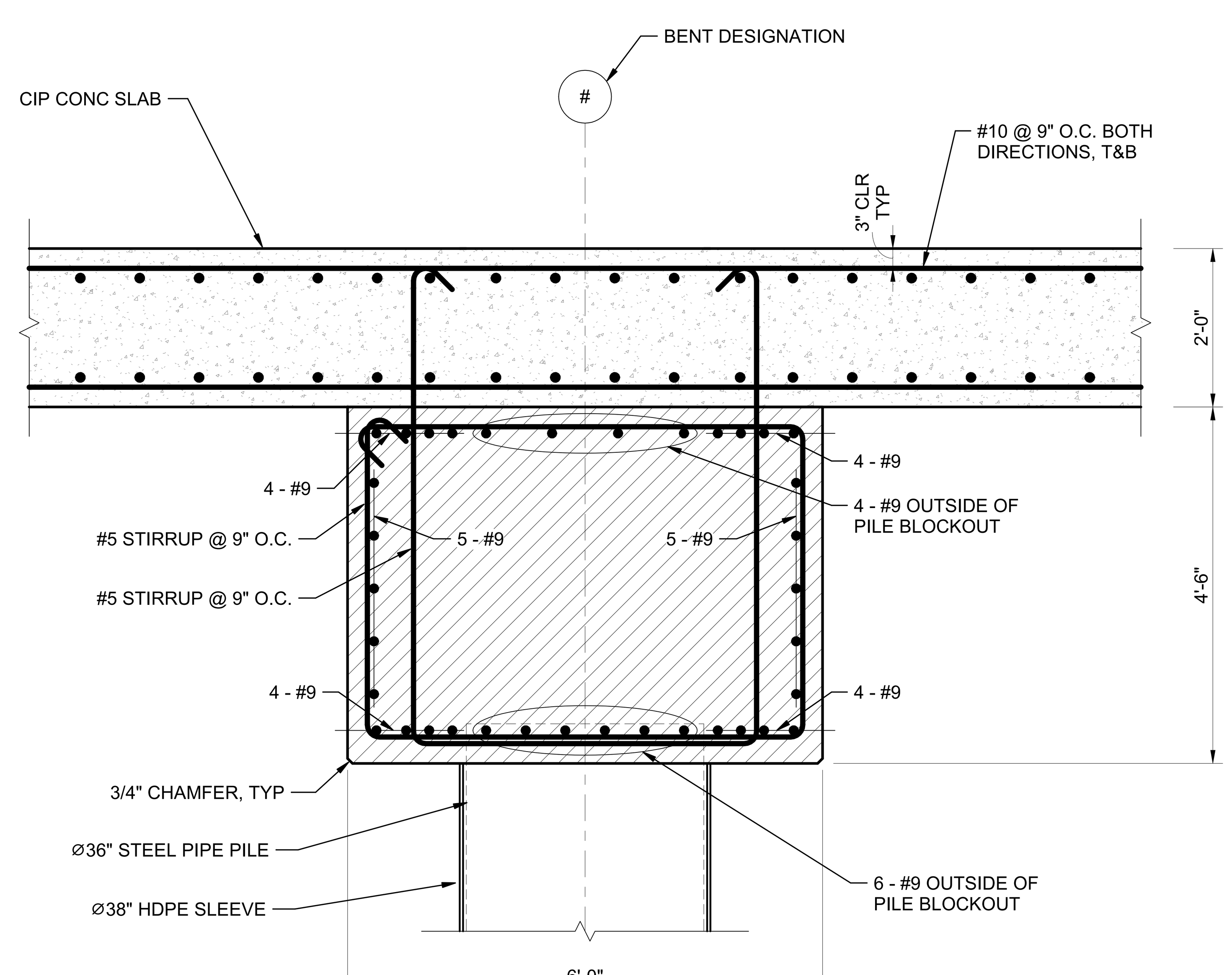
S-303



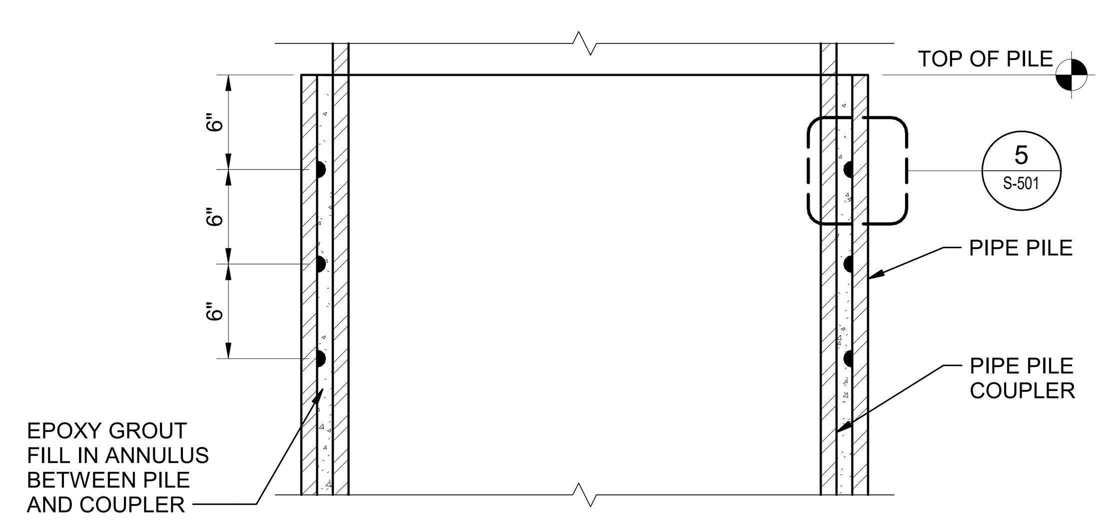
1 S-102 TYPICAL EDGE BEAM AND UTILITY TRENCH SECTION
3/8" = 1'-0"



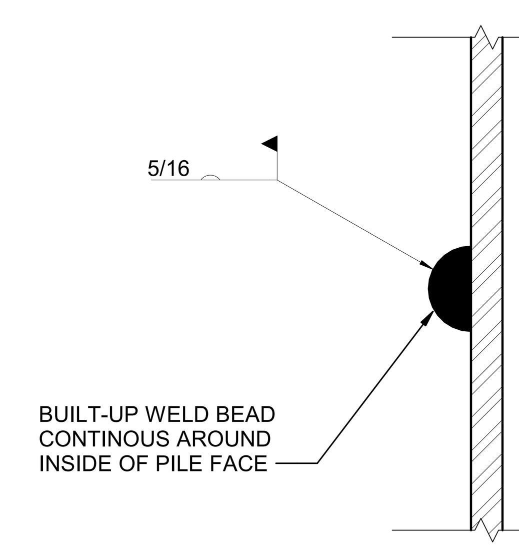
2 S-501 PILE LIFT ASSEMBLY DETAILS
1/2" = 1'-0"



3 S-301 TYPICAL PILE CAPITAL DETAIL
3/4" = 1'-0"



4 S-501 DETAIL AT TOP OF PILE
1 1/2" = 1'-0"



5 S-501 WELD BEAD DETAIL
3" = 1'-0"

SCALE: 3/4"=1'-0"

SCALE: 1/2"=1'-0"

SCALE: 3/8"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

NOT FOR CONSTRUCTION

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

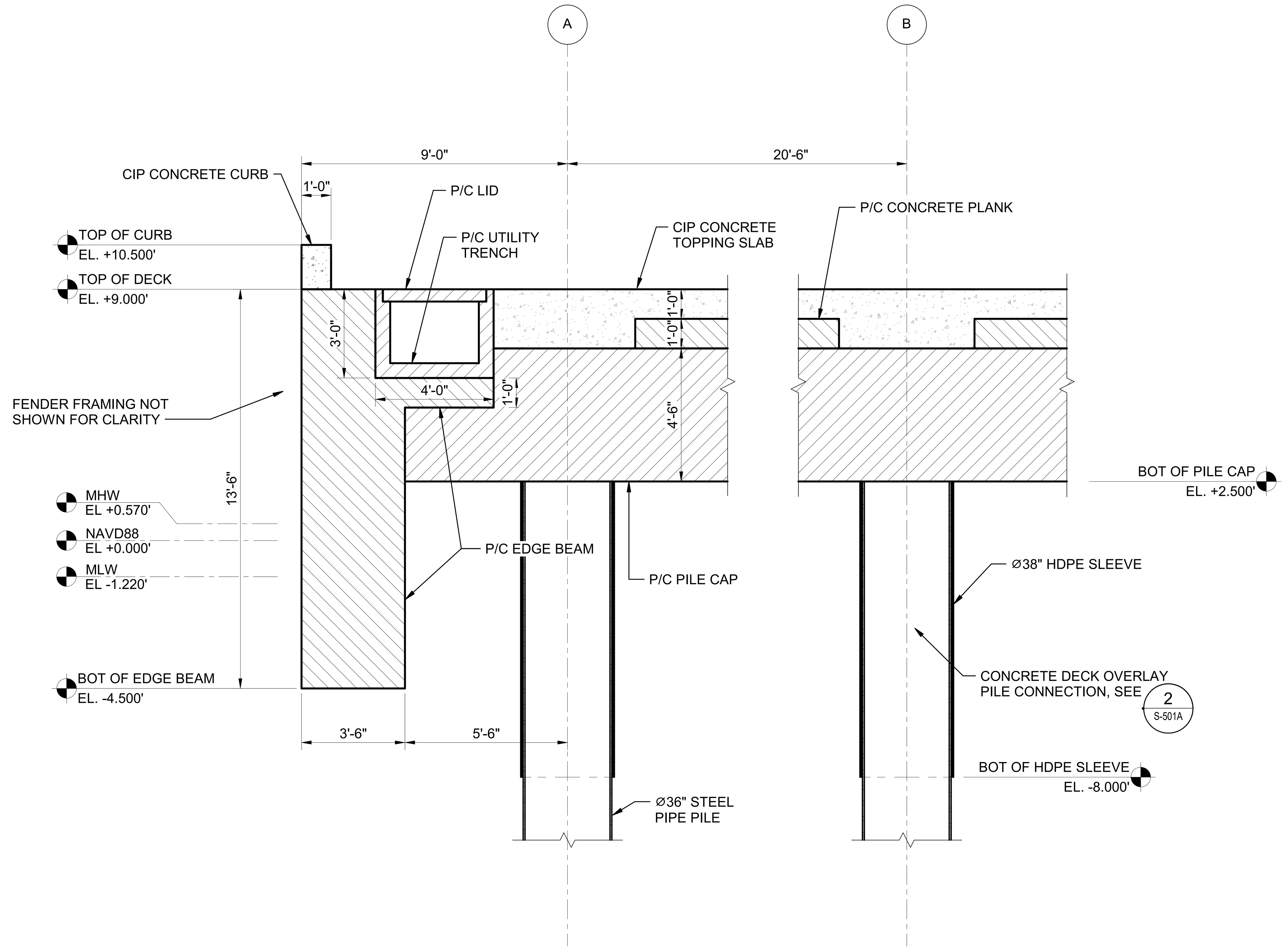
ALTERNATIVE 1 DOCK HYDRAULIC LIFT WITH PILE CAPITALS TYPICAL DETAILS

Drawing Scale
As indicated

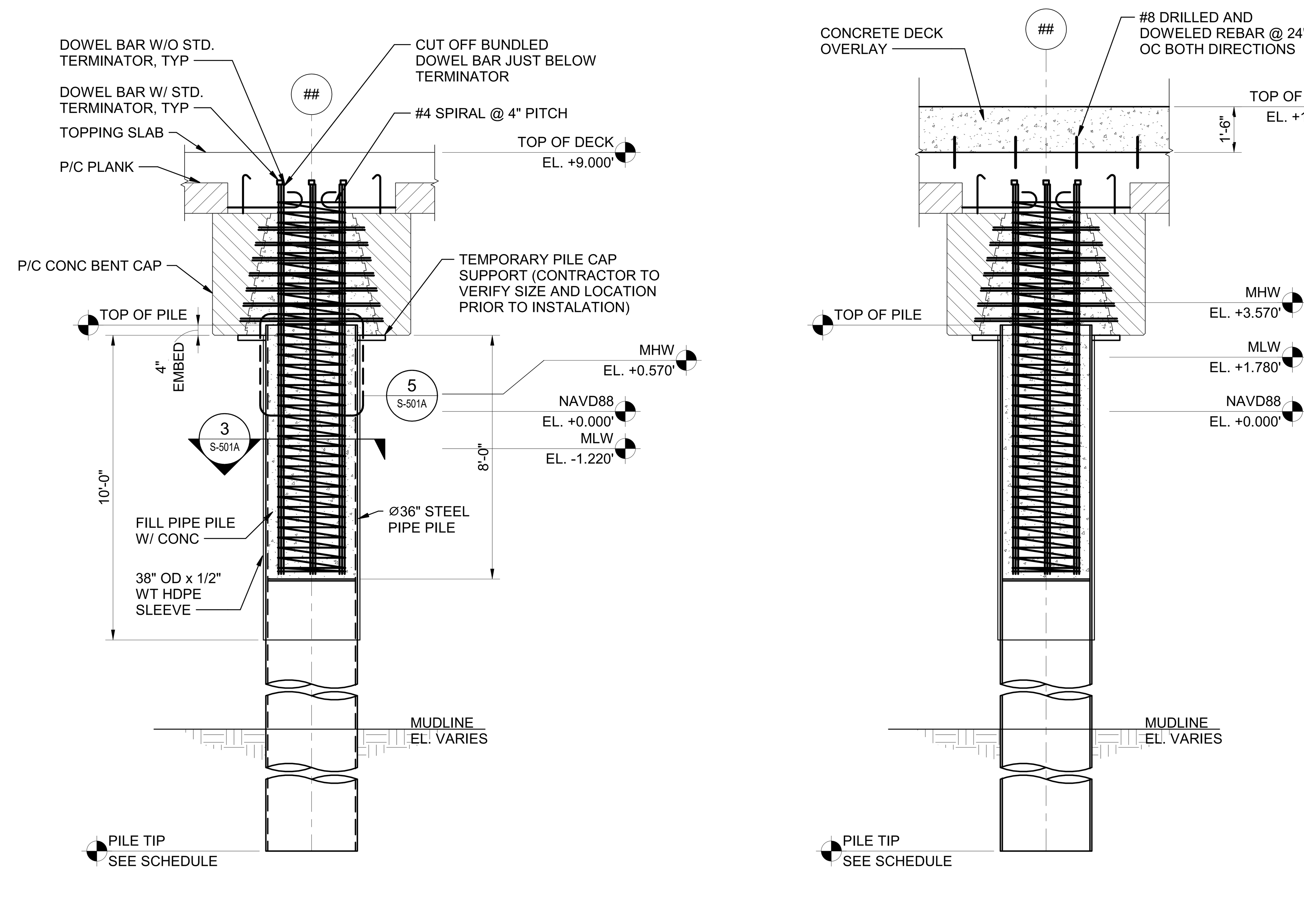
Project Number
0000-XX

Date Issued
05/14/2021

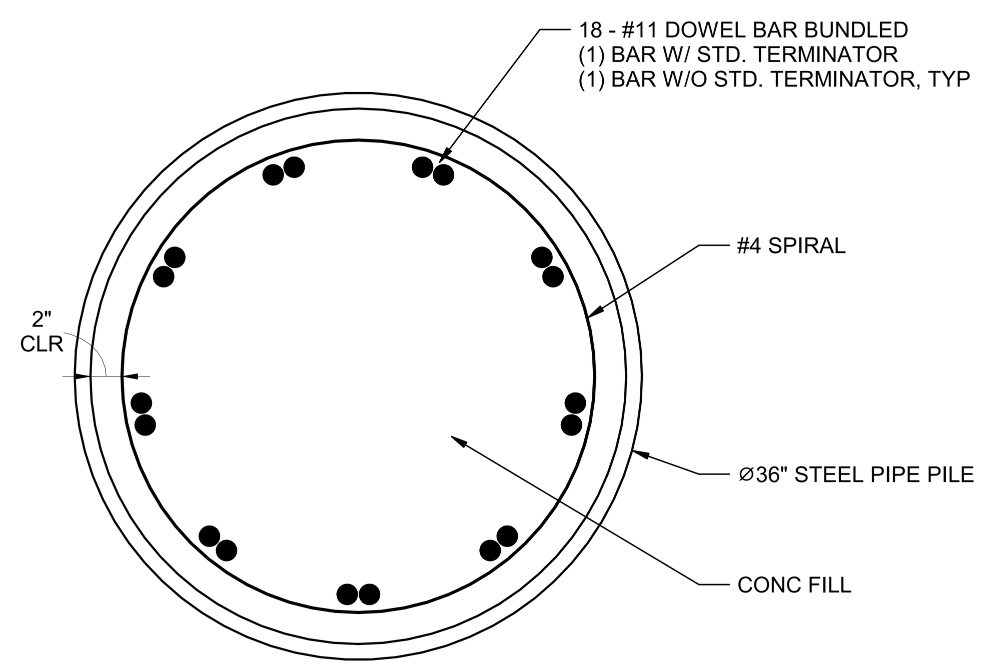
S-501



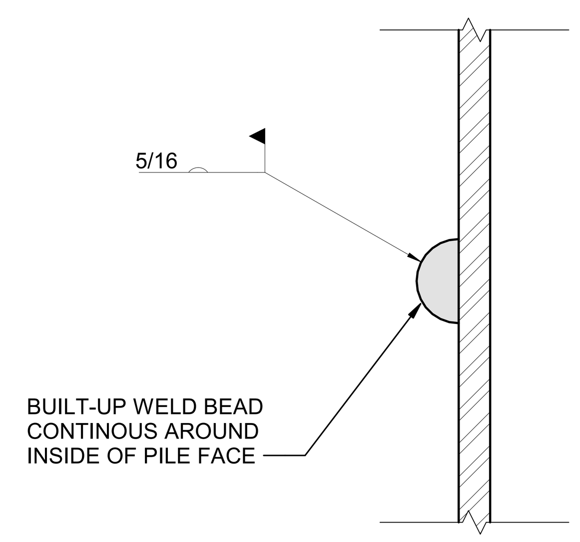
1 S-102A TYPICAL EDGE BEAM AND UTILITY TRENCH SECTION
3/8" = 1'-0"



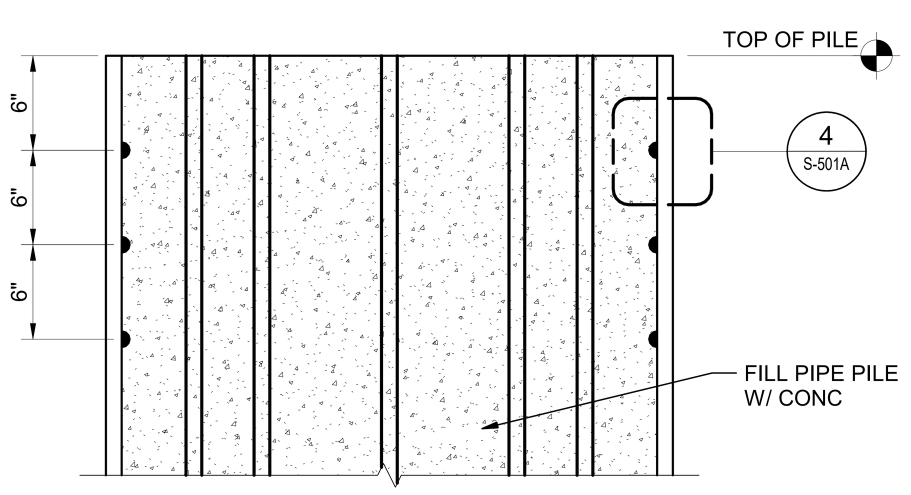
2 S-501A PILE CONNECTION DETAIL
3/8" = 1'-0"



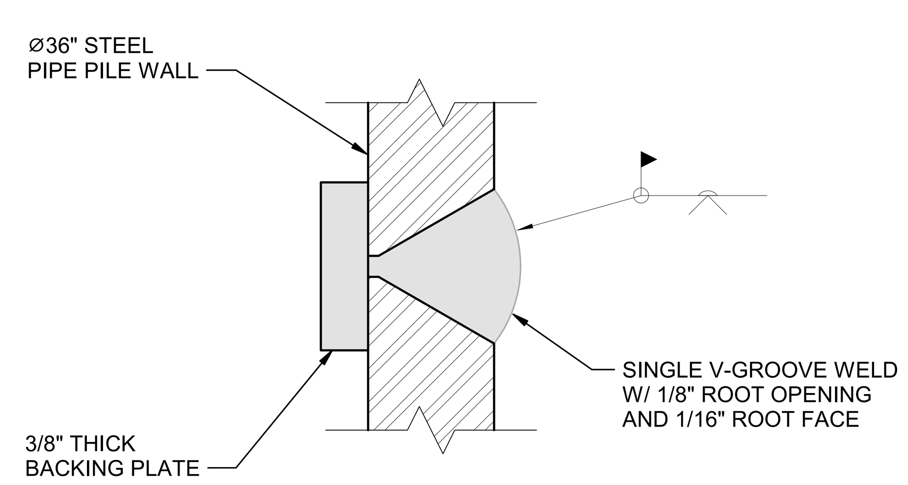
3 S-501A PILE SECTION
1 1/2" = 1'-0"



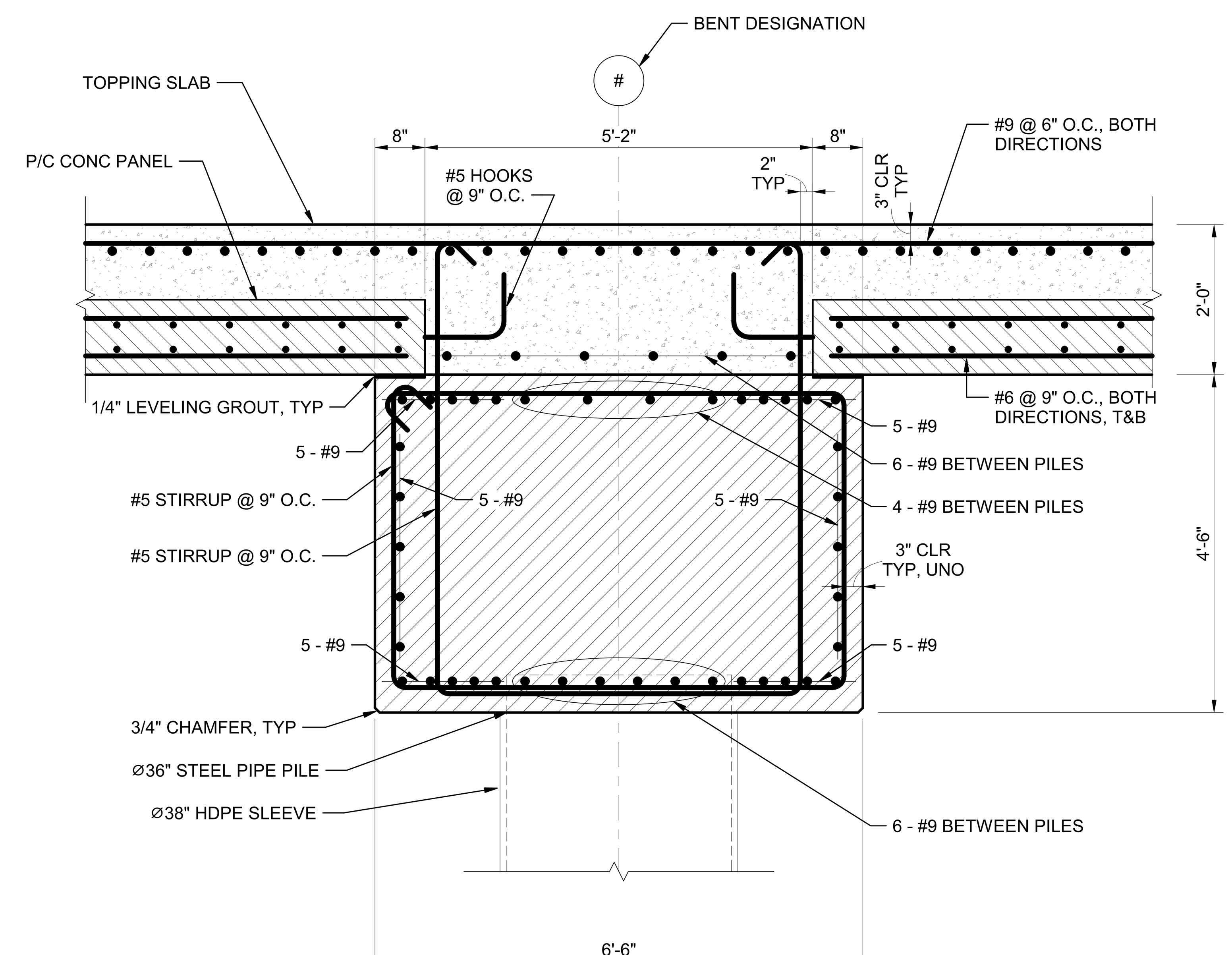
4 S-501A WELD BEAD DETAIL
3" = 1'-0"



5 S-501A DETAIL AT TOP OF PILE
1 1/2" = 1'-0"



6 PILE SPLICE DETAIL
12" = 1'-0"



7 S-102A TYPICAL BENT CAP DETAIL
3/4" = 1'-0"

1" 0'-0" 1" 2"
SCALE: 1"=1"

0'-6" 0'-0" 0'-3" 0'-6"
SCALE: 3"=1'-0"

1'-0" 0'-0" 0'-6" 1'-0"
SCALE: 1 1/2"=1'-0"

2'-0" 0'-0" 1'-0" 2'-0"
SCALE: 3/4"=1'-0"

4'-0" 0'-0" 2'-0" 4'-0"
SCALE: 3/8"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

ALTERNATIVE 2 DOCK CONCRETE DECK OVERLAY WITH LINEAR PILE CAPS TYPICAL DETAILS

Drawing Scale
As indicated

Project Number
0000-XX

Date Issued
05/14/2021

S-501A

ISELIN WHARF PILE SCHEDULE

LOCATION	PILE BENT/ROW DESIGNATION	DIMENSION	MATERIAL	CUT OFF ELEV. (NAVD88)	MUDLINE ELEV (NAVD88)	PILE TIP ELEV. (NAVD88)	LENGTH
ISELIN WHARF	A-1	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-67.11	-171' - 0"	173' - 0"
ISELIN WHARF	A-2	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-66.64	-171' - 0"	173' - 0"
ISELIN WHARF	A-3	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-64.28	-171' - 0"	173' - 0"
ISELIN WHARF	A-4	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-61.41	-171' - 0"	173' - 0"
ISELIN WHARF	A.6-1	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-66.32	-171' - 0"	173' - 0"
ISELIN WHARF	A.6-2	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-65.87	-171' - 0"	173' - 0"
ISELIN WHARF	A.6-3	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-63.56	-171' - 0"	173' - 0"
ISELIN WHARF	A.6-4	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-60.35	-171' - 0"	173' - 0"
ISELIN WHARF	B-1	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-65.74	-171' - 0"	173' - 0"
ISELIN WHARF	B-2	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-64.84	-171' - 0"	173' - 0"
ISELIN WHARF	B-3	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-61.95	-171' - 0"	173' - 0"
ISELIN WHARF	B-4	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-59.02	-171' - 0"	173' - 0"
ISELIN WHARF	D-2	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-61.13	-171' - 0"	173' - 0"
ISELIN WHARF	D-3	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-58.35	-171' - 0"	173' - 0"
ISELIN WHARF	D-4	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-54.43	-171' - 0"	173' - 0"
ISELIN WHARF	D-K	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-62.35	-171' - 0"	173' - 0"
ISELIN WHARF	D.3-3	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-56.61	-171' - 0"	173' - 0"
ISELIN WHARF	D.3-4	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-53.24	-171' - 0"	173' - 0"
ISELIN WHARF	D.8-3	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-55.98	-171' - 0"	173' - 0"
ISELIN WHARF	D.8-4	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-52.28	-171' - 0"	173' - 0"
ISELIN WHARF	E.4-4	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-50.11	-171' - 0"	173' - 0"
ISELIN WHARF	K-2	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-59.80	-171' - 0"	173' - 0"
ISELIN WHARF	K-3	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-54.90	-171' - 0"	173' - 0"
ISELIN WHARF	K-4	Ø36" x 1.0" WT	Steel ASTM A572 Gr 50	2' - 0"	-48.34	-171' - 0"	173' - 0"
ISELIN WHARF	A-5	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-57.30	-171' - 0"	173' - 0"
ISELIN WHARF	A-6	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-53.20	-179' - 0"	181' - 0"
ISELIN WHARF	A-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-48.73	-179' - 0"	181' - 0"
ISELIN WHARF	A-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-40.60	-179' - 0"	181' - 0"
ISELIN WHARF	A-9	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-28.99	-179' - 0"	181' - 0"
ISELIN WHARF	A-10	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-18.48	-137' - 0"	139' - 0"
ISELIN WHARF	A-11	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-15.84	-137' - 0"	139' - 0"
ISELIN WHARF	A-12	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-11.49	-137' - 0"	139' - 0"
ISELIN WHARF	A-13	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	.10.10	-110' - 0"	112' - 0"
ISELIN WHARF	A-14	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-8.82	-110' - 0"	112' - 0"
ISELIN WHARF	A-15	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-9.34	-110' - 0"	112' - 0"
ISELIN WHARF	A-16	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-9.41	-110' - 0"	112' - 0"
ISELIN WHARF	A-17	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-3.53	-110' - 0"	112' - 0"
ISELIN WHARF	A-18	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-110' - 0"	112' - 0"
ISELIN WHARF	A.5-17	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-110' - 0"	112' - 0"
ISELIN WHARF	A.9-11	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-7.54	-137' - 0"	139' - 0"
ISELIN WHARF	A.9-12	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	A.9-13	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-110' - 0"	112' - 0"
ISELIN WHARF	A.9-14	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-110' - 0"	112' - 0"
ISELIN WHARF	A.9-15	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-110' - 0"	112' - 0"
ISELIN WHARF	A.9-16	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-110' - 0"	112' - 0"
ISELIN WHARF	B-5	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-54.45	-171' - 0"	173' - 0"
ISELIN WHARF	B-6	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-51.38	-179' - 0"	181' - 0"
ISELIN WHARF	B-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-46.08	-179' - 0"	181' - 0"
ISELIN WHARF	B-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-34.07	-179' - 0"	181' - 0"
ISELIN WHARF	B-9	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-23.69	-137' - 0"	139' - 0"
ISELIN WHARF	B-10	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	B-M	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	C-5.1	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-52.33	-171' - 0"	173' - 0"
ISELIN WHARF	C-6	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-48.66	-179' - 0"	181' - 0"
ISELIN WHARF	C-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-43.45	-179' - 0"	181' - 0"
ISELIN WHARF	C-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	C-9	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"

ISELIN WHARF PILE SCHEDULE

LOCATION	PILE BENT/ROW DESIGNATION	DIMENSION	MATERIAL	CUT OFF ELEV. (NAVD88)	MUDLINE ELEV (NAVD88)	PILE TIP ELEV. (NAVD88)	LENGTH
ISELIN WHARF	C-10	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	D-5	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-49.35	-171' - 0"	173' - 0"
ISELIN WHARF	D-6	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-44.87	-179' - 0"	181' - 0"
ISELIN WHARF	D-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-41.07	-179' - 0"	181' - 0"
ISELIN WHARF	D-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	D-9	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	D-M	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	E-5	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-47.10	-171' - 0"	173' - 0"
ISELIN WHARF	E-6	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-42.48	-179' - 0"	181' - 0"
ISELIN WHARF	E-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-32.55	-179' - 0"	181' - 0"
ISELIN WHARF	E-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	E-9	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	E-M	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	F-5	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-44.27	-171' - 0"	173' - 0"
ISELIN WHARF	F-6	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-38.18	-179' - 0"	181' - 0"
ISELIN WHARF	F-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-29.50	-179' - 0"	181' - 0"
ISELIN WHARF	F-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	F-9	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	F-M	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	G-6	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-35.36	-179' - 0"	181' - 0"
ISELIN WHARF	G-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-28.34	-137' - 0"	139' - 0"
ISELIN WHARF	G-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	G-9	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	UNK	-137' - 0"	139' - 0"
ISELIN WHARF	G.8-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-27.15	-137' - 0"	139' - 0"
ISELIN WHARF	H-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-17.86	-137' - 0"	139' - 0"
ISELIN WHARF	H-L	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-11.59	-137' - 0"	139' - 0"
ISELIN WHARF	J-L	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-13.93	-137' - 0"	139' - 0"
ISELIN WHARF	K-5	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-41.29	-171' - 0"	173' - 0"
ISELIN WHARF	K-6	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-33.93	-179' - 0"	181' - 0"
ISELIN WHARF	K-7	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-27.67	-137' - 0"	139' - 0"
ISELIN WHARF	K-8	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-18.98	-137' - 0"	139' - 0"
ISELIN WHARF	K-L	Ø36" x 0.75" WT	Steel ASTM A572 Gr 50	2' - 0"	-14.23	-137' - 0"	139' - 0"

INSTITUTE SUPPORT DOCK PILE SCHEDULE

LOCATION	PILE NUMBER	DIMENSION	MATERIAL	CUT OFF ELEV. (NAVD88)	PILE TIP ELEV. (NAVD88)	LENGTH
INSTITUTE SUPPORT DOCK	P1-ID	Ø24"	Concrete, Precast Piles	12' - 0"	-40' - 0"	52' - 0"
INSTITUTE SUPPORT DOCK	P2-ID	Ø24"	Concrete, Precast Piles	12' - 0"	-40' - 0"	52' - 0"
INSTITUTE SUPPORT DOCK	P3-ID	Ø24"	Concrete, Precast Piles	12' - 0"	-40' - 0"	52' - 0"
INSTITUTE SUPPORT DOCK	P4-ID	Ø24"	Concrete, Precast Piles	12' - 0"	-40' - 0"	52' - 0"
INSTITUTE SUPPORT DOCK	P5-ID	Ø24"	Concrete, Precast Piles	12' - 0"	-40' - 0"	52' - 0"
INSTITUTE SUPPORT DOCK	P6-ID	Ø24"	Concrete, Precast Piles	12' - 0"	-40' - 0"	52' - 0"
INSTITUTE SUPPORT DOCK	P7-ID	Ø24" x 0.625" WT	Steel ASTM A572 Gr 50	18' - 0"	-50' - 0"	68' - 0"

ROBOTICS VEHICLE DOCK PILE SCHEDULE

LOCATION	PILE NUMBER	DIMENSION	MATERIAL	CUT OFF ELEV. (NAVD88)	PILE TIP ELEV. (NAVD88)	LENGTH
ROBOTICS VEHICLE DOCK	P1-RD	Ø24"	Concrete, Precast Piles	12' - 0"	-50' - 0"	62' - 0"
ROBOTICS VEHICLE DOCK	P2-RD	Ø24"	Concrete, Precast Piles	12' - 0"	-50' - 0"	62' - 0"
ROBOTICS VEHICLE DOCK	P3-RD	Ø24"	Concrete, Precast Piles	12' - 0"	-50' - 0"	62' - 0"
ROBOTICS VEHICLE DOCK	P4-RD	Ø24"	Concrete, Precast Piles	12' - 0"	-50' - 0"	62' - 0"
ROBOTICS VEHICLE DOCK	P5-RD	Ø24"	Concrete, Precast Piles	12' - 0"	-50' - 0"	62' - 0"
ROBOTICS VEHICLE DOCK	P6-RD	Ø24" x 0.625" WT	Steel ASTM A572 Gr 50	18' - 0"	-60' - 0"	78' - 0"

NOTES:

1. REFER TO SHEET S-001 FOR ADDITIONAL INFORMATION.
2. PILE CUT OFF, MUDLINE, AND EMBEDMENT ELEVATIONS ARE MEASURED VERTICALLY. DATUM: NAVD88 = 0.00'. SPECIFIED INSTALL LENGTH ACCOUNTS FOR PILE BATTER, WHERE APPLICABLE.
3. WHERE INDICATED, ELEVATIONS ARE INTERPOLATED FROM EXISTING / SURROUNDING BATHYMETRIC AND SUBBOTTOM PROFILE DATA.
4. TEST PILES SHALL INCLUDE AN ADDITIONAL 15 FEET OF PILE LENGTH. DRIVE TEST PILES TO NOTED TIP ELEVATION.
5. PIPE PILES SHALL BE DRIVEN TO SUPPORT THE FOLLOWING DEMAND LOADS (PLUS SAFETY FACTOR AS SHOWN IN THE SPECIFICATION):
   - A. XXX KIPS IN COMPRESSION (XX KIPS LRFD DESIGN).
   - B. XXX KIPS IN TENSIONS (XXX KIPS LRFD DESIGN).
   - C. XXX KIPS IN SHEAR (XXX KIPS LRFD DESIGN) OR A MINIMUM TIP ELEVATION SHOWN, WHICHEVER IS DEEPEST.
6. NOTIFY ENGINEER IF PILE FAILS TO DEVELOP CAPACITY AND / OR REQUIRED TIP ELEVATION.
7. PILES SHALL FOLLOW THE FOLLOWING DRIVING TOLERANCES. IN ADDITION, IF OBSTRUCTIONS ARE ENCOUNTERED DURING DRIVING OF PILES, CONTRACTOR SHALL FOLLOW THE FOLLOWING PROCEDURES:
   - A. PILE TOLERANCES. PILES SHALL BE DRIVEN WITH AN INCLINATION OF NOT MORE THAN 1/16-INCH PER LINEAR FOOT FROM THE VERTICAL AND THE PILE TOPS SHALL NOT VARY FROM THE DESIGN POSITION SHOWN BY MORE THAN THE FOLLOWING DIMENSIONS:
     - a. PILE CAPITALS FOR HYDRAULIC LIFT OPTION: 12 INCH IN DIRECTION TRANSVERSE TO DOCK, 12 INCH IN DIRECTION LONGITUDINAL TO DOCK.
     - b. PILE CAPS FOR DECK OVERLAY OPTION: 6 INCH IN DIRECTION TRANSVERSE TO DOCK, 6 INCH IN DIRECTION LONGITUDINAL TO DOCK.
     - c. FLOATING DOCK GUIDE PILES: 3 INCH IN ANY DIRECTION.
   - B. INITIAL DRIVING. CONTRACTOR SHALL MAKE AT LEAST 3 ATTEMPTS TO DRIVE PILES IF THEY WANDER MORE THAN 6 INCHES IN THE FIRST 10 TO 20 FEET OF DRIVING, INCLUDING DRIVING THE PILES, REMOVING THE PILES, REALIGNING THE PILES, AND RE-DRIVING PILES 3 TIMES. IF PILES ARE STILL NOT IN CORRECT POSITION AFTER 3 ATTEMPTS, NOTIFY THE ENGINEER.
   - C. OBSTRUCTIONS. WHERE OBSTRUCTIONS ARE ENCOUNTERED THAT RESULT IN A SUDDEN, UNEXPECTED INCREASE IN PENETRATION RESISTANCE AND DEVIATION FROM THE SPECIFIED TOLERANCES, PERFORM 1 OR MORE OF THE FOLLOWING ACTIONS AT THE DIRECTION OF THE ENGINEER:
     - a. REMOVE THE OBSTRUCTION AND REDRIVE.
     - b. PERFORM A CENTER TUBE INSPECTION.
     - c. EXTRACT, INSPECT, REPOSITION, AND REDRIVE THE PILE.
   - D. IF THE OBSTRUCTION CANNOT BE SPUDDED THROUGH OR OCCURS DEEPER THAN 15 FEET BELOW THE GROUND SURFACE, DRIVE ANOTHER PILE AT AN ADJACENT LOCATIONDIRECTED BY THE ENGINEER.
8. PILES SHALL ACHIEVE A MINIMUM BEARING CAPACITY SPECIFIED ON PLANS AND IN ACCORDANCE WITH THE SPECIFICATIONS, USING A HAMMER OF AN APPROVED TYPE WITH A CAPACITY AT LEAST EQUAL TO THE HAMMER MANUFACTURERS RECOMMENDATION FOR THE TOTAL WEIGHT OF PILE AND CHARACTERISTICS OF SUBSURFACE MATERIAL TO BE ENCOUNTERED. STEEL PIPE PILES SHALL BE DRIVEN "OPEN ENDED" TO SPECIFIED TIP ELEVATION TO ACHIEVE NECESSARY END BEARING CAPACITY.
9. THE CONTRACTOR SHALL COORDINATE THE PILE INSTALLATION SCHEDULE SO AS NOT TO INTERFERE WITH OR BE DETRIMENTAL TO THE CONCRETE PLACEMENT AND CURING OPERATIONS.

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

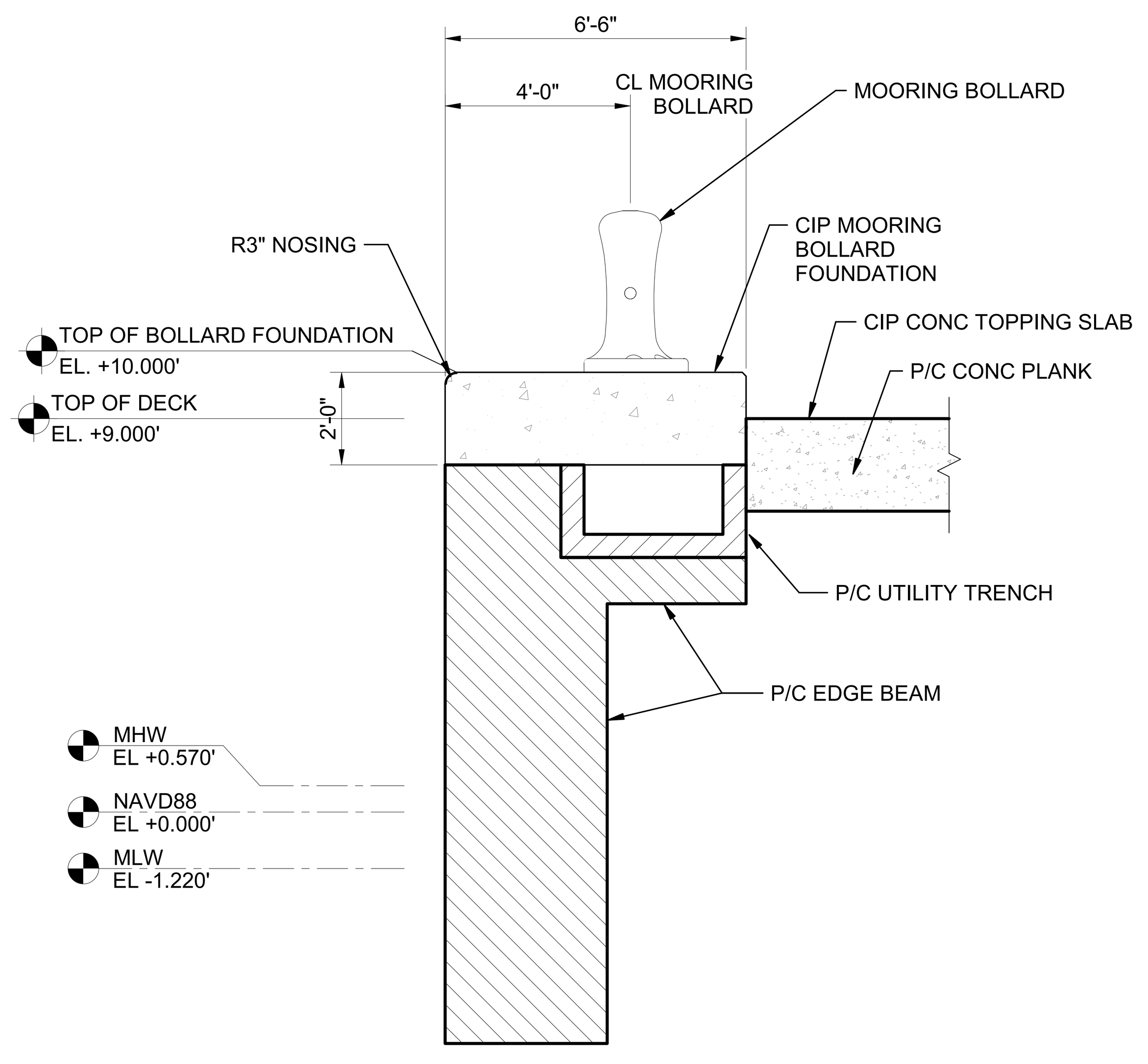
PILE SCHEDULE

Drawing Scale

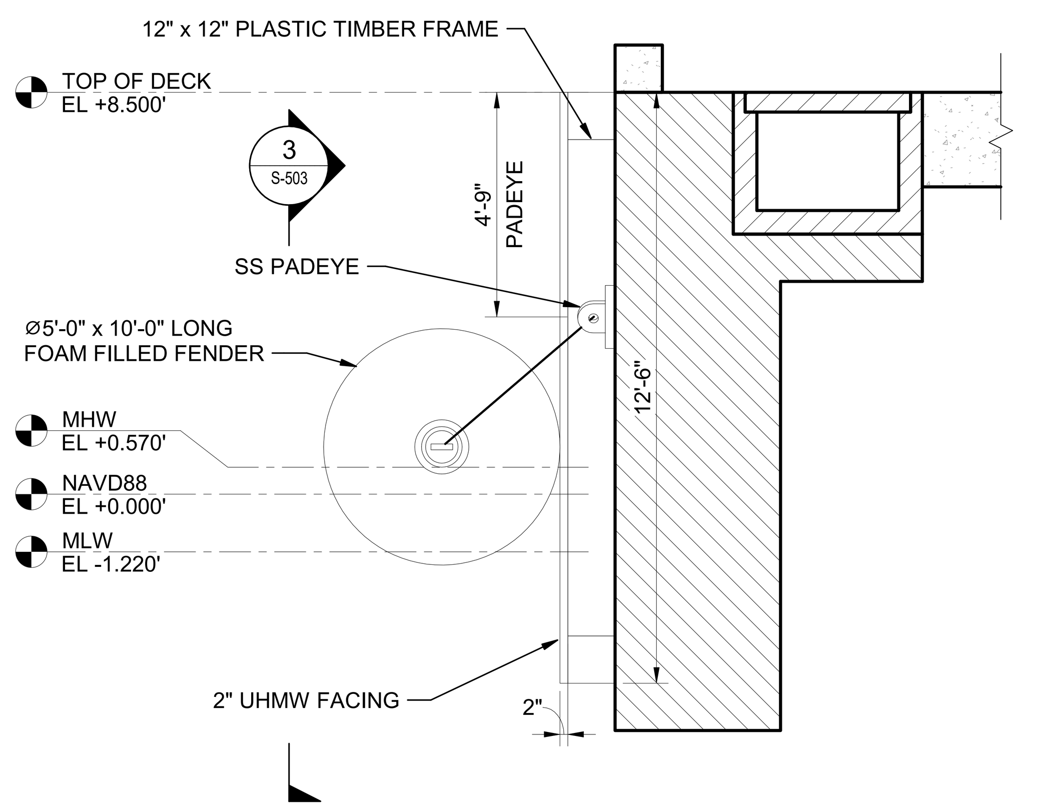
Project Number 0000-XX

Date Issued 04/23/21

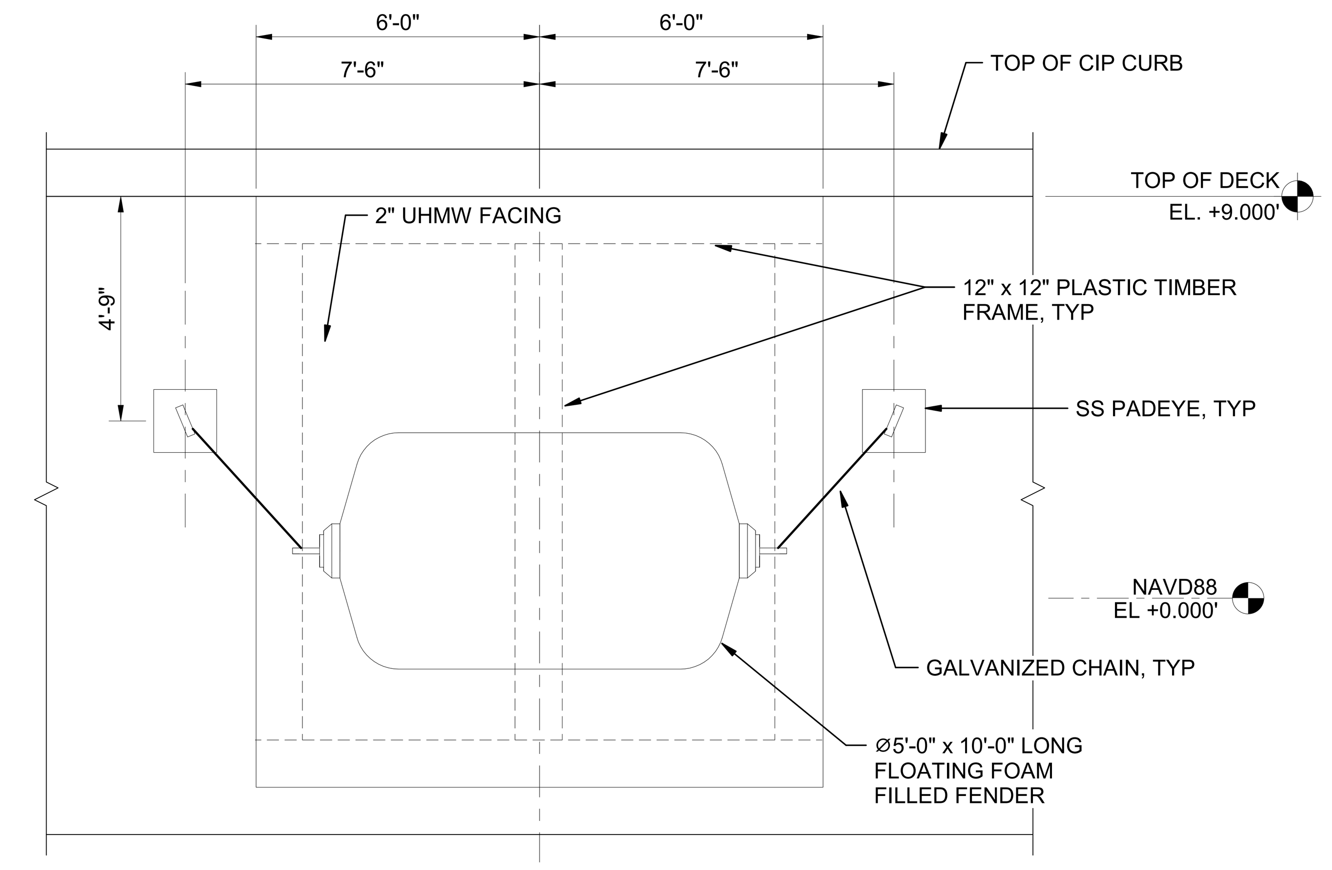
S-502



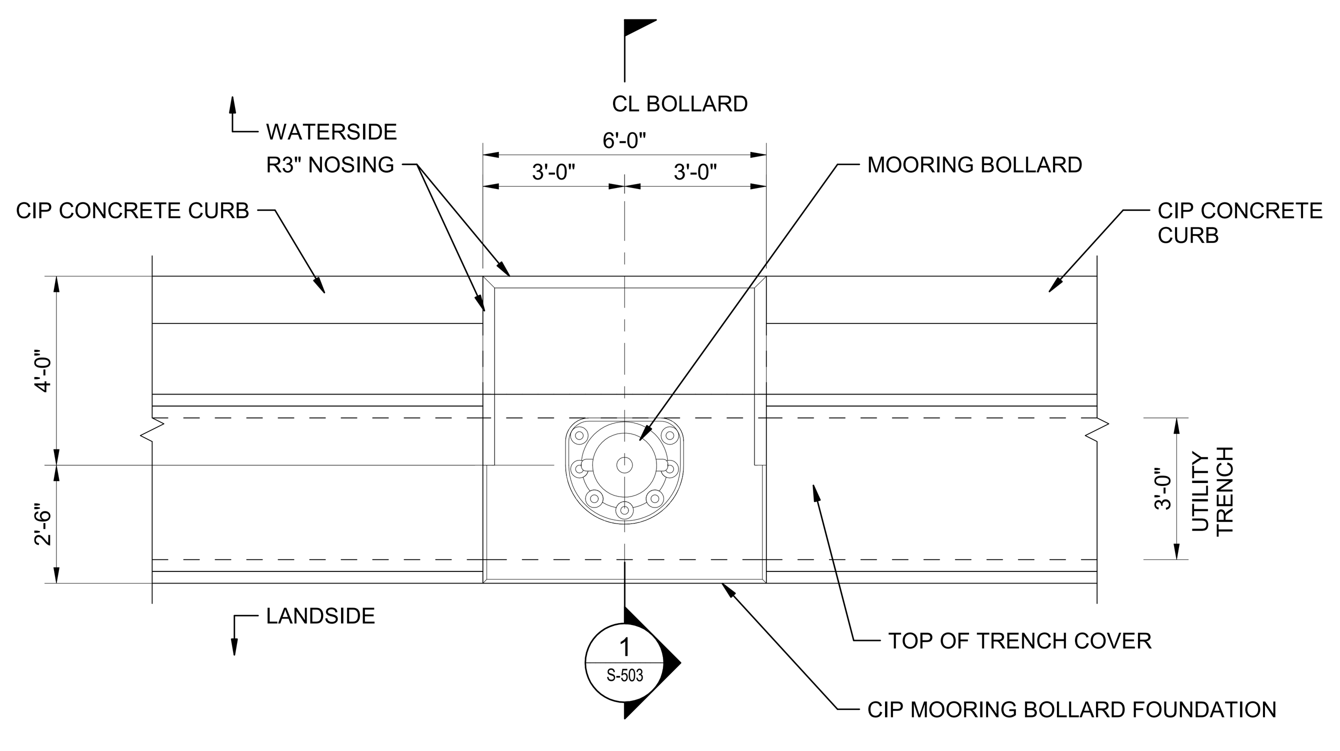
1 S-101 TYPICAL BOLLARD FOUNDATION SECTION
3/8" = 1'-0"



2 S-102 TYPICAL FENDER SECTION
3/8" = 1'-0"



3 S-503 FOAM FENDER MOUNTING SURFACE ELEVATION
3/8" = 1'-0"



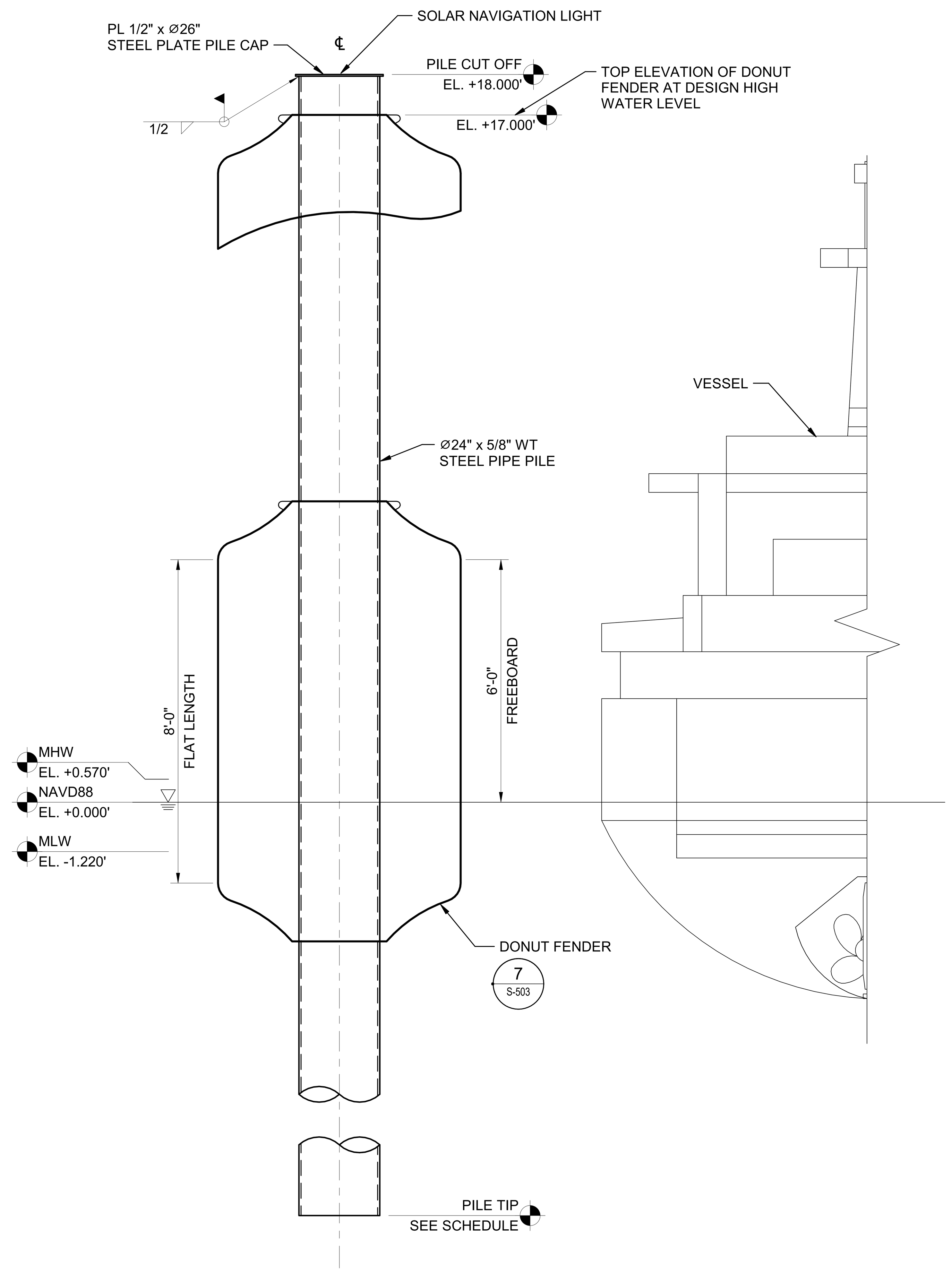
4 S-101 TYPICAL BOLLARD FOUNDATION PLAN
3/8" = 1'-0"

NOTES:

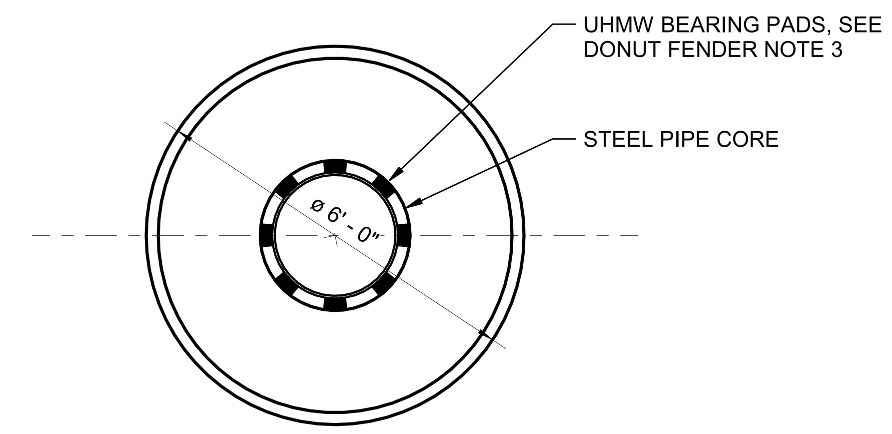
1. PILE SHALL BE ASTM A 572 GRADE 50.
2. PILE SHALL BE SEAMLESS WITHIN THE TRAVEL ELEVATIONS OF THE DONUT FENDER.
3. VESSEL FREEBOARD MUST MATCH DONUT FENDER FREEBOARD. FIELD ADJUSTMENT MAY BE NECESSARY.
4. THE REQUIRED DRAFT SHALL BE SUFFICIENT TO MAINTAIN THE MINIMUM FREEBOARD AS SHOWN.

DONUT FENDER NOTES:

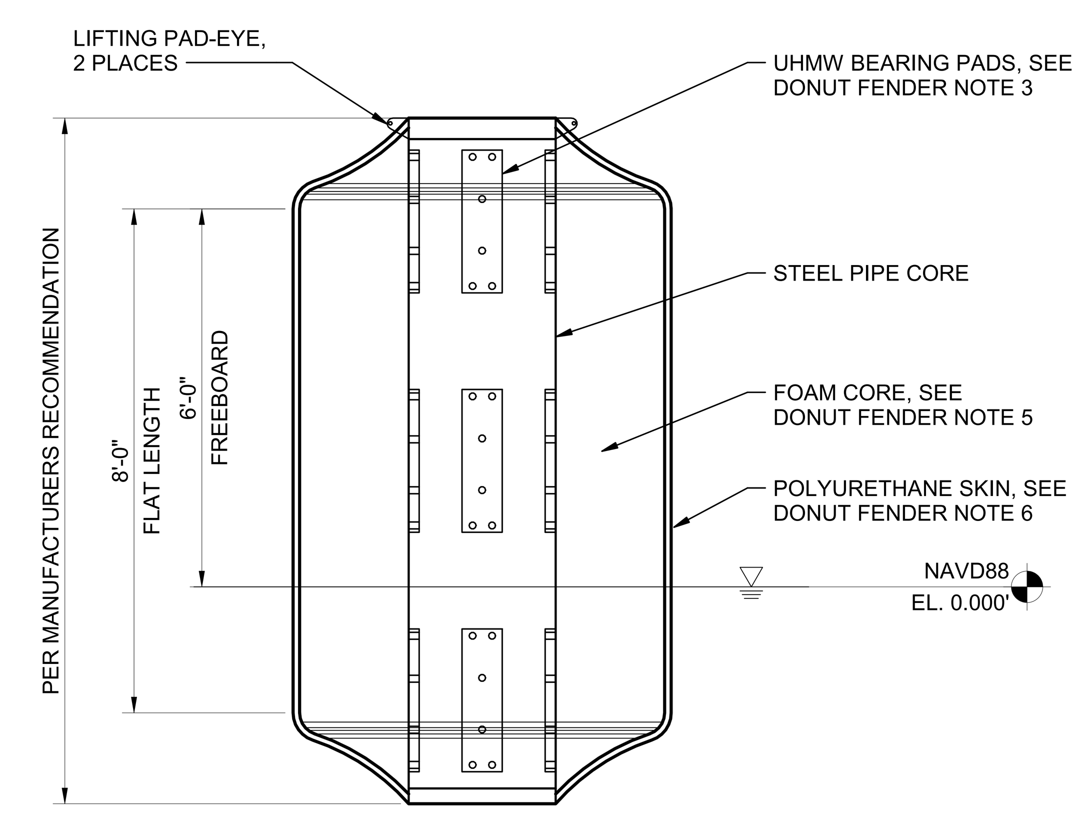
1. DONUT FENDER SHALL BE OCEAN GUARD MONOPILE DONUT FLOATING FENDER WITH "STANDARD CAPACITY" NOMINAL 6'-0" OD WITH 8'-0" FLAT LENGTH AS MANUFACTURED BY MARINE FENDERS INTERNATIONAL, INC. OR APPROVED EQUAL.
2. DONUT FENDER SHALL BE RATED FOR A MINIMUM 7 FT-KIP ENERGY ABSORPTION CAPACITY AT 60% FOAM COMPRESSION, DEVELOPING NO LARGER THAN A 24 KIP REACTION FORCE FOR A 2 FT CONTACT LENGTH.
3. MIN. 24 PCS. UHMW BEARING PADS AFFIXED WITH 316 STAINLESS STEEL FASTENERS.
4. DONUT FENDER STEEL CORE SHALL BE SANDBLASTED AND PAINTED WITH 2 PART MARINE EPOXY.
5. CLOSED-CELL POLYETHYLENE FOAM CORE.
6. 1 1/4" THICK DURABLE FILAMENT REINFORCED NON-MARKING POLYURETHANE SKIN. SKIN COLOR SHALL BE BLACK.



5 S-103 DONUT FENDER PILE ELEVATION
1/2" = 1'-0"



6 SECTION
1/2" = 1'-0"



7 S-503 DONUT FENDER DETAIL
1/2" = 1'-0"

2'-0" 0'-0" 2'-0" 4'-0"
SCALE: 1/2"=1'-0"

4'-0" 0'-0" 2'-0" 4'-0"
SCALE: 3/8"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

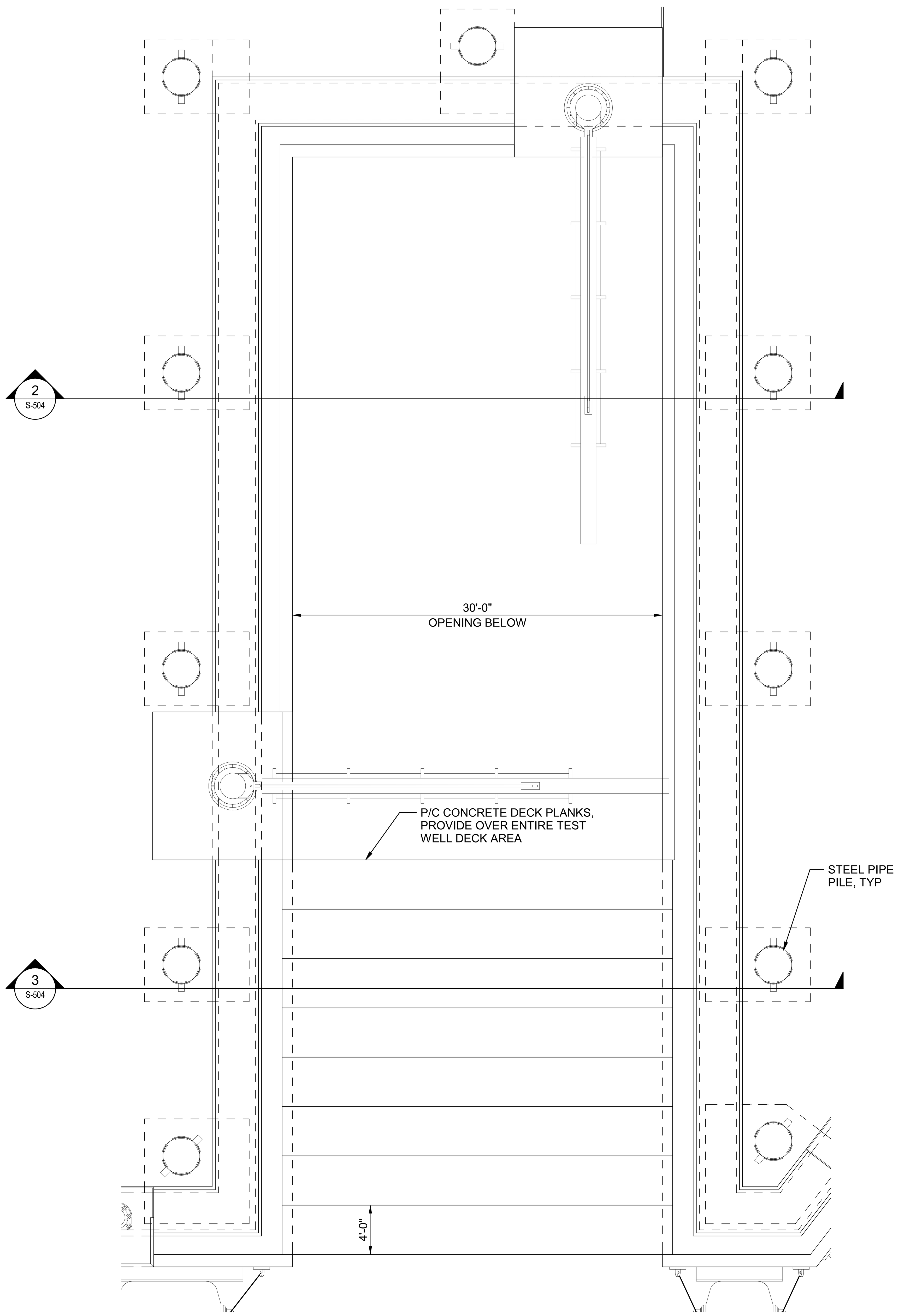
WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

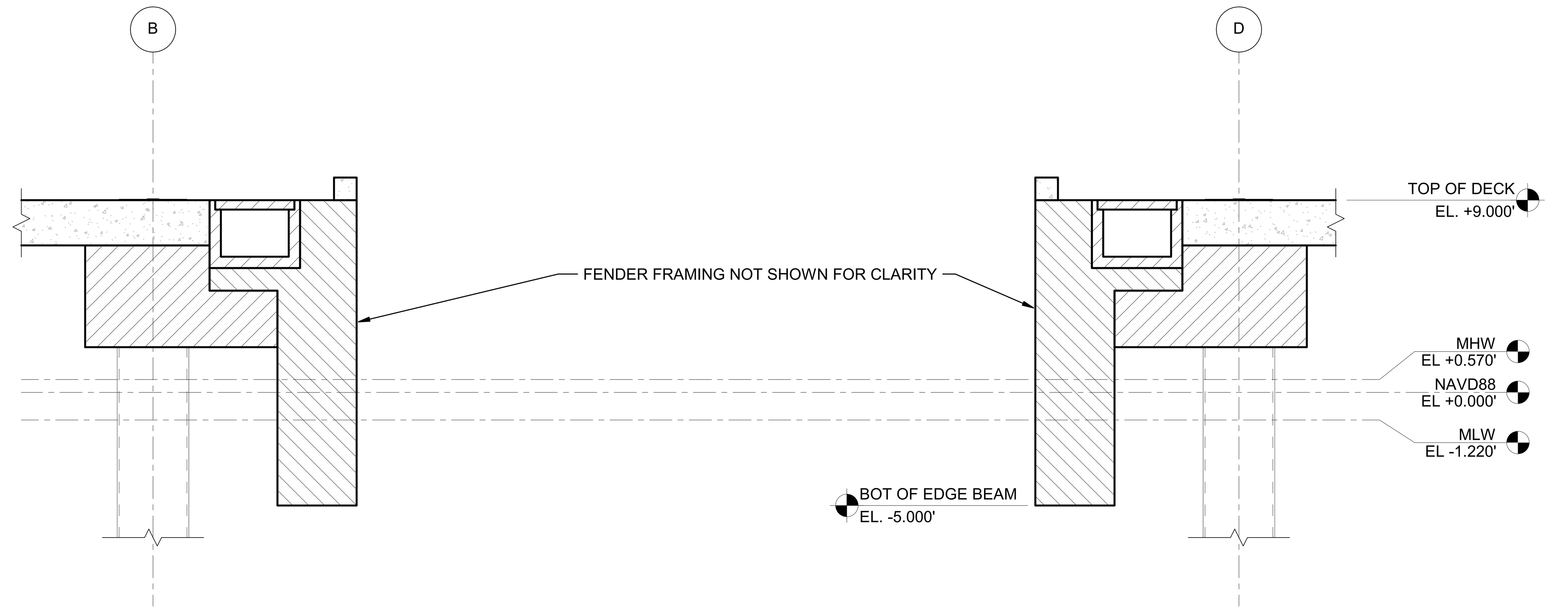
ISELIN DOCK TYPICAL DETAILS

Drawing Scale
As indicated
Project Number
0000-XX
Date Issued
05/14/2021

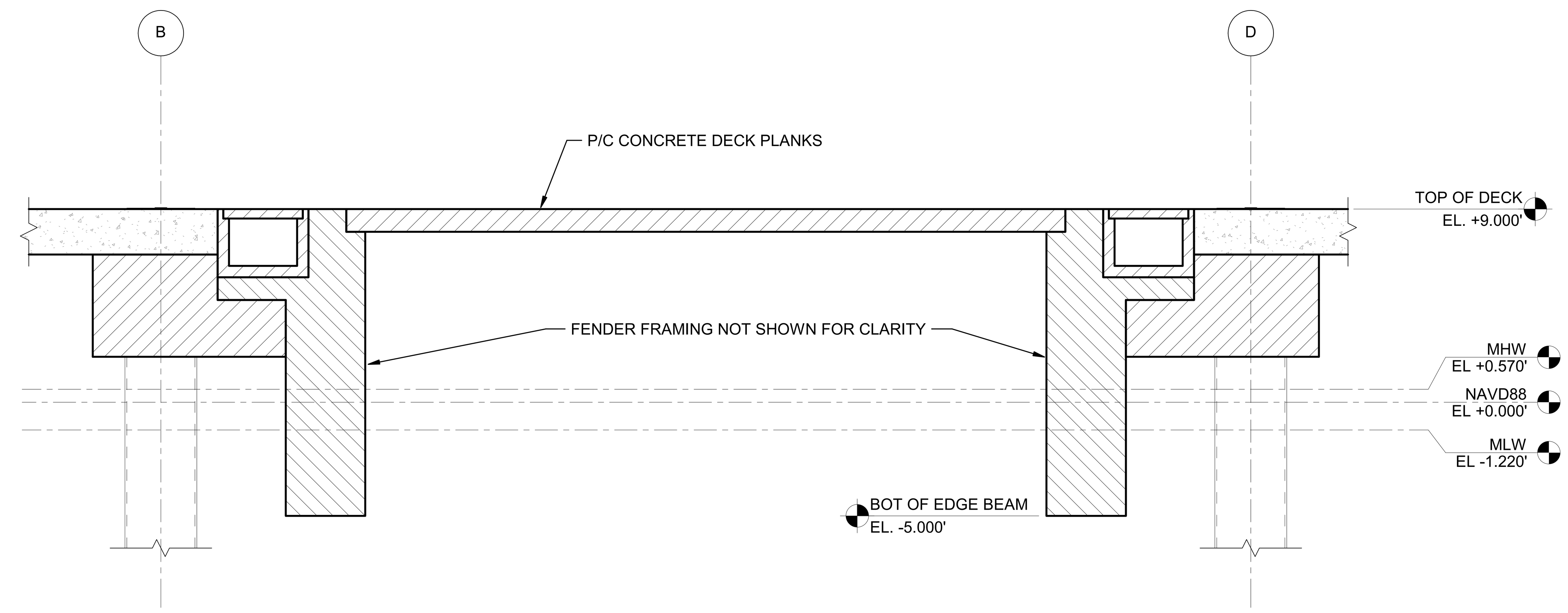
S-503



1 S-101 TEST WELL PLAN
3/16" = 1'-0"



2 S-504 TEST WELL SECTION WITHOUT REMOVABLE PLANKS
1/4" = 1'-0"



3 S-504 TEST WELL SECTION WITH REMOVABLE PLANKS
1/4" = 1'-0"

SCALE: 1/4"=1'-0"

SCALE: 3/16"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

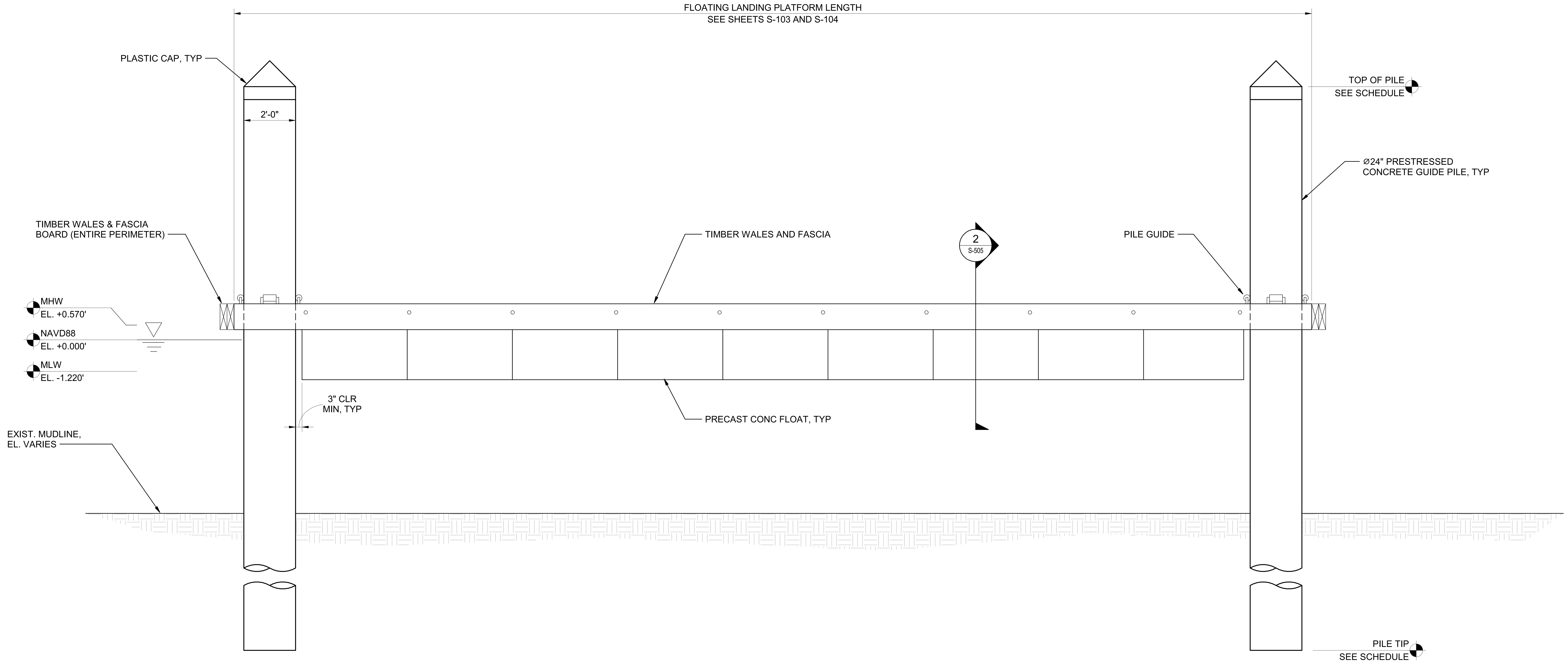
TEST WELL DETAILS

Drawing Scale
As indicated

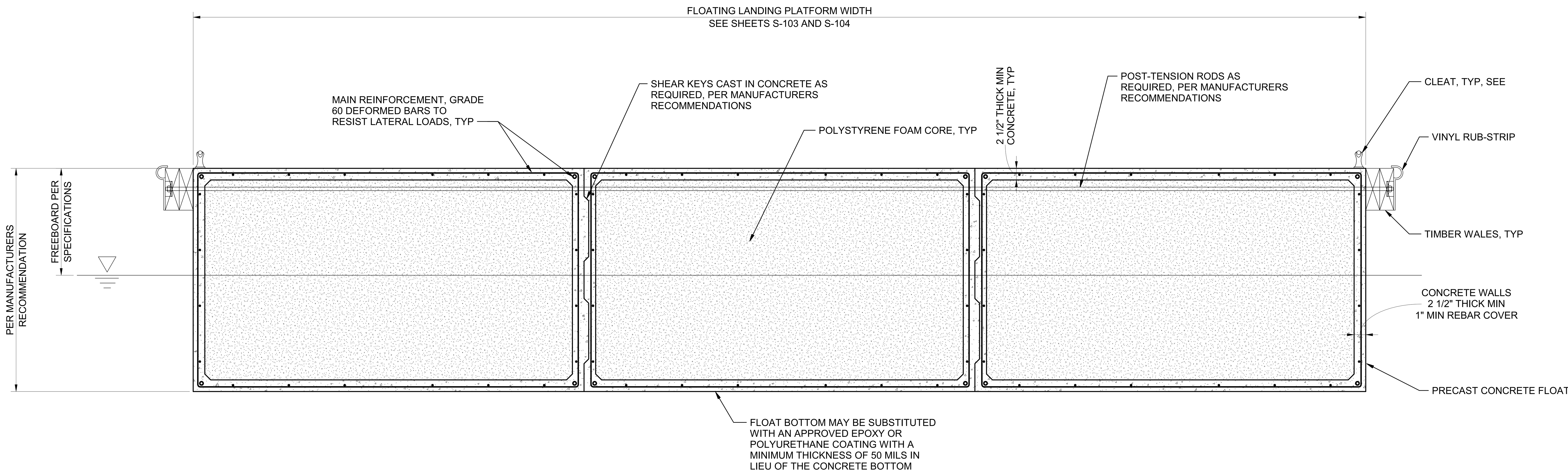
Project Number
0000-XX

Date Issued
05/14/2021

S-504



1
S-103
FLOATING DOCK ELEVATION
1/2" = 1'-0"



2
S-505
FLOATING DOCK SECTION
1" = 1'-0"

2'-0" 0'-0" 2'-0" 4'-0"
SCALE: 1/2"=1'-0"

1'-0" 0'-0" 1'-0" 2'-0"
SCALE: 1"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

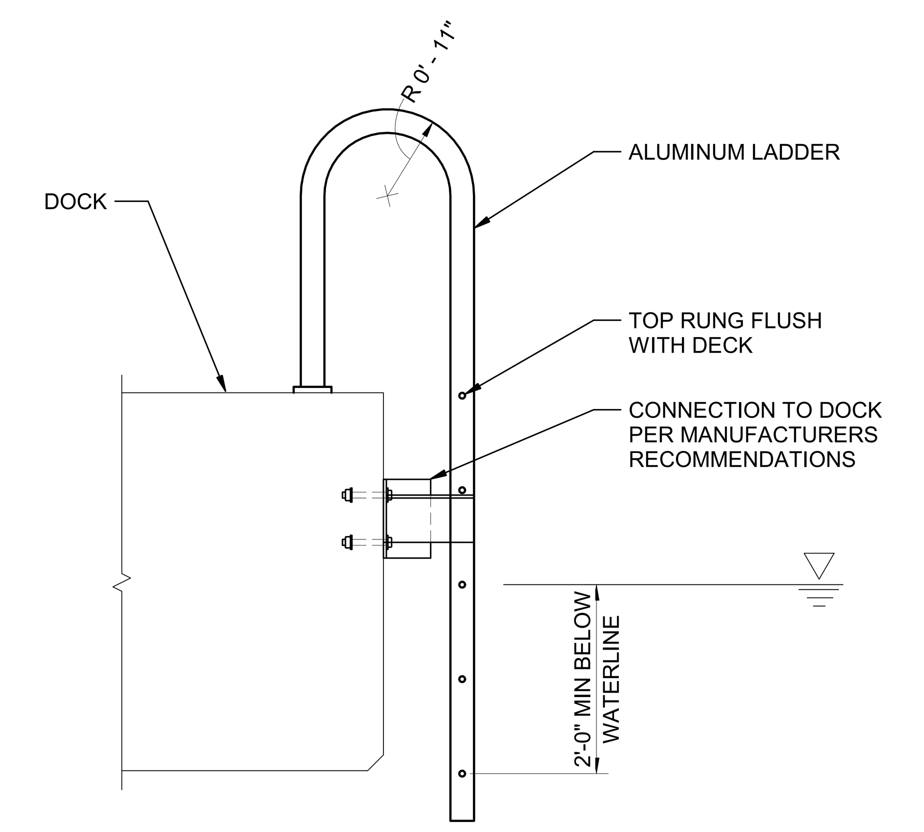
FLOATING DOCK TYPICAL SECTION AND ELEVATION

Drawing Scale
As indicated

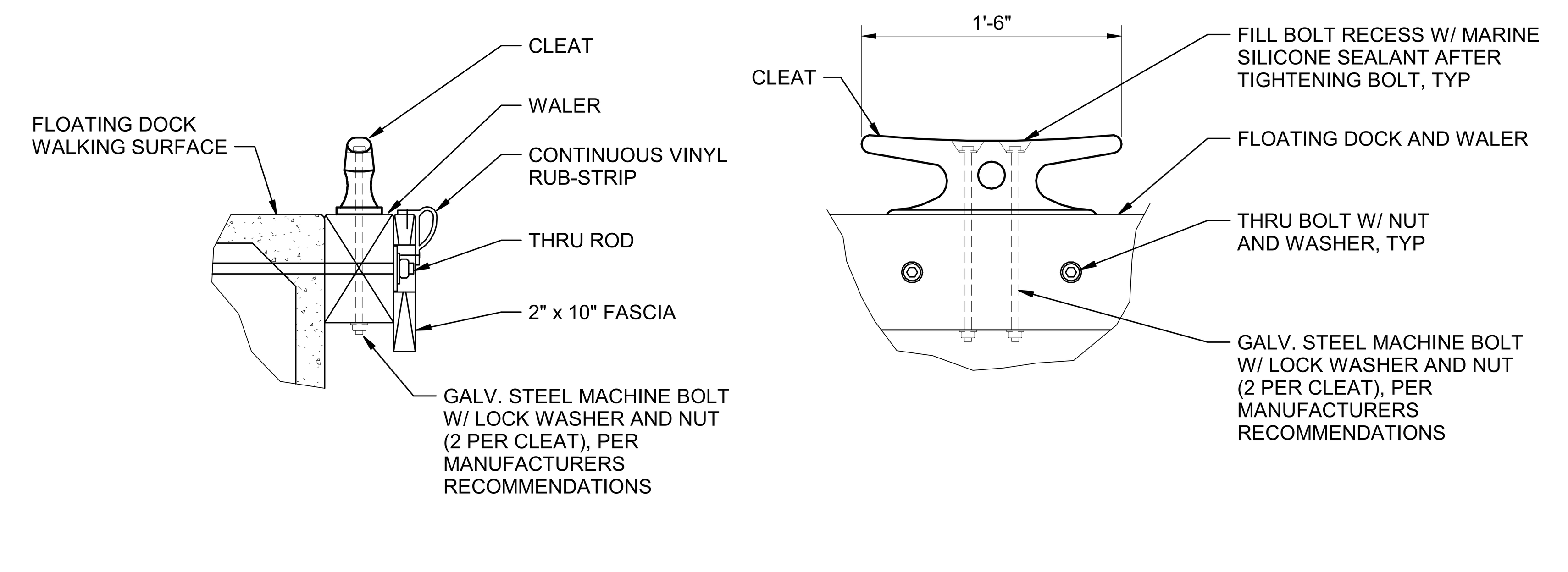
Project Number
0000-XX

Date Issued
04/27/21

S-505



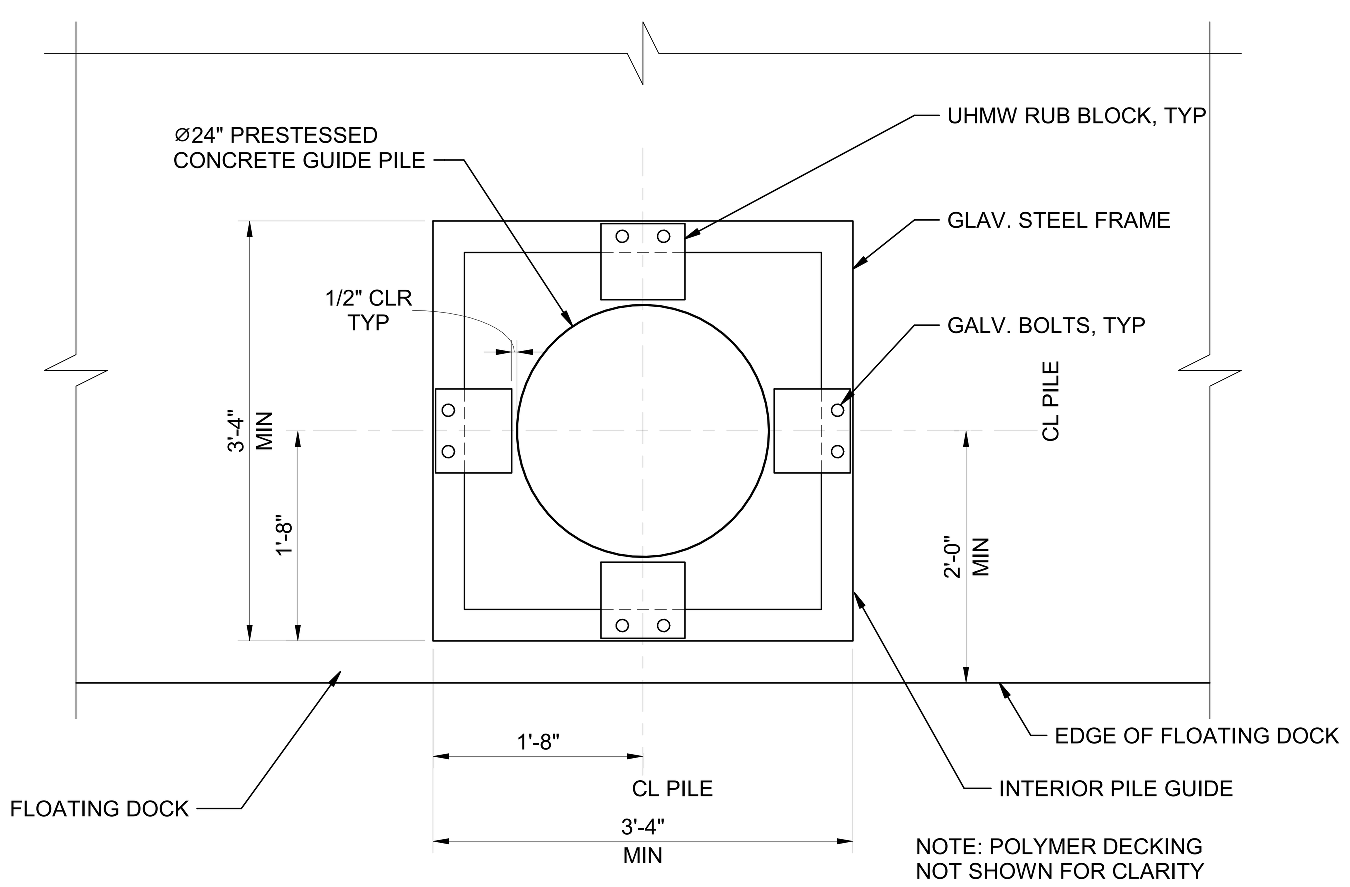
1 SAFETY LADDER DETAIL
3/4" = 1'-0"



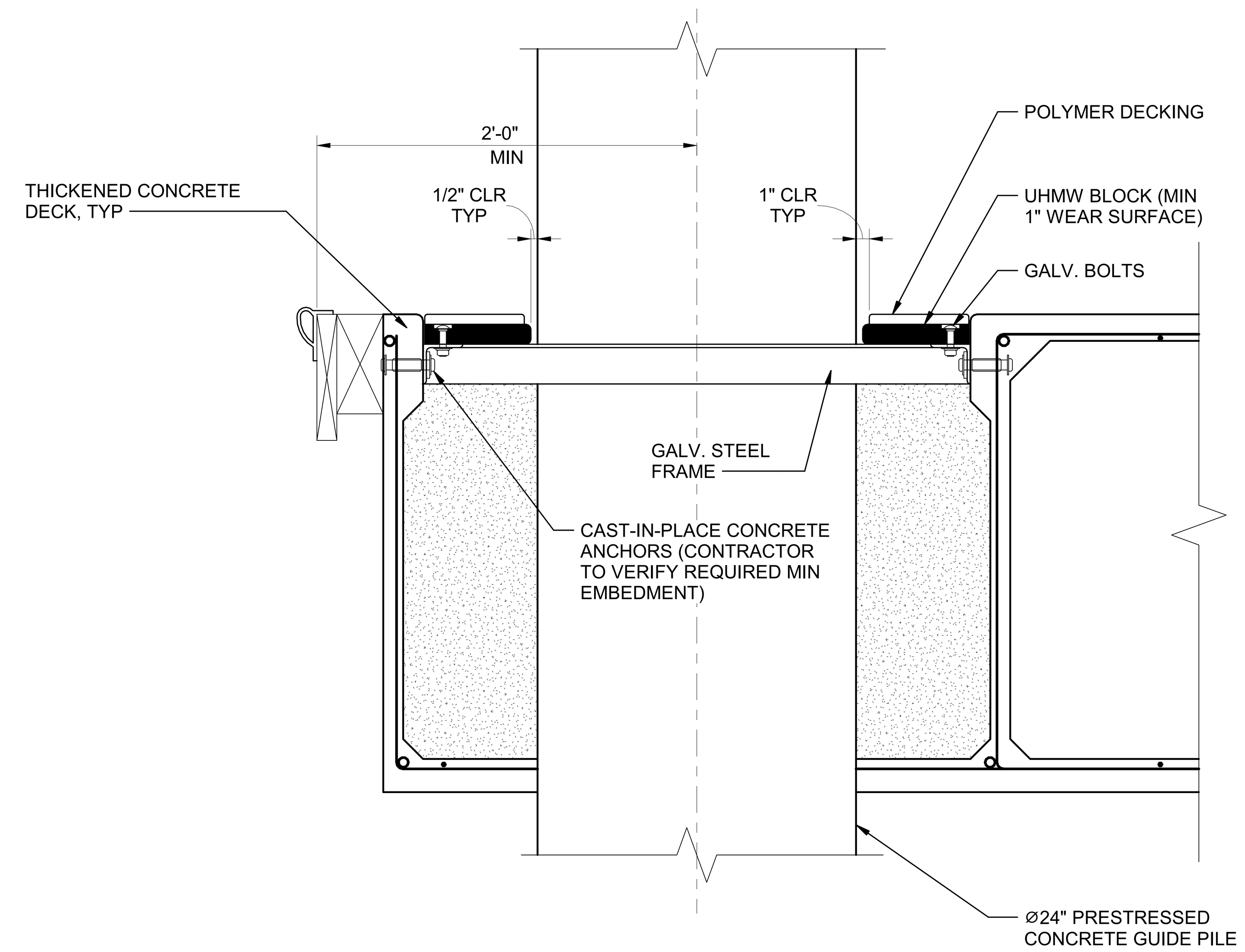
SECTION

ELEVATION

2 CLEAT DETAIL
1 1/2" = 1'-0"



3 PILE GUIDE PLAN
1" = 1'-0"



4 PILE GUIDE SECTION
1 1/2" = 1'-0"

1'-0" 0'-0" 0'-6" 1'-0"
SCALE: 1 1/2"=1'-0"

1'-0" 0'-0" 1'-0" 2'-0"
SCALE: 1"=1'-0"

2'-0" 0'-0" 1'-0" 2'-0"
SCALE: 3/4"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

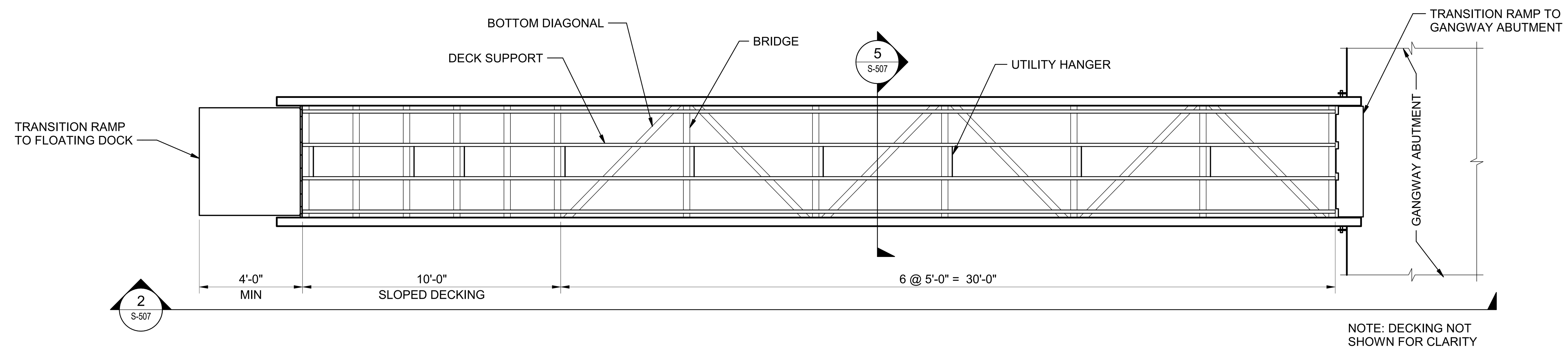
FLOATING DOCK TYPICAL DETAILS

Drawing Scale
As indicated

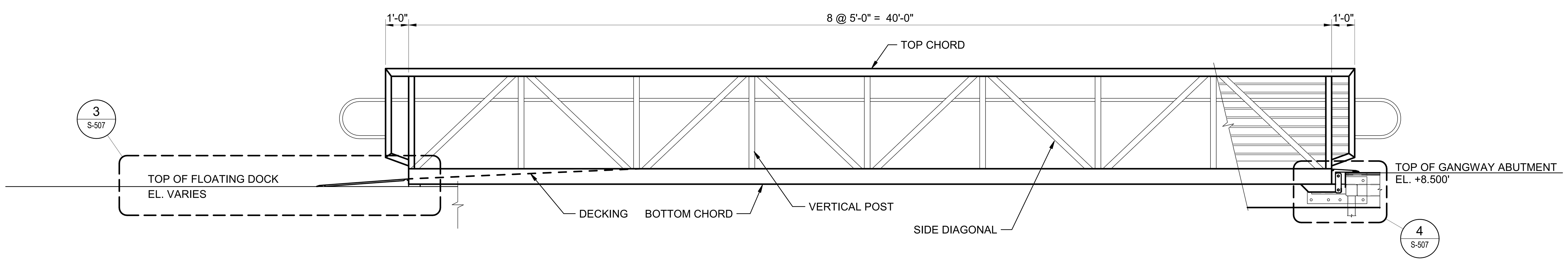
Project Number
0000-XX

Date Issued
04/27/21

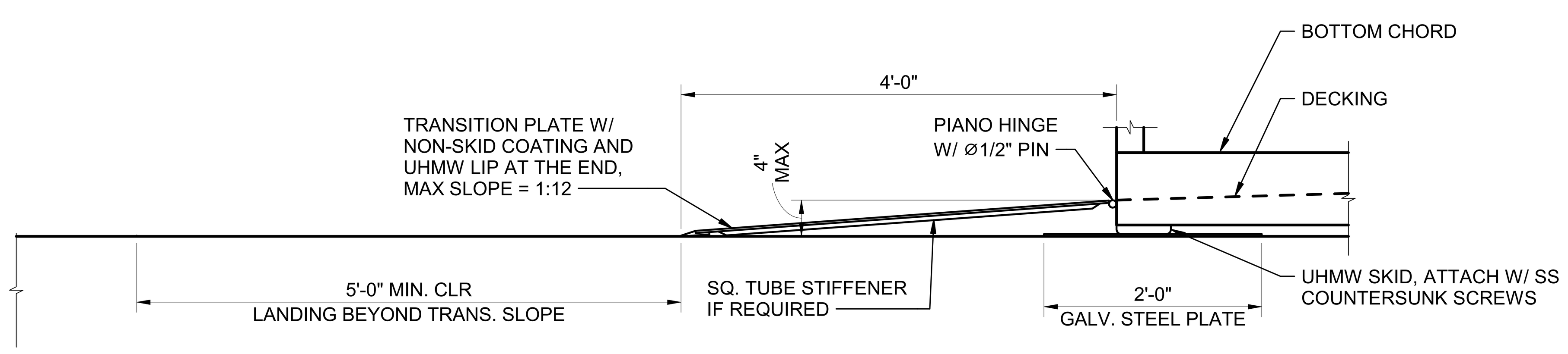
S-506



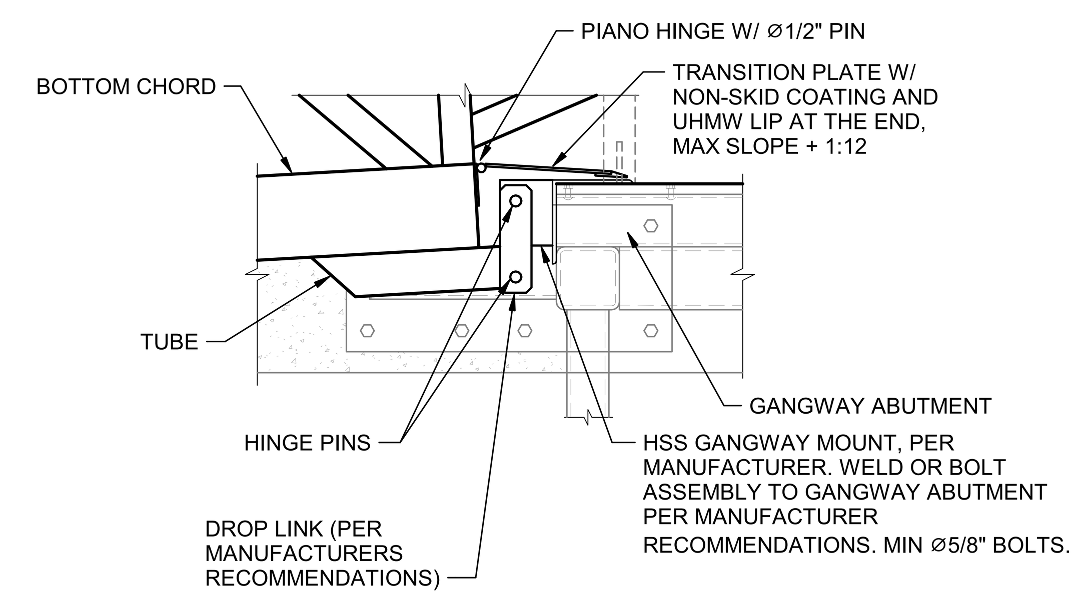
1 S-103 GANGWAY PLAN
3/8" = 1'-0"



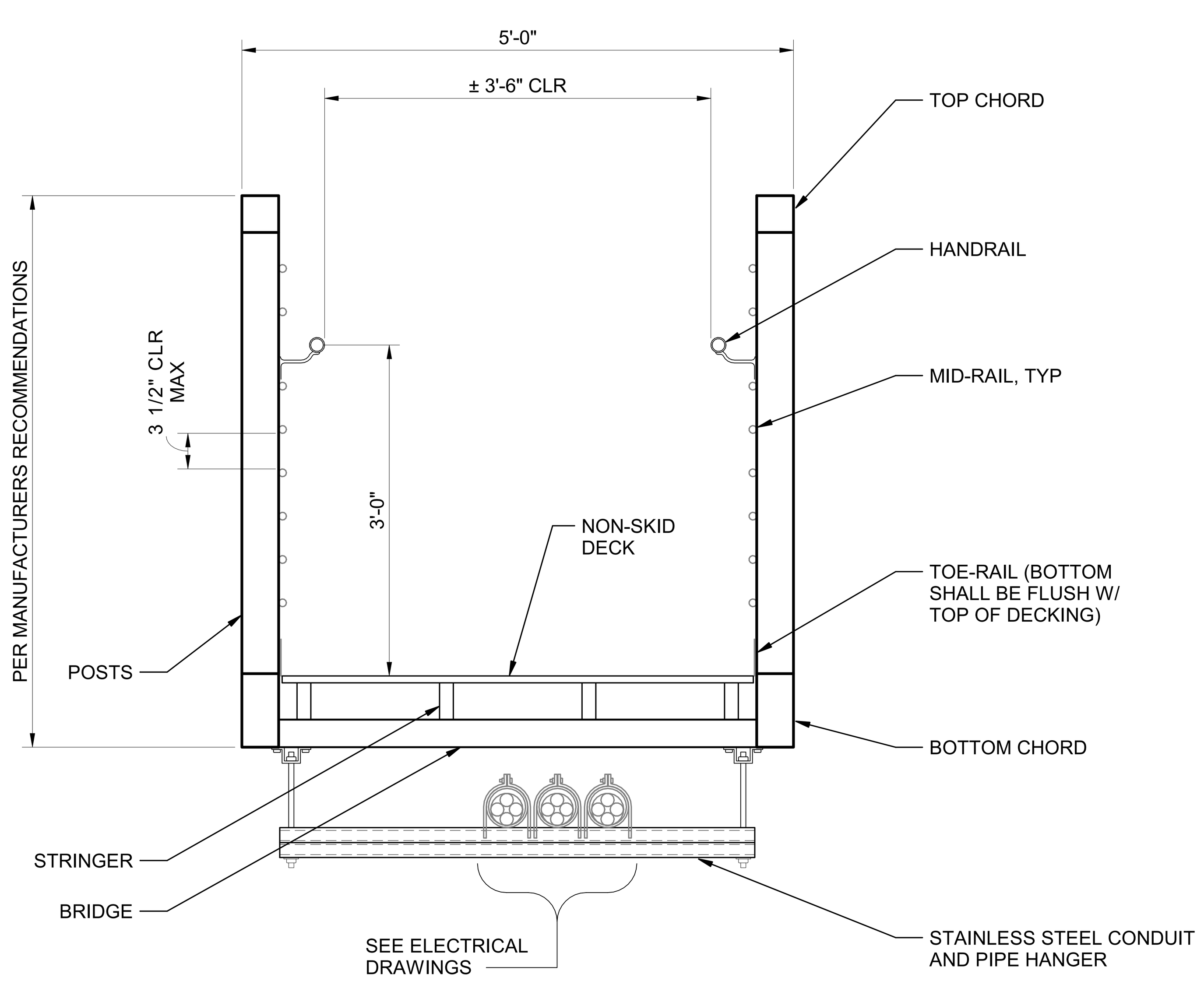
2 S-507 GANGWAY ELEVATION
3/8" = 1'-0"



3 S-507 GANGWAY DETAIL (FLOATING DOCK END)
1" = 1'-0"



4 S-507 GANGWAY DETAIL (GANGWAY ABUTMENT END)
1" = 1'-0"



5 S-507 GANGWAY SECTION
1" = 1'-0"

NOTES:

1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR STRUCTURAL STABILITY DURING CONSTRUCTION. THE STRUCTURE SHOWN ON THE DRAWINGS HAS BEEN DESIGNED FOR STABILITY IN THE FINAL CONFIGURATION ONLY.
2. THE CONTRACTOR SHALL BE RESPONSIBLE FOR STRUCTURAL DESIGN AND DETAILING OF THE GANGWAY AND MOUNTING HARDWARE SHOWN ON THIS SHEET. SEE SPECIFICATION FOR PERFORMANCE REQUIREMENTS.
3. ADJUSTABLE GANGWAY MUST BE FUNCTIONAL OVER ENTIRE TIDAL RANGE. NO PORTION OF GANGWAY SHALL BE SUBJECT TO SUBMERSION.
4. GANGWAY. RAMP, AND TRANSITION PLATE SHALL MEET CURRENT ADA ACCESSIBILITY GUIDELINES FOR RECREATIONAL FACILITIES. AS SUCH, MINIMUM LENGTHS AND MAXIMUM ALLOWED SLOPES SHALL BE MAINTAINED BETWEEN ALL DESIGN WATER LEVELS.
5. FRAMING SHALL BE 6061-T6 OR 6063-T6 ALUMINUM ALLOY CONFORMING TO ASTM B 209, B 221, AND B 303.
6. RAILING SHALL BE 6061-T6 ALUMINUM PIPE AND TUBING ASTM B 429. A 4" SPHERE SHALL NOT BE ABLE TO PASS THROUGH THE RAILING. RAILING SHALL EXTEND 1' BEYOND GANGWAY LENGTH AS SHOWN HEREIN.
7. DIRECT CONTACT BETWEEN ALUMINUM AND DISSIMILAR METALS IS NOT PERMITTED.

1'-0" 0'-0" 1'-0" 2'-0"
SCALE: 1"=1'-0"

4'-0" 0'-0" 2'-0" 4'-0"
SCALE: 3/8"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

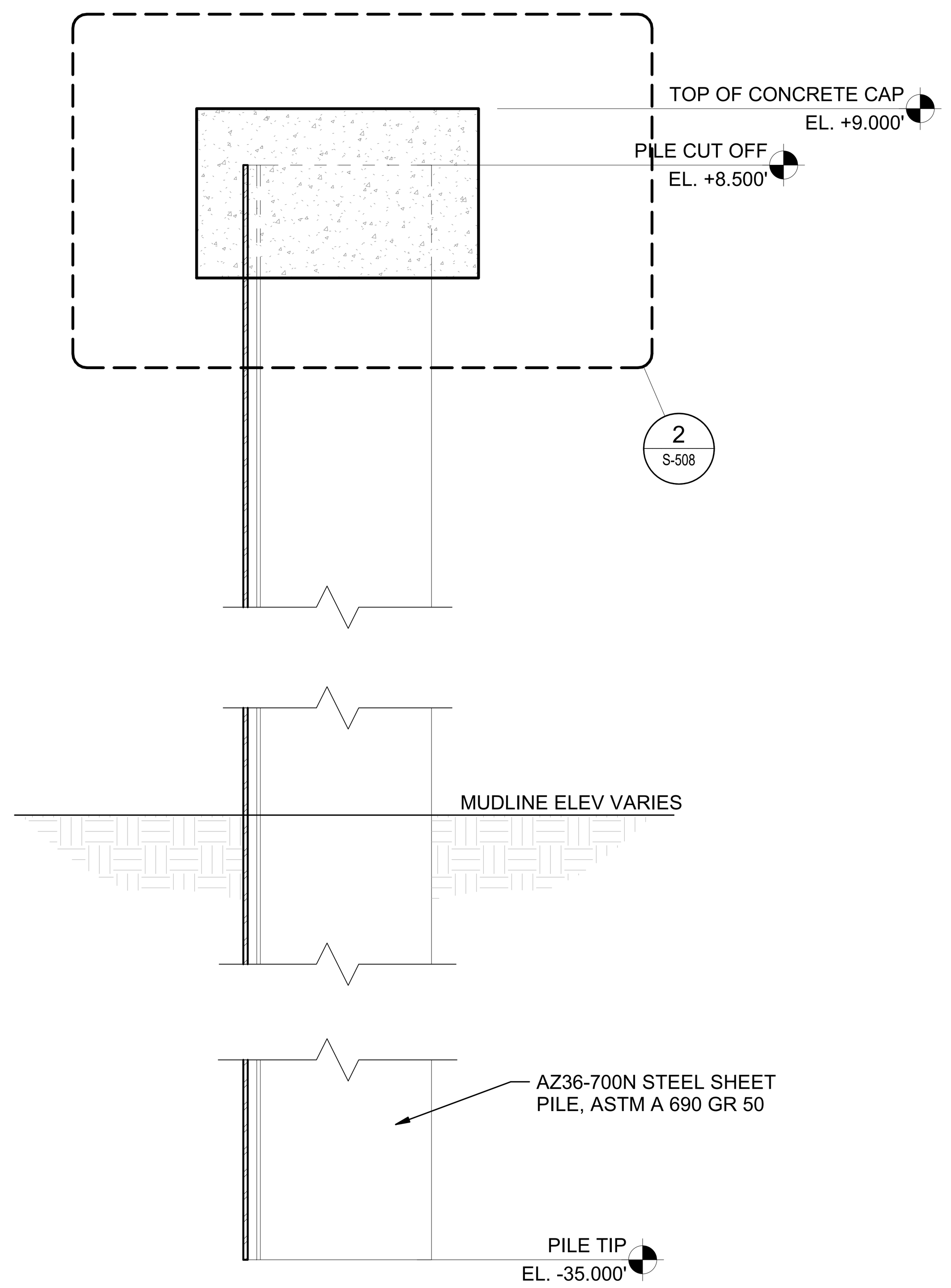
WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

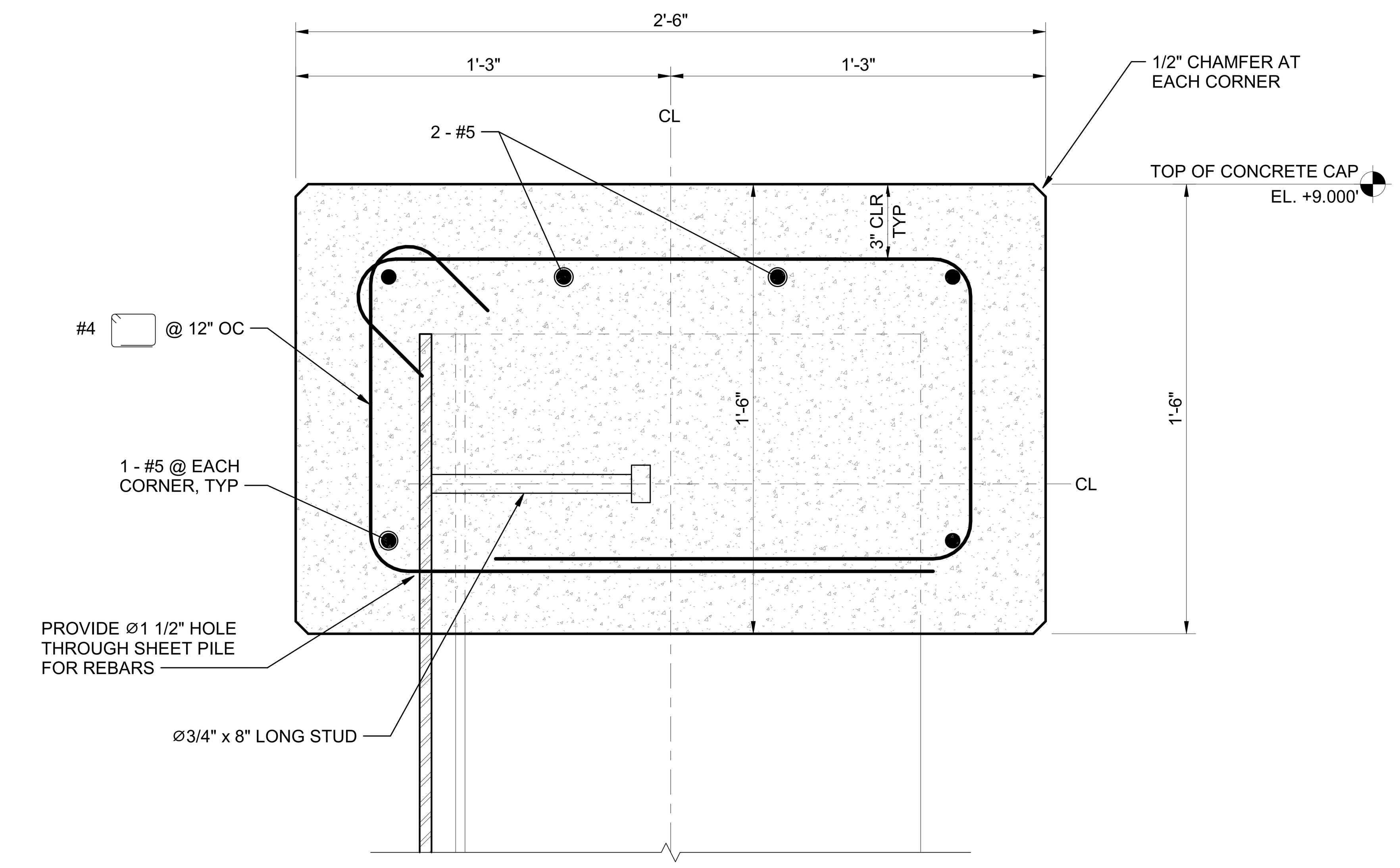
ALUMINUM GANGWAY TYPICAL DETAILS

Drawing Scale	As indicated
Project Number	0000-XX
Date Issued	04/27/21

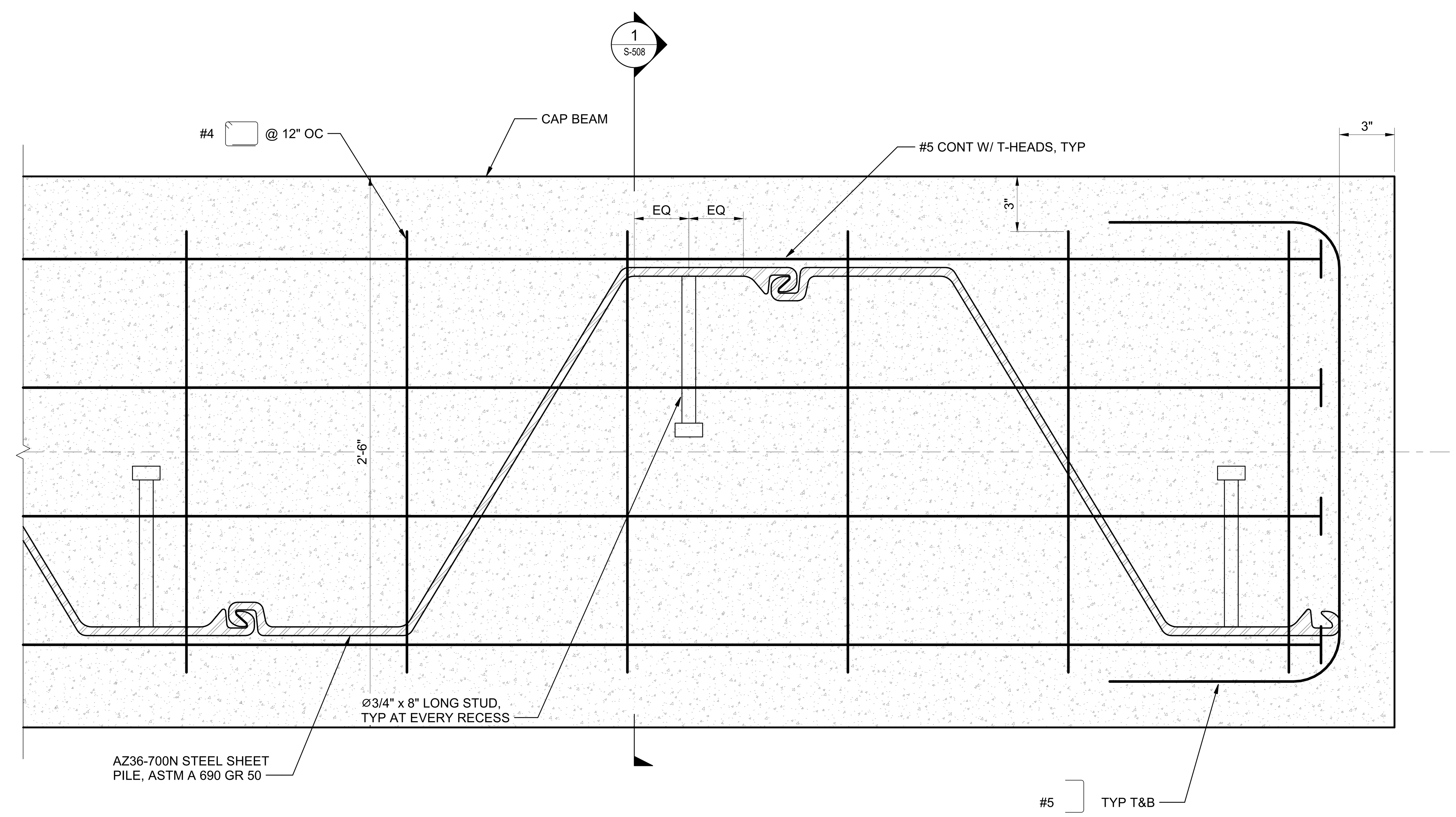
S-507



1 S-104 WAVE SCREEN SECTION
1" = 1'-0"



2 S-508 WAVE SCREEN CONCRETE CAP SECTION
3" = 1'-0"



3 S-103 DETAIL AT PILE CAP END
3" = 1'-0"

1'-0" 0'-0" 1'-0" 2'-0"
SCALE: 1"=1'-0"

0'-6" 0'-0" 0'-3" 0'-6"
SCALE: 3"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

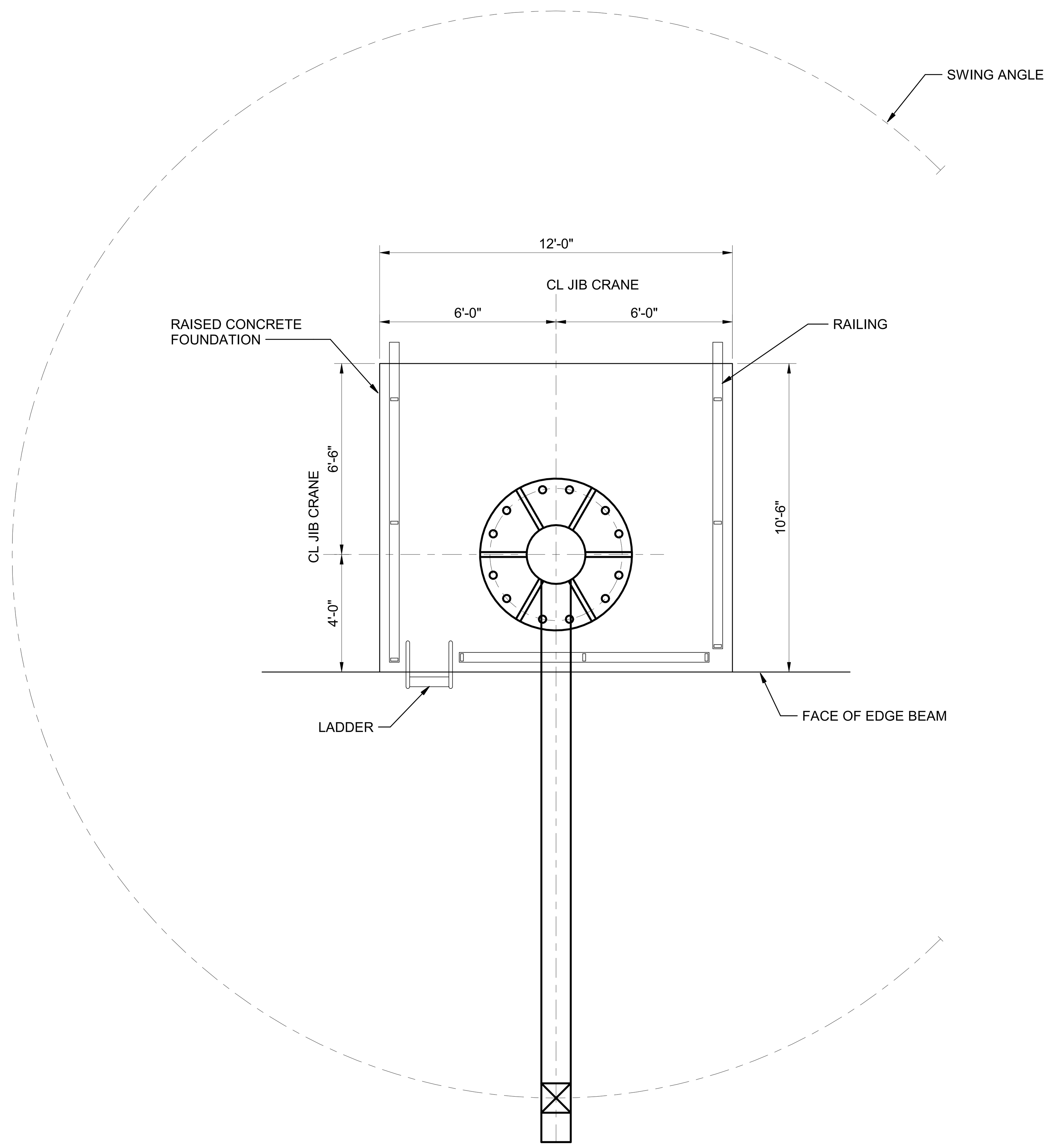
WAVE SCREEN TYPICAL DETAILS

Drawing Scale
As indicated

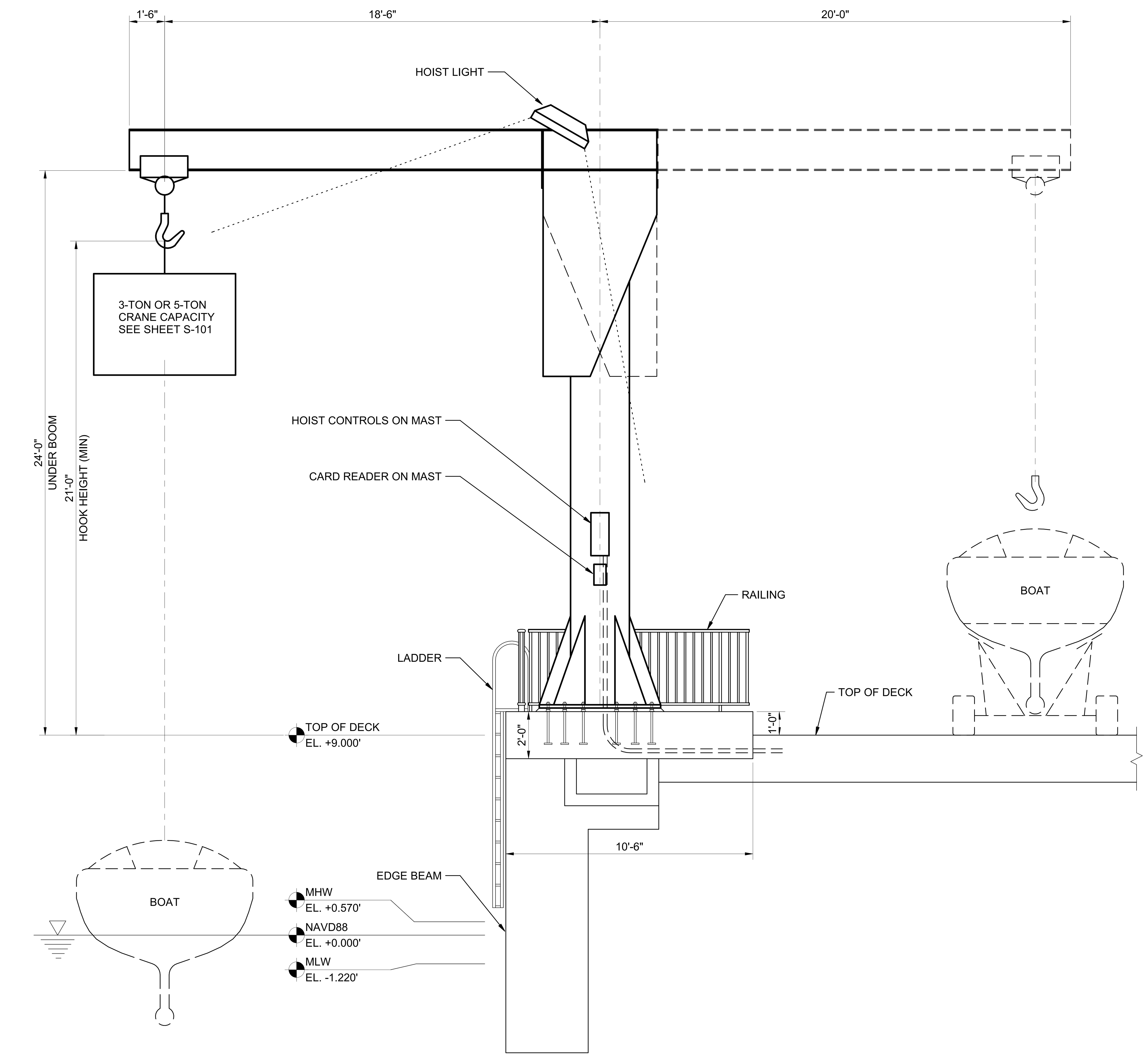
Project Number
0000-XX

Date Issued
04/28/21

S-508



1 S-101 JIB CRANE PLAN VIEW
3/8" = 1'-0"



2 JIB CRANE ELEVATION VIEW
3/8" = 1'-0"

NOTES:

1. LOCATION OF LADDER AND RAILING VARY DEPENDING UPON JIB CRANE LOCATION.

2. HOIST IS JIB CRANE MODEL 400-BPM, 3-TON CAPACITY "RELIABLE" (5-TON CRANE SIMILAR), AS MANUFACTURED BY STANSPEC, WITH 20' SPAN, 24' UNDER BOOM HEIGHT, 62" BASE PLATE FOR 12 - 1 1/4" ANCHOR BOLTS, 24" OD x 1/2" WT MAST, AND FIXED HOOK POSITION AS SHOWN. ROTATION SPEED IS 0.5 RPM AND HOIST SPEED IS 10 FEET PER MINUTE. HOIST CONTROLS SHALL BE A 6 - PUSHBOTTON STATION ON CRANE MAST WITH BUTTONS MARKED AS:

   ON / OFF / UP / DOWN / RIGHT / LEFT

3. HOIST SHALL HAVE A MAGNETIC CARD READER ON MAST TO ACTIVATE.

4. HOIST SHALL HAVE A 175 WATT METAL HALIDE LIGHT MOUNTED ATOP THE CRANE TO PROVIDE LIGHTING OF THE HOIST AREA, AND BE ON A SEPARATE CIRCUIT FROM THE HOIST WITH A STATIONARY ON/OFF SWITCH MOUNTED ON THE MAST.

4'-0" 0'-0" 2'-0" 4'-0"
SCALE: 3/8"=1'-0"

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMITTAL
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

JIB CRANE DETAILS

Drawing Scale
3/8" = 1'-0"

Project Number
0000-XX

Date Issued
05/06/21

S-509

Woods Hole Oceanographic Institution

86 WATER STREET - WOODS HOLE , MA 02543

CWATER PROJECT
ISELIN DOCK REPLACEMENT

30% CIVIL DESIGN PACKAGE

VICINITY MAP

LOCATION MAP

SHEET INDEX	
Sheet Number	SHEET TITLE
GENERAL	
G-001	COVER SHEET
G-002	GENERAL NOTES
G-003	GENERAL NOTES
EXISTING CONDITIONS	
V-100	OVERALL EXISTING CONDITIONS PLAN
V-101	EXISTING CONDITIONS PLAN
V-102	EXISTING CONDITIONS PLAN
V-103	EXISTING CONDITIONS PLAN
DEMOLITION	
CD100	OVERALL DEMOLITION PLAN
CD101	DEMOLITION PLAN
CD102	DEMOLITION PLAN
CD103	DEMOLITION PLAN
SITE	
CS100	OVERALL SITE PLAN

SHEET INDEX	
Sheet Number	SHEET TITLE
DRAINAGE & GRADING	
CG100	OVERALL GRADING & DRAINAGE PLAN
CG101	DRAINAGE & GRADING PLAN
CG102	DRAINAGE & GRADING PLAN
CG103	DRAINAGE & GRADING PLAN
CG201	DRAINAGE PROFILES
CG202	DRAINAGE PROFILES
CG501	DRAINAGE DETAILS
CG502	DRAINAGE DETAILS
UTILITY	
CU100	OVERALL UTILITY PLAN
CU101	UTILITY PLAN
CU102	UTILITY PLAN
CU103	UTILITY PLAN

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

COVER SHEET

Drawing Scale

Project Number

Date Issued
5/12/21

G-001

GENERAL NOTES

1. NOTES BELOW ARE NOT INTENDED TO REPLACE SPECIFICATIONS. SEE SPECIFICATIONS FOR REQUIREMENTS IN ADDITION TO GENERAL NOTES.
2. IN CASE OF DISCREPANCY BETWEEN THE CONTRACT DOCUMENTS AND THE ABOVE SPECIFICATIONS, THE CONTRACT DOCUMENTS SHALL GOVERN. GDOT STANDARD SPECIFICATION PAYMENT PROVISIONS DO NOT APPLY.
3. THE CONTRACTOR SHALL OBTAIN ALL APPLICABLE PERMITS AND LICENSES AND KEEP COPIES OF THE SAME ON SITE DURING CONSTRUCTION.
4. CONTRACTOR SHALL VERIFY ALL DIMENSIONS SHOWN ON THE PLANS WITH THE EXISTING CONDITIONS IN THE FIELD PRIOR TO COMMENCING DEMOLITION, FABRICATION, AND CONSTRUCTION. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE OWNER OF DISCREPANCIES BETWEEN EXISTING CONDITIONS AND THE CONTRACT DOCUMENTS.
5. ALL INFORMATION SHOWN ON THESE DRAWINGS RELATIVE TO EXISTING CONDITIONS IS GIVEN AS THE BEST PRESENT KNOWLEDGE, BUT WITHOUT GUARANTEE OF ACCURACY. THE CONTRACTOR SHALL REPORT IMMEDIATELY TO THE OWNER ANY CONDITIONS CONFLICTING WITH THE DRAWINGS. FIELD MODIFICATIONS TO THE DRAWINGS SHALL NOT BE MADE WITHOUT THE CONSENT OF THE OWNER.
6. THE CONTRACTOR SHALL ENSURE THAT ALL PIPES, CATCH BASINS, MANHOLES, SWALES, ETC., WITHIN AND NEAR THE AREA OF WORK ARE KEPT FREE FROM MATERIAL THAT WOULD HAMPER THE PERFORMANCE OF THE DRAINAGE SYSTEMS. UPON COMPLETION OF CONSTRUCTION, REMOVE ACCUMULATED SEDIMENT, DISPOSE OF ALL UNSUITABLE OR EXCESS EXCAVATED MATERIALS AWAY FROM OWNER'S PROPERTY.
7. WHERE CROSSING ANY EXISTING SUBSTRUCTURES WITH NEW SUBSURFACE IMPROVEMENTS, THE CONTRACTOR SHALL TRENCH CAREFULLY TO LOCATE ALL SUBSTRUCTURES AT THESE CROSSINGS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR REPAIRING ALL SUBSTRUCTURES DAMAGED DURING CONSTRUCTION AT NO ADDITIONAL COST TO THE OWNER.
8. ALL AREAS OUTSIDE THE "PROJECT LIMITS" WHICH ARE DAMAGED BY THE CONTRACTOR, SHALL BE RESTORED BY THE CONTRACTOR TO THEIR ORIGINAL CONDITION. THE RESTORATION SHALL BE DONE AT NO ADDITIONAL COST TO THE OWNER.
9. SAFE CONSTRUCTION EXCAVATION SLOPES AND SHORING ARE THE RESPONSIBILITY OF THE CONTRACTOR AND SHOULD COMPLY WITH ALL OSHA AND OTHER APPLICABLE SAFETY REGULATIONS.
10. EXCAVATED SOIL MAY BE USED FOR BACK FILLING AND BORROW PROVIDED IT MEETS THE SPECIFICATIONS. THE CONTRACTOR SHALL PERFORM QUALITY CONTROL TESTING OF BACK FILL AND BORROW MATERIAL. THE CONTRACTOR SHALL SUBMIT THE QUALIFICATIONS OF THE SOIL TESTING COMPANY WHICH WILL PERFORM THE QUALITY CONTROL TESTS. THE SOIL TESTING COMPANY SHALL HAVE A MINIMUM OF FIVE YEARS EXPERIENCE DOING RELATED WORK.
11. EXISTING LANDFILL MATERIAL:
    A. EXCAVATED LANDFILL MATERIAL SHALL BE DISPOSED OF IN A SUBTITLE "D" LANDFILL. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROFILING AND TESTING THE EXCAVATED MATERIAL IN ACCORDANCE WITH THE REQUIREMENTS OF THE SUBTITLE "D" FACILITY.
    B. SITE WORKERS CANNOT BE IN CONTACT WITH EXPOSED LANDFILL WASTE AND SOILS FOR MORE THAN 250 DAYS PER YEAR.
12. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE MAINTENANCE OF THE CONSTRUCTION SITE AND THE AREAS OF WORK WHILE PERFORMING THE WORK OF THIS CONTRACT. CONSTRUCTION DEBRIS SHALL BE REMOVED FROM THE CONSTRUCTION SITE ON A DAILY BASIS. NO BURNING OF DEBRIS SHALL BE PERMITTED.
13. THE CONTRACTOR SHALL ABIDE BY ALL APPLICABLE LOCAL, STATE AND FEDERAL ENVIRONMENTAL PROTECTION STANDARDS, LAWS AND REGULATIONS.
14. ITEMS INDICATED TO BE REMOVED AND REINSTALLED SHALL BE REMOVED BY THE CONTRACTOR, STORED AND REINSTALLED WITHOUT DAMAGE. DAMAGED ITEMS SHALL BE REPLACED AT NO COST TO THE OWNER.
15. ALL APPLICABLE SAFETY REGULATIONS SHALL BE STRICTLY FOLLOWED. METHODS OF DEMOLITION, CONSTRUCTION, AND ERECTION OF STRUCTURAL MATERIAL ARE THE CONTRACTOR'S RESPONSIBILITY.
16. THE CONTRACTOR SHALL PREPARE, LAYOUT AND INSTALL WORK IN SUCH A MANNER AS NOT TO DELAY OR INTERFERE WITH THE CARRYING FORWARD OF THE WORK OF THE CONTRACT AND/OR ANY WORK DESIGNATED TO BE PERFORMED UNDER ANY OTHER CONTRACTS AND/OR TERMINAL OPERATIONS.
17. ALL INGRESS AND EGRESS TO THE CONSTRUCTION SITE SHALL BE KEPT READILY ACCESSIBLE AND UNOBSTRUCTED AT ALL TIMES. CONSTRUCTION EQUIPMENT WILL NOT BE PERMITTED TO OBSTRUCT ROADWAYS AND/OR PASSAGEWAYS. ANY DEBRIS FALLING ON ROADWAYS AS A RESULT OF CONTRACTOR HAULING MATERIAL OR MOVING EQUIPMENT SHALL BE IMMEDIATELY CLEANED UP.
18. THE CONTRACTOR SHALL SUBMIT SHOP DRAWINGS FOR APPROVAL OF TEMPORARY CONSTRUCTION STRUCTURES AND SUPPORT AS REQUIRED, SUCH AS SHEETING FOR TRENCH EXCAVATIONS. SHOP DRAWINGS SHALL INCLUDE DESIGN CALCULATIONS AND ASSUMPTIONS, AND DRAWINGS SHOWING LOCATION, EXTENT AND CONSTRUCTION DETAILS OF SAID TEMPORARY STRUCTURES AND SUPPORTS PROPOSED BY THE CONTRACTOR. ALL TEMPORARY STRUCTURES SHALL BE DESIGNED BY A PROFESSIONAL ENGINEER LICENSED IN THE STATE OF GEORGIA.
19. ALL PRECAUTIONS SHALL BE TAKEN AS NECESSARY OR MAY BE REQUIRED, TO PERMANENTLY PREVENT CONTAMINATED WATER, GASOLINE OR ANY OTHER CONTAMINANT FROM ENTERING EXCAVATIONS MADE DURING THE CONTRACT WORK.
20. DISPOSAL OF HAZARDOUS OR CONTAMINATED MATERIALS, GROUNDWATER OR SOIL ENCOUNTERED SHALL BE IN ACCORDANCE WITH ALL FEDERAL, STATE AND LOCAL REQUIREMENTS.
21. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PERFORMANCE OF ALL WORK ON THE CONTRACT DOCUMENTS INCLUDING DEMOLITION AND REMOVALS AND INSTALLATION OF ALL MATERIALS IN COMPLIANCE WITH CODES, RULES AND REGULATIONS GOVERNING SAID WORK.
22. THE CONTRACTOR SHALL KEEP AND MAINTAIN A SET OF PROJECT PLANS AND SPECIFICATIONS ON THE SITE AT ALL TIMES.

COORDINATION

1. THE CONTRACTOR SHALL COORDINATE CONSTRUCTION ACTIVITIES WITH OWNER.
2. THE EXISTING FACILITY WILL REMAIN OPERATIONAL DURING CONSTRUCTION. CONTRACTOR SHALL COORDINATE DEMOLITION AND INSTALLATION OF ALL WORK WITH THE OWNER TO LIMIT DISRUPTION OF FACILITY OPERATIONS.
3. SEE THE SPECIFICATIONS FOR ADDITIONAL COORDINATION REQUIREMENTS.

UTILITIES

1. PRIOR TO CONSTRUCTION OR EXCAVATION, THE CONTRACTOR SHALL ASSUME THE RESPONSIBILITY OF LOCATING ANY AND ALL UNDERGROUND UTILITIES (PUBLIC OR PRIVATE) THAT MAY EXIST OR CROSS THROUGH THE AREA OF CONSTRUCTION WHETHER OR NOT THEY ARE SHOWN ON THESE PLANS.
2. THIS PLAN DOES NOT GUARANTEE THE EXISTENCE, NONEXISTENCE, SIZE, TYPE, LOCATION, ALIGNMENT OR DEPTH OF ANY OR ALL UNDERGROUND UTILITIES OR OTHER FACILITIES. WHERE SURFACE FEATURES (MANHOLES, CATCH BASINS, VALVES, ETC.) ARE UNAVAILABLE OR INCONCLUSIVE, INFORMATION SHOWN MAY BE FROM UTILITY OWNER'S RECORDS AND/OR ELECTRONIC LINE TRACING, THE RELIABILITY OF WHICH IS UNCERTAIN. THE CONTRACTOR SHALL PERFORM WHATEVER TEST EXCAVATION OR OTHER REINVESTIGATION IS NECESSARY TO VERIFY LOCATIONS AND CLEARANCES.
3. UNLESS OTHERWISE NOTED, UTILITIES ARE TO BE RELOCATED BY THE RESPECTIVE OWNER.
4. STATE LAW MANDATES THE NOTIFICATION OF UTILITY OWNERS 48 HOURS IN ADVANCE OF EXCAVATION. FOR LOCATION OF UTILITIES CALL THE "UTILITY PROTECTION CENTER" AT 1-800-282-7411, 48 HOURS PRIOR TO LAND DISTURBANCE ACTIVITY.
5. CONTRACTOR SHALL CONFORM TO THE "GEORGIA HIGH VOLTAGE SAFETY ACT" AND SHALL CONTACT THE NECESSARY AUTHORITIES PRIOR TO START OF CONSTRUCTION.
6. THE CONTRACTOR SHALL PROVIDE 3 BUSINESS DAYS ADVANCE WRITTEN NOTICE TO THE OWNER PRIOR TO ANY WATER, ELECTRICAL, OR OTHER UTILITY SYSTEM SHUTDOWNS.
7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR REPAIRING, AT HIS SOLE EXPENSE, ANY EXISTING UTILITIES DAMAGED DURING CONSTRUCTION.

DEMOLITION

1. THE CONTRACTOR SHALL PROTECT FOR ALL UTILITIES TO REMAIN IN PLACE.
2. ALL MATERIALS REMOVED UNDER DEMOLITION, NOT TO BE RELOCATED OR TO BE TURNED OVER TO THE OWNER, SHALL BE REMOVED FROM THE SITE.

CONSTRUCTION

1. CONTRACTOR SHALL NOT INITIATE ANY LAND DISTURBING ACTIVITY UNTIL AUTHORIZED TO PROCEED BY OWNER.
2. SUBMITTALS ON MATERIALS FOR THIS PROJECT SHALL BE PROVIDED TO THE OWNER FOR APPROVAL AS DESCRIBED IN PROJECT MANUAL.
3. EXISTING VEGETATION SURROUNDING THE CONSTRUCTION AREA SHALL REMAIN IN A NATURAL STATE.
4. FINISHED SLOPES SHALL BE GRADED TO ENSURE POSITIVE DRAINAGE AWAY FROM ALL PAVEMENTS AND TO PROPOSED DITCHES AND BASINS.

MAINTENANCE OF TRAFFIC

1. ANY MAINTENANCE OF TRAFFIC ACTIVITIES SHALL BE IN ACCORDANCE WITH MASSDOT STANDARDS AND GENERAL NOTES.
2. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL WORK ZONE SIGNING AND ANY OTHER TRAFFIC CONTROL DEVICES NECESSARY TO PERFORM THE WORK. UPON COMPLETION OF THE WORK, THE CONTRACTOR SHALL IMMEDIATELY REMOVE ALL SUCH TEMPORARY DEVICES.

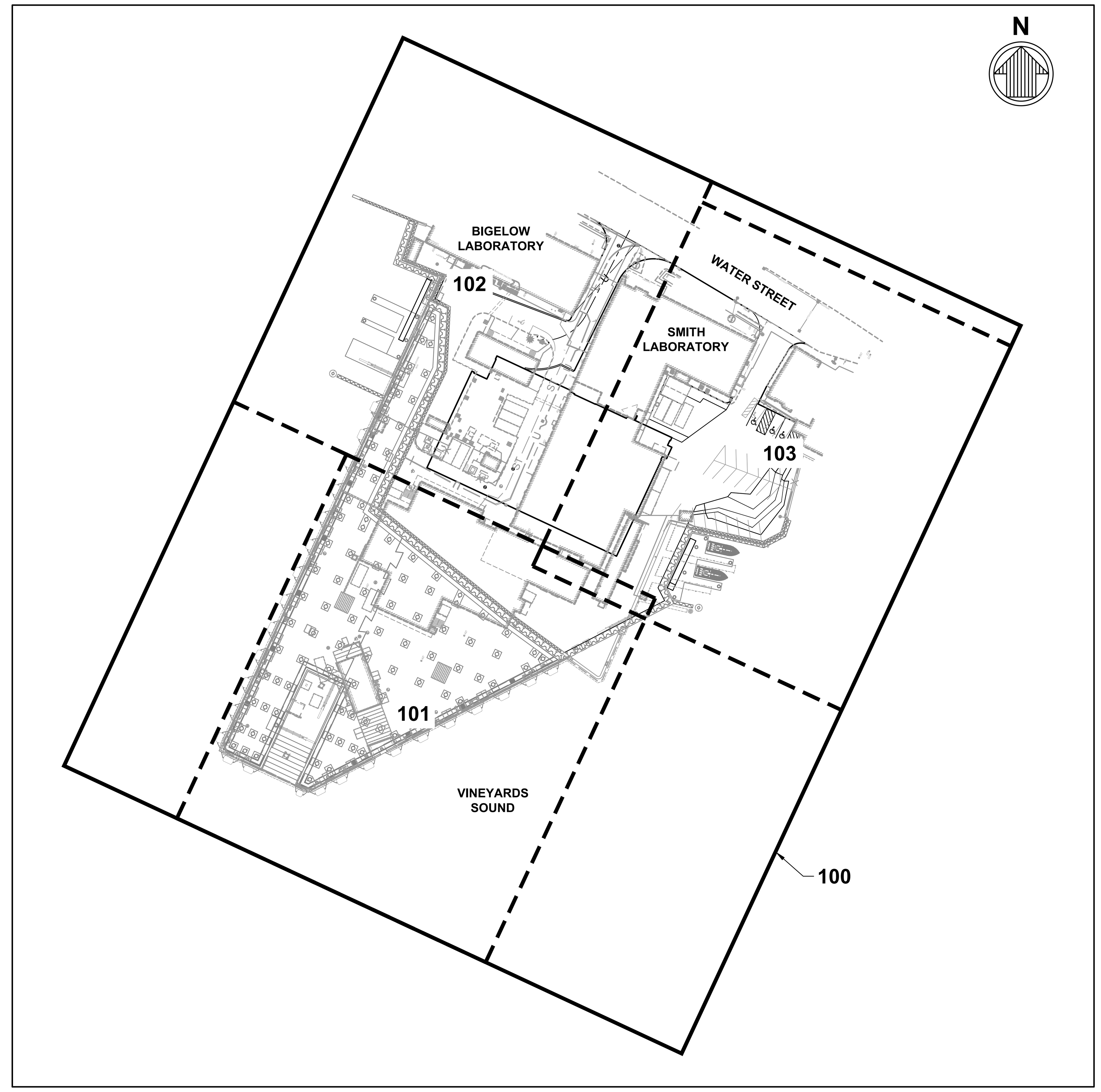
SURVEY NOTES

1. VERTICAL DATUM - ELEVATIONS SHOWN ARE IN FEET AND ARE BASED ON NAVD 88 DATUM.
2. HORIZONTAL DATUM - MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, NAD 83.
3. THESE DRAWINGS ARE BASED ON A FIELD SURVEY PREPARED BY FELDMAN LAND SURVEYORS OF BOSTON, MASSACHUSETTS IN DECEMBER, 2019.

GEOTECHNICAL NOTE

THE GEOTECHNICAL EXPLORATIONS WERE PERFORMED BY MOFFATT & NICHOL.
REPORTS ARE AS FOLLOWS:
- ====================

=========



KEY PLAN
1" = 60'

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

GENERAL NOTES

Drawing Scale	
Project Number	
Date Issued 5/12/21	

G-002

ABBREVIATIONS LIST

ABBREVIATIONS	DESCRIPTIONS
A	
AASHTO	AMERICAN ASSOCIATION OF STATE HIGHWAY & TRANSPORTATION OFFICIALS
ABBR	ABBREVIATION
ABV	ABOVE
AC	ACRE
ACI	AMERICAN CONFERENCE INSTITUTE
A.D.	GRADE CHANGE
ADA	AMERICANS WITH DISABILITIES ACT
ADMIN	ADMINISTRATION
AISC	AMERICAN INSTITUTE OF STEEL CONSTRUCTION
ALNMT	ALIGNMENT
APPROX	APPROXIMATE
AREMA	AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASOCIATION
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
AVE	AVENUE
AWS	AMERICAN WELDING SOCIETY
B	
B/L	BREAKLINE/BASELINE
BLDG	BUILDING
BMP	BEST MANAGEMENT PRACTICE
BOT	BOTTOM
BP	BEGINNING POINT
C	
C	CONDUIT
CF	CUBIC FEET
CJ	CONSTRUCTION JOINT
CLR	CLEAR
CMP	CORRUGATED METAL PIPE
CN	CURVE NUMBER
CO	CLEANOUT
COF	CORNER OF FENCE
COL	COLUMN
COMM	COMMUNICATION
CONC	CONCRETE
CONN	CONNECTION
CONST	CONSTRUCTION
COORD	COORDINATES
CSP	CORRUGATED STEEL PIPE
CTR	CENTER
CY	CUBIC YARD
C/L	CENTERLINE
D	
DC	DEGREE OF CURVATURE
DDCV	DOUBLE DETECTOR CHECK VALVE
DEG	DEGREE
DIA	DIAMETER
DIM	DIMENSION
DIP	DUCTILE IRON PIPE
DOM	DOMESTIC
DWG	DRAWING
E	
E	EXTERNAL DISTANCE
EA	EACH
EC	END CURVE
EG	EXISTING GRADE / EXISTING GROUND
EJ	EXPANSION JOINT
EL OR ELEV	ELEVATION
ELEC	ELECTRICAL
EMH	ELECTRIC MANHOLE
ENTR	ENTRANCE
EP	ENDING POINT
EOG	EDGE OF GRAVEL
EOP	EDGE OF PAVEMENT
EOW	EDGE OF WALKING
EPA	ENVIRONMENTAL PROTECTION ACT
EPD	ENVIRONMENTAL PROTECTION DIVISION
EQ	EQUAL
EQUIP	EQUIPMENT
ES&PC	EROSION SEDIMENT & POLLUTION CONTROL
ETC.	ETCETERA
EW	EACH WAY
EX OR EXIST	EXISTING
F	
FDN	FOUNDATION
FDC	FIRE DEPARTMENT CONNECTION
FFE	FINISHED FLOOR ELEVATION
FG	FINISHED GROUND
FH	FIRE HYDRANT
FT	FOOT OR FEET
FR	FRAME
FUT	FUTURE
G	
GABC	GRADED AGGREGATE BASE COURSE
GALV	GALVANIZED
GDOT	GEORGIA DEPARTMENT OF TRANSPORTATION
GI	GRATE INLET
GPD	GALLONS PER DAY
GPM	GALLONS PER MINUTE
GR	GRADE
GSWCC	GEORGIA SOIL & WATER CONSERVATION COMMISSION
GV	NATURAL GAS VALVE
GW	GUY WIRE
H	
HDPE	HIGH-DENSITY POLYETHYLENE
HORIZ	HORIZONTAL
HVAC	HEATING VENTILATION AND AIR CONDITIONING
HWY	HIGHWAY
HYD	HYDRANT
I	
INC	INCORPORATE
IE	INVERT ELEVATION
INV	INVERT
IT	INFORMATION TECHNOLOGY
J	
JT	JOINT
K	
KSI	KIPS PER SQUARE INCH

ABBREVIATIONS LIST

ABBREVIATIONS	DESCRIPTIONS
L	
L	LENGTH
LAT	LATITUDE / LATERAL
LB	POUND
LF	LINEAR FEET
LG	LONG
LH	LEFT HAND
LLC	LIMITED LIABILITY COMPANY
LONG	LONGITUDE
LP	LIGHT POLE
LT	LEFT
M	
MAX	MAXIMUM
MH	MANHOLE
MIN	MINIMUM
MJ	MULTI JOINT
ML	MAIN LINE
MM	MILLIMETER
MP	MILE POST
N	
NAD	NORTH AMERICAN DATUM
NAVD	NORTH AMERICAN VERTICAL DATUM
NEMA	NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
N/F	NOW OR FORMELY
NIC	NOT IN CONTRACT
NO	NUMBER
NOM	NOMINAL
NPDES	NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
NRC	NATIONAL RESPONSE CENTER
NTS	NOT TO SCALE
O	
OC	ON CENTER COMMUNICATION
OD	OUTER DIAMETER
OE	OVERHEAD ELECTRICAL
OFF	OFFSET
OSHA	OCCUPATIONAL SAFETY & HEALTH ADMINISTRATION
OUTBD	OUTBOUND
P	
P	PROPOSED
PKWY	PARKWAY
PHDPE	PERFORATED HIGH-DENSITY POLYETHYLENE PIPE
PC	POINT OF CURVATURE
PCF	POUNDS PER CUBIC FOOT
PI	POINT OF INTERSECTION
PIN	PROPERTY IDENTIFICATION NUMBER
PIV	POST INDICATOR VALVE
PL	PLATE
PNL	PANEL
PP	POWER POLE
P/S	PRESTRESSED
PROP	PROPOSED
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
PT	POINT OF TANGENT
PVC	POLYVINYL CHLORIDE/POINT OF VERTICAL CURVATURE
PVI	POINT OF VERTICAL INTERSECTION
PVT	POINT OF VERTICAL INTERSECTION
R	
R	RATE OF GRADIENT CHANGE
R OR RAD	RADIUS
RCP	REINFORCED CONCRETE PIPE
RD	ROAD
REINF	REINFORCING
REQD	REQUIRED
RH	RIGHT HAND
RT	RIGHT
ROW OR R/W	RIGHT-OF-WAY
S	
SCH	SCHEDULE
SD	STORM DRAIN
SDMH	STORM DRAIN MANHOLE
SF	SQUARE FEET
SPCC	SPILL PREVENTION, CONTROL, & COUNTERMEASURE
SPECS	SPECIFICATIONS
SQ	SQUARE
SS	STAINLESS STEEL OR SANITARY SEWER
SSMH	SANITARY SEWER MANHOLE
STA	STATION
STD	STANDARD
STL	STEEL
STRUC	STRUCTURE OR STRUCTURAL
SGD	SUBGRADE DRAIN
SY	SQUARE YARDS
T	
T/	TOP OF
T	TANGENT
T&B	TOP & BOTTOM
TBD	TO BE DETERMINED
TBM	TEMPORARY BENCH MARK
TEL	TELEPHONE
TEMP	TEMPORARY
TFR	TRANSFORMER
TOB	TOP OF BANK
TOS	TOP OF STEEL
TRAVS	TRAVERSE
TYP	TYPICAL
TP OR T/P	TOP OF PAVEMENT
TW	TOP OF WALK
U	
UC	UNDERGROUND CONDUIT
UE	UNDERGROUND ELECTRICAL
UNG	UNDERGROUND NATURAL GAS
UON	UNLESS OTHERWISE NOTED
V	
VERT	VERTICAL
VS	VERSUS

ABBREVIATIONS LIST

ABBREVIATIONS	DESCRIPTIONS
W	
W	WATER
W/	WITH
WM	WATER METER
WT	WATER TIGHT
WV	WATER VALVE
WWF	WELDED WIRE FABRIC
X	
XFMR	TRANSFORMER
Y	
YI	NYOPLAST YARD INLET

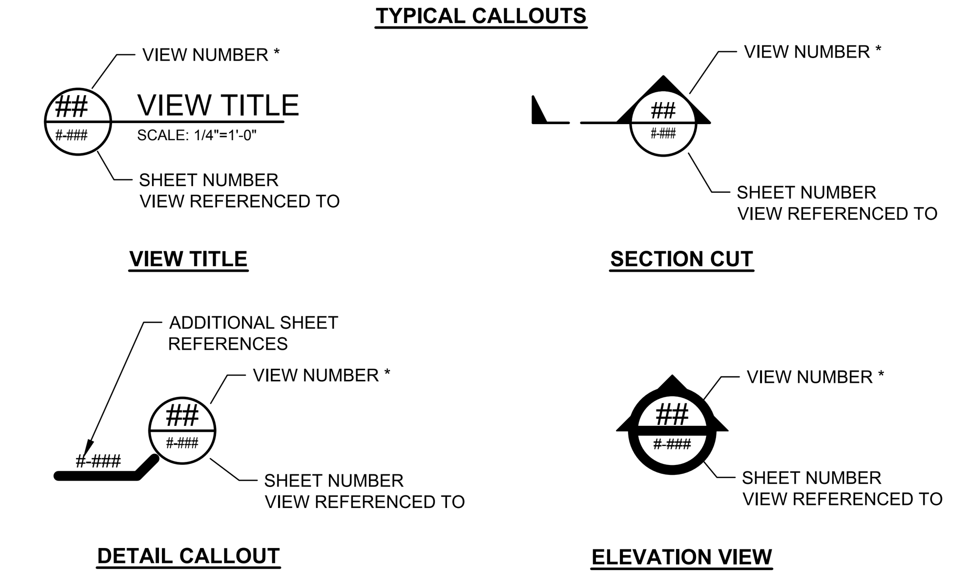
SYMBOLS LIST

SYMBOLS	DESCRIPTION
&	AND
%	PERCENT
"	SECONDS OR INCH
Ø	DIAMETER

LEGEND

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	EXISTING PAVEMENT EDGE - ASPHALT	— X —	EXISTING 8' PERIMETER SECURITY FENCE
	EXISTING GRAVEL YARD	— FS —	EXISTING FLUORIDE LINE
	EXISTING TREE LINE	— FM —	EXISTING FORCE MAIN
C	EXISTING COMMUNICATIONS VAULT	— UNG —	EXISTING UNDERGROUND NATURAL GAS
	EXISTING CONTROL POINT/BENCHMARK	— SS —	EXISTING SANITARY SEWER
16	EXISTING CONTOURS	— SD —	EXISTING STORM DRAINAGE PIPE
E	EXISTING ELECTRICAL BOX/TRANSFORMER/VAULT	— W —	EXISTING WATER LINE
	EXISTING FLARED END SECTION	— W —	ABANDONED EXISTING UTILITY LINE
	EXISTING FIRE HYDRANT		
	EXISTING STORM DRAINAGE GRATE INLET		PROPOSED GRAVEL
	EXISTING LIGHT POLE		PROPOSED SUBBALAST
	EXISTING POWER POLE		PROPOSED TREE LINE
S	EXISTING SANITARY MANHOLE	16	PROPOSED CONTOURS
	EXISTING SIGN		PROPOSED FLARED END SECTION
SD	EXISTING STORM MANHOLE		PROPOSED CONTROL STRUCTURE
W	EXISTING WATER METER		PROPOSED DRAINAGE GRATE INLET
	EXISTING WATER/GAS/SEWER VALVE		PROPOSED POWER POLE
— AM —	EXISTING AMMONIA LINE		PROPOSED SIGN
— A —	EXISTING COMPRESSED AIR LINE	X 17.99	PROPOSED SPOT ELEVATION
— C —	EXISTING UNDERGROUND COMMUNICATIONS	— SD —	PROPOSED STORM DRAINAGE PIPE
	EXISTING RAILROAD CENTERLINE	— OE —	PROPOSED OVERHEAD ELECTRICAL
— OE —	EXISTING OVERHEAD ELECTRICAL	— CA —	PROPOSED COMPRESSED AIR LINE
— UE —	EXISTING UNDERGROUND ELECTRICAL	— X —	PROPOSED FENCE
			PROPOSED CONCRETE BARRIER

TYPICAL CALLOUTS



*VIEW NUMBER IS BASED ON THE (DACS) LOCATION OF THE LOWER-LEFT EXTENTS OF THE VIEW ON THE REFERENCED SHEET. WHEN REFERENCING DRAWING INFORMATION BETWEEN SHEETS, BOTH THE VIEW AND SHEET NUMBERS MUST BE QUOTED TOGETHER - EITHER IN A CALLOUT FORMAT AS SHOWN ABOVE OR IN THE FORM;"VIEW NO./SHEET NO." (EG. A1/G-101).

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

GENERAL NOTES

Drawing Scale

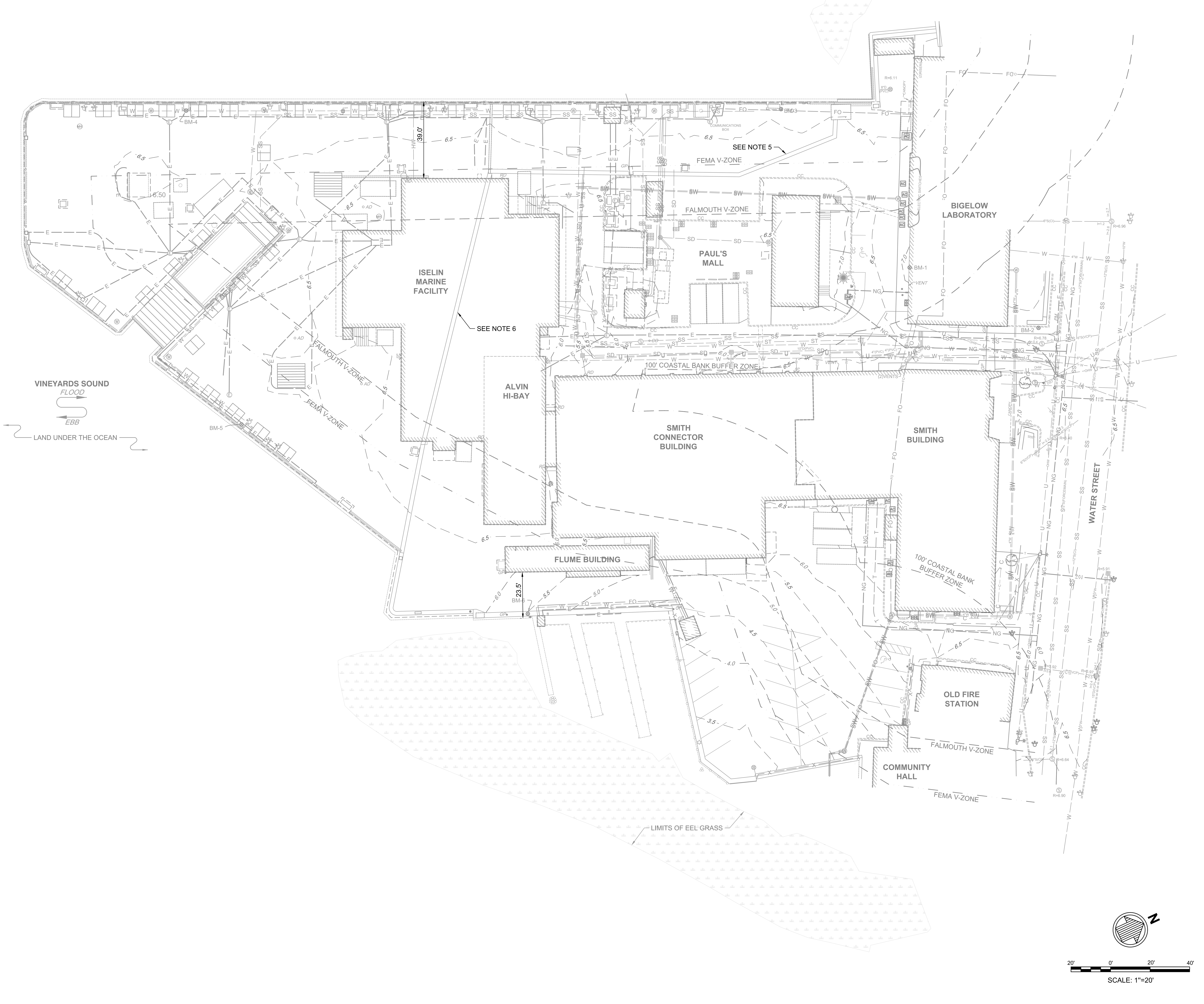
Project Number

Date Issued
5/12/21

G-003

NOTES

1. EXACT LOCATION OF UTILITIES TO BE VERIFIED BY CONTRACTOR PRIOR TO BEGINNING WORK.
2. CONTRACTOR TO EXERCISE PROPER CARE WHEN EXCAVATING.
3. TOPOGRAPHIC DATA SHOWN IS BASED ON SURVEY PROVIDED BY FELDMAN LAND SURVEYORS, PREPARED12-18-2019.
4. LAND SUBJECT TO COASTAL FLOWAGE.
5. EXISTING BULKHEAD REGULATED AS COASTAL BANK.
6. EXISTING BULKHEAD LOCATION SHOWN UNDER ISELIN MARINE FACILITY IS AN APPROXIMATION.



moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

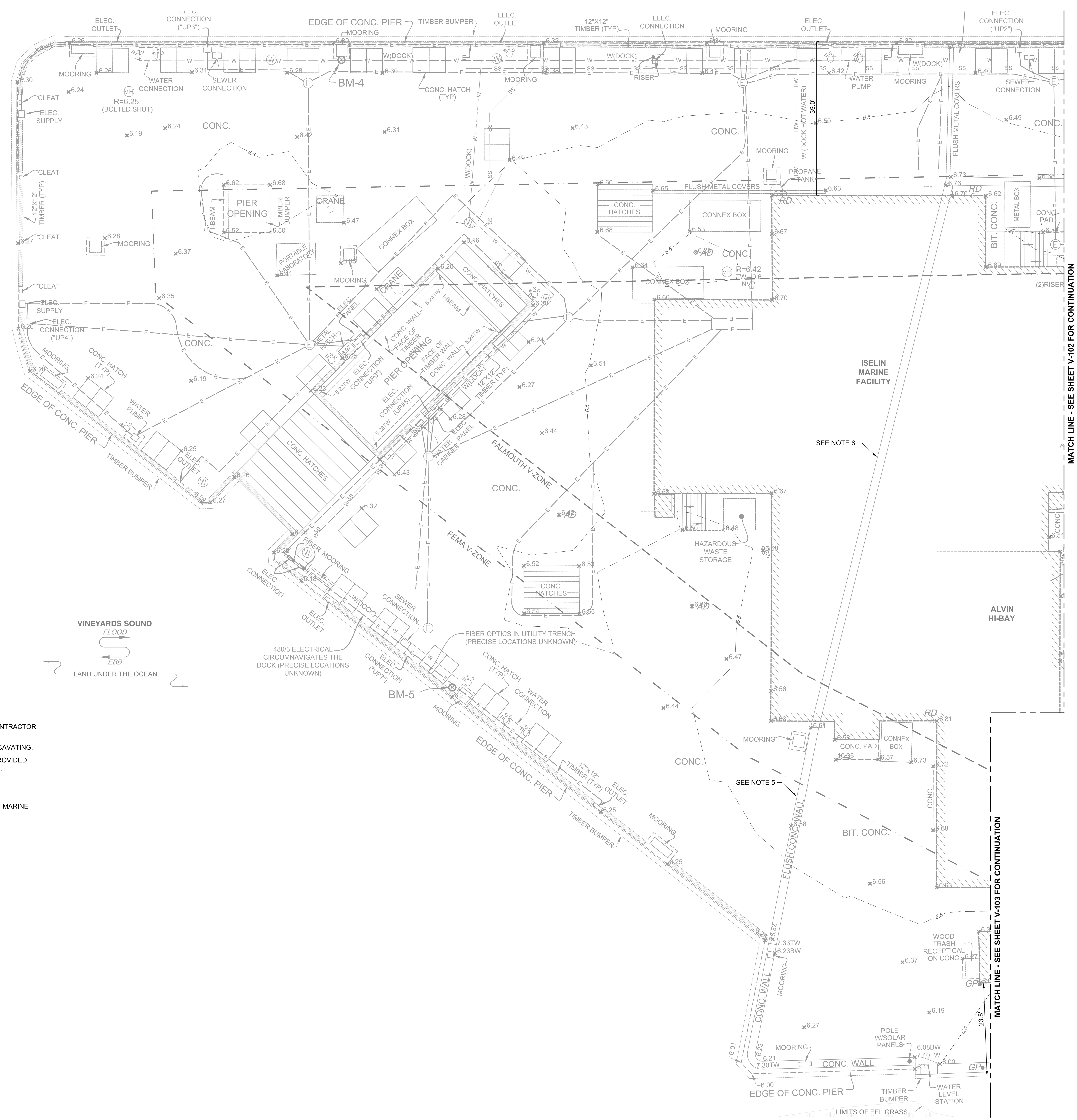
OVERALL EXISTING CONDITIONS PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

V-100



NOTES

1. EXACT LOCATION OF UTILITIES TO BE VERIFIED BY CONTRACTOR PRIOR TO BEGINNING WORK.
2. CONTRACTOR TO EXERCISE PROPER CARE WHEN EXCAVATING.
3. TOPOGRAPHIC DATA SHOWN IS BASED ON SURVEY PROVIDED BY FELDMAN LAND SURVEYORS, PREPARED12-18-2019.
5. LAND SUBJECT TO COASTAL FLOWAGE.
6. EXISTING BULKHEAD REGULATED AS COASTAL BANK.
7. EXISTING BULKHEAD LOCATION SHOWN UNDER ISELIN MARINE FACILITY IS AN APPROXIMATION.

20' 0' 20' 40'

SCALE: 1"=20'

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

EXISTING CONDITIONS PLAN

Drawing Scale

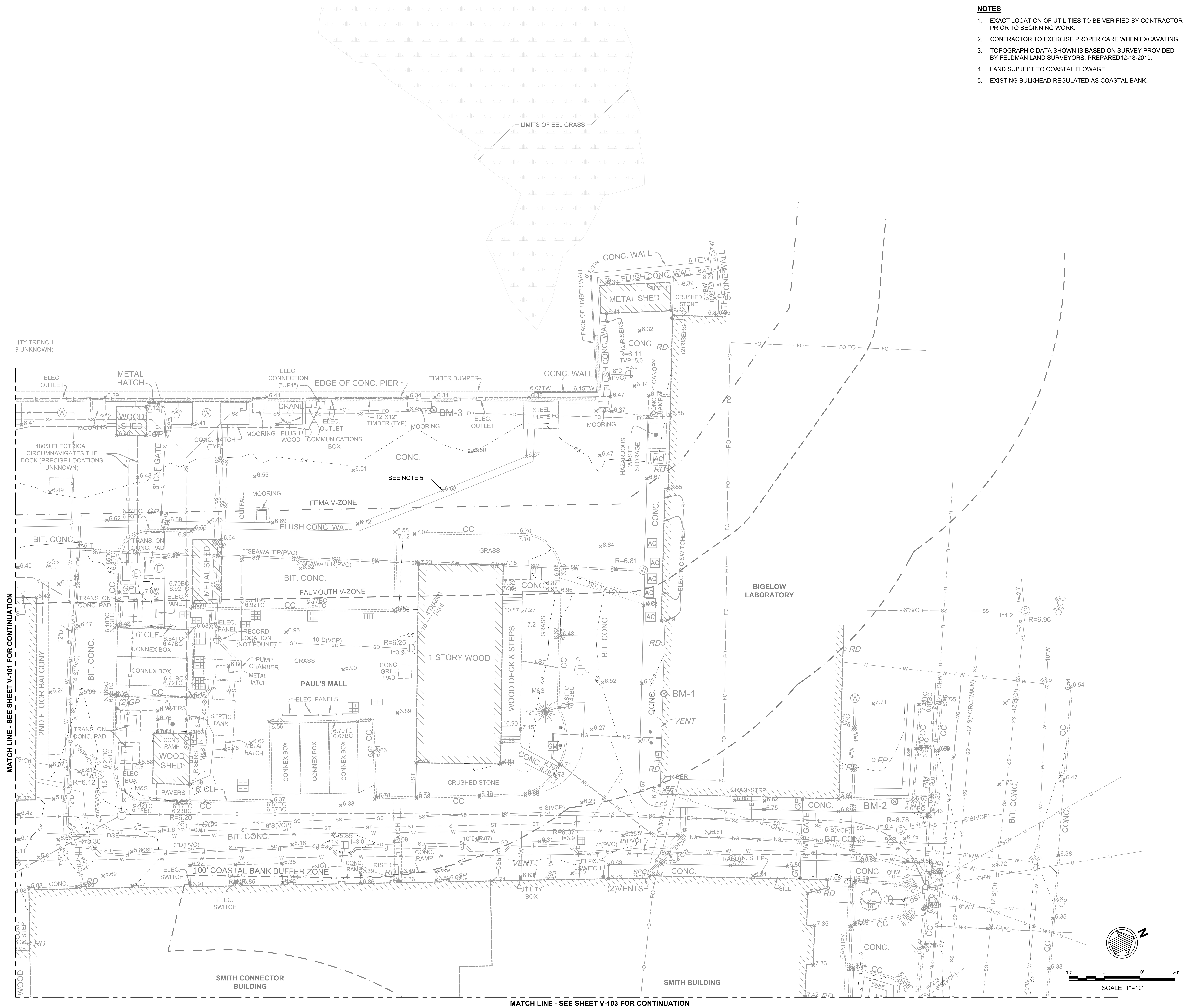
Project Number

Date Issued
5/12/21

V-101

NOTES

1. EXACT LOCATION OF UTILITIES TO BE VERIFIED BY CONTRACTOR PRIOR TO BEGINNING WORK.
2. CONTRACTOR TO EXERCISE PROPER CARE WHEN EXCAVATING.
3. TOPOGRAPHIC DATA SHOWN IS BASED ON SURVEY PROVIDED BY FELDMAN LAND SURVEYORS, PREPARED12-18-2019.
4. LAND SUBJECT TO COASTAL FLOWAGE.
5. EXISTING BULKHEAD REGULATED AS COASTAL BANK.



MATCH LINE - SEE SHEET V-101 FOR CONTINUATION

MATCH LINE - SEE SHEET V-103 FOR CONTINUATION

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

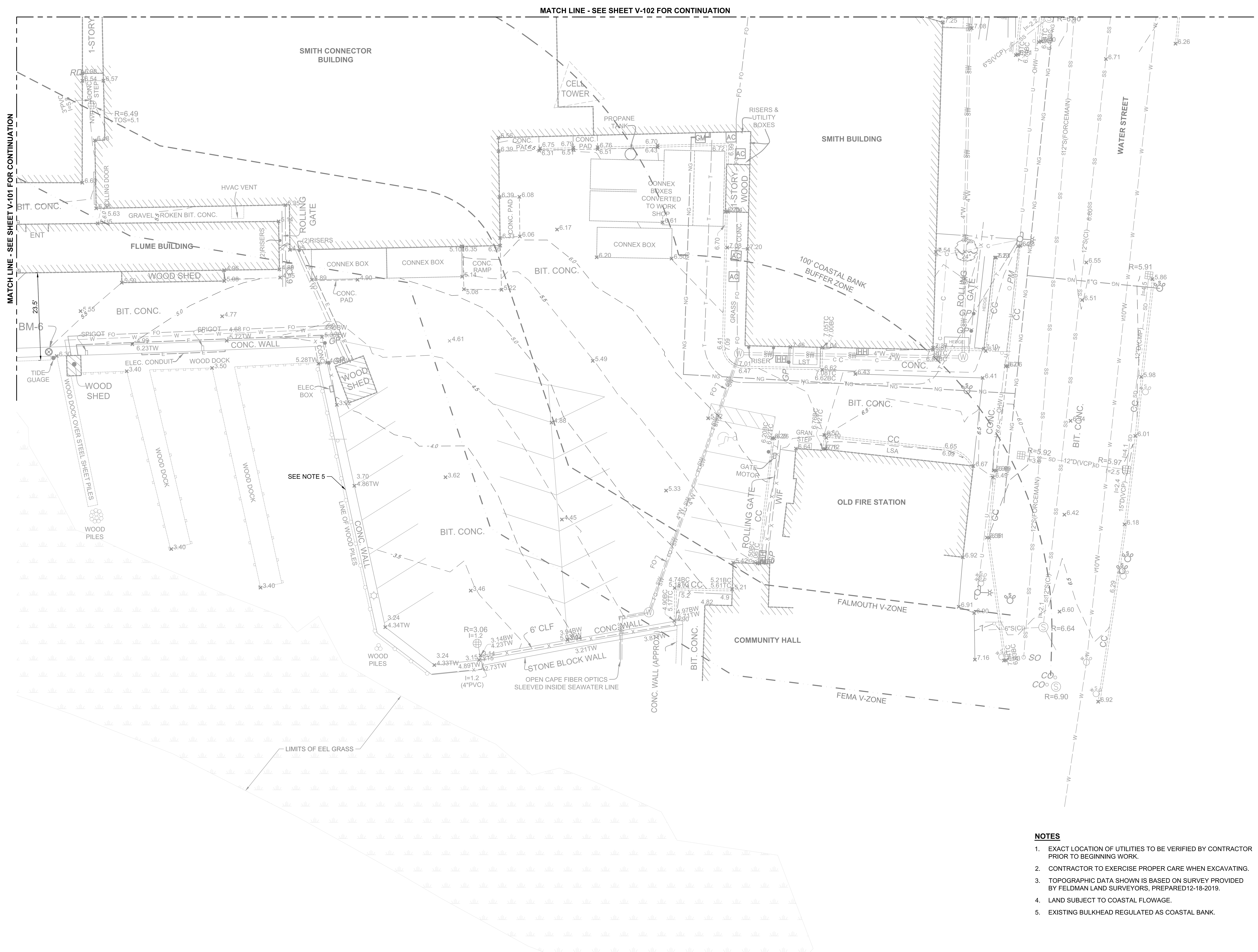
EXISTING CONDITIONS PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

V-102



NOTES

1. EXACT LOCATION OF UTILITIES TO BE VERIFIED BY CONTRACTOR PRIOR TO BEGINNING WORK.
2. CONTRACTOR TO EXERCISE PROPER CARE WHEN EXCAVATING.
3. TOPOGRAPHIC DATA SHOWN IS BASED ON SURVEY PROVIDED BY FELDMAN LAND SURVEYORS, PREPARED12-18-2019.
4. LAND SUBJECT TO COASTAL FLOWAGE.
5. EXISTING BULKHEAD REGULATED AS COASTAL BANK.

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

EXISTING CONDITIONS PLAN

Drawing Scale

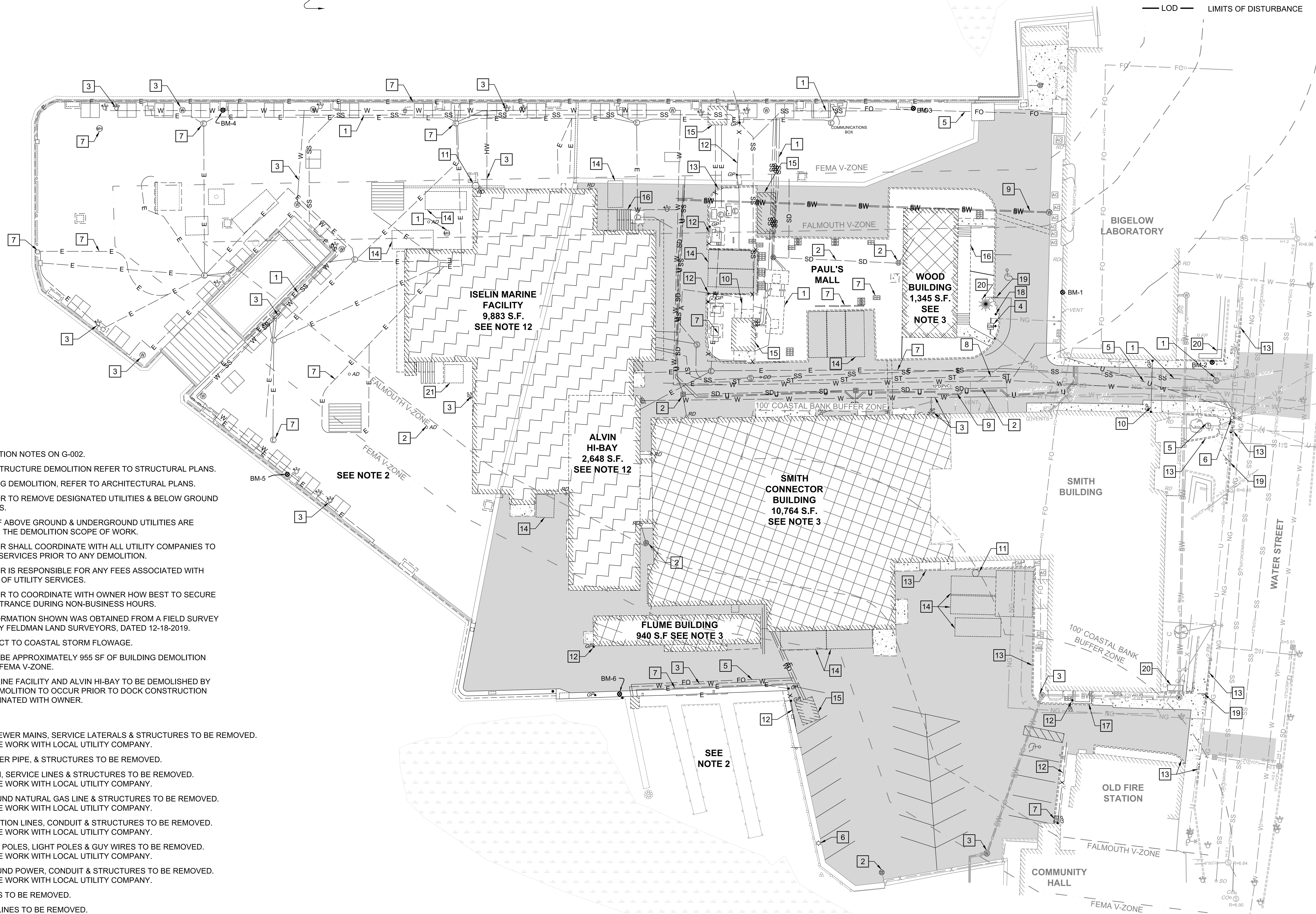
Project Number

Date Issued
5/12/21

V-103

LEGEND

(pattern)	BUILDING DEMOLITION TO OCCUR IN CONJUNCTION WITH DOCK CONSTRUCTION
(pattern)	VERTICAL BUILDING & PAD DEMOLITION
(pattern)	ASPHALT DEMOLITION
(pattern)	CONCRETE DEMOLITION
— LOD —	LIMITS OF DISTURBANCE



NOTES

1. SEE DEMOLITION NOTES ON G-002.
2. FOR DOCK STRUCTURE DEMOLITION REFER TO STRUCTURAL PLANS.
3. FOR BUILDING DEMOLITION, REFER TO ARCHITECTURAL PLANS.
4. CONTRACTOR TO REMOVE DESIGNATED UTILITIES & BELOW GROUND STRUCTURES.
5. REMOVAL OF ABOVE GROUND & UNDERGROUND UTILITIES ARE INCLUDED IN THE DEMOLITION SCOPE OF WORK.
6. CONTRACTOR SHALL COORDINATE WITH ALL UTILITY COMPANIES TO TERMINATE SERVICES PRIOR TO ANY DEMOLITION.
7. CONTRACTOR IS RESPONSIBLE FOR ANY FEES ASSOCIATED WITH DISRUPTION OF UTILITY SERVICES.
8. CONTRACTOR TO COORDINATE WITH OWNER HOW BEST TO SECURE THE SITE ENTRANCE DURING NON-BUSINESS HOURS.
9. UTILITY INFORMATION SHOWN WAS OBTAINED FROM A FIELD SURVEY PROVIDED BY FELDMAN LAND SURVEYORS, DATED 12-18-2019.
10. LAND SUBJECT TO COASTAL STORM FLOWAGE.
11. THERE WILL BE APPROXIMATELY 955 SF OF BUILDING DEMOLITION WITHIN THE FEMA V-ZONE.
12. INSELIN MARINE FACILITY AND ALVIN HI-BAY TO BE DEMOLISHED BY OTHERS. DEMOLITION TO OCCUR PRIOR TO DOCK CONSTRUCTION AND COORDINATED WITH OWNER.

KEYNOTES

1. SANITARY SEWER MAINS, SERVICE LATERALS & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
2. STORM SEWER PIPE, & STRUCTURES TO BE REMOVED.
3. WATER MAIN, SERVICE LINES & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
4. UNDERGROUND NATURAL GAS LINE & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
5. COMMUNICATION LINES, CONDUIT & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
6. POWER LINE POLES, LIGHT POLES & GUY WIRES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
7. UNDERGROUND POWER, CONDUIT & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
8. STEAM LINES TO BE REMOVED.
9. SEAWATER LINES TO BE REMOVED.
10. COMPRESSED AIR LINES TO BE REMOVED.
11. PROPANE TANK TO BE REMOVED.
12. GATE & FENCING TO BE REMOVED & RELOCATED.
13. CURB & GUTTER TO BE REMOVED.
14. CONEX BOX TO BE REMOVED & RELOCATED.
15. SHED TO BE REMOVED & RELOCATED.
16. WOODEN DECK/STAIRS TO BE REMOVED.
17. WALL TO BE REMOVED.
18. BOLLARDS TO BE REMOVED.
19. SIGNAGE TO BE REMOVED.
20. VEGETATION TO BE REMOVED.
21. HAZARDOUS WASTE STORAGE TO BE REMOVED.

SCALE: 1"=20'

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

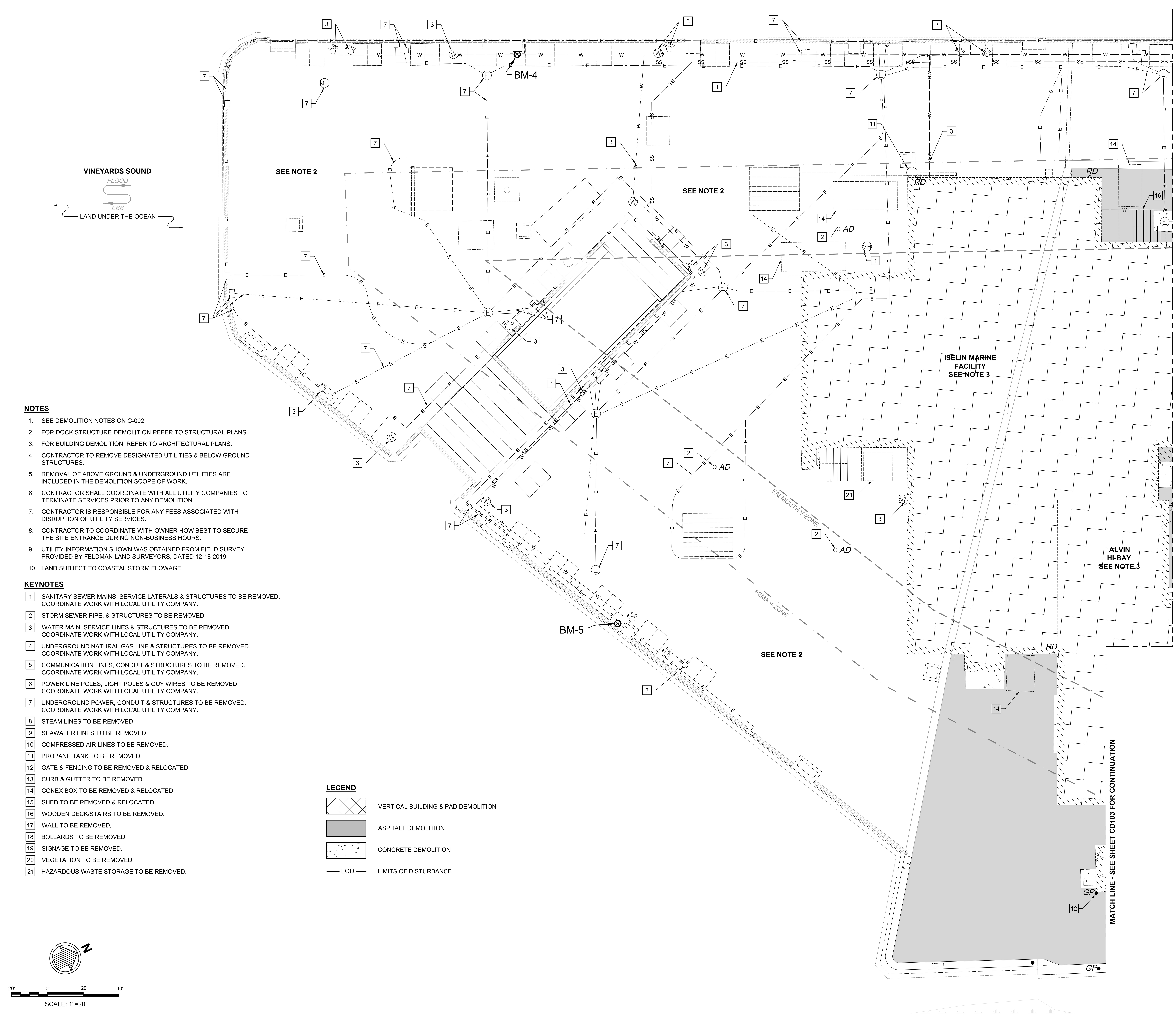
OVERALL DEMOLITION PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CD100



NOTES

1. SEE DEMOLITION NOTES ON G-002.
2. FOR DOCK STRUCTURE DEMOLITION REFER TO STRUCTURAL PLANS.
3. FOR BUILDING DEMOLITION, REFER TO ARCHITECTURAL PLANS.
4. CONTRACTOR TO REMOVE DESIGNATED UTILITIES & BELOW GROUND STRUCTURES.
5. REMOVAL OF ABOVE GROUND & UNDERGROUND UTILITIES ARE INCLUDED IN THE DEMOLITION SCOPE OF WORK.
6. CONTRACTOR SHALL COORDINATE WITH ALL UTILITY COMPANIES TO TERMINATE SERVICES PRIOR TO ANY DEMOLITION.
7. CONTRACTOR IS RESPONSIBLE FOR ANY FEES ASSOCIATED WITH DISRUPTION OF UTILITY SERVICES.
8. CONTRACTOR TO COORDINATE WITH OWNER HOW BEST TO SECURE THE SITE ENTRANCE DURING NON-BUSINESS HOURS.
9. UTILITY INFORMATION SHOWN WAS OBTAINED FROM FIELD SURVEY PROVIDED BY FELDMAN LAND SURVEYORS, DATED 12-18-2019.
10. LAND SUBJECT TO COASTAL STORM FLOWAGE.

KEYNOTES

1. SANITARY SEWER MAINS, SERVICE LATERALS & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
2. STORM SEWER PIPE, & STRUCTURES TO BE REMOVED.
3. WATER MAIN, SERVICE LINES & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
4. UNDERGROUND NATURAL GAS LINE & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
5. COMMUNICATION LINES, CONDUIT & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
6. POWER LINE POLES, LIGHT POLES & GUY WIRES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
7. UNDERGROUND POWER, CONDUIT & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
8. STEAM LINES TO BE REMOVED.
9. SEAWATER LINES TO BE REMOVED.
10. COMPRESSED AIR LINES TO BE REMOVED.
11. PROPANE TANK TO BE REMOVED.
12. GATE & FENCING TO BE REMOVED & RELOCATED.
13. CURB & GUTTER TO BE REMOVED.
14. CONEX BOX TO BE REMOVED & RELOCATED.
15. SHED TO BE REMOVED & RELOCATED.
16. WOODEN DECK/STAIRS TO BE REMOVED.
17. WALL TO BE REMOVED.
18. BOLLARDS TO BE REMOVED.
19. SIGNAGE TO BE REMOVED.
20. VEGETATION TO BE REMOVED.
21. HAZARDOUS WASTE STORAGE TO BE REMOVED.

LEGEND

- VERTICAL BUILDING & PAD DEMOLITION
- ASPHALT DEMOLITION
- CONCRETE DEMOLITION
- LOD — LIMITS OF DISTURBANCE

SCALE: 1"=20'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

DEMOLITION PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CD101

NOTES

1. SEE DEMOLITION NOTES ON G-002.
2. FOR DOCK STRUCTURE DEMOLITION REFER TO STRUCTURAL PLANS.
3. FOR BUILDING DEMOLITION, REFER TO ARCHITECTURAL PLANS.
4. CONTRACTOR TO REMOVE DESIGNATED UTILITIES & BELOW GROUND STRUCTURES.
5. REMOVAL OF ABOVE GROUND & UNDERGROUND UTILITIES ARE INCLUDED IN THE DEMOLITION SCOPE OF WORK.
6. CONTRACTOR SHALL COORDINATE WITH ALL UTILITY COMPANIES TO TERMINATE SERVICES PRIOR TO ANY DEMOLITION.
7. CONTRACTOR IS RESPONSIBLE FOR ANY FEES ASSOCIATED WITH DISRUPTION OF UTILITY SERVICES.
8. CONTRACTOR TO COORDINATE WITH OWNER HOW BEST TO SECURE THE SITE ENTRANCE DURING NON-BUSINESS HOURS.
9. UTILITY INFORMATION SHOWN WAS OBTAINED FROM FIELD SURVEY PROVIDED BY FELDMAN LAND SURVEYORS, DATED 12-18-2019.
10. LAND SUBJECT TO COASTAL STORM FLOWAGE.

KEYNOTES

1	SANITARY SEWER MAINS, SERVICE LATERALS & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
2	STORM SEWER PIPE, & STRUCTURES TO BE REMOVED.
3	WATER MAIN, SERVICE LINES & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
4	UNDERGROUND NATURAL GAS LINE & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
5	COMMUNICATION LINES, CONDUIT & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
6	POWER LINE POLES, LIGHT POLES & GUY WIRES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
7	UNDERGROUND POWER, CONDUIT & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
8	STEAM LINES TO BE REMOVED.
9	SEAWATER LINES TO BE REMOVED.
10	COMPRESSED AIR LINES TO BE REMOVED.
11	PROPANE TANK TO BE REMOVED.
12	GATE & FENCING TO BE REMOVED & RELOCATED.
13	CURB & GUTTER TO BE REMOVED.
14	CONEX BOX TO BE REMOVED & RELOCATED.
15	SHED TO BE REMOVED & RELOCATED.
16	WOODEN DECK/STAIRS TO BE REMOVED.
17	WALL TO BE REMOVED.
18	BOLLARDS TO BE REMOVED.
19	SIGNAGE TO BE REMOVED.
20	VEGETATION TO BE REMOVED.
21	HAZARDOUS WASTE STORAGE TO BE REMOVED.

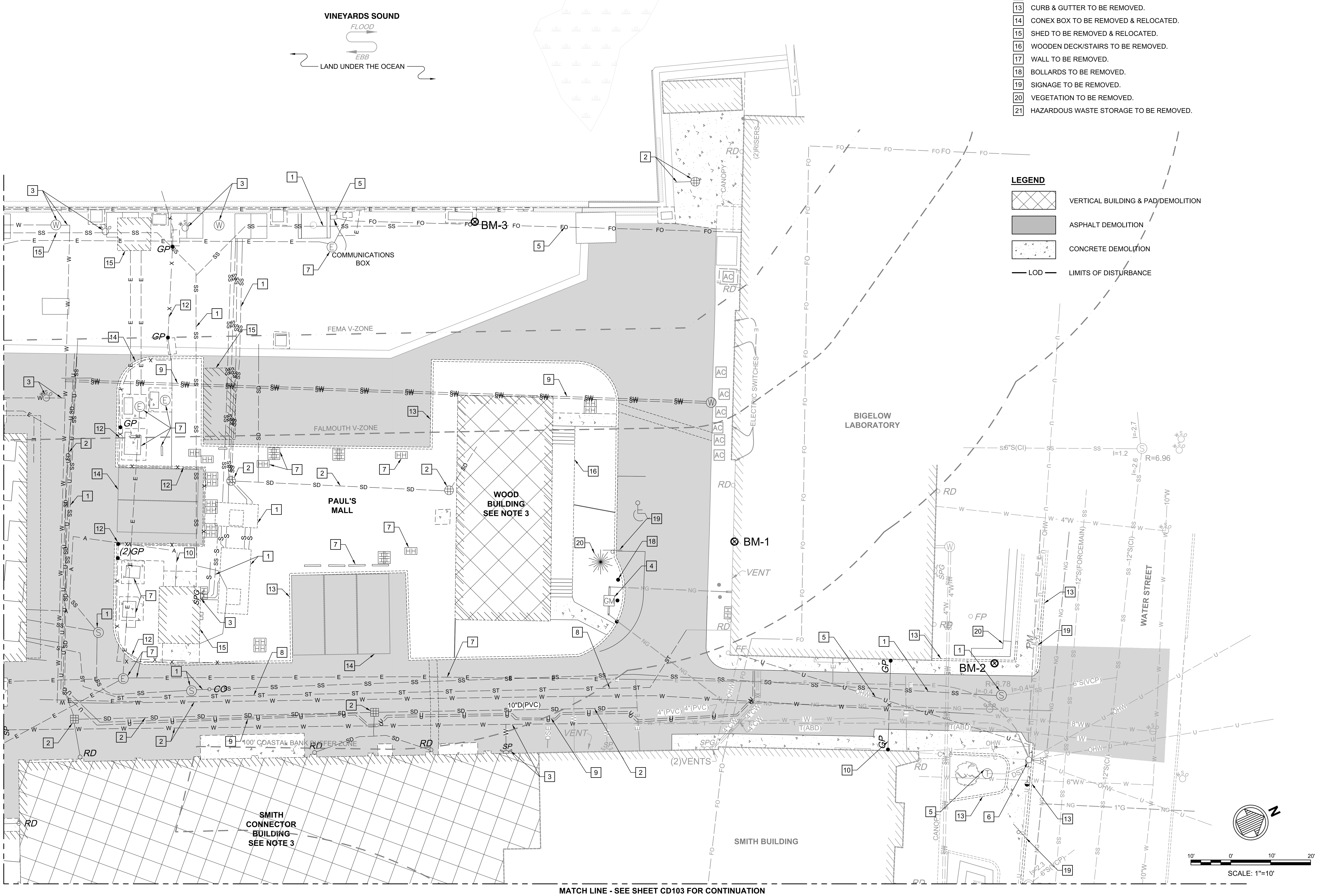
LEGEND

VERTICAL BUILDING & PAD DEMOLITION

ASPHALT DEMOLITION

CONCRETE DEMOLITION

LOD — LIMITS OF DISTURBANCE



SCALE: 1"=10'

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

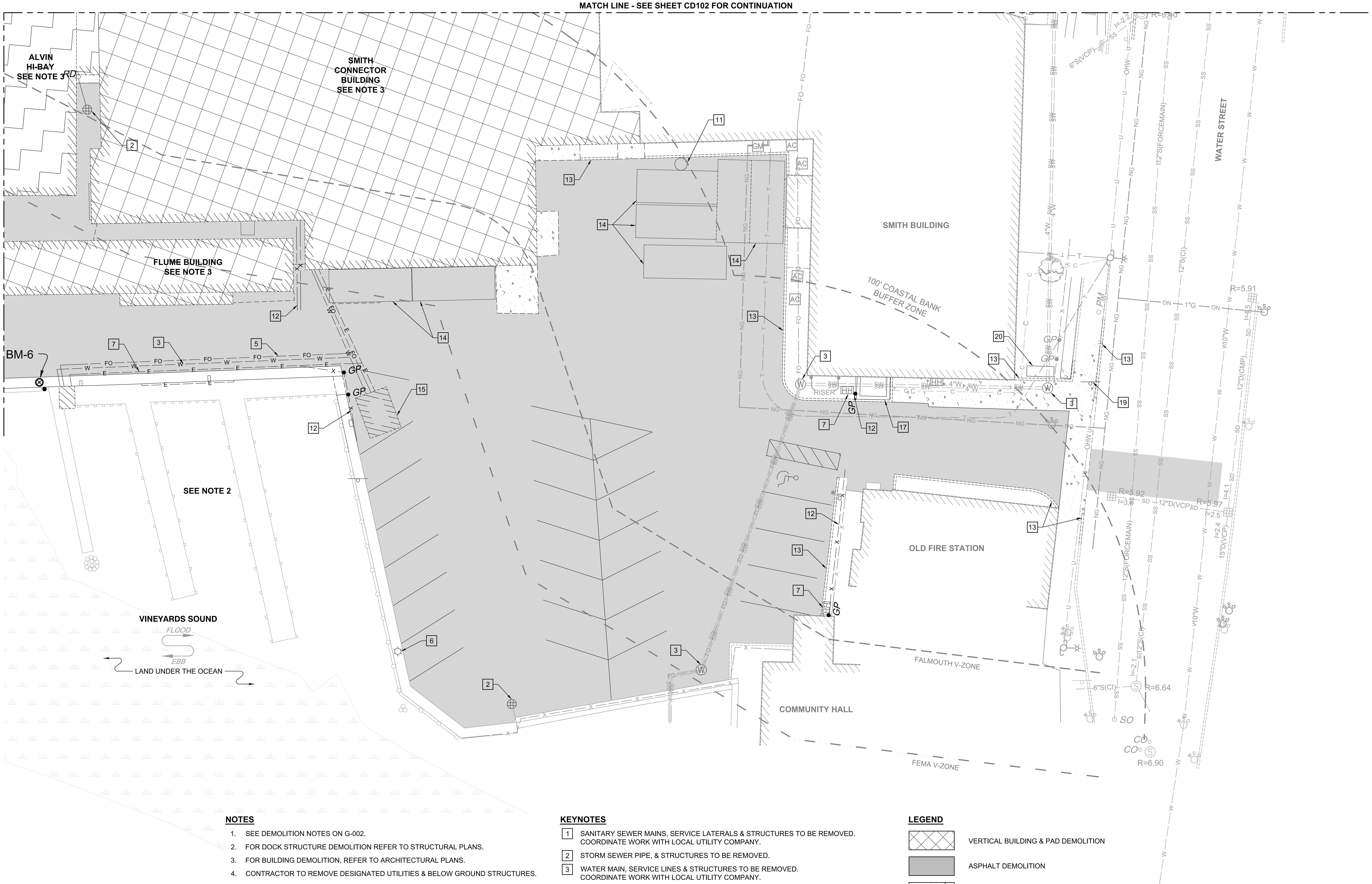
DEMOLITION PLAN

Drawing Scale

Project Number

Date Issued 5/12/21

CD102



NOTES

1. SEE DEMOLITION NOTES ON G-002.
2. FOR DOCK STRUCTURE DEMOLITION REFER TO STRUCTURAL PLANS.
3. FOR BUILDING DEMOLITION, REFER TO ARCHITECTURAL PLANS.
4. CONTRACTOR TO REMOVE DESIGNATED UTILITIES & BELOW GROUND STRUCTURES.
5. REMOVAL OF ABOVE GROUND & UNDERGROUND UTILITIES ARE INCLUDED IN THE DEMOLITION SCOPE OF WORK.
6. CONTRACTOR SHALL COORDINATE WITH ALL UTILITY COMPANIES TO TERMINATE SERVICES PRIOR TO ANY DEMOLITION.
7. CONTRACTOR IS RESPONSIBLE FOR ANY FEES ASSOCIATED WITH DISRUPTION OF UTILITY SERVICES.
8. CONTRACTOR TO COORDINATE WITH OWNER HOW BEST TO SECURE THE SITE ENTRANCE DURING NON-BUSINESS HOURS.
9. UTILITY INFORMATION SHOWN WAS OBTAINED FROM FIELD SURVEY PROVIDED BY FELDMAN LAND SURVEYORS, DATED 12-18-2019.
10. LAND SUBJECT TO COASTAL STORM FLOWAGE.

KEYNOTES

1. SANITARY SEWER MAINS, SERVICE LATERALS & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
2. STORM SEWER PIPE, & STRUCTURES TO BE REMOVED.
3. WATER MAIN, SERVICE LINES & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
4. UNDERGROUND NATURAL GAS LINE & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
5. COMMUNICATION LINES, CONDUIT & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
6. POWER LINE POLES, LIGHT POLES & GUY WIRES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
7. UNDERGROUND POWER, CONDUIT & STRUCTURES TO BE REMOVED. COORDINATE WORK WITH LOCAL UTILITY COMPANY.
8. STEAM LINES TO BE REMOVED.
9. SEAWATER LINES TO BE REMOVED.
10. COMPRESSED AIR LINES TO BE REMOVED.
11. PROPANE TANK TO BE REMOVED.
12. GATE & FENCING TO BE REMOVED & RELOCATED.
13. CURB & GUTTER TO BE REMOVED.
14. CONEX BOX TO BE REMOVED & RELOCATED.
15. SHED TO BE REMOVED & RELOCATED.
16. WOODEN DECK/STAIRS TO BE REMOVED.
17. WALL TO BE REMOVED.
18. BOLLARDS TO BE REMOVED.
19. SIGNAGE TO BE REMOVED.
20. VEGETATION TO BE REMOVED.
21. HAZARDOUS WASTE STORAGE TO BE REMOVED.

LEGEND

- VERTICAL BUILDING & PAD DEMOLITION
- ASPHALT DEMOLITION
- CONCRETE DEMOLITION
- LOD — LIMITS OF DISTURBANCE

10' 0' 10' 20'
SCALE: 1"=10'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

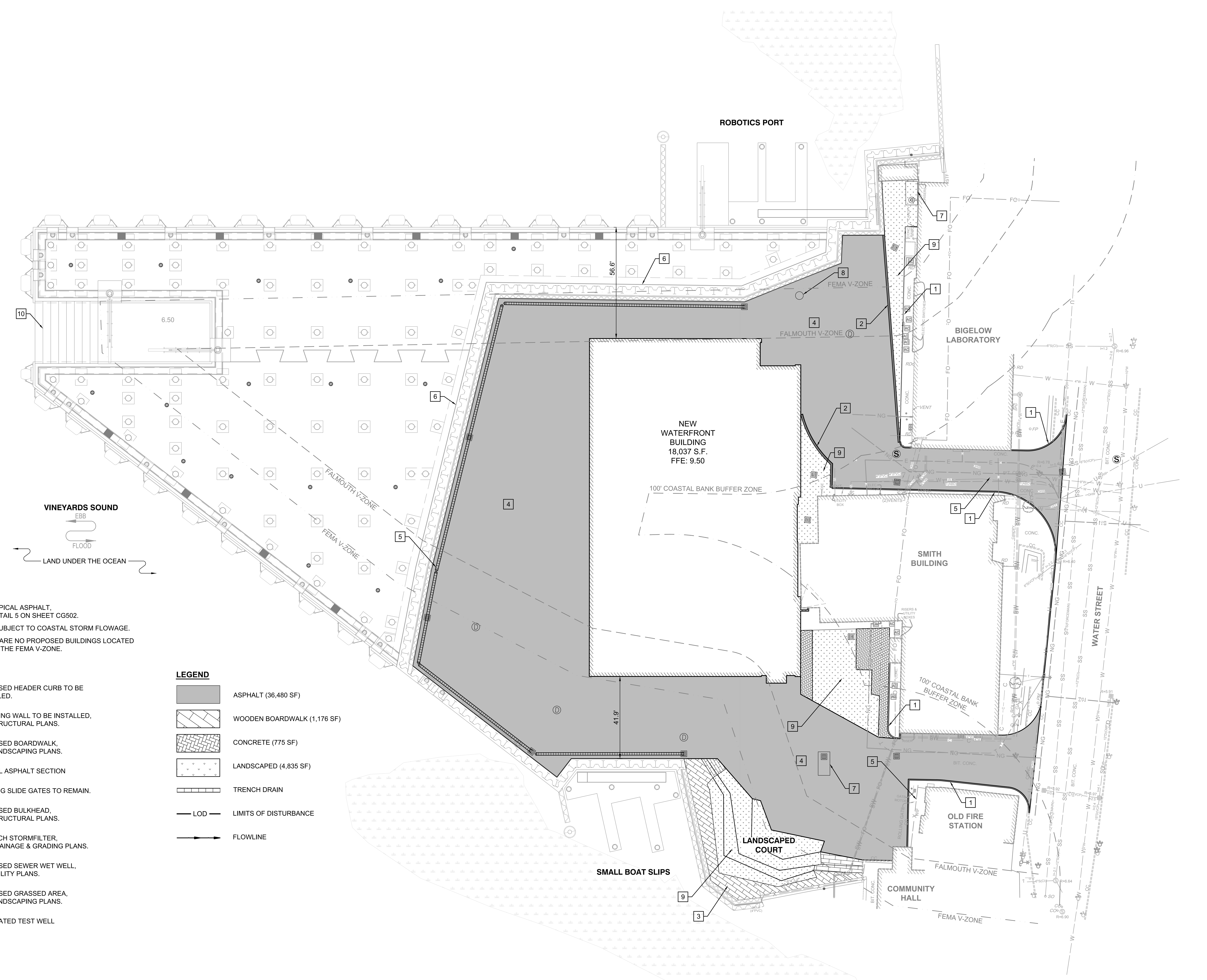
DEMOLITION PLAN

Drawing Scale

Project Number

Date Issued 5/12/21

CD103



NOTES

1. FOR TYPICAL ASPHALT, SEE DETAIL 5 ON SHEET CG502.
2. LAND SUBJECT TO COASTAL STORM FLOWAGE.
3. THERE ARE NO PROPOSED BUILDINGS LOCATED WITHIN THE FEMA V-ZONE.

KEYNOTES

1. PROPOSED HEADER CURB TO BE INSTALLED.
2. RETAINING WALL TO BE INSTALLED, SEE STRUCTURAL PLANS.
3. PROPOSED BOARDWALK, SEE LANDSCAPING PLANS.
4. TYPICAL ASPHALT SECTION
5. EXISTING SLIDE GATES TO REMAIN.
6. PROPOSED BULKHEAD, SEE STRUCTURAL PLANS.
7. CONTECH STORMFILTER, SEE DRAINAGE & GRADING PLANS.
8. PROPOSED SEWER WET WELL, SEE UTILITY PLANS.
9. PROPOSED GRASSED AREA, SEE LANDSCAPING PLANS.
10. RELOCATED TEST WELL

LEGEND

- ASPHALT (36,480 SF)
- WOODEN BOARDWALK (1,176 SF)
- CONCRETE (775 SF)
- LANDSCAPED (4,835 SF)
- TRENCH DRAIN
- LOD — LIMITS OF DISTURBANCE
- FLOWLINE

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

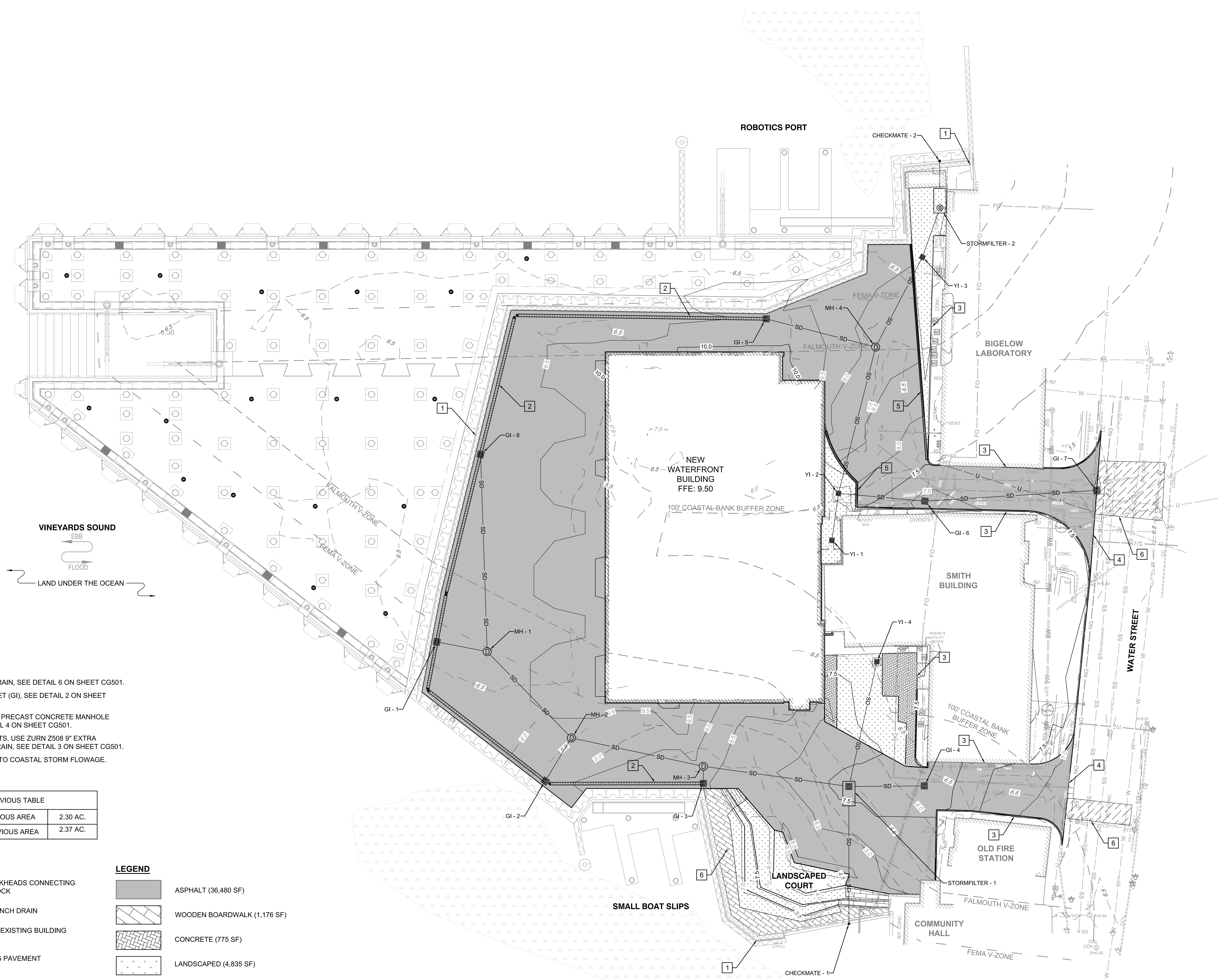
OVERALL SITE PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CS100



NOTES

1. FOR TRENCH DRAIN, SEE DETAIL 6 ON SHEET CG501.
2. FOR GRATE INLET (GI), SEE DETAIL 2 ON SHEET CG501.
3. FOR STANDARD PRECAST CONCRETE MANHOLE (MH), SEE DETAIL 4 ON SHEET CG501.
4. FOR DOCK INLETS, USE ZURN Z508 9" EXTRA HEAVY-DUTY DRAIN, SEE DETAIL 3 ON SHEET CG501.
5. LAND SUBJECT TO COASTAL STORM FLOWAGE.

IMPERVIOUS TABLE	
EXISTING IMPERVIOUS AREA	2.30 AC.
PROPOSED IMPERVIOUS AREA	2.37 AC.

KEYNOTES

1. PROPOSED BULKHEADS CONNECTING TO EXISTING DOCK
2. PROPOSED TRENCH DRAIN
3. TIE GRADES TO EXISTING BUILDING ELEVATIONS
4. TIE TO EXISTING PAVEMENT ELEVATIONS
5. PROPOSED RETAINING WALL, SEE STRUCTURAL PLANS FOR DETAILS
6. PROPOSED BOARDWALK PER LANDSCAPING PLANS.
7. EXISTING PAVEMENT TO BE REMOVED AND REPLACED FOR NEW UTILITY TIE IN LOCATIONS.

LEGEND

- ASPHALT (36,480 SF)
- WOODEN BOARDWALK (1,176 SF)
- CONCRETE (775 SF)
- LANDSCAPED (4,835 SF)
- BITUMINOUS PAVEMENT REPLACEMENT (1,212 SF)
- TRENCH DRAIN
- LOD — LIMITS OF DISTURBANCE
- FLOWLINE

moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

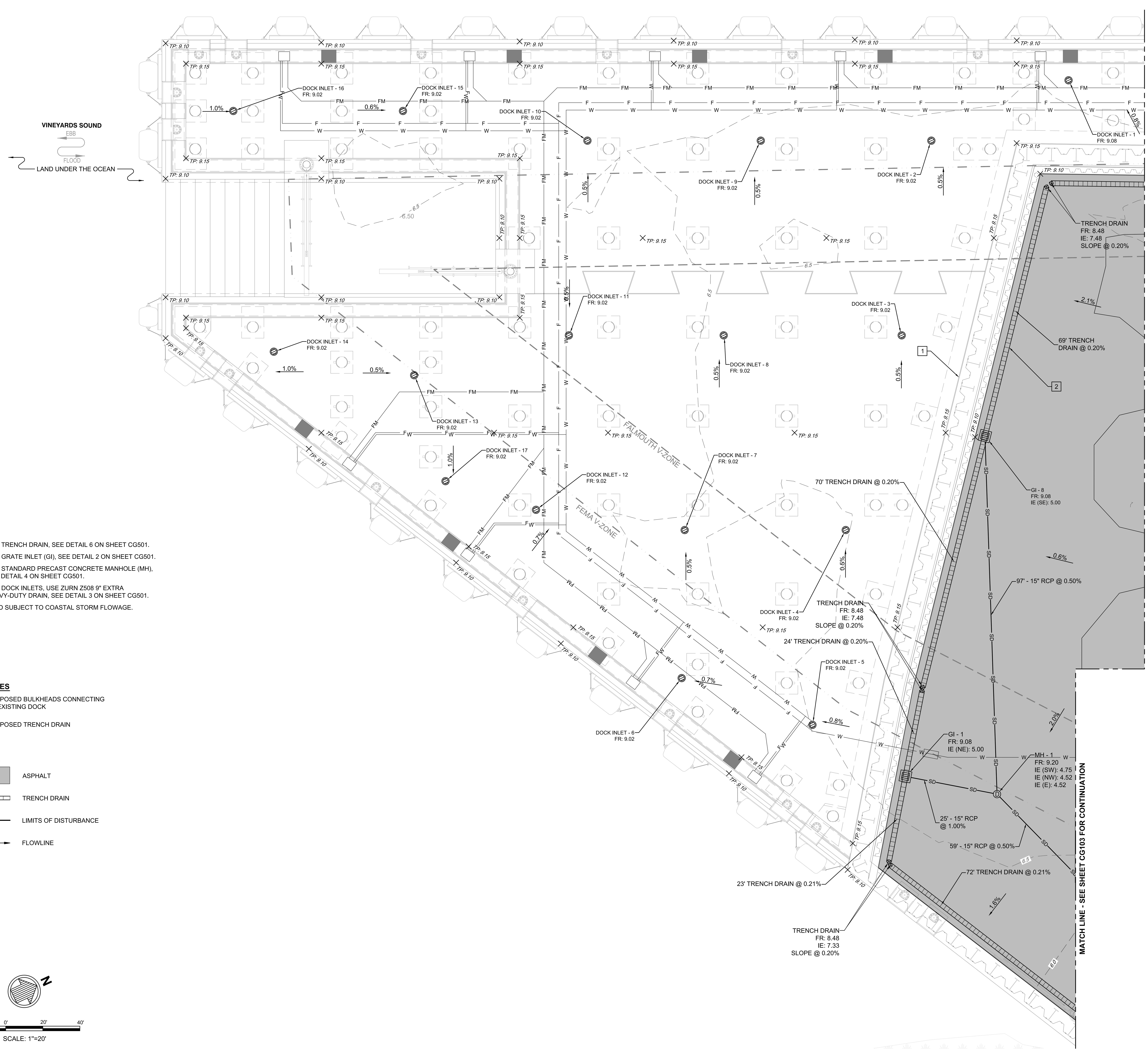
OVERALL GRADING & DRAINAGE PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CG100



NOTES

1. FOR TRENCH DRAIN, SEE DETAIL 6 ON SHEET CG501.
2. FOR GRATE INLET (GI), SEE DETAIL 2 ON SHEET CG501.
3. FOR STANDARD PRECAST CONCRETE MANHOLE (MH), SEE DETAIL 4 ON SHEET CG501.
4. FOR DOCK INLETS, USE ZURN Z508 9" EXTRA HEAVY-DUTY DRAIN, SEE DETAIL 3 ON SHEET CG501.
5. LAND SUBJECT TO COASTAL STORM FLOWAGE.

KEYNOTES

1 PROPOSED BULKHEADS CONNECTING TO EXISTING DOCK

2 PROPOSED TRENCH DRAIN

LEGEND

ASPHALT

TRENCH DRAIN

LOD — LIMITS OF DISTURBANCE

FLOWLINE

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

DRAINAGE & GRADING PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CG101

NOTES

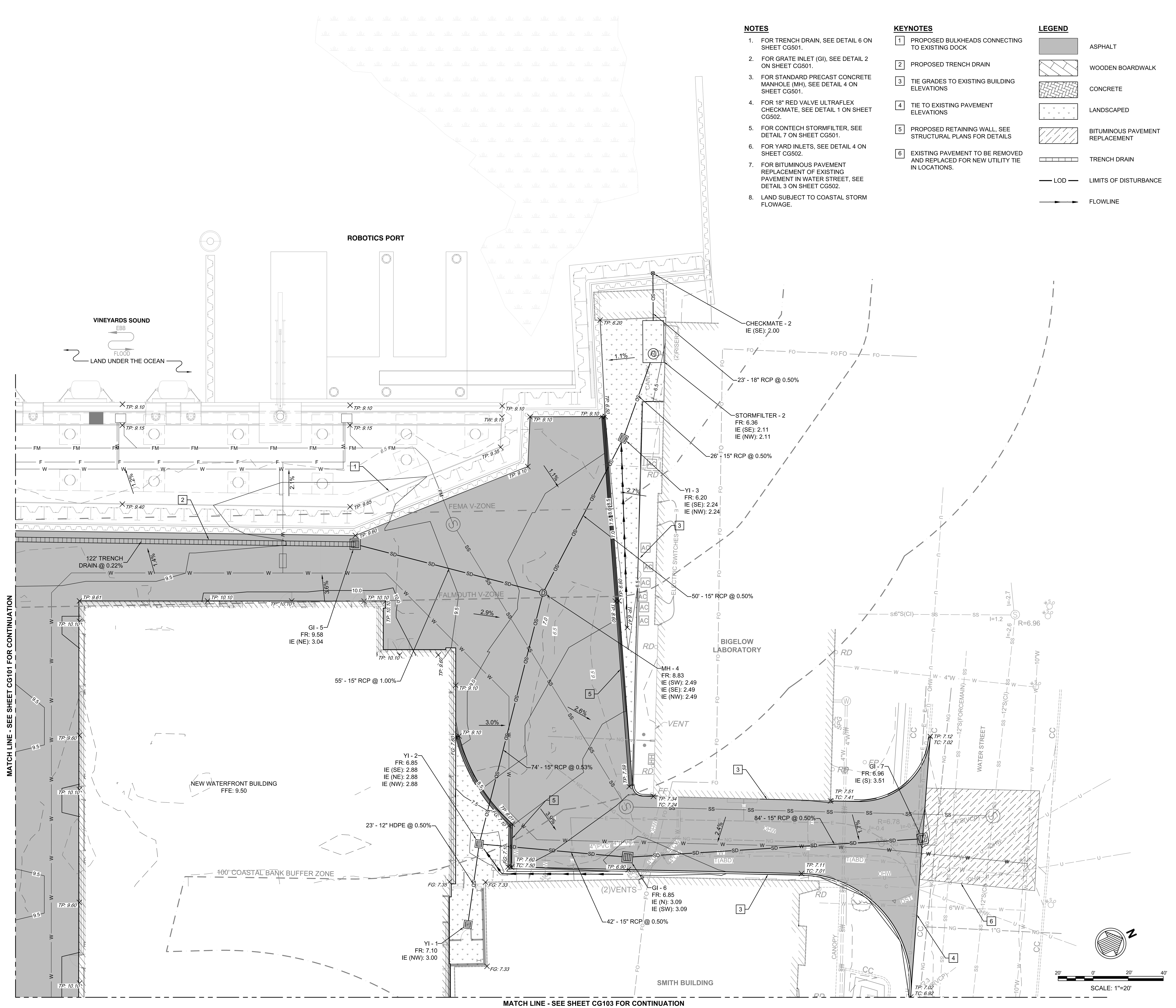
1. FOR TRENCH DRAIN, SEE DETAIL 6 ON SHEET CG501.
2. FOR GRATE INLET (GI), SEE DETAIL 2 ON SHEET CG501.
3. FOR STANDARD PRECAST CONCRETE MANHOLE (MH), SEE DETAIL 4 ON SHEET CG501.
4. FOR 18" RED VALVE ULTRAFLEX CHECKMATE, SEE DETAIL 1 ON SHEET CG502.
5. FOR CONTECH STORMFILTER, SEE DETAIL 7 ON SHEET CG501.
6. FOR YARD INLETS, SEE DETAIL 4 ON SHEET CG502.
7. FOR BITUMINOUS PAVEMENT REPLACEMENT OF EXISTING PAVEMENT IN WATER STREET, SEE DETAIL 3 ON SHEET CG502.
8. LAND SUBJECT TO COASTAL STORM FLOWAGE.

KEYNOTES

1. PROPOSED BULKHEADS CONNECTING TO EXISTING DOCK
2. PROPOSED TRENCH DRAIN
3. TIE GRADES TO EXISTING BUILDING ELEVATIONS
4. TIE TO EXISTING PAVEMENT ELEVATIONS
5. PROPOSED RETAINING WALL, SEE STRUCTURAL PLANS FOR DETAILS
6. EXISTING PAVEMENT TO BE REMOVED AND REPLACED FOR NEW UTILITY TIE IN LOCATIONS.

LEGEND

- ASPHALT
- WOODEN BOARDWALK
- CONCRETE
- LANDSCAPED
- BITUMINOUS PAVEMENT REPLACEMENT
- TRENCH DRAIN
- LOD — LIMITS OF DISTURBANCE
- FLOWLINE



NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

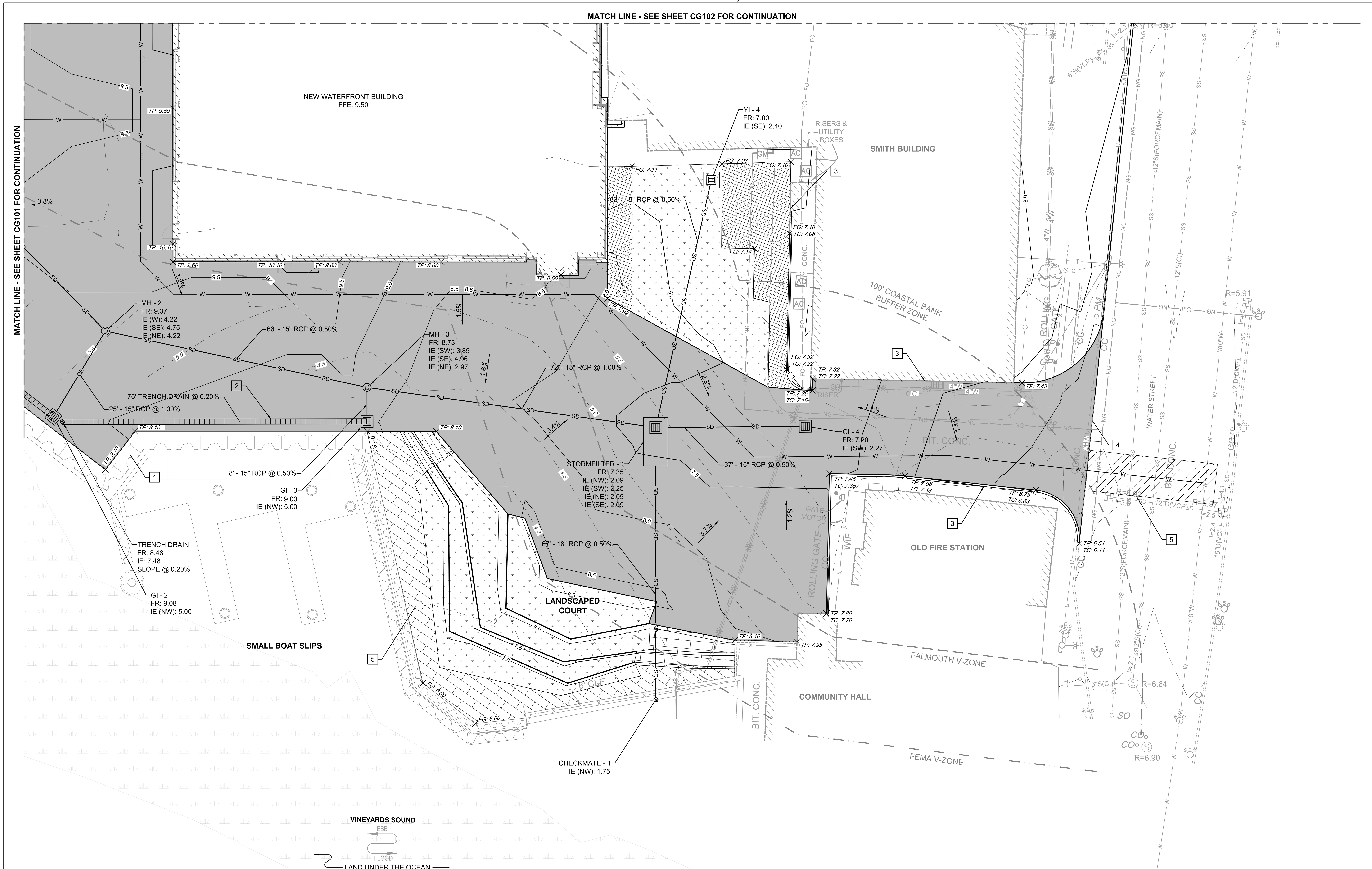
DRAINAGE & GRADING PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CG102



NOTES

1. FOR TRENCH DRAIN, SEE DETAIL 6 ON SHEET CG501.
2. FOR GRATE INLET (GI), SEE DETAIL 2 ON SHEET CG501.
3. FOR STANDARD PRECAST CONCRETE MANHOLE (MH), SEE DETAIL 4 ON SHEET CG501.
4. FOR 18" RED VALVE ULTRAFLEX CHECKMATE, SEE DETAIL 1 ON SHEET CG502.
5. FOR CONTECH STORMFILTER, SEE DETAIL 7 ON SHEET CG501.
6. FOR YARD INLETS, SEE DETAIL 4 ON SHEET CG502.
7. FOR BITUMINOUS PAVEMENT REPLACEMENT OF EXISTING PAVEMENT IN WATER STREET, SEE DETAIL 3 ON SHEET CG502.
8. LAND SUBJECT TO COASTAL FLOWAGE.

KEYNOTES

1. PROPOSED BULKHEADS CONNECTING TO EXISTING DOCK
2. PROPOSED TRENCH DRAIN
3. TIE GRADES TO EXISTING BUILDING ELEVATIONS
4. TIE TO EXISTING PAVEMENT ELEVATIONS
5. PROPOSED BOARDWALK PER LANDSCAPING PLANS.
6. EXISTING PAVEMENT TO BE REMOVED AND REPLACED FOR NEW UTILITY TIE IN LOCATIONS.

LEGEND

- ASPHALT (36,480 SF)
- WOODEN BOARDWALK (1,176 SF)
- CONCRETE (775 SF)
- LANDSCAPED (4,835 SF)
- BITUMINOUS PAVEMENT REPLACEMENT (1,212 SF)
- TRENCH DRAIN
- LOD — LIMITS OF DISTURBANCE
- FLOWLINE

moffatt & nichol
Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

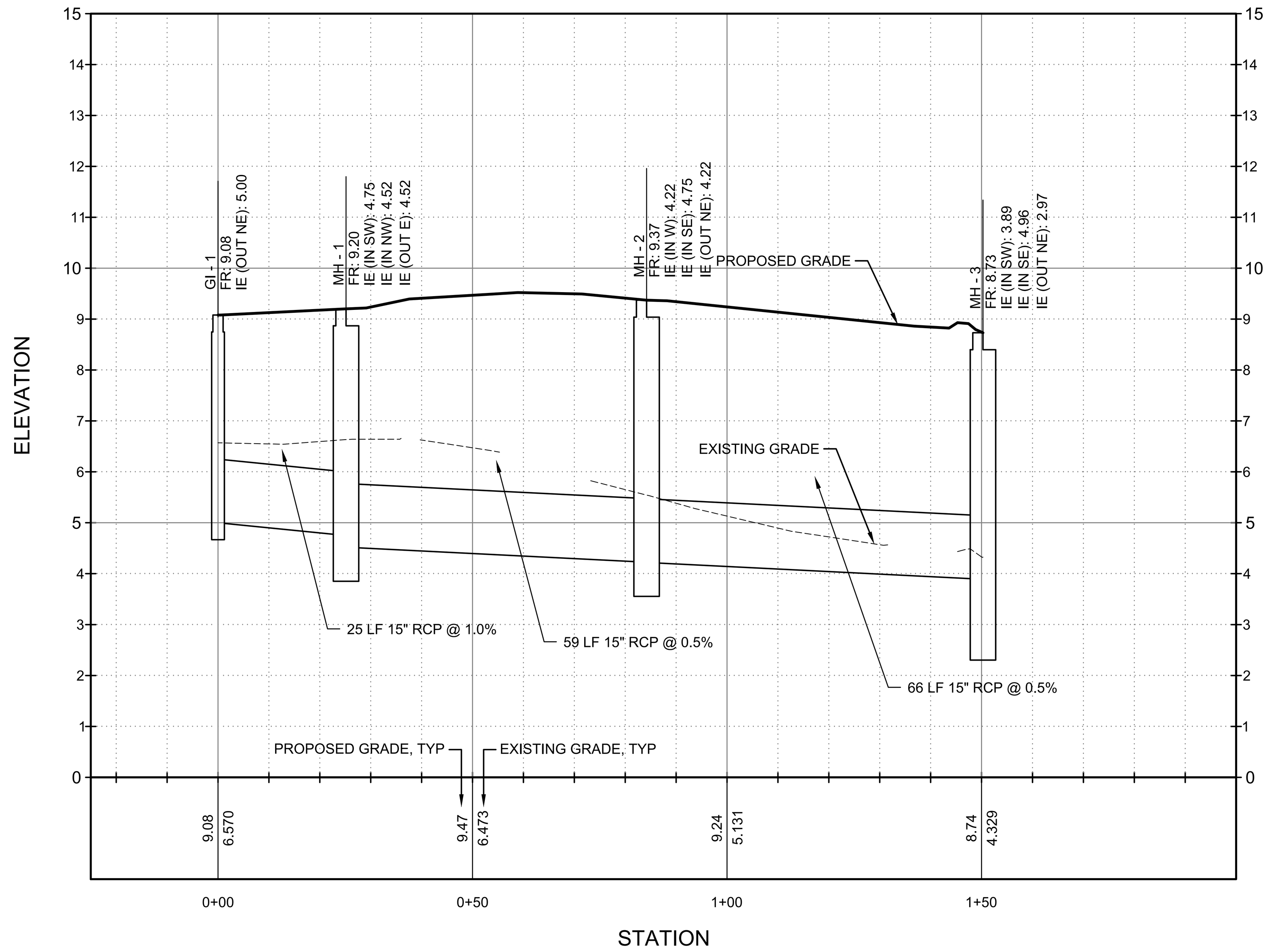
DRAINAGE & GRADING PLAN

Drawing Scale

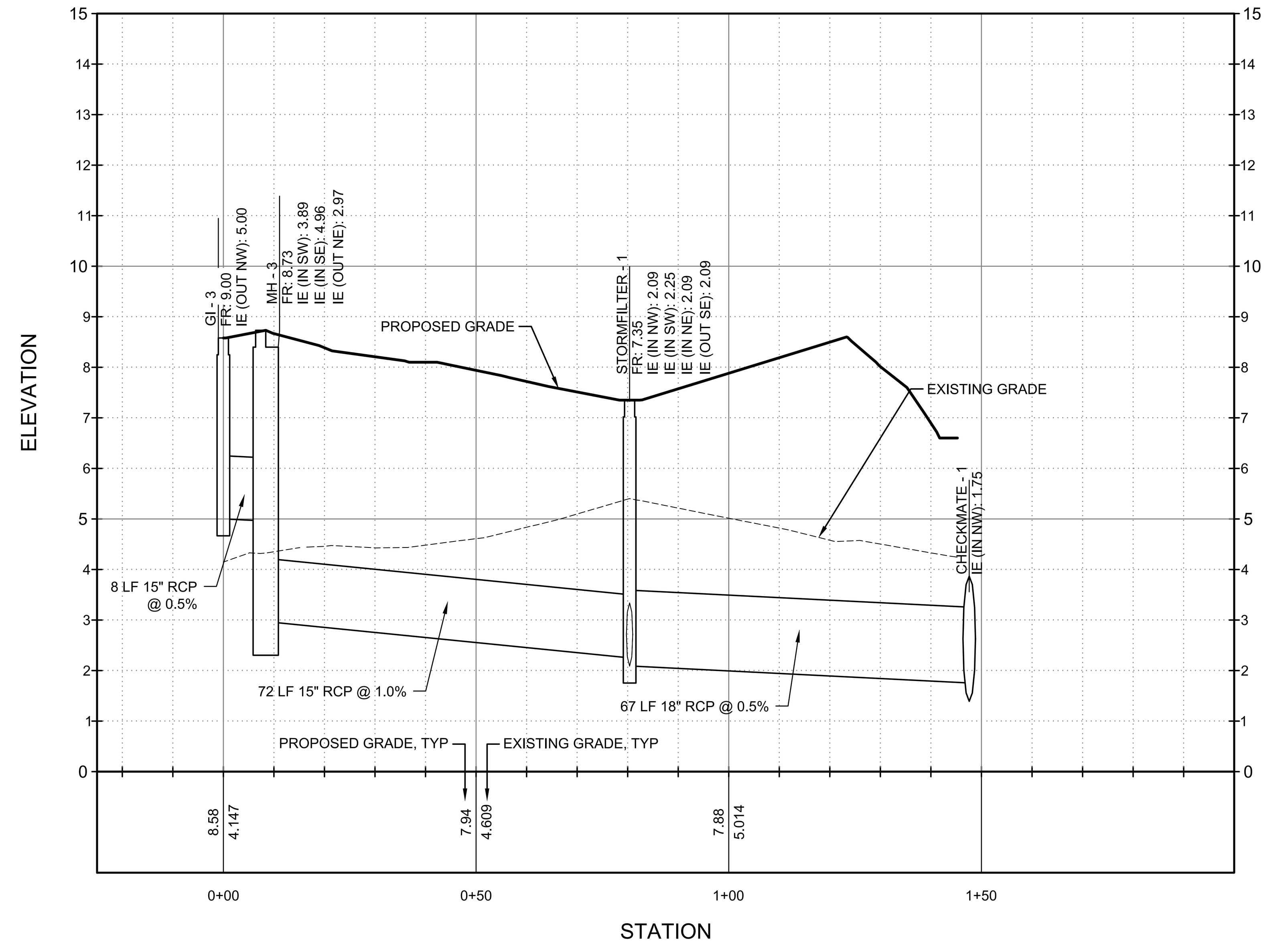
Project Number

Date Issued
5/12/21

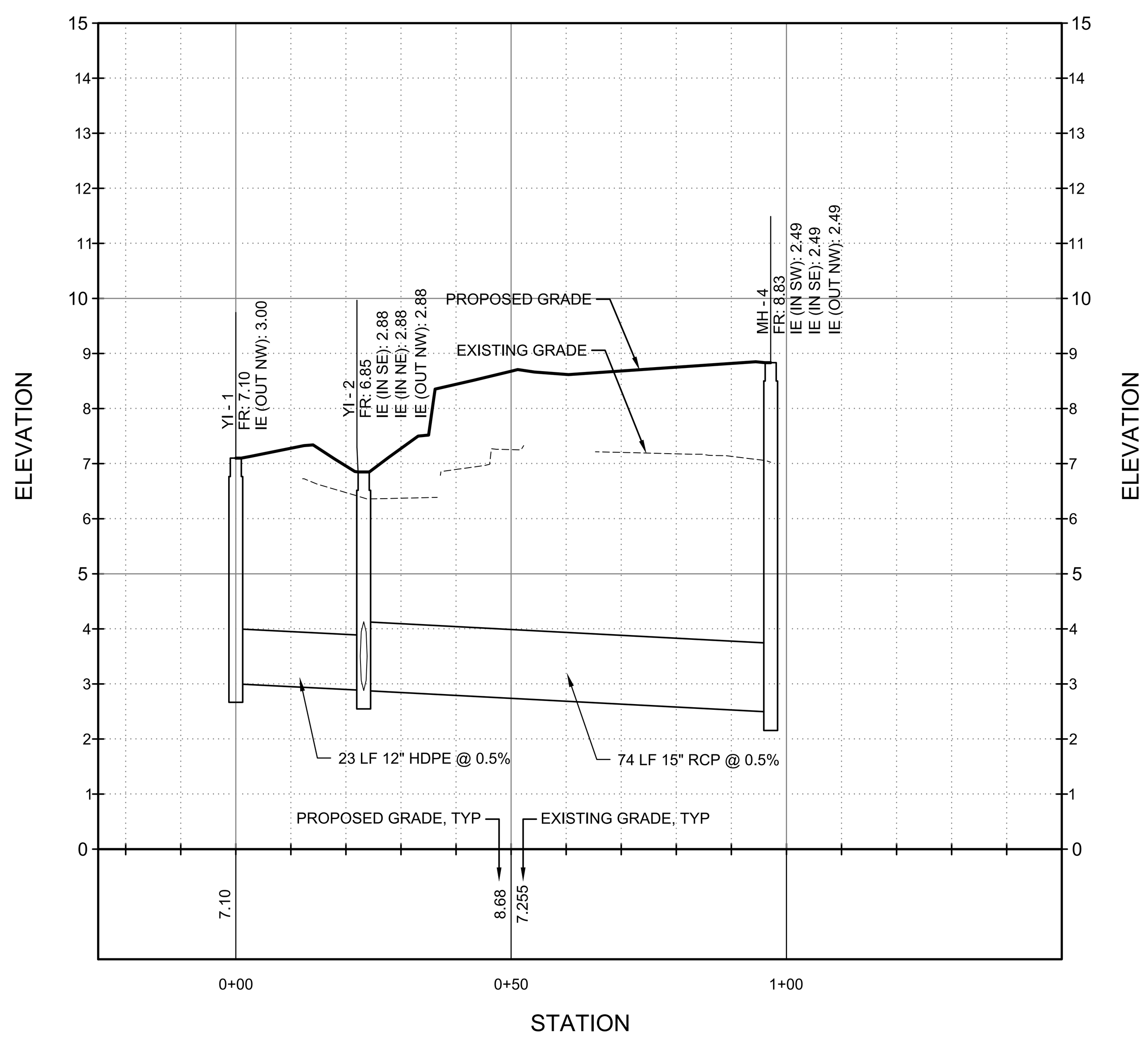
CG103



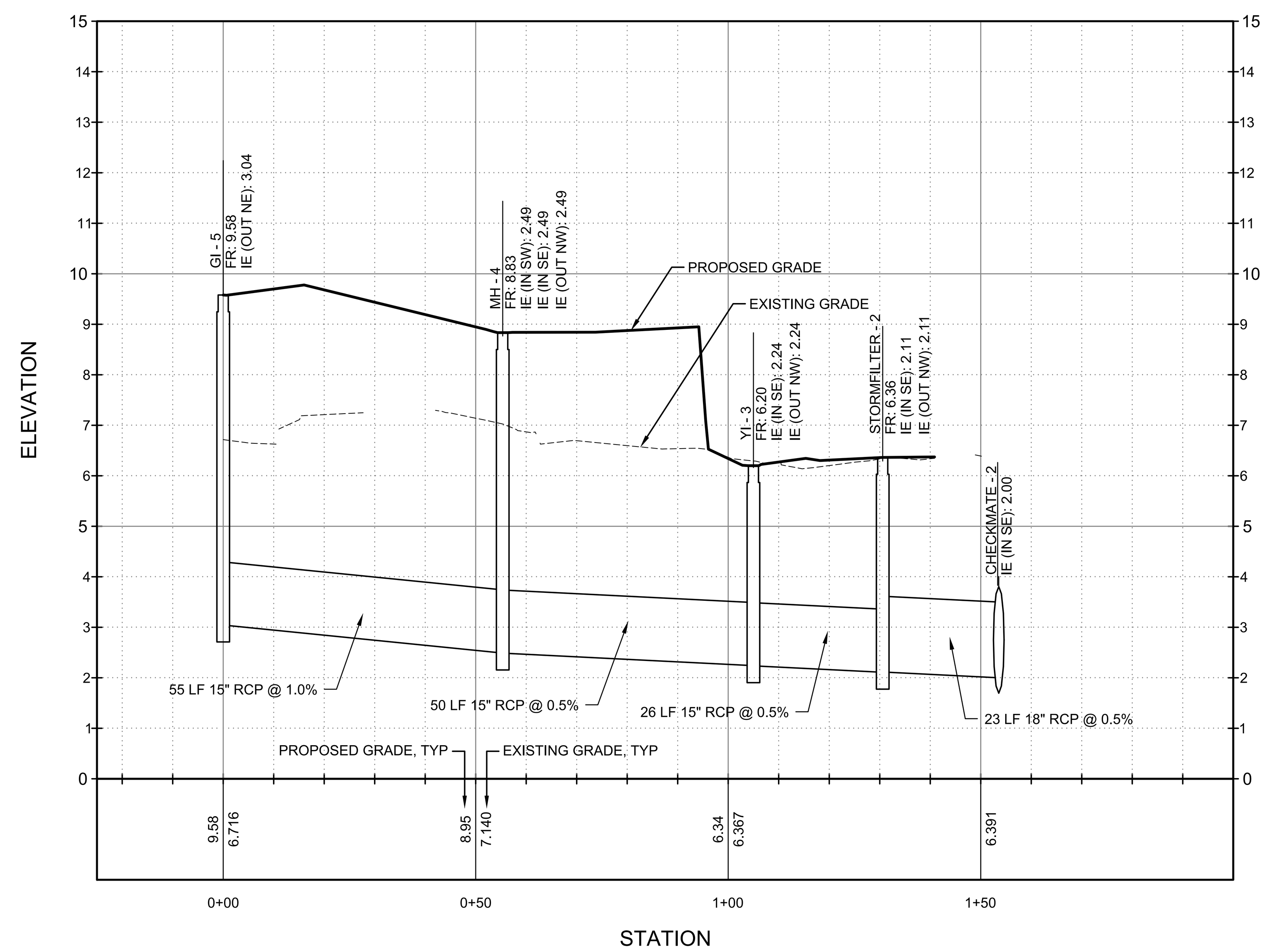
STORM PROFILE - GI-1 TO MH-3
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'



STORM PROFILE - GI-3 TO CHECKMATE-1
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'



STORM PROFILE - YI-1 TO MH-4
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'



STORM PROFILE - GI-5 TO CHECKMATE-2
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

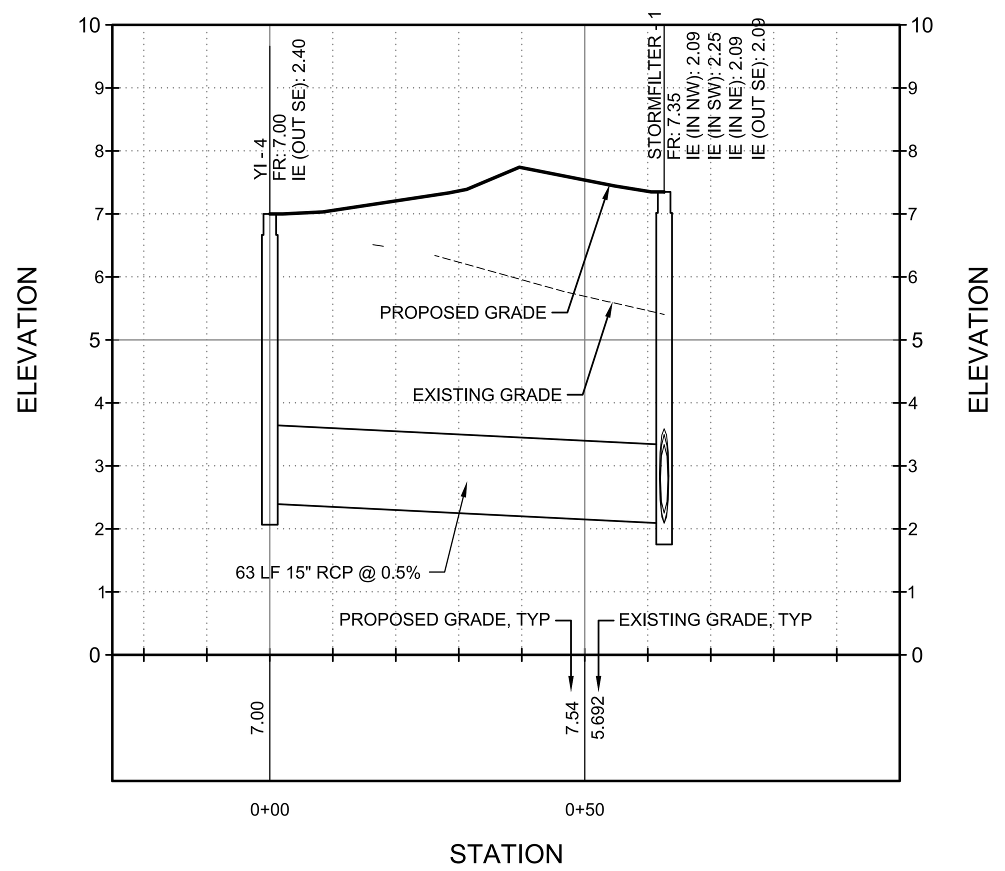
DRAINAGE PROFILES

Drawing Scale

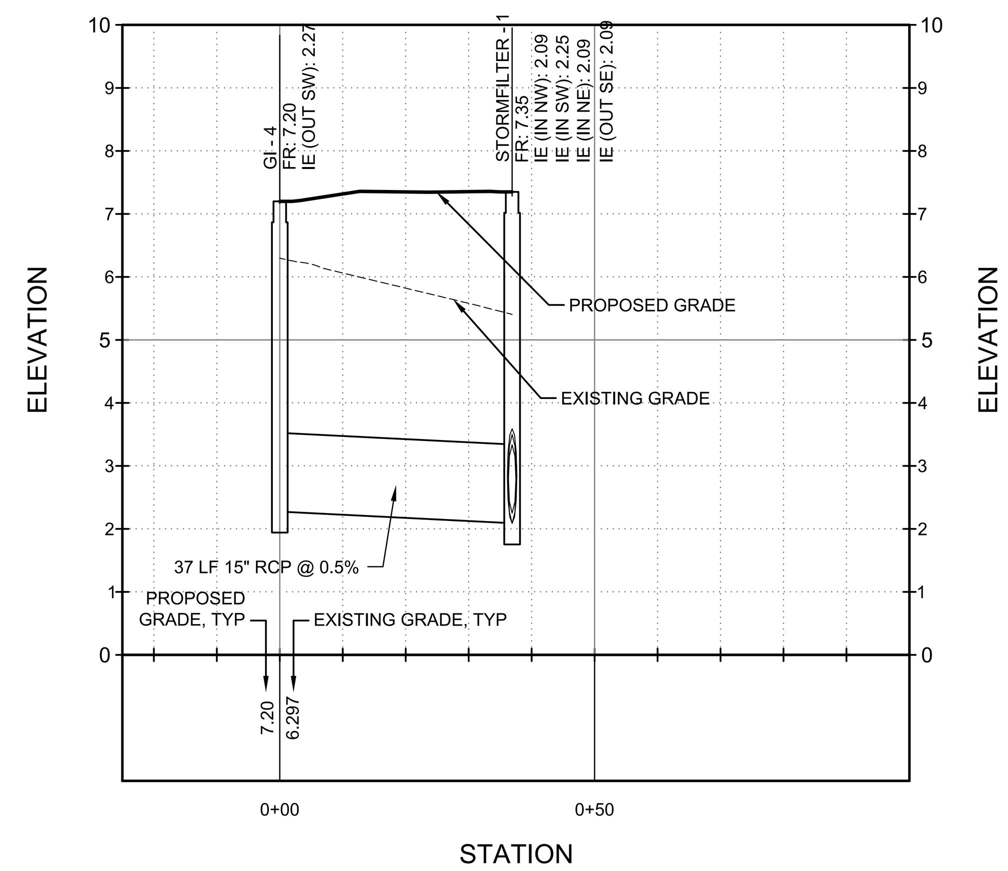
Project Number

Date Issued
5/12/21

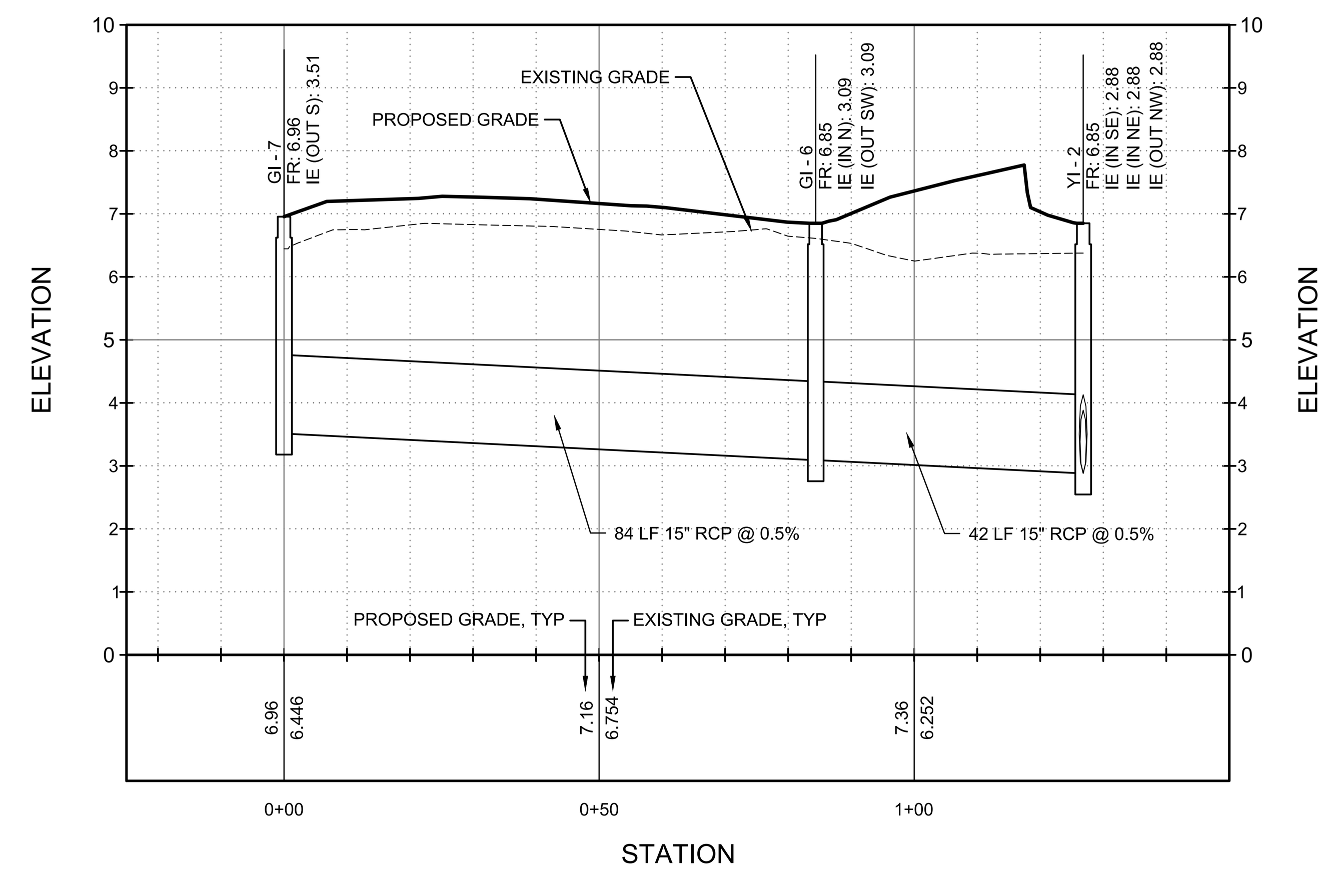
CG201



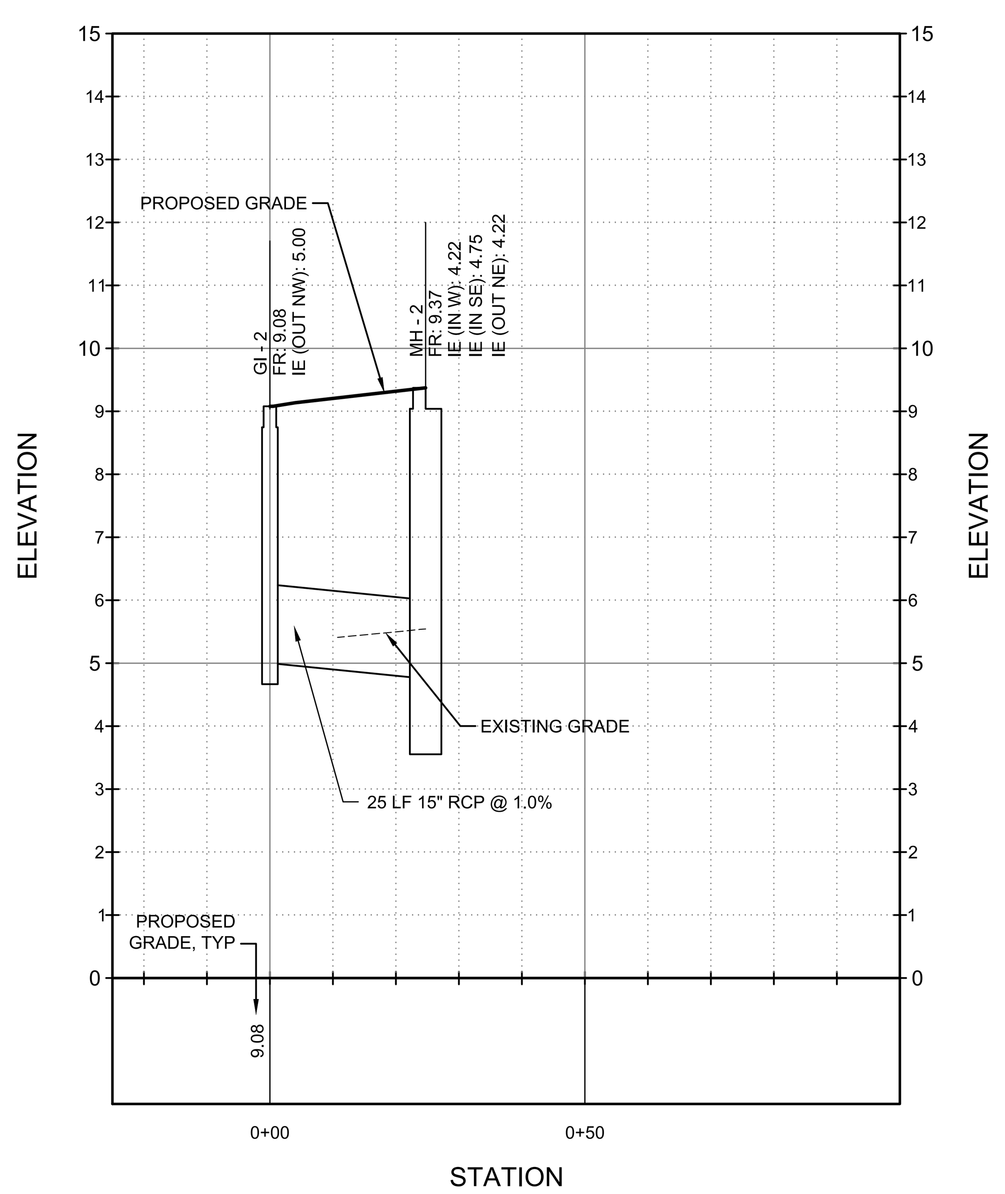
STORM PROFILE - YI-4 TO STORMFILTER-1
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'



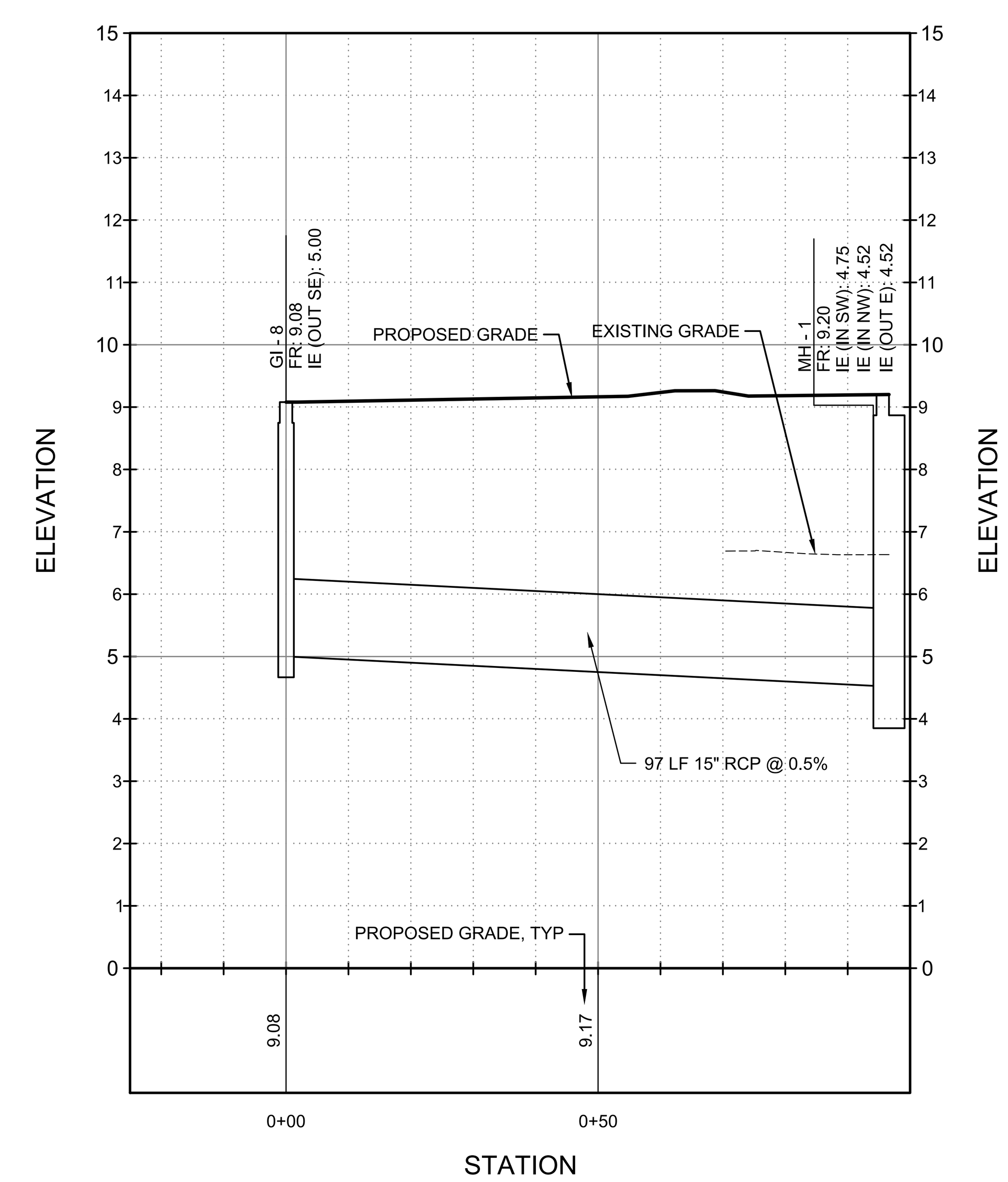
STORM PROFILE - GI-4 TO STORMFILTER-1
HORIZTONAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'



STORM PROFILE - GI-7 TO YI-2
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'



STORM PROFILE - GI-2 TO MH-2
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'



STORM PROFILE - GI-8 TO MH-1
HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 2'

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

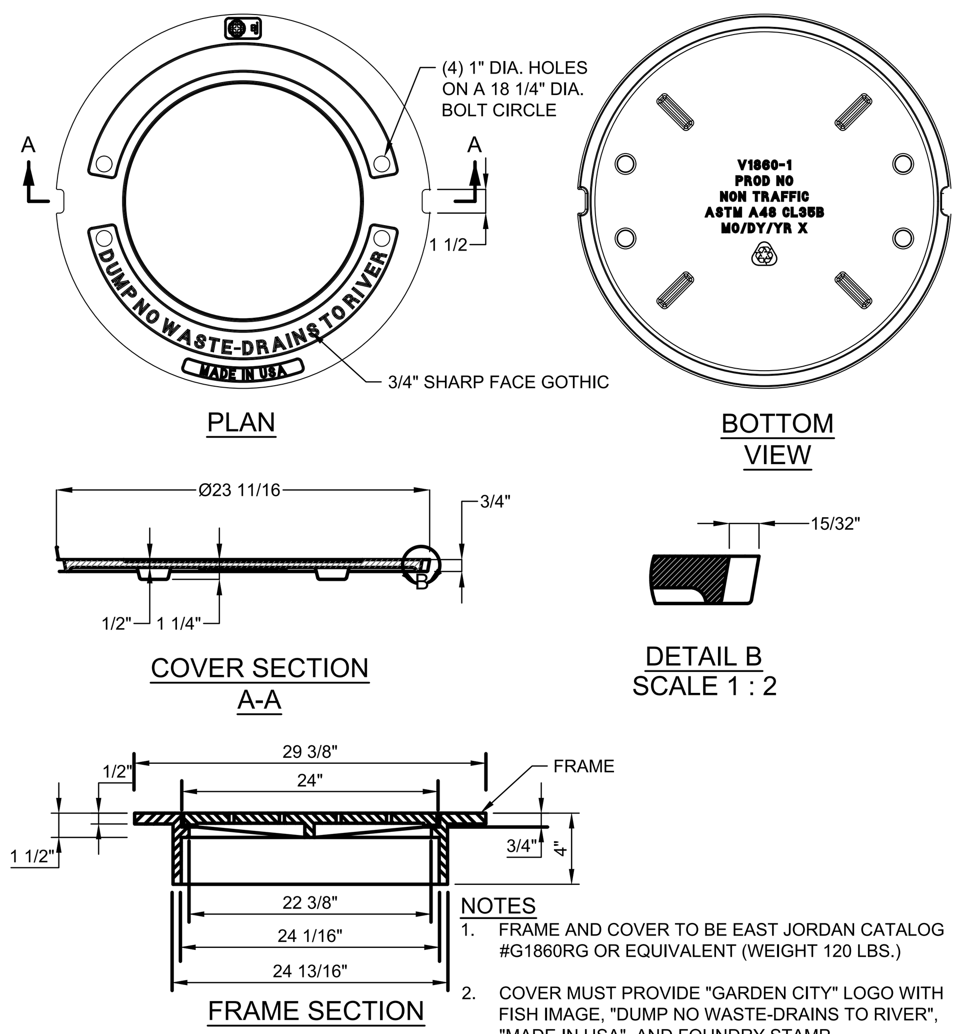
WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

DRAINAGE PROFILES

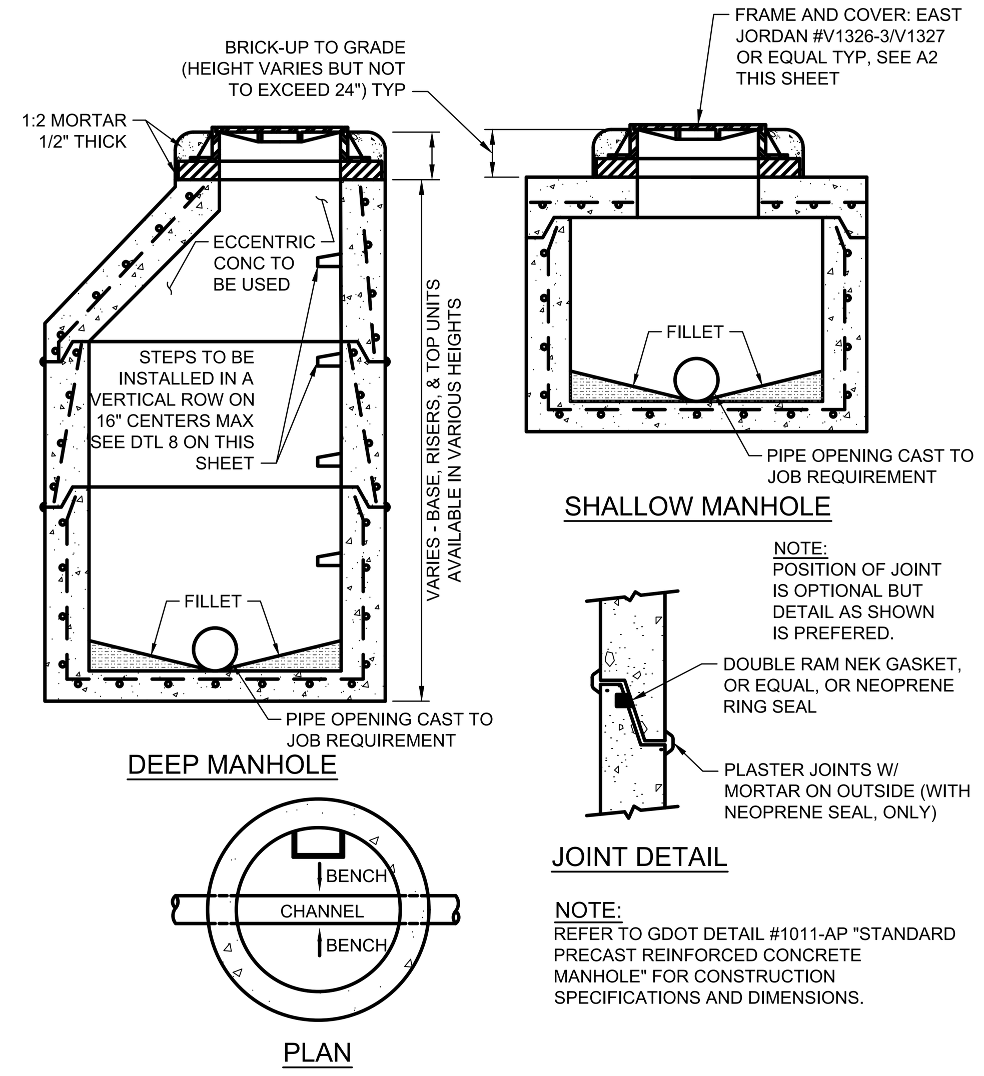
Drawing Scale	
Project Number	
Date Issued 5/12/21	

CG202



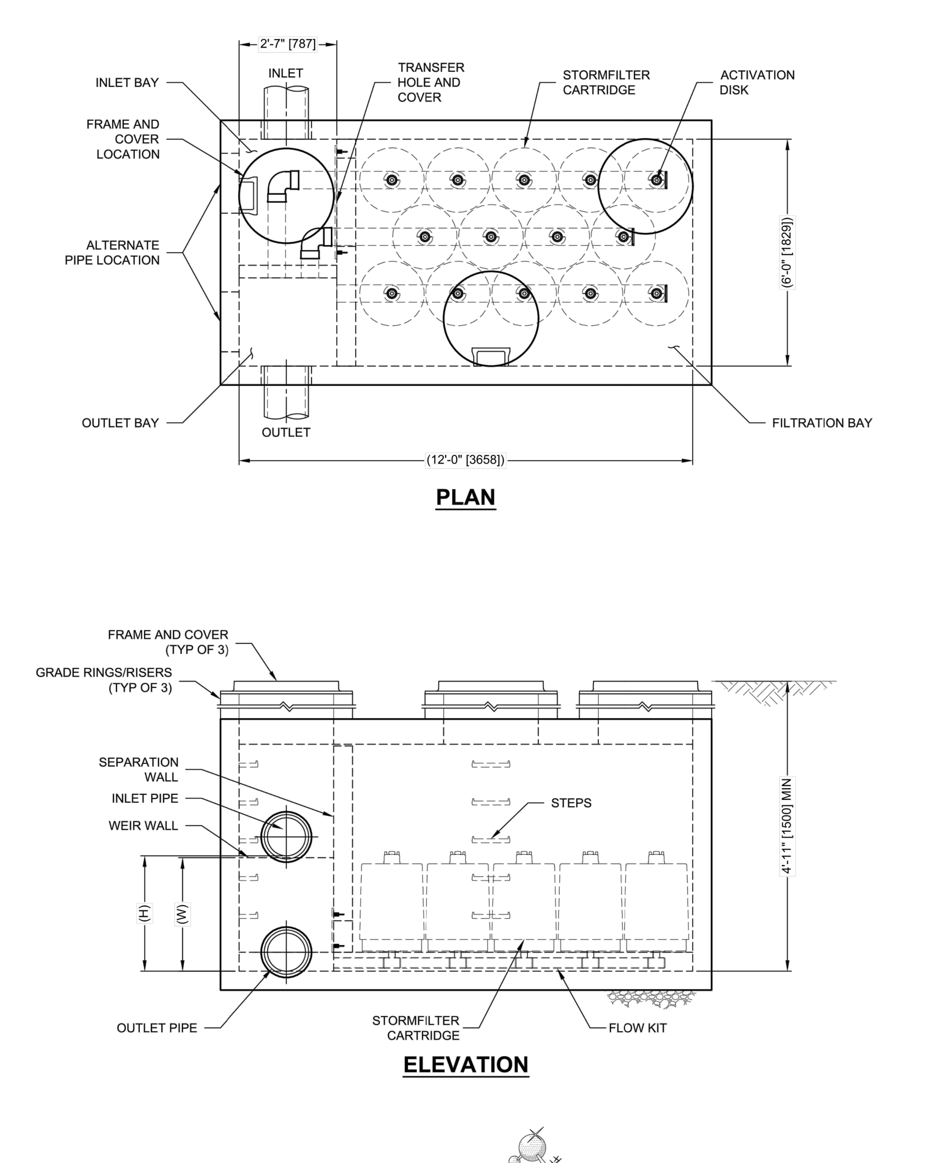
NOTES
1. FRAME AND COVER TO BE EAST JORDAN CATALOG #G1860RG OR EQUIVALENT (WEIGHT 120 LBS.)
2. COVER MUST PROVIDE "GARDEN CITY" LOGO WITH FISH IMAGE, "DUMP NO WASTE-DRAINS TO RIVER", "MADE IN USA", AND FOUNDRY STAMP

1 CG501 INLET FRAME & COVER
SCALE: NTS



NOTE:
REFER TO GDOT DETAIL #1011-AP "STANDARD PRECAST REINFORCED CONCRETE MANHOLE" FOR CONSTRUCTION SPECIFICATIONS AND DIMENSIONS.

4 CG501 STANDARD PRECAST CONCRETE MANHOLE
SCALE: NTS

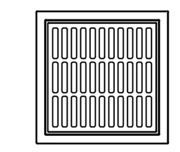


STORMFILTER DESIGN NOTES

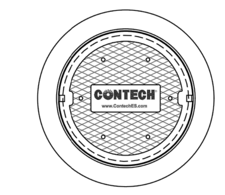
- STORMFILTER TREATMENT CAPACITY VARIES BY CARTRIDGE COUNT AND LOCALLY APPROVED SURFACE AREA SPECIFIC FLOW RATE. PEAK CONVEYANCE CAPACITY TO BE DETERMINED BY ENGINEER OF RECORD
- A 6' x 12' [1829 x 3658] PEAK DIVERSION STYLE STORMFILTER IS SHOWN WITH THE MAXIMUM NUMBER OF CARTRIDGES (14) AND IS AVAILABLE IN A LEFT INLET (AS SHOWN) OR A RIGHT INLET CONFIGURATION
- ALL PARTS AND INTERNAL ASSEMBLY PROVIDED BY CONTECH UNLESS NOTED OTHERWISE

CARTRIDGE SIZE (in. [mm])	27 [686]			18 [457]			LOW DROP		
RECOMMENDED HYDRAULIC DROP (H) (ft. [mm])	3.05 [930]			2.3 [701]			1.8 [549]		
HEIGHT OF WEIR (W) (ft. [mm])	3.00 [914]			2.25 [686]			1.75 [533]		
SPECIFIC FLOW RATE (gpm/sf [L/s/m^2])	2 [1.36]	1.67* [1.13]*	1 [0.68]	2 [1.36]	1.67* [1.13]*	1 [0.68]	2 [1.36]	1.67* [1.13]*	1 [0.68]
CARTRIDGE FLOW RATE (gpm [L/s])	22.5 [1.42]	18.79 [1.19]	11.25 [0.71]	15 [0.95]	12.53 [0.79]	7.5 [0.47]	10 [0.63]	8.35 [0.53]	5 [0.32]

* 1.67 gpm/sf [1.13 L/s/m^2] SPECIFIC FLOW RATE IS APPROVED WITH PHOSPHOSORB® (PSORB) MEDIA ONLY



FRAME AND GRATE
(24" SQUARE)
(NOT TO SCALE)



FRAME AND COVER
(30" ROUND)
(NOT TO SCALE)

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID	
WATER QUALITY FLOW RATE (cfs [L/s])	
PEAK FLOW RATE (cfs [L/s])	
RETURN PERIOD OF PEAK FLOW (yrs)	
CARTRIDGE FLOW RATE	
CARTRIDGE SIZE (27, 18, LOW DROP (LD))	
MEDIA TYPE (PERLITE, ZPG, PSORB)	
NUMBER OF CARTRIDGES REQUIRED	
INLET BAY RIM ELEVATION	
FILTER BAY RIM ELEVATION	

PIPE DATA:	INVERT	MATERIAL	DIAMETER
INLET PIPE 1			
INLET PIPE 2			
OUTLET PIPE			

NOTES/SPECIAL REQUIREMENTS:

PERFORMANCE SPECIFICATION
FILTER CARTRIDGES SHALL BE MEDIA-FILLED, PASSIVE, SIPHON ACTUATED, RADIAL FLOW, AND SELF CLEANING. **RADIAL MEDIA DEPTH SHALL BE 7" [178].** FILTER MEDIA CONTACT TIME SHALL BE AT LEAST **37 SECONDS**. SPECIFIC FLOW RATE SHALL BE **2 GPM/SF [1.36 L/s/m^2] (MAXIMUM)**. SPECIFIC FLOW RATE IS THE MEASURE OF THE FLOW (GPM) DIVIDED BY THE MEDIA SURFACE CONTACT AREA (SF). MEDIA VOLUMETRIC FLOW RATE SHALL BE **6 GPM/CF [13.39 L/s/m^3] OF MEDIA (MAXIMUM).**

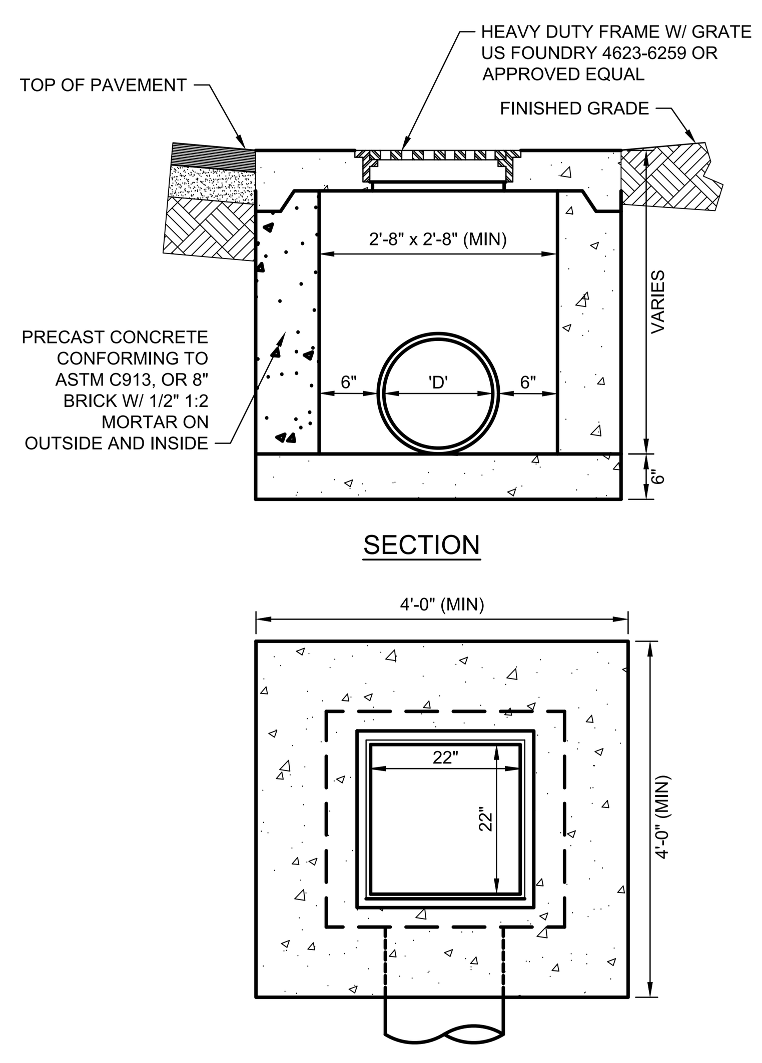
GENERAL NOTES
1. CONTECH TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. DIMENSIONS MARKED WITH ( ) ARE REFERENCE DIMENSIONS. ACTUAL DIMENSIONS MAY VARY.
3. ALTERNATE DIMENSIONS ARE IN MILLIMETERS [mm] UNLESS NOTED OTHERWISE.
4. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR CONTECH REPRESENTATIVE. www.ContechES.com
5. STORMFILTER WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING. CONTRACTOR TO CONFIRM STRUCTURE MEETS REQUIREMENTS OF PROJECT.
6. STRUCTURE SHALL MEET AASHTO HS20 LOAD RATING, ASSUMING EARTH COVER OF 0' - 10' [3048] AND GROUNDWATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION. CASTINGS SHALL MEET AASHTO M306 AND BE CAST WITH THE CONTECH LOGO.

INSTALLATION NOTES
A. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY ENGINEER OF RECORD.
B. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE STORMFILTER STRUCTURE.
C. CONTRACTOR TO INSTALL JOINT SEALANT BETWEEN ALL SECTIONS AND ASSEMBLE STRUCTURE.
D. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES. MATCH OUTLET PIPE INVERT WITH OUTLET BAY FLOOR.
E. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO PROTECT CARTRIDGES FROM CONSTRUCTION-RELATED EROSION RUNOFF.
F. CONTRACTOR TO REMOVE THE TRANSFER OPENING COVER WHEN THE SYSTEM IS BROUGHT ONLINE.

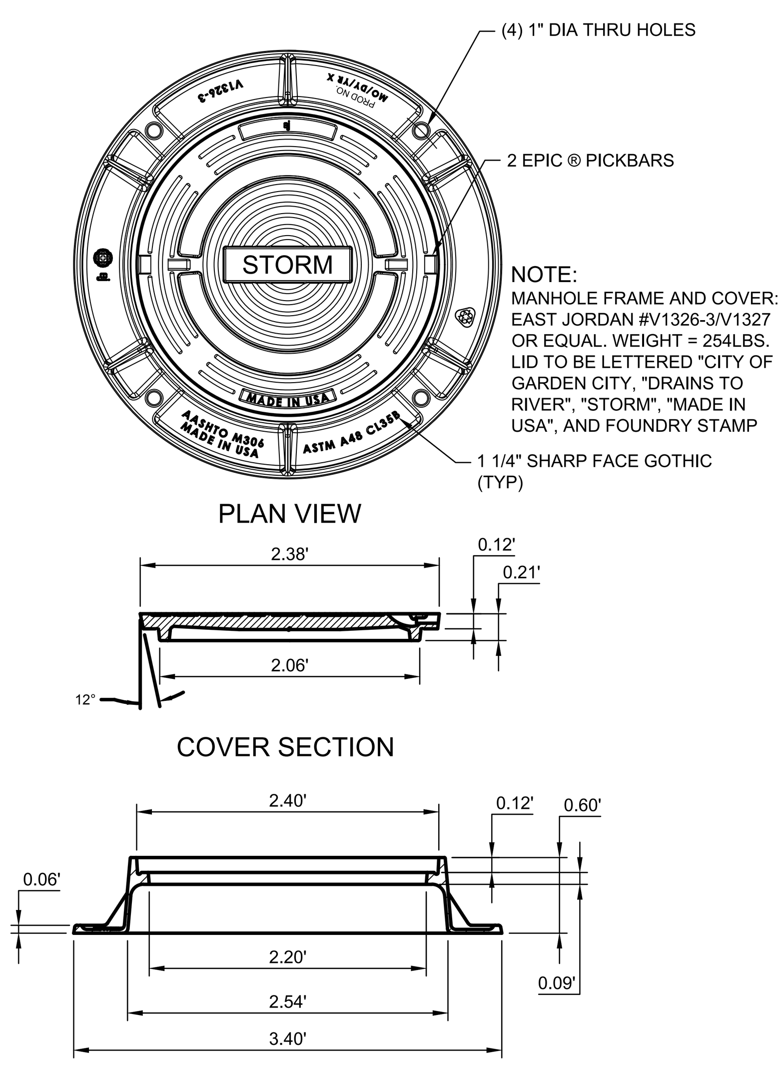
CONTECH® ENGINEERED SOLUTIONS LLC
www.ContechES.com
9025 Centre Pointe Dr., Suite 400, West Chester, OH 45069
800-526-3999 513-645-7000 513-645-7993 FAX

SFPD0612 (6' x 12')
PEAK DIVERSION STORMFILTER
STANDARD DETAIL

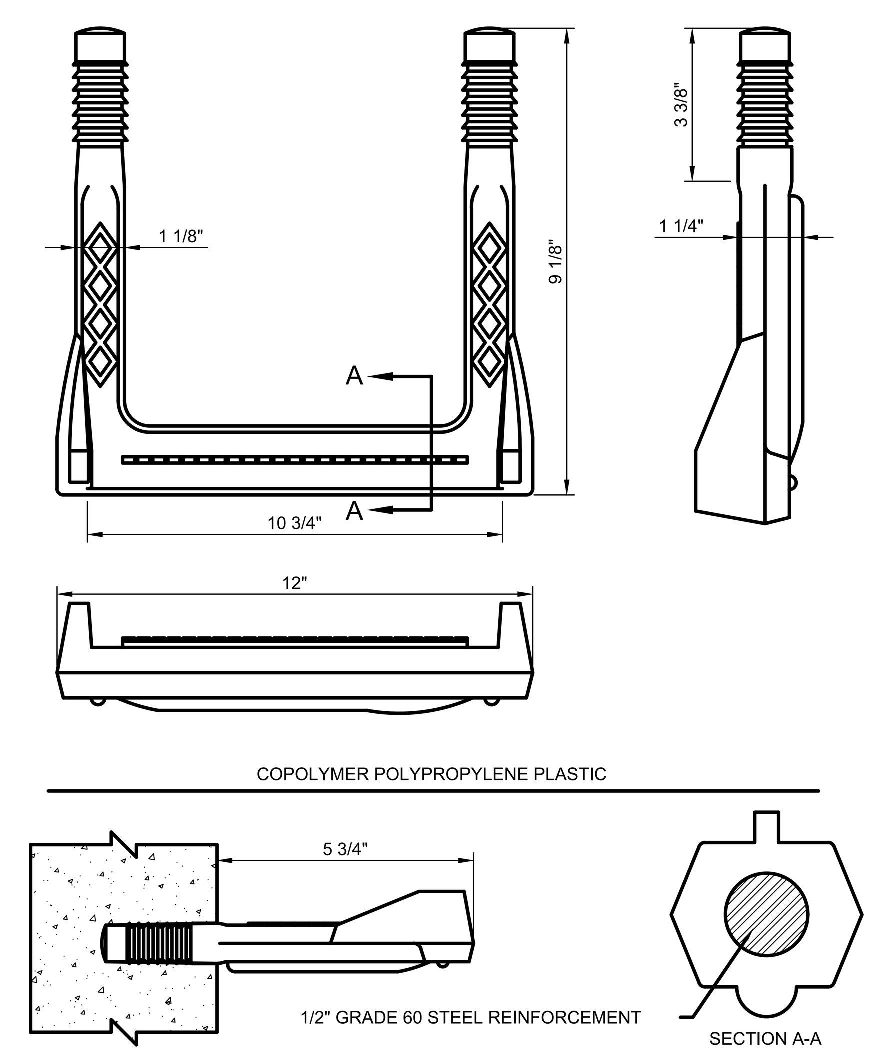
7 CG501 CONTECH STORMFILTER
SCALE: NTS



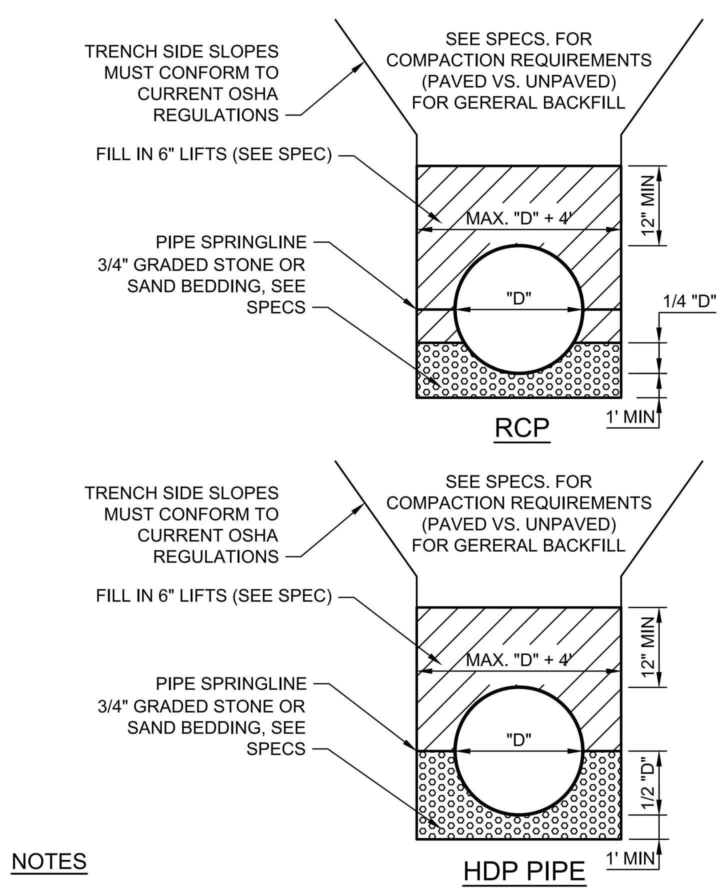
2 CG501 GRATE INLET DETAIL
SCALE: NTS



5 CG501 MANHOLE COVER & FRAME DETAIL
SCALE: NTS

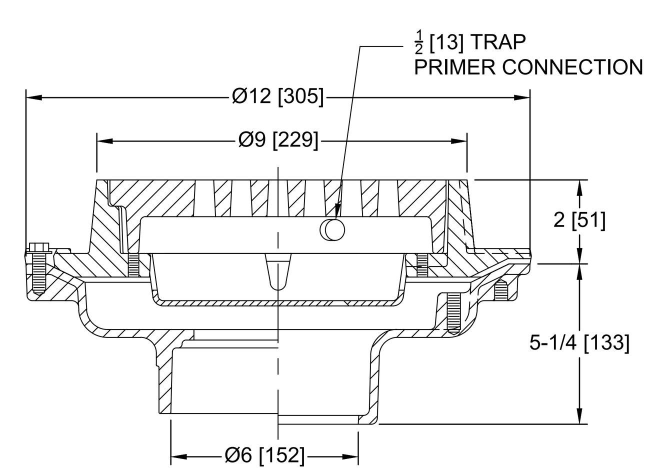


8 CG501 MANHOLE STEP-POLYPROPYLENE
SCALE: NTS

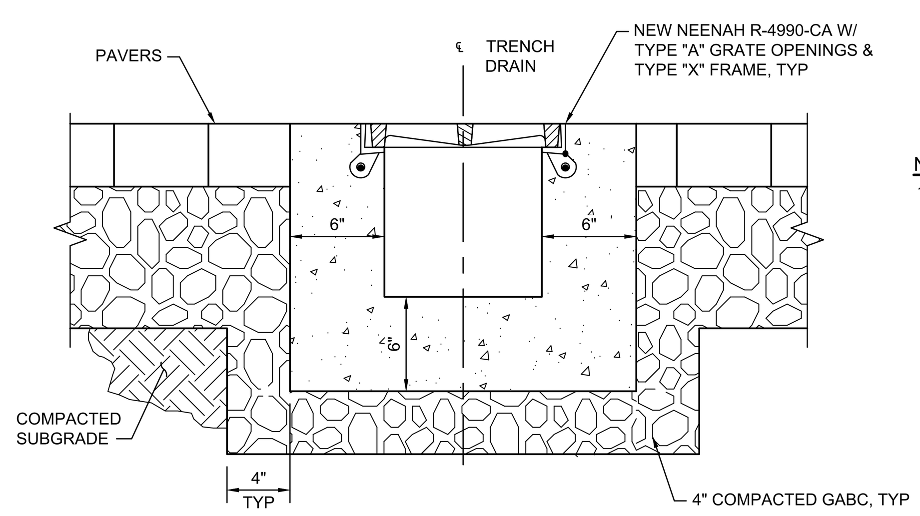


NOTES
1. THIS DETAIL SHALL ONLY APPLY WHEN IN PLACE MATERIALS ARE UNSUITABLE FOR PIPE BEDDING. SEE THE SPECIFICATIONS FOR BEDDING REQUIREMENTS.
2. FOR PIPE UNDER 48" DIA THE MINIMUM BEDDING DEPTH BELOW THE PIPE IS 1'. FOR 48" DIA AND LARGER, 2' OF BEDDING SHALL BE USED UNDER PIPE. (ONLY APPLIES TO THIS DETAIL WHERE EXISTING MATERIALS ARE UNSUITABLE FOR BEDDING).
3. WHERE THE ENGINEER DETERMINES ADDITIONAL UNDERCUTTING AND STONE BEDDING IS REQUIRED BEYOND THAT SHOWN ON THE DETAILS TO PROVIDE A STABLE SUBGRADE, IT SHALL BE PAID FOR AT THE COST OF REMOVING THE ADDITIONAL UNSUITABLE MATERIAL BEYOND THAT SHOWN ON THE DETAILS, AND FURNISHING AND INSTALLING ADDITIONAL STONE BEDDING. NO PAYMENT FOR ADDITIONAL STONE OR SAND BEDDING BEYOND THE QUANTITY SHOWN ON THE DETAILS SHALL BE PAID WITHOUT PRIOR WRITTEN APPROVAL OF LOCATION, QUANTITY, AND OVERALL PRICE BY ENGINEER.
4. ALL STORM PIPE JOINTS SHOULD BE WRAPPED IN FILTER FABRIC.

9 CG501 CUSTOM PIPE BEDDING
SCALE: NTS



3 CG501 ZURN Z508 9-IN EXTRA HEAVY-DUTY DRAIN
SCALE: NTS



NOTE:
1. CAST-IN-PLACE CONCRETE SHALL INCLUDE SYNTHETIC FIBERS AT A DOSAGE RATE OF 1.5 LBS/YD^3. FIBERS SHALL BE MASTERFIBER M100 B4 BASF, PSI FIBERSTRAND F BY EUCLID CHEMICAL, SIKAFIBER PPM 150 BY SIKA, OR APPROVED EQUAL.

6 CG501 TRENCH DRAIN SECTION
SCALE: NTS

moffatt & nichol
Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

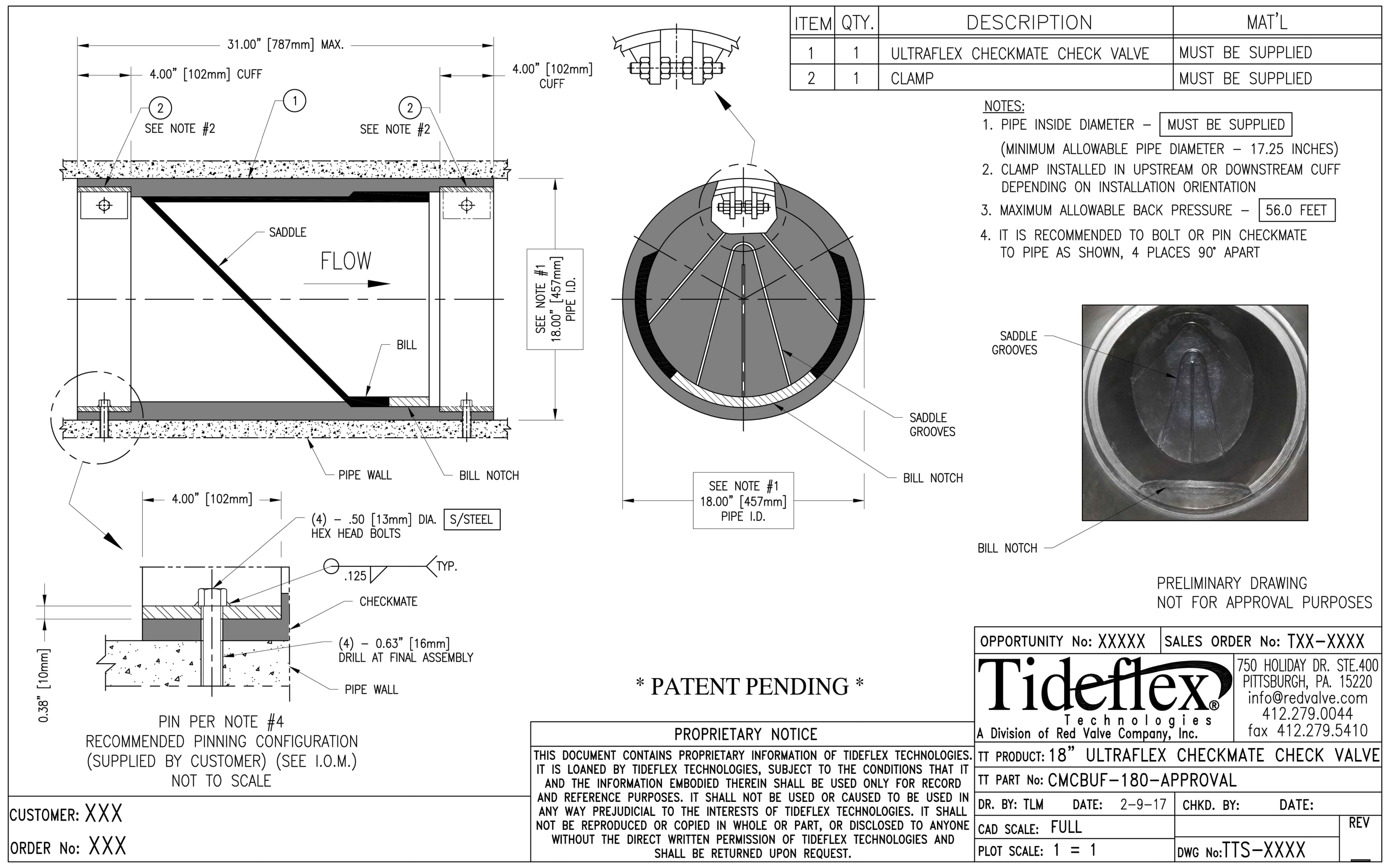
DRAINAGE DETAILS

Drawing Scale

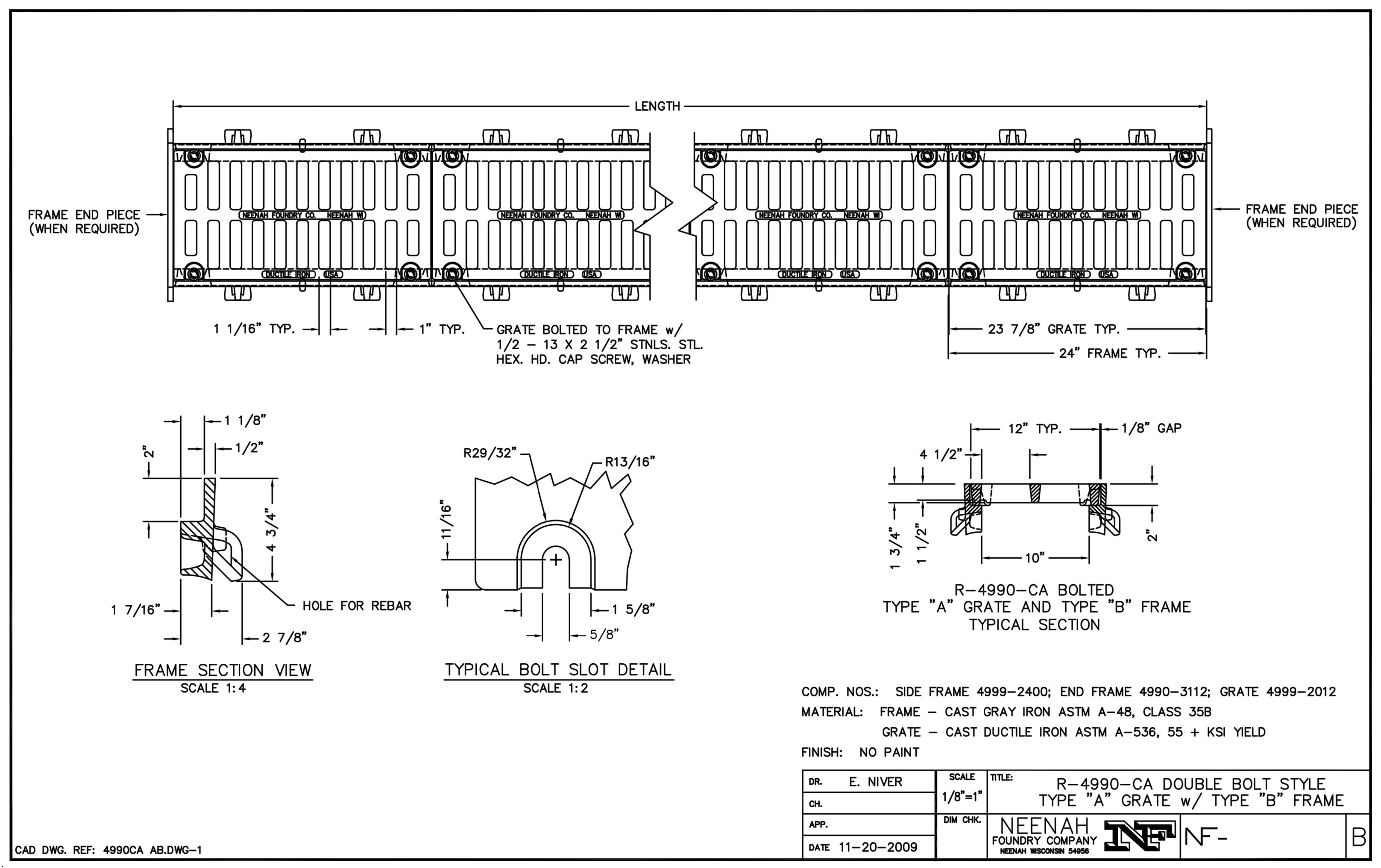
Project Number

Date Issued
5/12/21

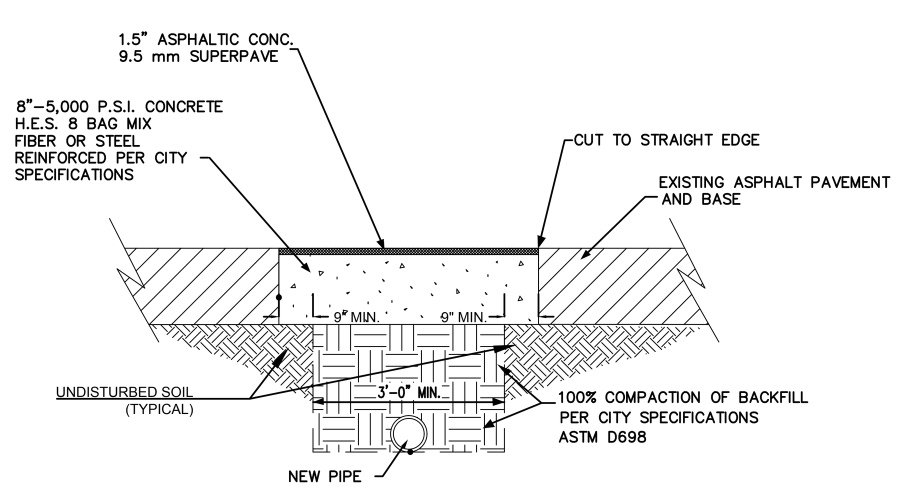
CG501



1 CG502 RED VALVE 18-IN CHECKMATE ULTRAFLEX
SCALE: NTS

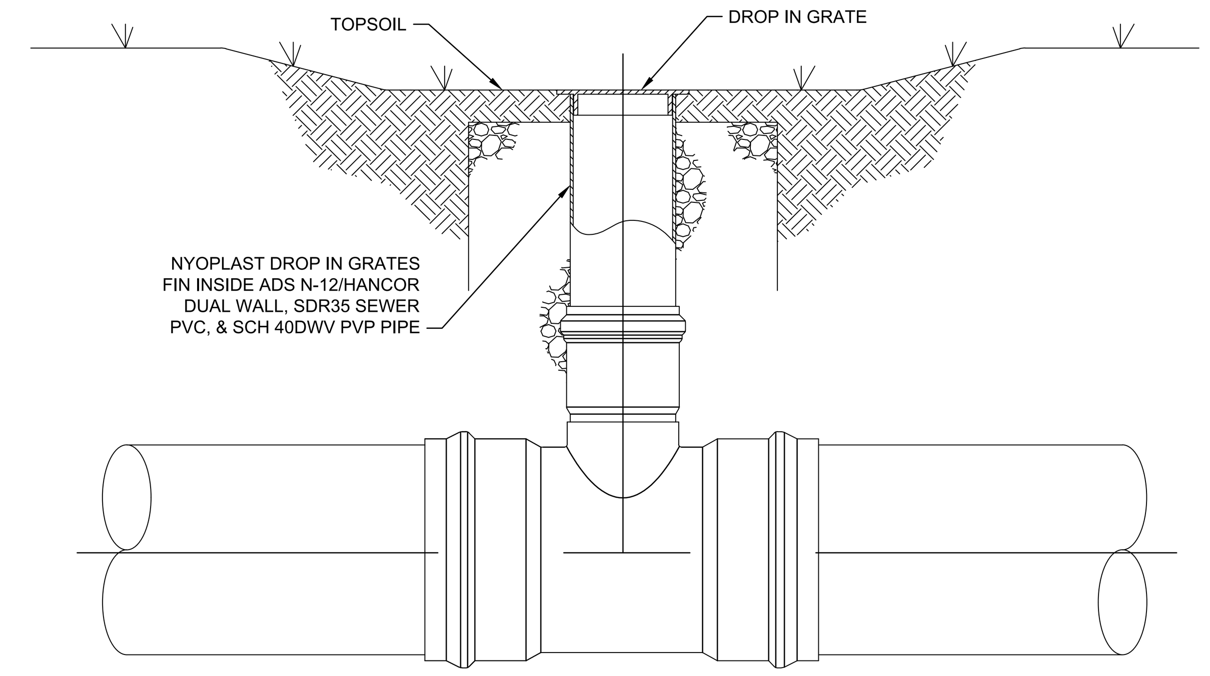


2 CG502 TRENCH DRAIN FRAME
SCALE: NTS

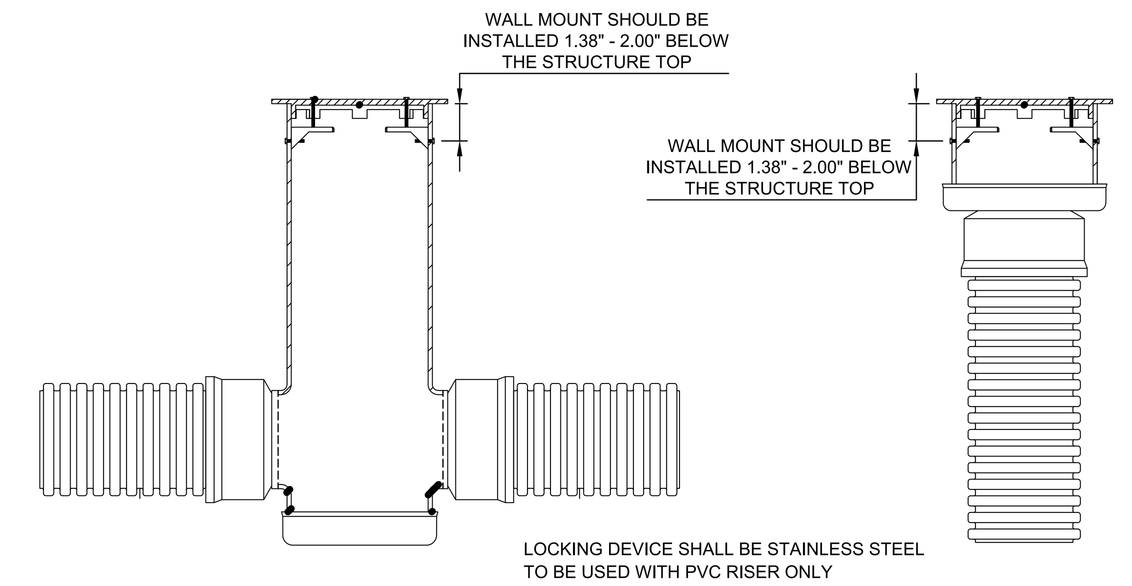


NOTES:
1. COMPACT BASE AND SUB-BASE TO 100% STANDARD (ASTM D698) PER SECTION 02200, PART 3.01B OF CITY TECHNICAL SPECIFICATIONS.
2. CONCRETE IN THE ROW TO BE 5000PSI PER SECTION 03300, CHAPTER 3.2 AND REINFORCED WITH FIBERMESH OR STEEL PER SECTION 3300, CHAPTER 5 OF CITY TECHNICAL SPECIFICATIONS.
3. ALL LATERAL STREET CUTS MUST BE COVERED WITH STEEL PLATES OF SUFFICIENT THICKNESS TO SPAN THE CUT WITHOUT NOTICABLE DEFLECTION. PLATES TO REMAIN IN PLACE UNTIL THE CONCRETE BASE HAS GAINED SUFFICIENT STRENGTH TO WITHSTAND TRAFFIC LOADS (24 HOUR MINIMUM).
4. WITH LONGITUDINAL CUTS EXCEEDING 150 FEET IN LENGTH, THE CONCRETE IN THE TRENCH WILL BE BROUGHT FLUSH WITH THE EXISTING PAVEMENT. PAVING WILL BE SAW CUT TO A STRAIGHT EDGE AND THE ENTIRE WIDTH OF THE ROADWAY WILL BE RESURFACED WITH A MINIMUM OF 1.5" OF 9.5mm HOT ASPHALT SUPERPAVE.
5. ALL STREET PATCHES MUST BE SQUARE OR RECTANGULAR WITH STRAIGHT, SAW CUT EDGES.

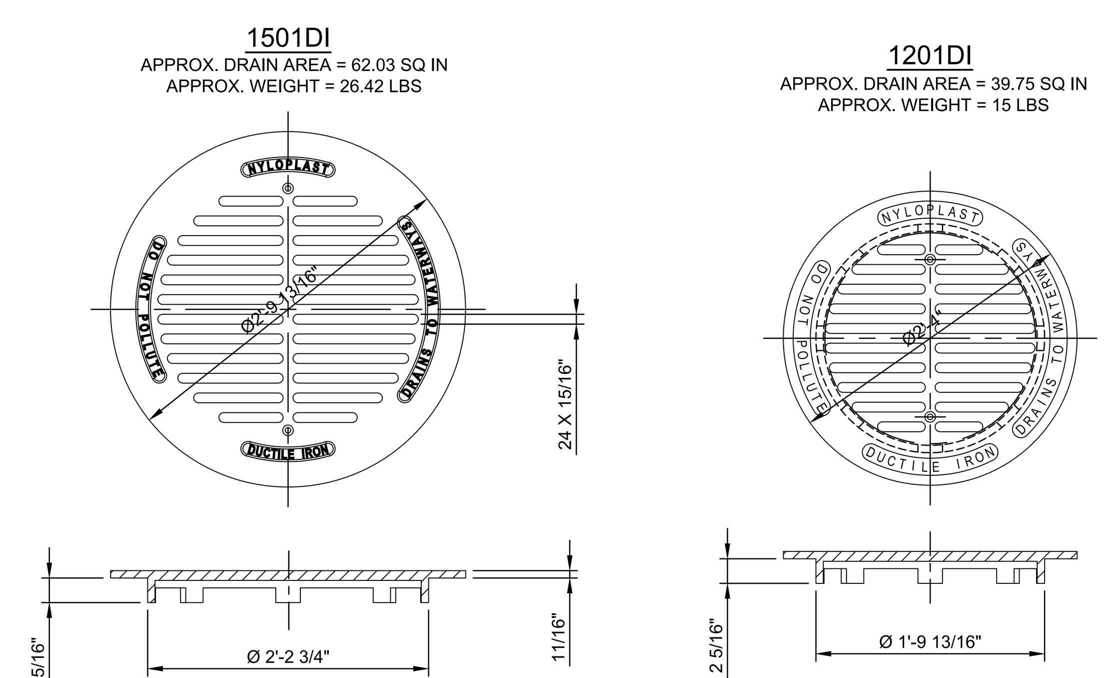
3 CG502 BITUMINOUS PAVEMENT REPLACEMENT
SCALE: NTS



6 IN - 24 IN DROP IN GRATE INSTALLATION



10 IN - 24 IN DROP-IN LOCKING KIT - P/N 1024DROPLOCK

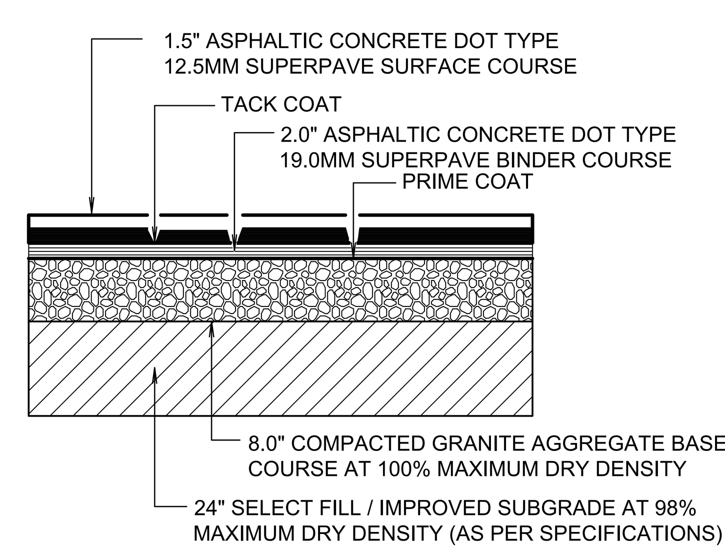


15 IN DROP IN

12 IN DROP IN

NOTE
DIMENSIONS ARE FOR REFERENCE ONLY, ACTUAL DIMENSIONS MAY VARY. DIMENSIONS ARE IN INCHES, GRATE HAS LIGHT DUTY RATING QUALITY: MATERIALS SHALL CONFORM TO ASTM A536 GRADE 70-50-05 PAINT: CASTINGS ARE FURNISHED WITH A BLACK PAINT, SIZE OF OPENING MEETS REQUIREMENTS OF AMERICAN DISABILITY ACT AS STATED IN FEDERAL REGISTER PART III, DEPARTMENT OF JUSTICE, 28 CFR PART 36.

4 CG502 YARD INLET
SCALE: NTS



moffatt & nichol
Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

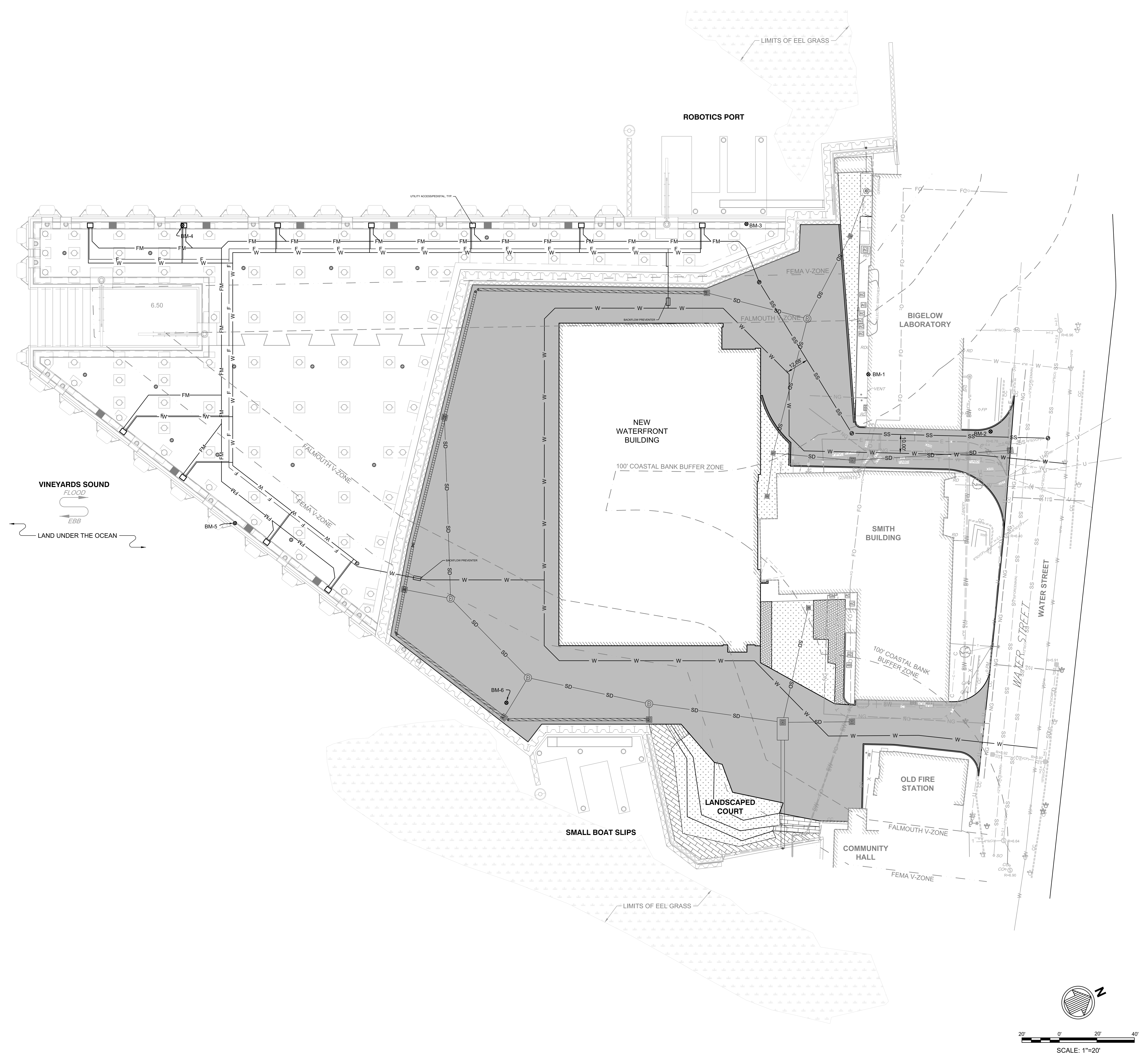
DRAINAGE DETAILS

Drawing Scale

Project Number

Date Issued
5/12/21

CG502



moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

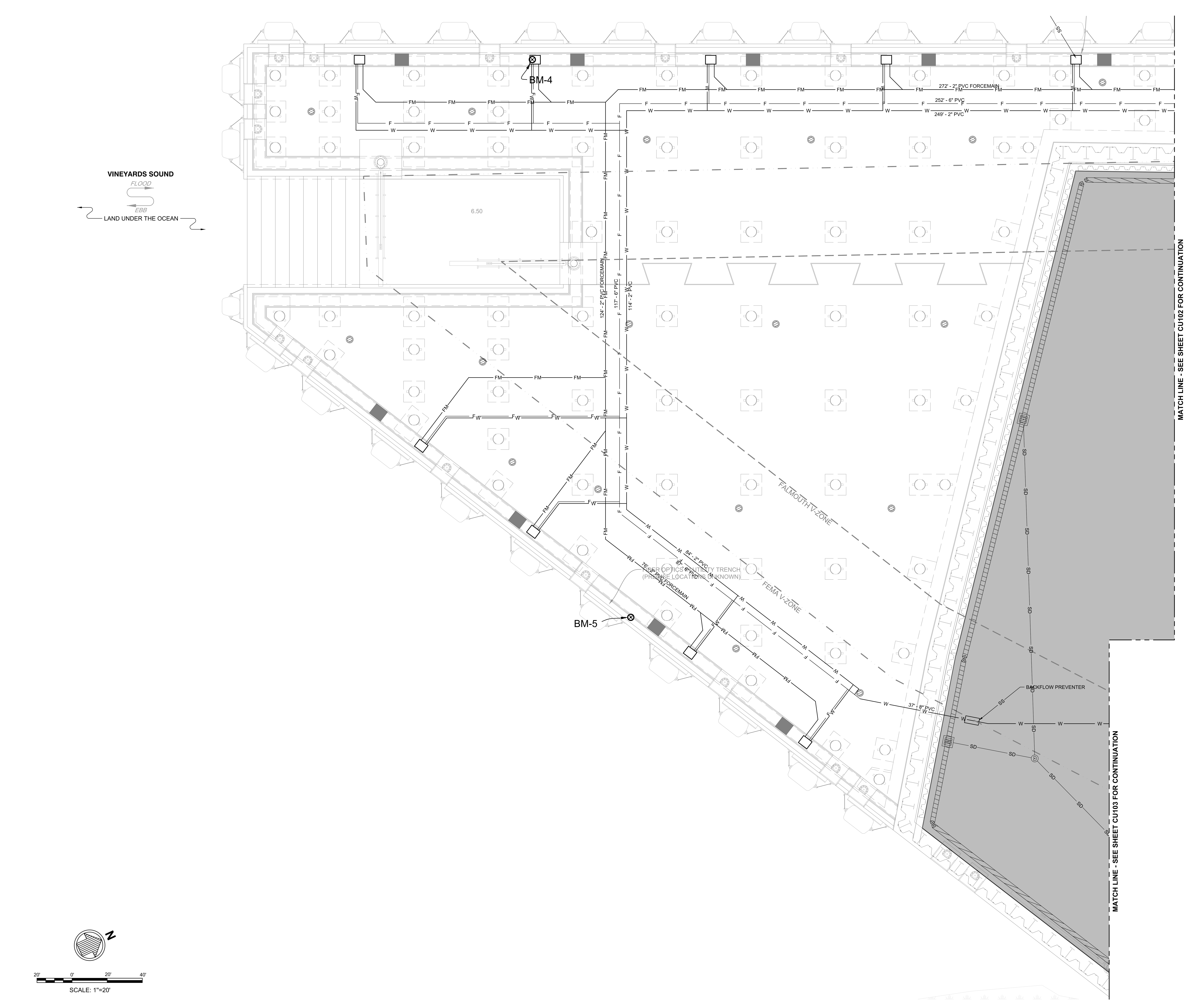
OVERALL UTILITY PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CU100



moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

NOT FOR CONSTRUCTION

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK
REPLACEMENT

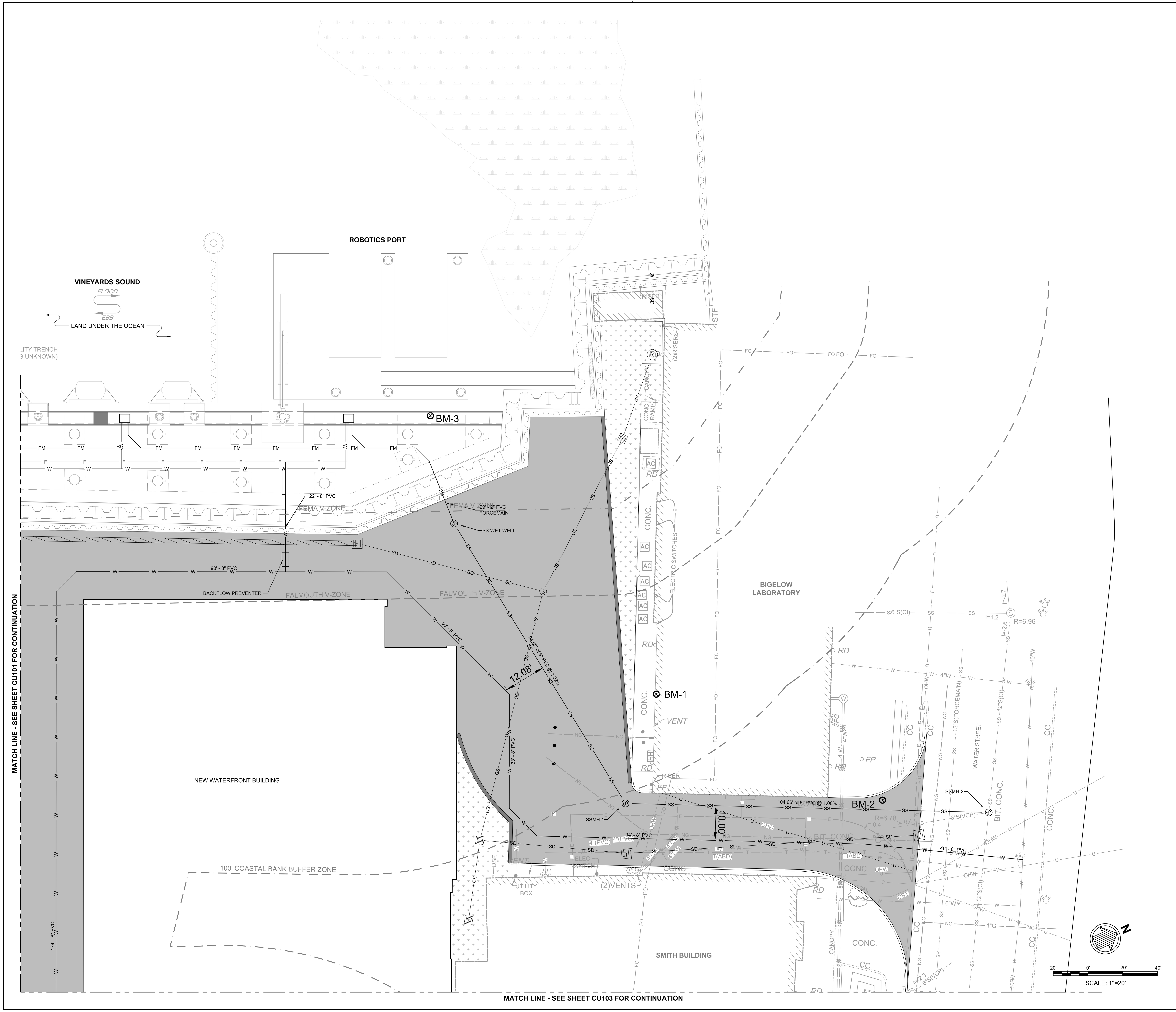
UTILITY PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CU101



NOT FOR CONSTRUCTION

moffatt & nichol

Marine Engineer
Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT: ISELIN DOCK REPLACEMENT

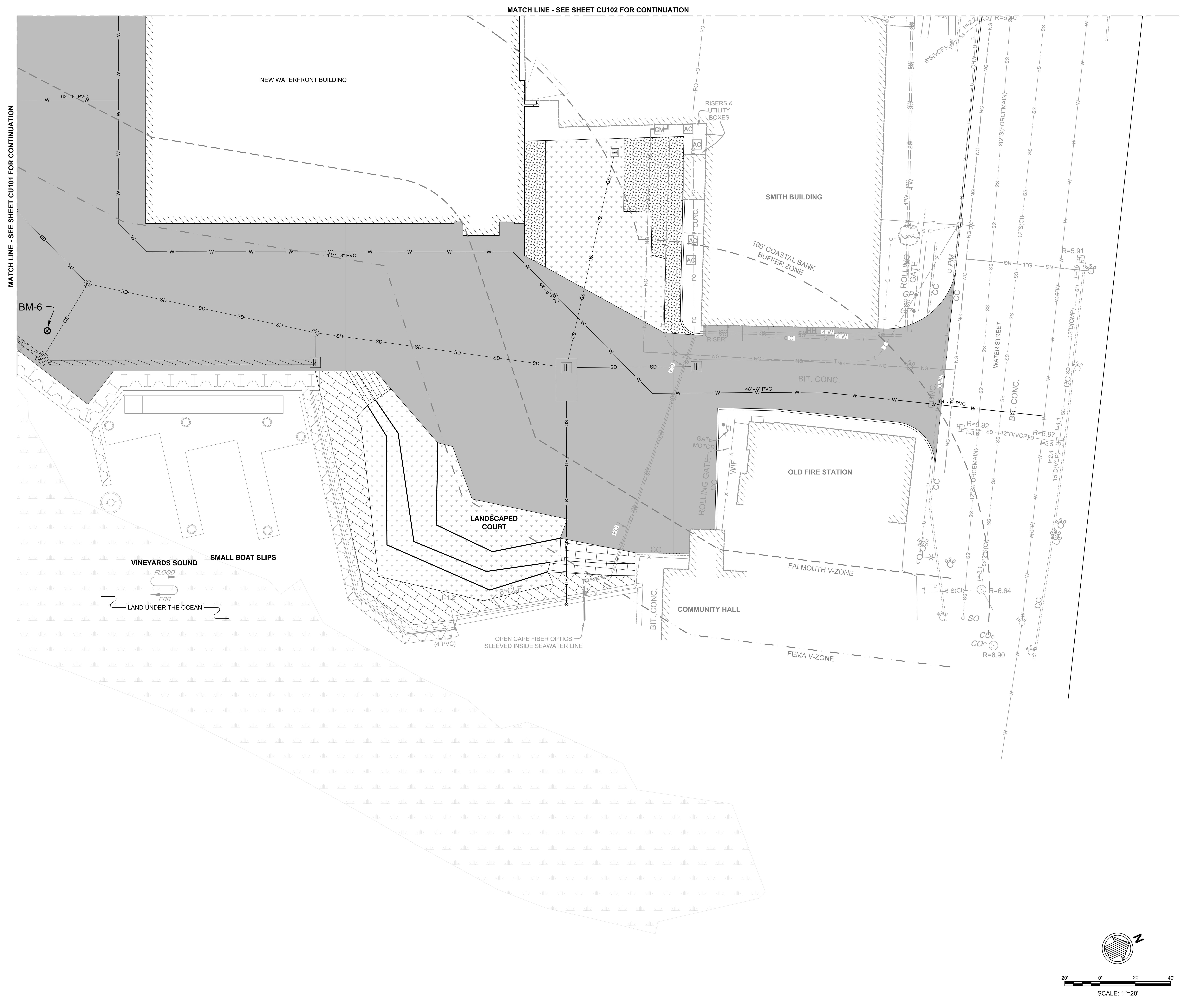
UTILITY PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CU102



moffatt & nichol

Marine Engineer

Moffatt & Nichol
180 Wells Avenue, Suite 302
Newton, MA 02459
Tel: 617-299-7330
Fax: 562-377-5106

#	DATE	DESCRIPTION
B	5/28/21	NOI SUBMISSION
A	5/12/21	30% DESIGN DEVELOPMENT

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

CWATER PROJECT:
ISELIN DOCK REPLACEMENT

UTILITY PLAN

Drawing Scale

Project Number

Date Issued
5/12/21

CU103

Attachment L

Woods Hole Group, Flood Analysis

Evaluation of July 16, 2014 Federal Emergency Management Agency Flood Insurance Study for the Woods Hole Oceanographic Institution Facilities in Woods Hole, MA

Prepared For:
Woods Hole Oceanographic Institution
266 Woods Hole Road
MS #56
Woods Hole, MA 02543

Prepared By:
Woods Hole Group, Inc.
81 Technology Park Drive
East Falmouth, MA 02536

February 16, 2021

Evaluation of July 16, 2014 Federal Emergency Management Agency Flood Insurance Study for the Woods Hole Oceanographic Institution Facilities in Woods Hole, MA

February 16, 2021

Prepared for:
Woods Hole Oceanographic Institution
266 Woods Hole Road
MS #56
Woods Hole, MA 02543

Prepared by:
Woods Hole Group
81 Technology Park Drive
East Falmouth MA 02536
(508) 540-8080

Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION

Woods Hole Group has completed an evaluation of the July 16, 2014 Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for the Woods Hole Oceanographic Institution (WHOI) Iselin Marine Facility in Woods Hole, MA. The evaluation included a coastal engineering analysis using methodologies described in the "Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update" (FEMA, 2007) to Appendix D and "Guidance for Coastal Flooding Analyses and Mapping" (FEMA, 2003). Specific components of the FEMA study evaluated by Woods Hole Group include the following:

- Topography
- Stillwater elevations
- Wave climatology
- Wave setup
- Overland wave transformation
- Flood zone and Base Flood Elevation (BFE) mapping

FEMA's analyses for these components of the Flood Insurance Study (FIS) are described in this report, including data sources, assumptions, methods of analysis, and findings. The objectives of the evaluation were two fold. First, to evaluate the accuracy of the effective FIRM, and if warranted to develop a map showing revised, more accurate flood zones for current day conditions. Second, to evaluate potential changes to the flood zones, given conceptual plans for redevelopment at the Iselin Facility.

For the evaluation of current day conditions, inconsistencies in FEMA's approach were identified, and corrections were applied as part of the independent Woods Hole Group analysis. Results of the evaluation provide justification for changes in FEMA's effective flood zones at the Iselin Facility. The central portion of the pier is currently mapped in an AE (El 12) Zone. The revised analysis indicates that it would be more appropriate to remap this area in three different zones from AE (El 13), to AE (El 12), and AE (El 11), from south to north across the pier.

Evaluation of potential flood zone changes that would result from raising the elevation of the Iselin pier by +2.5 ft (Alternative A) and +4.0 ft (Alternative B) were also considered. With these changes, the flood zone across the central portion of the pier was found to be an AE (El 11). A description of the Woods Hole Group evaluation is provided in the following sections.

2.0 ELEVATION DATA

The elevations (topography and bathymetry) describing the study area were obtained from multiple sources. The overland data was taken from USGS 2014 LiDAR data, while the bathymetry for the surrounding water was taken from NOAA sounding data. The LiDAR deck elevations for the pier were confirmed and updated through an on the ground RTK GPS survey. Woods Hole Group performed the RTK survey on January 24, 2018 by collecting spot elevations at the locations shown in Figure 1. The survey data closely matched the LiDAR elevations obtained previously for the pier. The combination of LiDAR data and RTK survey points were used to define a site specific shore normal transect across the long axis of the pier, from south to north, which was used for the FEMA based overland wave propagation modeling. Figure 2 shows the location of the site specific transect in relation to FEMA's transects 174 and 175, used to map the flood zones along the edges of Great Harbor. Potential changes to the flood zones resulting from raising the elevation of the pier deck (Alternatives A and B) were simulated by simply adding 2.5 ft and 4.0 ft to the surveyed elevations along the site specific transect.

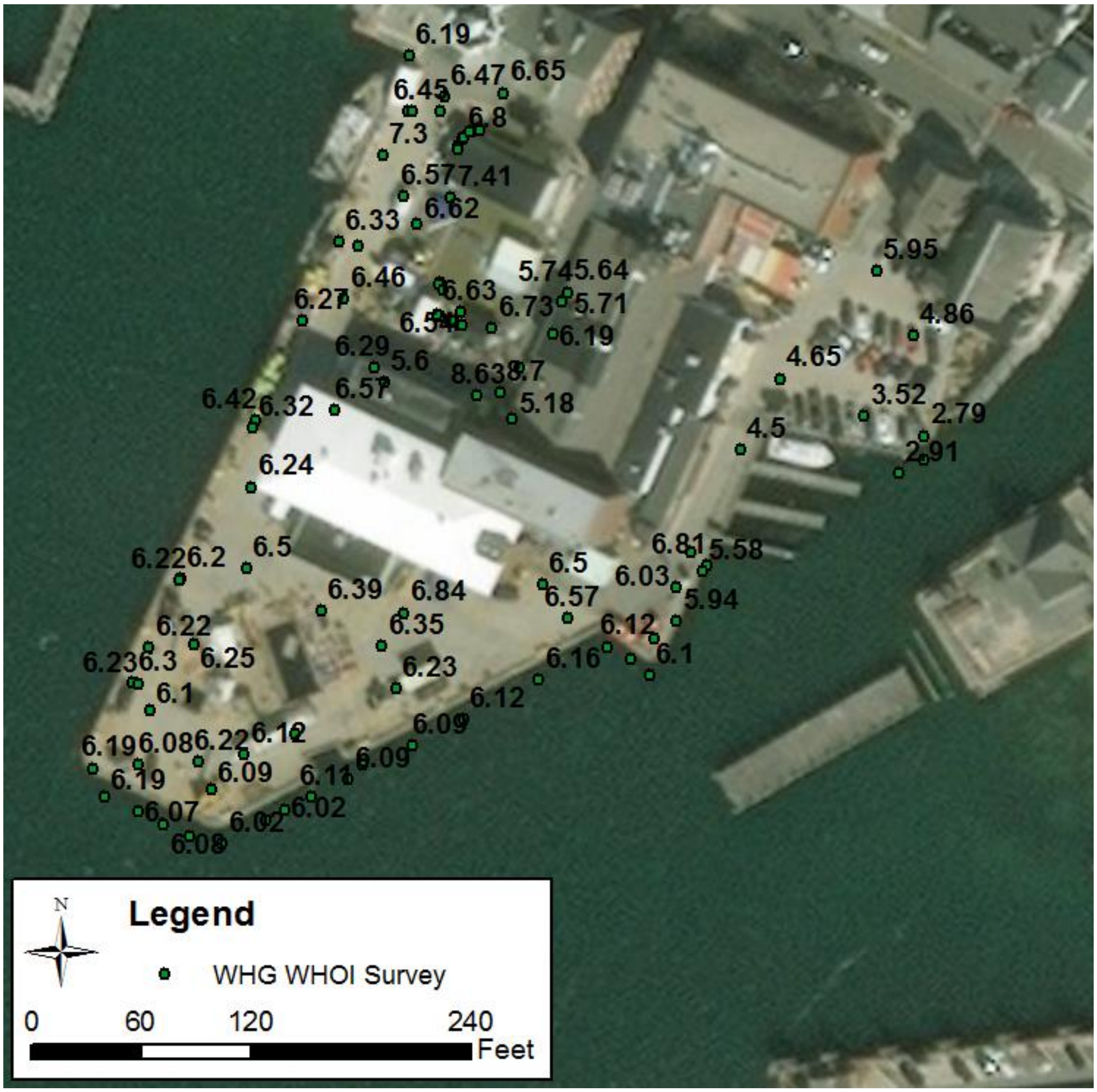


Figure 1. Woods Hole Group RTK GPS survey points (elevations in ft NAVD88).

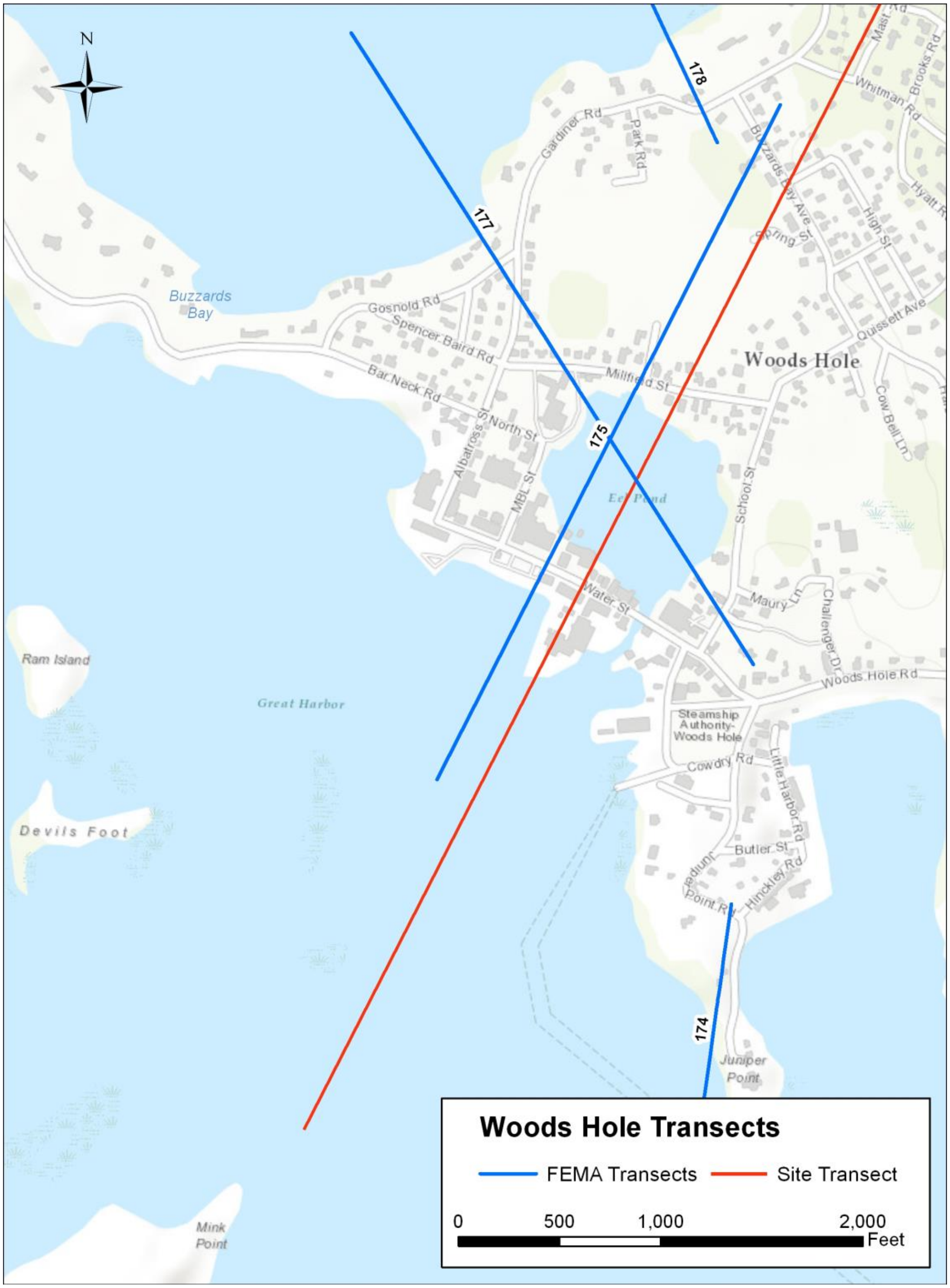


Figure 2. Location of FEMA's transects 174 and 175 used to map Great Harbor, in relation to the site specific transect established for the Iselin Marine Facility.

3.0 STILLWATER ELEVATIONS

A fundamental component of FEMA's detailed FIS process is the determination of the 1-percent-annual-chance stillwater level (SWEL). The SWEL is the elevation of the water due to the effects of astronomic tides and storm surge on the water surface. The SWL is integral in establishing the base inundation levels, determining the average slope for wave setup calculations, and determining water depths along transects for overland wave transformation.

For the current review, the SWEL for Transect 175 in Woods Hole was not revised, and was determined to be accurate for the site specific transect. The 1% annual chance SWELs for FEMA's July 16, 2014 FIRMs were taken from the previously effective FIS reports for the communities in Barnstable County. FEMA's 1% annual chance SWEL for Transect 175 was 10.1 ft NAVD88, which is consistent with the USACE Tidal Flood Profiles (1988) for this area. Consequently, no changes were made to FEMA's SWEL.

4.0 WIND AND WAVE CLIMATOLOGY

Evaluation of 100-year wave conditions is another fundamental component of FEMA's detailed FIS process. FEMA utilizes the energy-based significant wave height and peak wave period as the basis for coastal engineering analyses performed in support of mapping flood zones and associated water levels. Where the fetch is unlimited, deepwater wave conditions are generally taken from statistical analyses of measured buoy data or wave hindcast studies. In sheltered waters where the fetch length is limited due to the proximity of offshore landmasses or offshore engineered structures, a restricted fetch analysis is performed to develop the appropriate wave conditions. The waves are then transformed closer to the shoreline and inner harbor areas, and then used for calculations of wave setup, wave runup and overtopping, and for overland wave transformation modeling.

FEMA utilized the restricted fetch method for generating significant wave conditions at Transect 175, located immediately west of the Iselin Marine Facility. The Automated Coastal Engineering System (ACES) software available through the Coastal Engineering and Design Analysis System (CEDAS, Version 4.0) was used by FEMA to generate the 100-yr wave conditions. The analysis assumes that that wave conditions will be solely wind generated waves from storm winds. The geometry of the shoreline and landforms that surround Transect 175 were defined by establishing a series of radial fetches at 10 degree intervals (Figure 3). The fetch bands were used in the Wave Prediction – Wind Adjustment and Wave Growth (restricted fetch) module of ACES to define the distance and depth over water that storm winds can generate local waves. FEMA used a 100-yr wind speed of 78.74 miles per hour to simulate the storm wave conditions. The resulting 1% annual exceedance (100-year exceedance interval) significant wave height and period developed by FEMA for Transect 175 are summarized in Table 1.

During evaluation of the wind and wave climatology data developed by FEMA, Woods Hole Group found justification for revising the 100-yr wind speed. Analysis of available nearby data indicated that FEMA's wind speed was higher than supported by the data. Woods Hole Group utilized the BUZM3 buoy in Buzzards Bay, which has a 30-year record of wind data, to determine the 100-yr wind speed necessary for the fetch limited wave assessment. The winds from BUZM3 were binned by direction and averages were calculated every 3 hours for each year in the entire 30-yr dataset. The bin with the highest winds, that would create the largest waves, was found to approach from the SSW (160 to 180 degrees). The maximum of the binned 3-hour average wind speeds were found for each year, and an extremal analysis was used to determine a 100-yr wind speed of 63.5 miles per hour.

Woods Hole Group established a new set of radial fetches for the site specific transect at the Iselin Marine Facility. A total of seventeen (17) radials were established at 10 degree intervals extending from the south end of the site (Figure 3). The ACES Wave Prediction – Wind Adjustment and Wave Growth program was used with the revised 100-yr wind speed of 63.5 miles per hour to generate site specific waves for the site (Table 1; Figure 4). The resulting waves are higher than those predicted by FEMA for Transect 175, primarily because the Iselin site is more exposed to wind generated waves from the south and southeast. The larger waves were considered reasonable for this site and were therefore used for the ensuing analyses.

Table 1. Summary of FEMA and Site Specific Wave Conditions.

Transect No.	Significant Wave Height (ft)	Peak Wave Period (sec)
FEMA Transect No. 175	4.01	3.57
Site specific Iselin transect	5.67	4.51

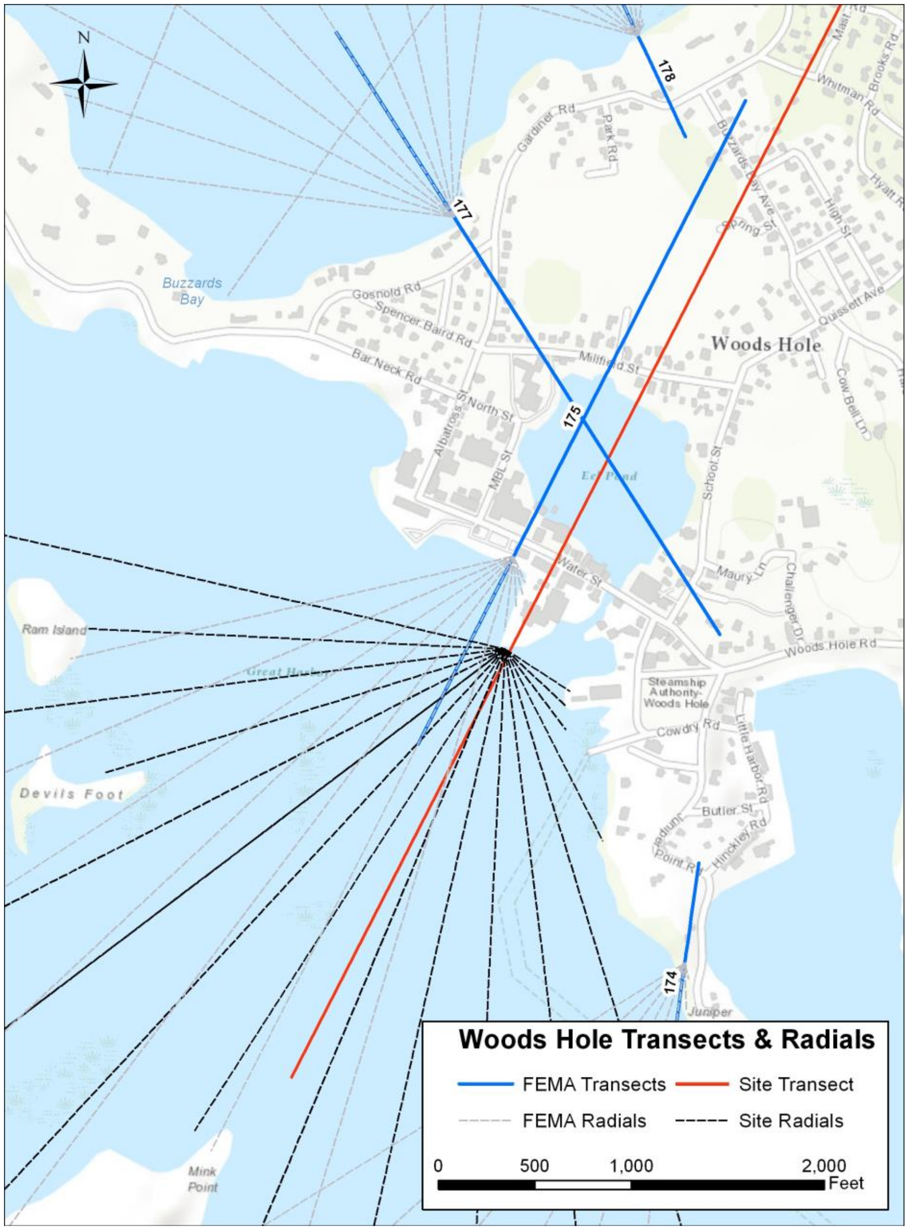


Figure 3. Location of FEMA and site specific radials used for the fetch limited ACES modeling.

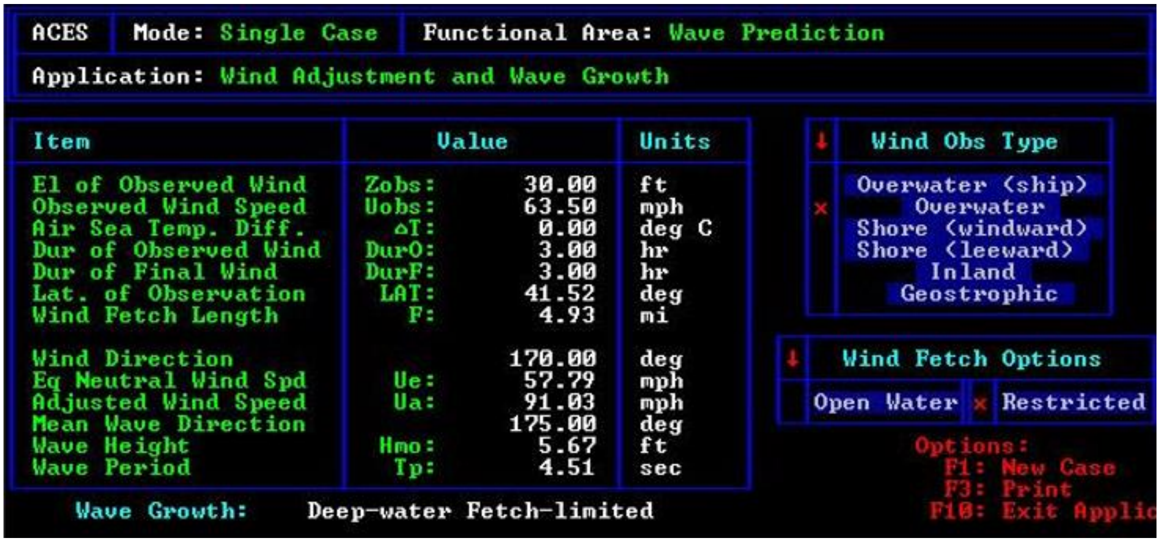


Figure 4. ACES model input and output wave conditions for the site specific transect showing a 100-yr wave height of 5.67 ft and associated period of 4.51 sec.

5.0 WAVE SETUP

The processes associated with wave setup have been recently incorporated into FEMA's detailed FIS evaluations. Wave setup refers to the increase in water level at the shoreline due to the breaking of waves and transfer of momentum to the water column. Wave setup is affected by the height of the waves, the speed at which waves approach the shore, and the slope of the ground near the shoreline. For the 2014 Barnstable County FIS, wave setup was computed by FEMA using the Direct Integration Method (DIM). At Transect 175 FEMA's wave setup value from DIM was 1.99 ft.

Recent studies on wave setup have demonstrated that the DIM over predicts the magnitude of wave setup when compared with physics-based modeling approaches. As such, Woods Hole Group conducted an independent analysis of wave setup using the numerical model Simulating Waves Nearshore (SWAN). SWAN is a third-generation wave model, approved by FEMA, for obtaining realistic estimates of wave parameters in coastal areas from given wind, bottom, and current conditions. SWAN includes wave generation, dissipation, non-linear interactions, and transformations. It also includes bottom friction, currents, shoaling, refraction, diffraction, depth induced breaking, and wave setup. SWAN represents a model-based approach that accounts for the physics of the waves, including the process of wave setup. The model was therefore selected as an improved alternate to the empirically based DIM utilized by FEMA for computing wave setup.

SWAN can be operated in both 1-D and 2-D modes. The 1-D model approach was considered to be more conservative for wave setup, since the 2-D model accounts for effects of the surrounding bathymetry and shoreline configuration on the wave form as it travels towards the coastline. The 1-D model is also consistent with FEMA's transect based analyses and readily allows representation of rapidly changing shoreline conditions at a high resolution.

SWAN 1-D was run at the site specific Iselin transect using bathymetric conditions from the most recent NOAA survey conducted in 2001 and topographic conditions from the combined LiDAR and Woods Hole Group RTK survey. The transect data were interpolated to an evenly-spaced 1 meter resolution for input to SWAN 1-D. Water levels were set to reflect the 100-year SWEL of 10.1 ft NAVD, as discussed in Section 3.0. Incident wave heights corresponding to the two conditions summarized in Table 1 were used; FEMA's Transect 175 (4.01 ft and 3.57 sec) and the site specific Iselin transect (5.67 ft and 4.51 sec). Waves were assumed to conservatively approach normal to the shoreline (along the axis of the transects) and spectral spreading was turned off in the model (to ensure that the peak energy was not muted). This represents a conservative assumption where the model computed wave setup using peak wave conditions, rather than a spectral spread of the waves.

Results from the SWAN 1-D simulations were reviewed and the maximum wave setup along the transect for each wave condition was identified. The revised wave setup was then added to the SWEL to determine the total water level (TWL) for the site specific Iselin transect. Table 2 shows a comparison between the wave setup, SWEL and TWL applied by FEMA in the 2014 FIS for Barnstable County and the revised values computed by Woods Hole Group. The wave set-up dynamically computed by SWAN 1-D using the revised wave conditions produced results that are 1.46 ft lower than those used in the 2014 FIS for the neighboring Transect 175. The lower value of wave setup is considered reasonable given the deeper water offshore and the existing nearshore slopes.

Table 2. Comparison of FEMA's 2014 Wave Setup and Water Levels with Revised Values Computed for This Study.

Parameter	FEMA FIS Transect 175	Iselin Transect w/ FEMA Waves	Iselin Transect w/ Revised Waves
1% Annual Chance SWEL(ft, NAVD88)	10.1	10.1	10.1
Wave Setup (ft)	1.99	0.33	0.53
TWL(ft, NAVD88)	12.09	10.43	10.63

6.0 OVERLAND WAVE TRANSFORMATION

Overland wave heights were calculated using the Wave Height Analysis for Flood Insurance Studies (WHAFIS) software within the Coastal Hazard Analysis for Mapping Program (CHAMP), following the methodology described in the FEMA Guidelines and Specifications. Corrected water levels and wave setup values from Table 2 were specified in CHAMP to develop a TWL. Definitions for the major topographic and structural features along the site specific Iselin transect were identified from the elevations described above. Three separate simulations were performed with WHAFIS; one for the existing conditions, and two additional simulations for Alternatives A and B.

7.0 FLOOD ZONE AND BASE FLOOD ELEVATION (BFE) MAPPING

The flood zone and BFE mapping was performed according to the procedures outlined in FEMA's Guidelines and Specifications. The resulting mapping is shown in Figures 5, 6, and 7. A summary of mapping for each scenario is as follows:

- <u>Effective FEMA July 2014 FIRM (Figure 5)</u> – This shows a VE (El 15) zone extending 25 to 44 ft inland from the edge of the pier, and an AE (El 12) zone across the central portion of the pier. The effective LiMWA is coincident with the VE/AE Zone boundary, and therefore FEMA does not show a Coastal A Zone on the current maps. The Falmouth Wetland Regulations 10.38(2)(b)3 state that the landward boundary of the VE Zone is presumed to be 25 ft landward of the boundary shown on the FEMA FIRM. As shown on Figure 5, the Falmouth VE zone presumed boundary constrains the proposed building envelope, especially on the western side of the pier.

- <u>Mapping for Existing Conditions Based on Site Specific WHG Modeling (Figure 6)</u> – The Woods Hole Group site specific modeling for existing conditions shows a VE (El 15) zone extending 25 to 44 ft inland from the edge of the pier. Accordingly, the site specific transect modeling confirms that the FEMA FIRM accurately depicts the location of the VE zone on the subject property. The central portion of the site is mapped with three separate AE Zones that decrease in elevation in 1 ft increments from south to north (i.e., AE (El 13) to AE (12), to AE (11)). A revised LiMWA is shown to follow the VE/AE Zone boundary on the east and west sides of the pier, and the AE Zone (El 13/12) boundary at the south end of the pier.

- <u>Mapping for Alternatives A and B (Figure 7)</u> – Changes to the flood zones based on conceptual plans to raise the pier an additional +2.5 ft and +4.0 ft would move the VE Zone (El 15) to the edge of the pier and lower the flood zone on the entire pier to an AE Zone (El 11). The modeled flood zones do not change appreciably between the two Alternatives. However, it should be noted that any portion of the pier raised above the elevation of 10.63 ft NAVD88 would be mapped entirely outside the flood plain (i.e., not a VE Zone or an AE Zone).

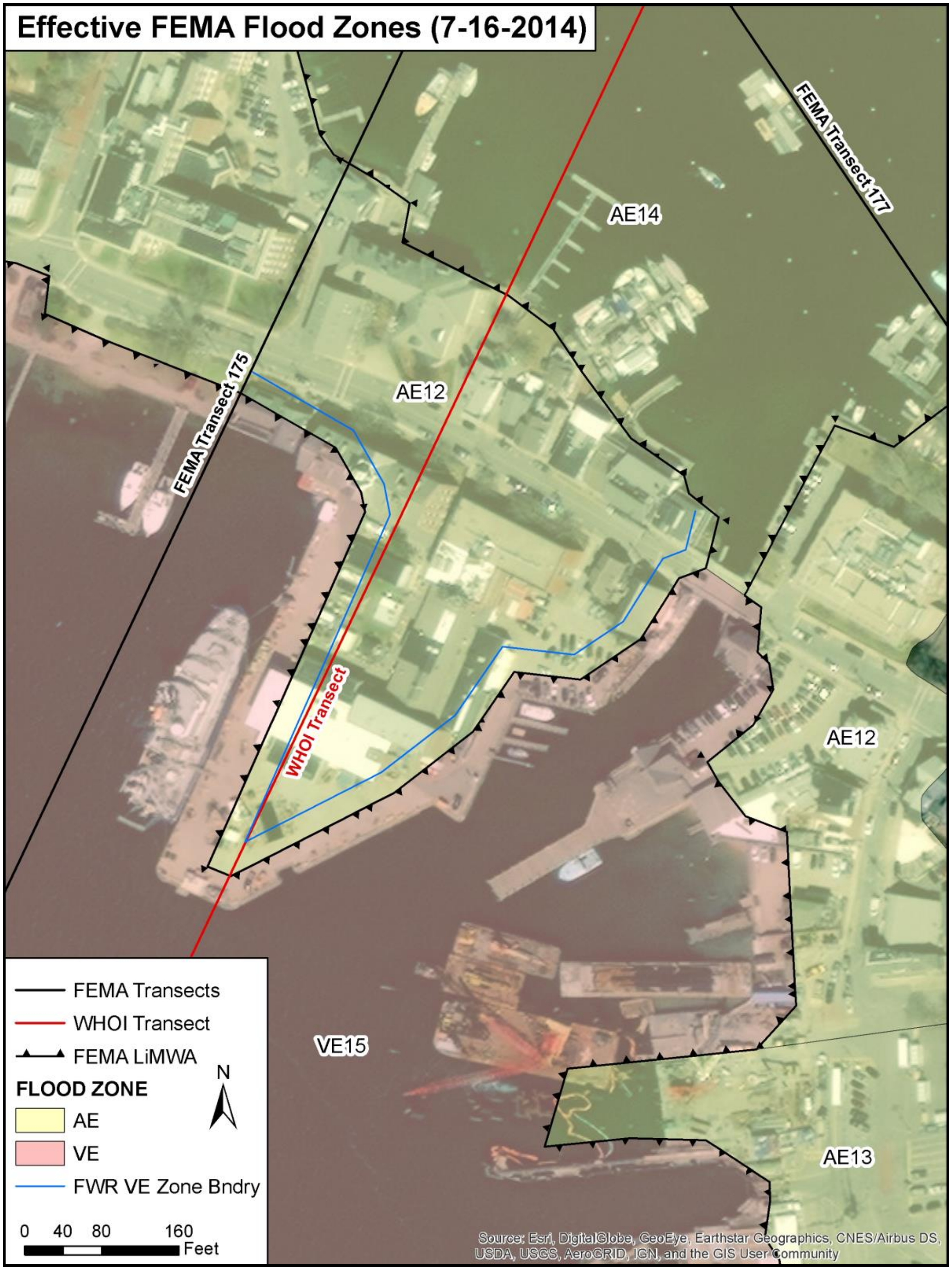


Figure 5. FEMA effective July 2014 FIRM flood zones.

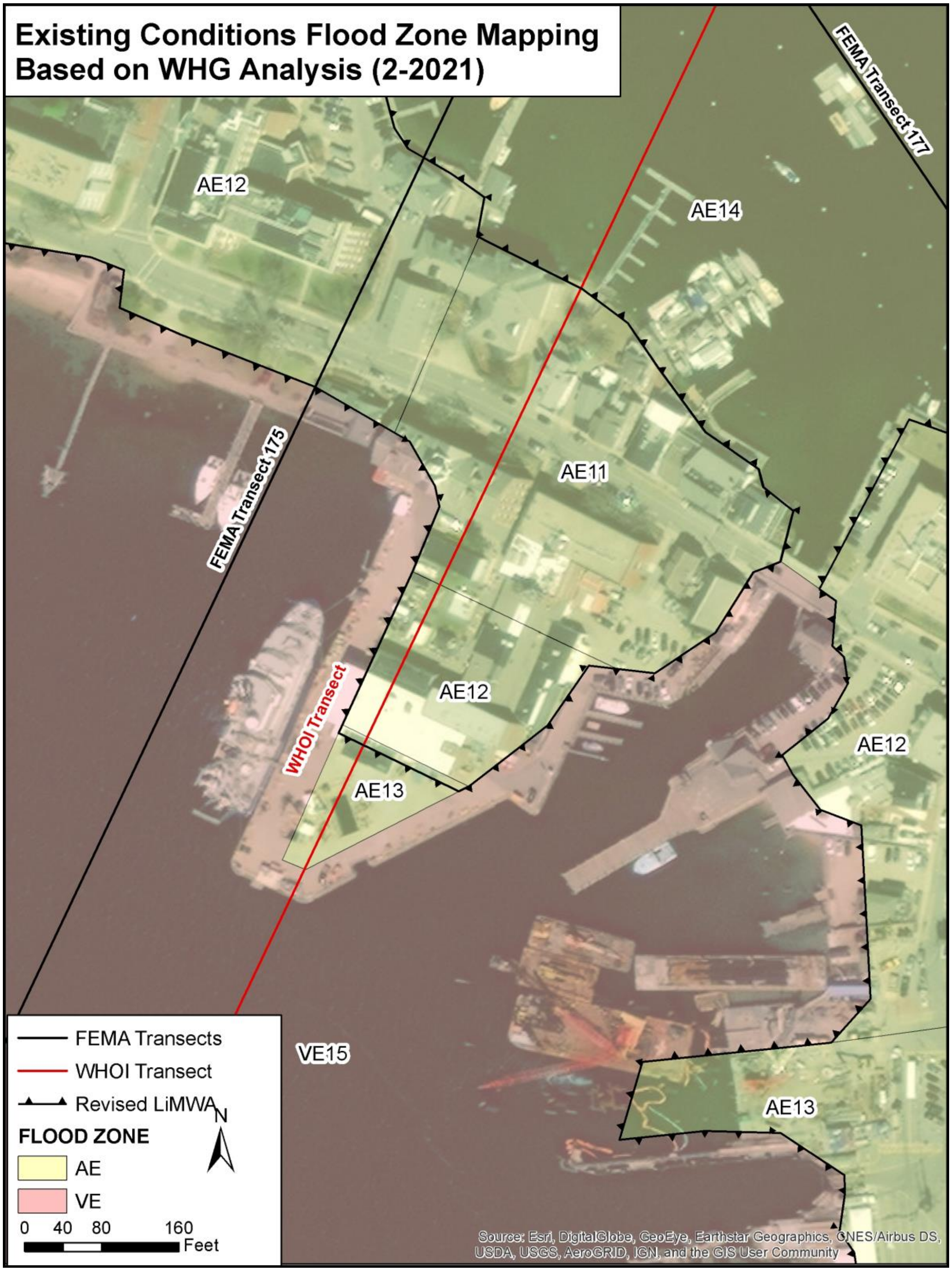


Figure 6. Flood zones for existing conditions based on Woods Hole Group site specific modeling.

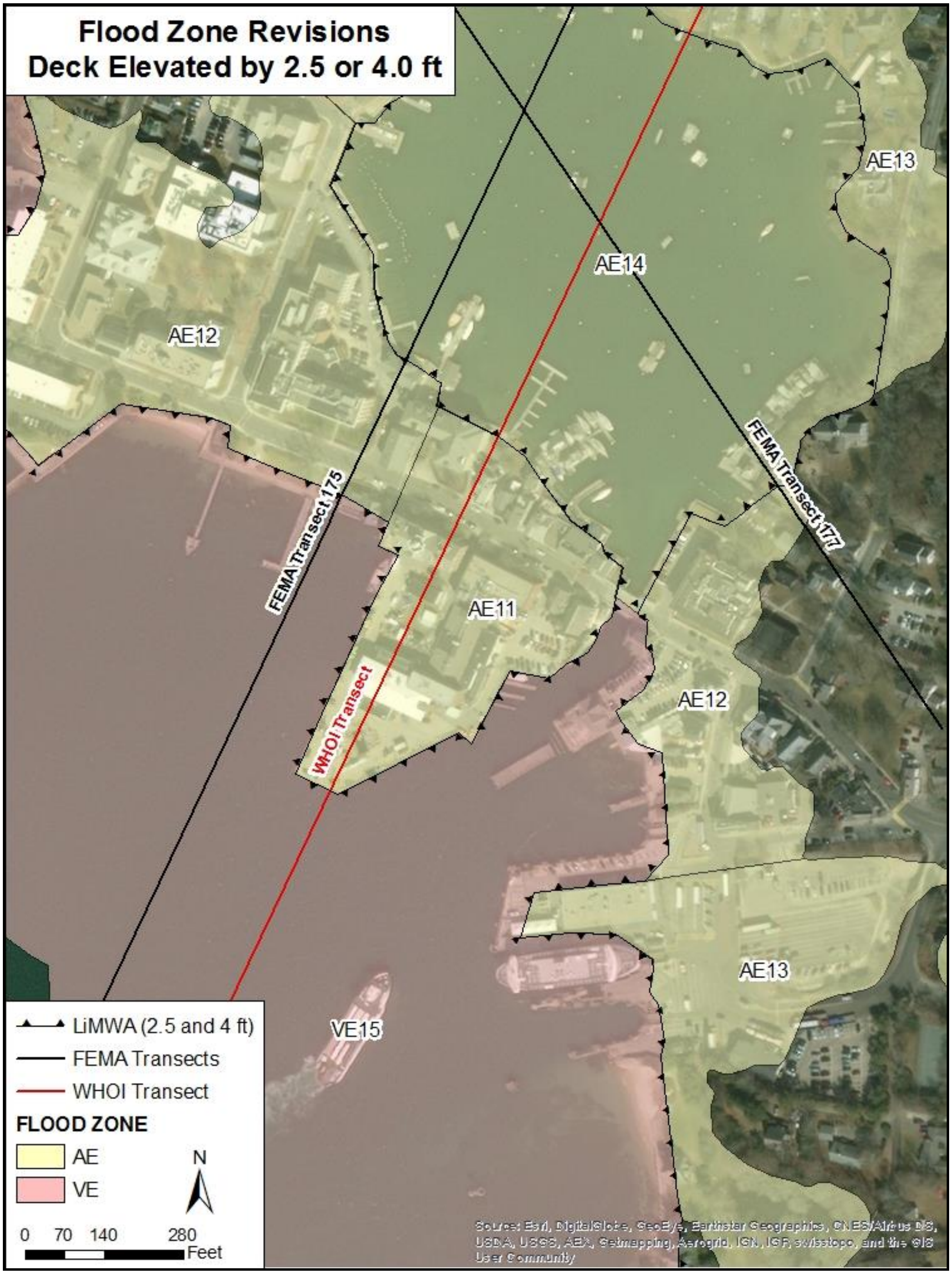


Figure 7. Woods Hole Group proposed flood zones for Alternatives A and B (i.e., raising the elevation of the pier).

8.0 REFERENCES CITED

Federal Emergency Management Agency, Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update , Final Draft, Washington, D.C., February 2007.

Federal Emergency Management Agency, Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix D: Guidance for Coastal Flooding Analyses and Mapping , Washington, D.C., April 2003.