APPLIED COASTAL
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FINAL TECHNICAL MEMORANDUM

To: Chris Krahforst, Town of Hull

Date: December 11, 2020

From: John Ramsey, P.E. and Morgan Simms, P.G.

Re: FINAL Assessment of Historical Structures and Environmental Conditions

The Town of Hull is pursuing implementation of the most appropriate engineering solution, as well as likely reconfiguration of existing structures and/or nature-based strategies for protection of existing infrastructure. The approach being pursued is intended to improve coastal and environmental resiliency along this area, with added benefits to the low lying roadway and critical infrastructure. The project is focused upon working towards the most appropriate solution for sustainability, where a more stable beach will allow the system to adapt more naturally to relative sea-level rise.

Prior to evaluating alternatives to mitigate flooding at the site, it is critical to fully evaluate both historical conditions and existing coastal resource areas that could potentially be impacted by the project. This memo compiles historical information and environmental information as well as data collected specifically for this project. This final memorandum completes the FY20 grant work within the requested extension period.

1. PROJECT SITE

13 Marginal Road is a town-owned parcel located at the southern end of Hull on the bayside of the peninsula (Figure 1). This parcel is located on the seaward side of Marginal Road and contains Town Pump Station #4. The project shoreline faces northwest and is vulnerable to north and northwest winds and tidal surge. It is situated within the Weir River Area of Critical Concern (ACEC), located in the southeast corner of Hingham Bay. The property is sheltered from direct wave exposure by the Hull peninsula to the east, Sunset Point to the north, and Worlds End to the west. Elevation measurements of the pump station property and surrounding shoreline were collected in January 2019 (Woods Hole Group/CLS, 2019) (Figure 2). The pump station is situation on top of a revetment, where the concrete slab is at an elevation of 10-12 ft NAVD (Figure 3). The seaward toe of the revetment is at elevation 0-1 ft NAVD, then elevation grades landward to 5-6 ft NAVD and reaches a maximum of 7-8 ft NAVD on the landward side proximal to the road, and the road itself has an elevation ranging from 6-8 ft NAVD. Mean High Water (MHW) is 4.3 ft NAVD, meaning that the majority of the revetment is covered at high tide. The original

construction plans for Pump Station #4 are referenced to U.S.G.S. Mean Sea Level (MSL) and show that when constructed, MHW passed through the structure in approximately the same place it does today. This is shown in Figure 4, where the MHW line is highlighted in blue and the edge of the revetment is highlighted in red.

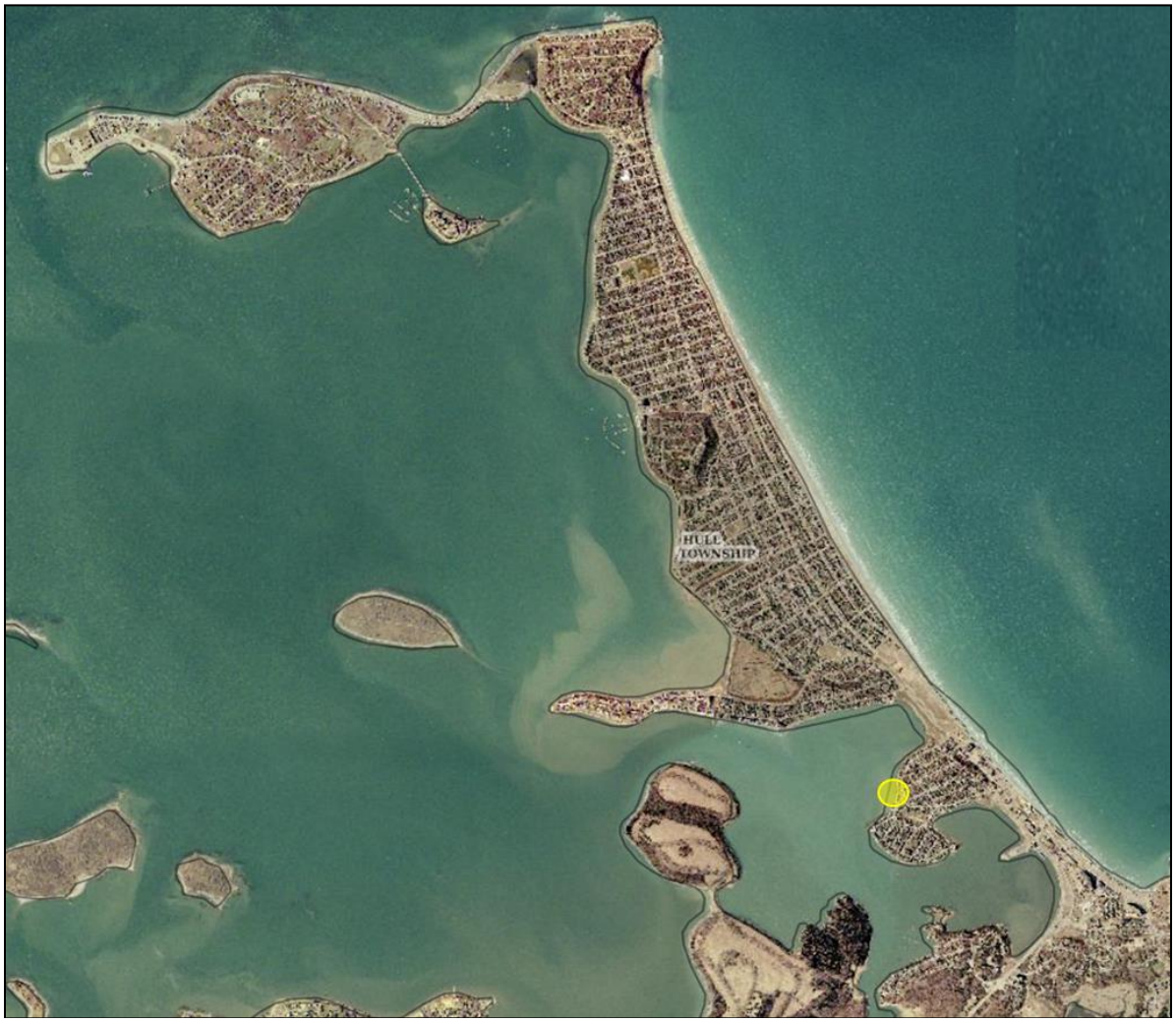

Figure 1. Marginal Road is circled in yellow, located at the southern end of Hull on the bayside of the peninsula.

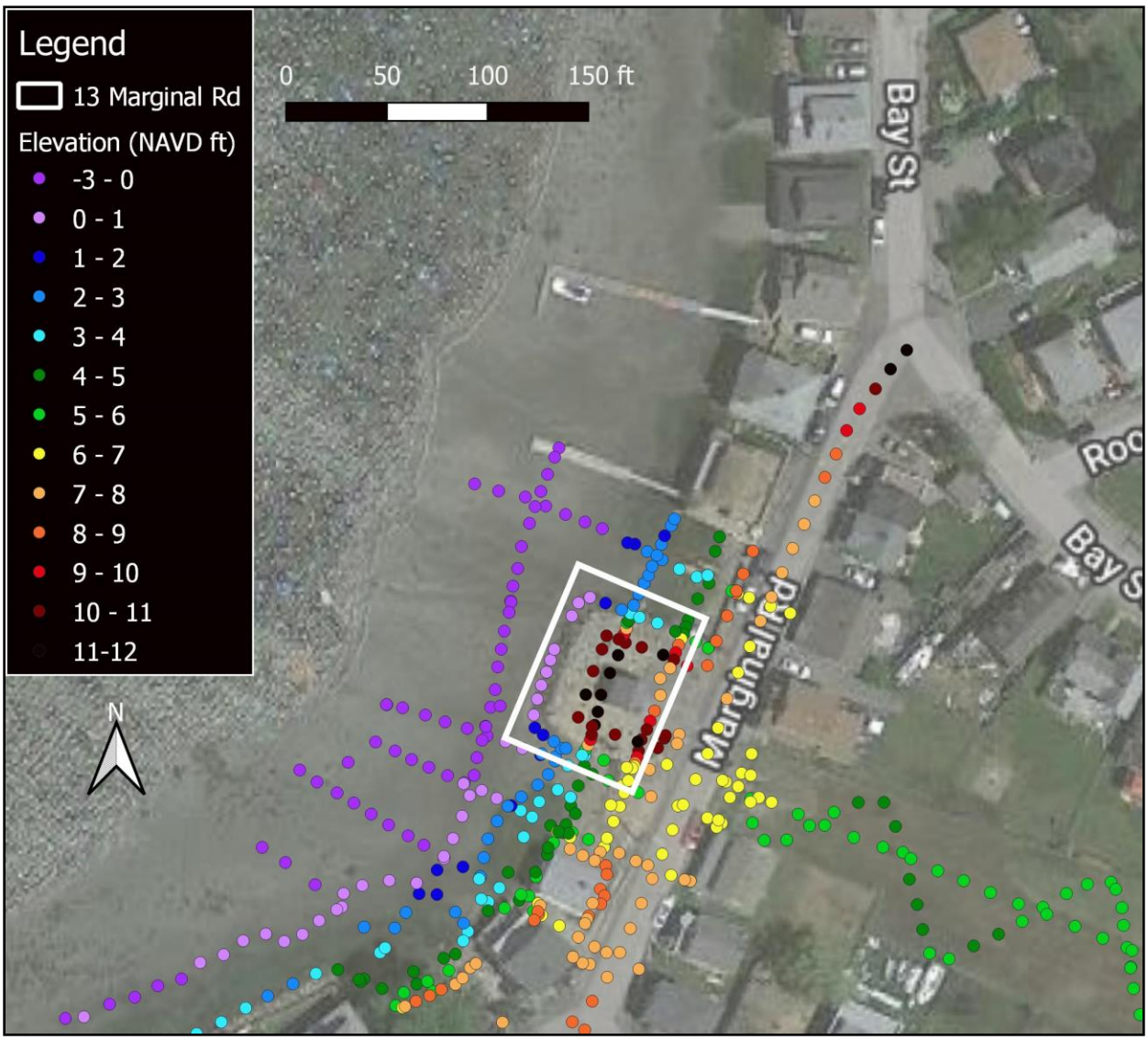

Figure 2. Elevation data (NAVD ft) at 13 Marginal Road, outlined in white, as well as the surrounding area. Collected in January 2019 by Woods Hole Group (Woods Hole Group 2019).

Figure 3. The pump station is situated on a pile-supported concrete slab fronted by a grouted armor stone revetment. The tide line is visible on the left side of this photo.

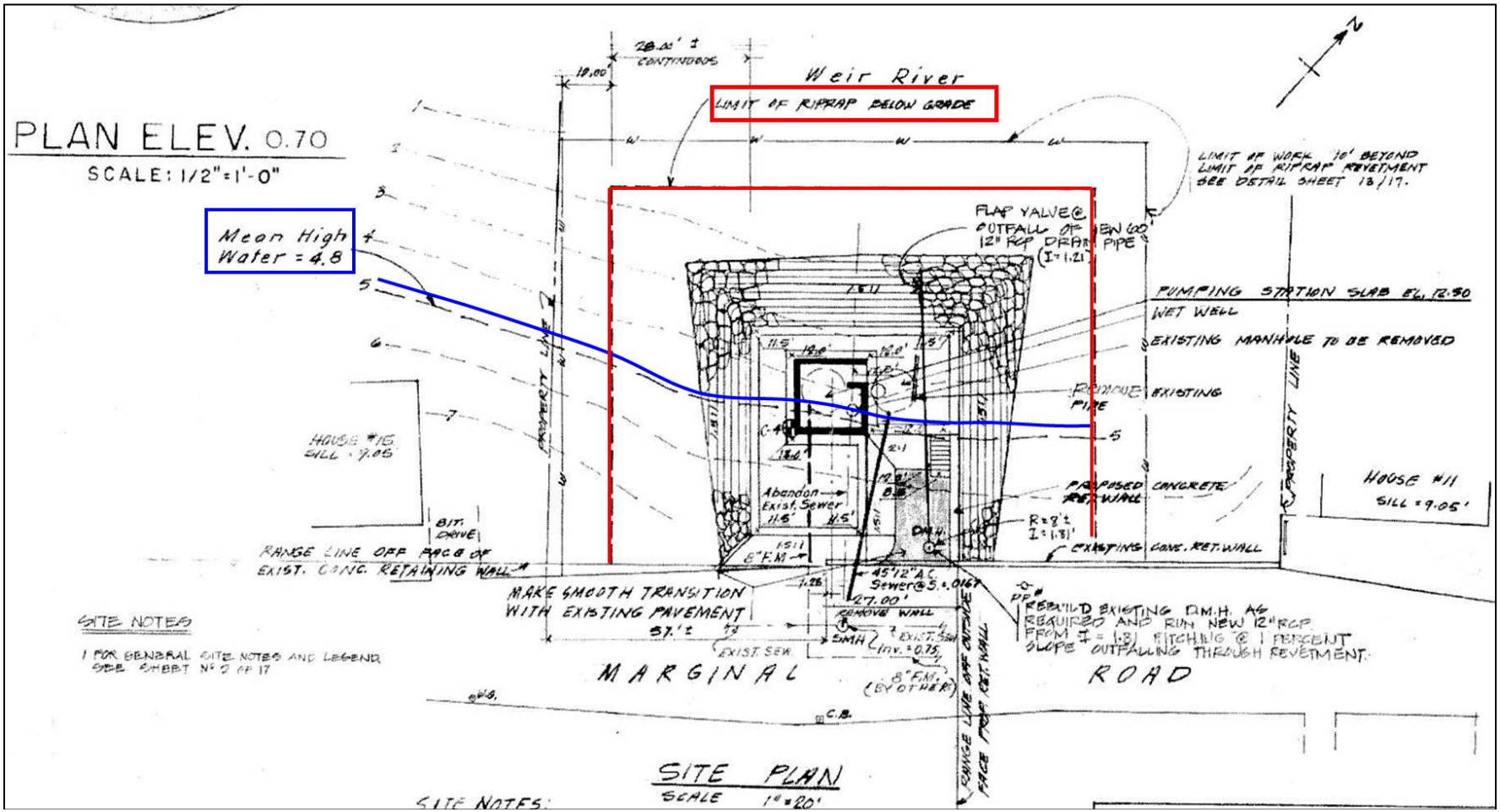

Figure 4. Original construction plans from 1974 for Pump Station #4. These plans are referenced to USGS MSL and show the MHW contour approximately halfway between the revetment toe and landward edge.

2. ENVIRONMENTAL CONDITIONS

2.1 Flooding

To the northeast of the pump station, the roadway is fronted by a concrete knee wall that ties into the rock revetment at the base of the pump station. Historically, the southwest plot was fronted by a similar knee wall; however, this was damaged during storms and fell into disrepair. It was removed because it was considered a hazard and no other protection was ever put in place. This has created a flood pathway that allows flooding of Marginal Road and the surrounding properties during storms and high tides. The 10% annual chance storm elevation is 8.4 ft NAVD, indicating that the area surrounding the pump station and the road flood regularly in relatively frequent coastal storms. A full wave design analysis was completed and submitted in July 2020 and is included as Attachment 1 to this document. The pump station property and adjacent roadway are located within the 1% annual chance flood zone on the northwest side of Sagamore Hill and, when flooded, isolates residents in Hampton Hill from the main Hull peninsula, as shown on the FEMA flood map in Figure 5.

Figure 5. FEMA flood map data provided by ResilientMA.org. The proposed project site, 13 Marginal Road, is located within the AE zone, indicating a 1% annual chance of flooding. When the project area is flooded, Hampton Hill becomes isolated from the main Hull peninsula.

An analysis of waves and storm surge was completed as part of Task 2 of this project and are discussed in detail in a separate memo.

2.2 Coastal Resource Areas

13 Marginal Road is within the Weir River Area of Critical Concern (ACEC). This ACEC was designated in 1986 and covers 950 acres, one of the most extensive salt marsh systems in

the greater Boston metropolitan area that supports over 100 migratory resident bird species. It is home to an abundance of shellfish that feed the bird population, and the flats are also nursery and feeding areas for a wide variety of finfish (mass.gov). This designation is crucial in developing alternatives for providing increased resiliency, as natural alternatives will be prioritized to reduce impacts.

As part of a site characterization, Woods Hole Group flagged and delineated saltmarsh along the southern end of the intertidal zone of the town-owned parcel, and this saltmarsh extends onto the adjacent property to the south. While it was winter when the delineation occurred, it was apparent that these flagged areas were densely vegetated with salt marsh cordgrass (*Spartina alterniflora*) (Woods Hole Group 2019). The *Spartina alterniflora* resources were re-delineated by Applied Coastal in November 2020, as shown in Figure 6. Coordinates and elevations were collected in MA State Plane ft and NAVD 88, respectively, using a Leica RTK GPS. The saltmarsh resources extends from 4-5 ft NAVD88 down to approximately 0-1 ft NAVD88 in undisturbed areas north and south of the pump station. This more complete delineation of saltmarsh resources was facilitated by the removal of the pile-supported dwelling immediately to the south of the pump station.

Of note, the project area is not within or adjacent to any Natural Heritage Estimated or Priority Habitat for any endangered species.

Shellfish suitability proximal to the project site is shown in Figure 7. Approximately 25 feet seaward of the revetment toe, there is suitability for blue mussels. This suitability data was verified by a shellfish survey, completed by Megalodon Environmental and included as Attachment 2 to this memo. Megalodon's survey found no eelgrass within the project area, which was consistent with MADEP state-wide aerial surveys provided within the MassGIS OLIVER website. One (1) quahog and one (1) cluster of three (3) blue mussels were observed from two (2) of the one hundred twenty-five (125) sample stations. No other shellfish were found within the sampled area. Given these findings, a project in the area fronting the revetment will have negligible impacts to shellfish or shellfish habitat.

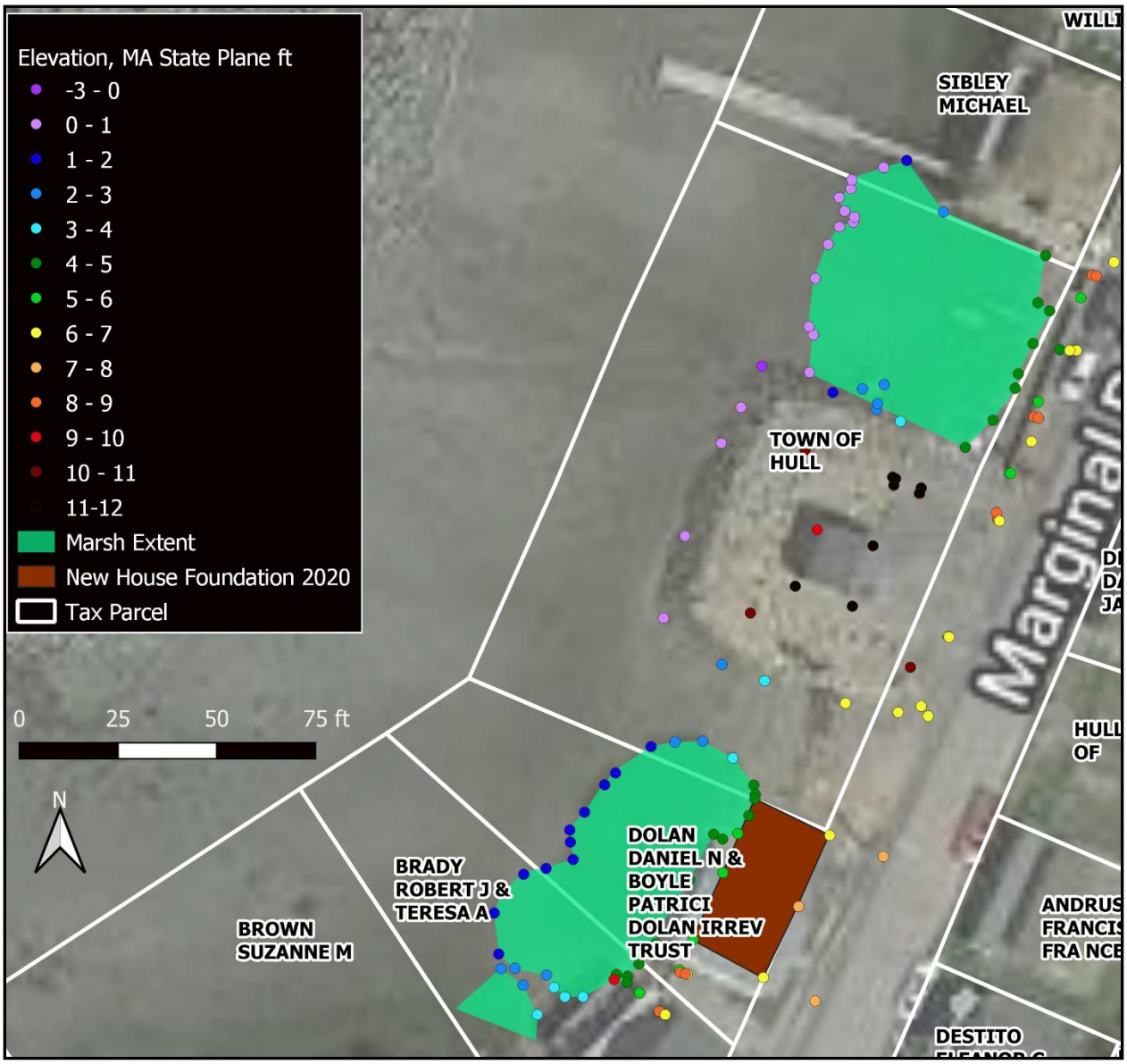

Figure 6. Saltmarsh extents and elevation collected November 10, 2020 by Applied Coastal. 13 Marginal Rd is the tax parcel owned by Town of Hull.

Figure 7. Approximately 25 feet seaward of the toe of the revetment is a shellfish suitability area for blue mussels shown with green hatching.

3. CONCLUSION

This town-owned parcel is located in a low-lying area and was originally constructed within the inter-tidal zone; therefore, the foundation has been exposed to tidal action for decades. Further, the low-lying nature of the area allows frequent storm events to flood across the roadway in this area, leading to additional infrastructure damage (e.g. broken sewer line connections to the pump station). Due to this original construction location as well as sea level rise, the foundation of this pump station is deteriorating and the Town is seeking resiliency alternatives that can be constructed within an ACEC. Specifically, the town seeks to evaluate a combination of nature-based solutions that will mitigate flooding impacts. Adjacent property owners also suffer from repetitive flooding and generally are supportive of this project as it likely will provide some relief to them, as well.

4. REFERENCES

2019, Woods Hole Group, *Shoreline Resiliency Investigation for 13 Marginal Road Town of Hull, MA.* Memorandum.

ATTACHMENT 1.
DESIGN WAVE ANALYSIS

APPLIED COASTAL
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TECHNICAL MEMORANDUM

To: Chris Krahforst, Town of Hull

Date: July 24, 2020

From: Sean W. Kelley, P.E.

Re: Design wave analysis for Marginal Road, Hull, Massachusetts

An analysis of waves was performed for the shoreline area surrounding the pump station located at 13 Marginal Road. Since the site is situated within the Weir River (Figure 1), and has no open ocean exposure, waves in this area are locally generated by winds blowing over Boston Harbor. Design wave conditions developed for this analysis required the determination of water levels and extreme wind speeds in the region of Boston Harbor. An examination of the historical tide record from Boston Harbor showed that when winds are oriented along the fetch that develops the largest waves at the study site (i.e., winds blowing from the northwest), water levels during storms do not exceed the predicted astronomical tide. This indicates that water levels equal to the highest astronomical tide (HAT) predicted for Boston Harbor are appropriate for the determination of extreme wave conditions at the Marginal Road site.

A. Historical Water Levels and Winds

Historical records of tides are available from the Boston Harbor Tide gauge from 1921 to present (NOAA Tides and Currents), and meteorological data are available from Boston Logan International Airport from 1945 to present (National Weather Service Climate Data Online). Using these records, wind conditions were developed for the analysis of waves, and the relationship between extreme wind speeds and tide levels in the harbor was investigated.

A return-frequency analysis of winds that blow along the longest fetch to the study site was carried out using the Logan Airport record. The longest wind fetch is to the NNW, from the study site to the mouth of the Weir River between Worlds End and Sunset Point. The 1% (100-year return frequency) wind speed for the NNW compass sector is 55.5 mph. The 1% wind speed for the NW sector is slightly higher, at 60.0 mph.

Water levels during the top wind speed events in the Logan record from the NW and WNW compass sectors were determined by accessing the tide record for Boston Harbor. The 100-year water level for the NOAA Boston tide gauge is reported to be 10.04 feet NAVD (FEMA, 2016), which is 3.12 feet higher than the HAT determined by NOAA. A recent January 2018 northeast storm caused water levels at the Boston tide gauge to rise to 9.6 feet NAVD (Figure 2), which is only 0.4 feet less than the 1% water level for the Boston tide gauge. It can be seen in Figure 2

that maximum water levels occurred while winds were blowing from the north. For this event, peak surge levels (water levels above the astronomical tide) happened to perfectly coincide with the highest astronomical tide of that month. However, wind speeds during this max surge ranged between 20 and 30 mph, which is far less than the wind speeds that would cause the largest waves at the Marginal Road study location.

Figure 1. Location of the Marginal Road site within the Weir River Estuary.

The historical record of winds and tides for Boston shows that during the top wind events for the NW and WNW compass sectors, the measured tide does not exceed the predicted astronomical tide, and can often be lower than predicted. An example of this is presented in Figure 3, for Hurricane Edna (September 1954), a storm event which has the highest recorded wind speed from the NW and WNW compass sectors. In Figure 3 it can be seen that during the time of maximum winds, the observed water levels were at or lower than the predicted astronomical tide, which is observed for the other events from these sectors. The reason this occurs is that winds from these sectors are oriented to cause a blow down of water levels in the Harbor, unlike when storm winds blow from the north to east sectors, which tend to force ocean water to build up against the coastline of Massachusetts Bay and surge into Boston Harbor.

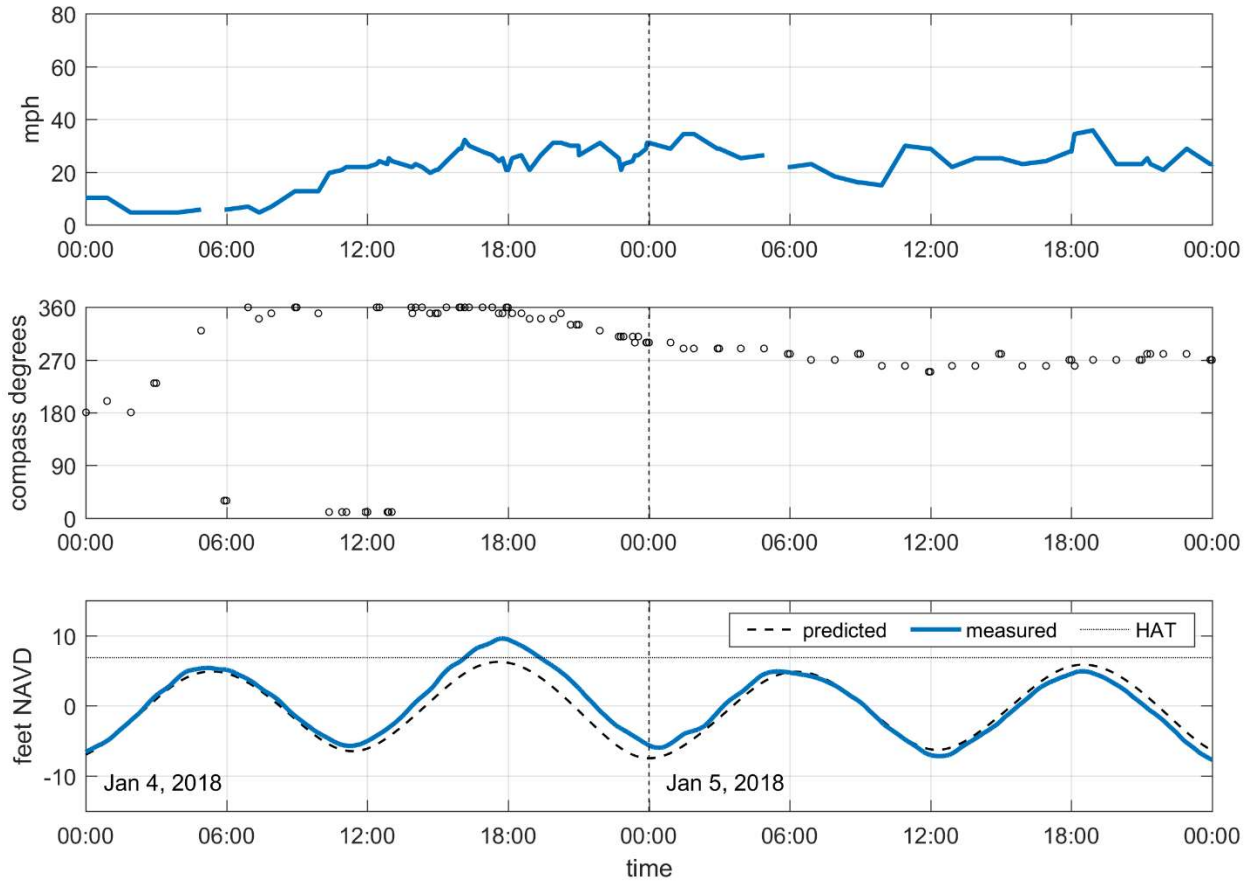

Figure 2. Boston Logan wind speed and direction (top and middle plots) together with predicted and measured tides for Boston Harbor (bottom plot) during the January 2018 northeast storm that produced extreme high water levels in the harbor. The highest astronomical tide (HAT) level determined by NOAA is also shown with the plot of tides.

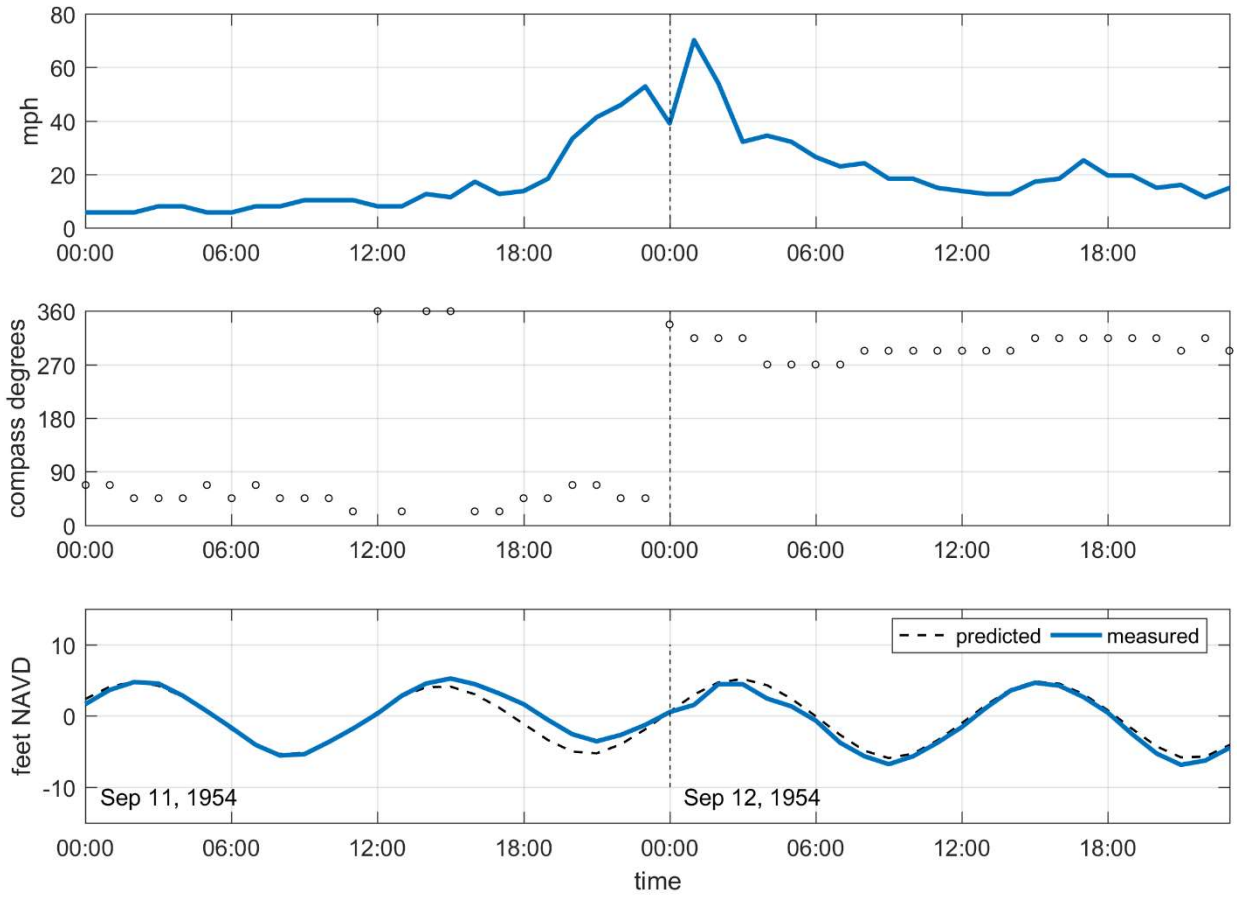

Figure 3. Boston Logan wind speed and direction (top and middle plots) together with predicted and measured tides for Boston Harbor (bottom plot) during the Hurricane Edna, the storm that produced the highest recorded winds from the NW and WNW compass sectors.

B. Design Wave Analysis

The determination of design wave conditions at the Marginal Road study site proceeded using a 100-year wind speed of the NW and WNW compass sectors, and a water level equal to the HAT for Boston Harbor of 6.9 feet NAVD. The two-dimensional (2D) wave model SWAN was utilized to determine wave conditions in the Weir River that result from these extreme winds blowing across open water areas and channels of Boston Harbor. An existing wave model grid was available which includes the Weir River and Hingham Bay. This is a regular Cartesian grid with a 40-meter mesh (Figure 4).

Appling the 100-year wind conditions from the NW and WNW compass sectors to the wave model results in a maximum wave height in the Weir River (offshore of the study site) of 2.4 feet and a period of 2.6 seconds. A contour plot of wave heights for the NW wind case with vectors indicating wave direction is presented in Figure 5.

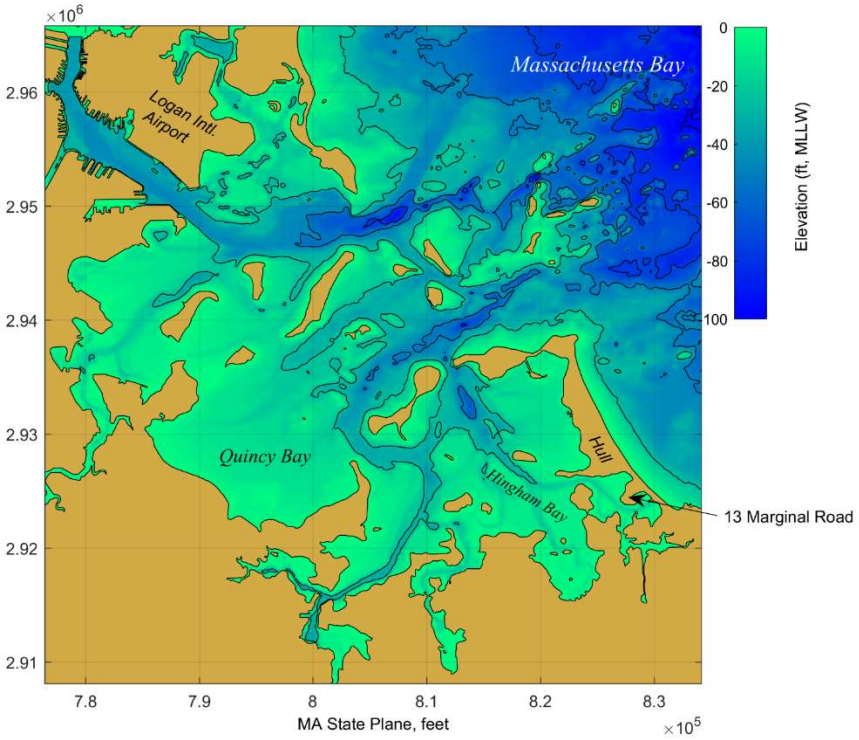

Figure 4. Bathymetry of the SWAN wave model computational mesh of Boston Harbor, with indicated study site at Marginal Road.

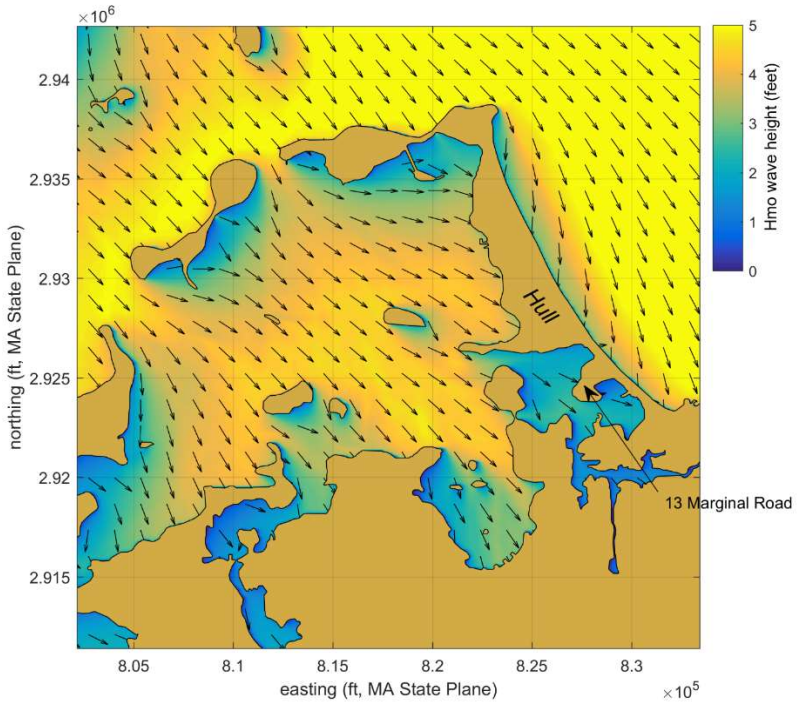

Figure 5. Wave model output for 100-year NW wind case. Color contours indicate specific wave height, while vectors show wave direction.

As a final step, the wave condition output from the 2D SWAN model was used in the determination of wave heights between the open water of the Weir River and the shoreline of the study site. The method of Battjes and Janssen (1978) was used to compute wave heights across the surf zone. This methodology computed wave breaking and wave setup as waves approach the shoreline. 2014 USGS LiDAR data were used to specify the cross-shore profile of the beach at 13 Marginal Road. The results of the wave height computations are presented in Figure 6, which shows significant wave height (Hmo) from the 0 NAVD contour up to the point where the still water elevation (SWEL, corresponding to the HAT for Boston Harbor) intersects the beach profile.

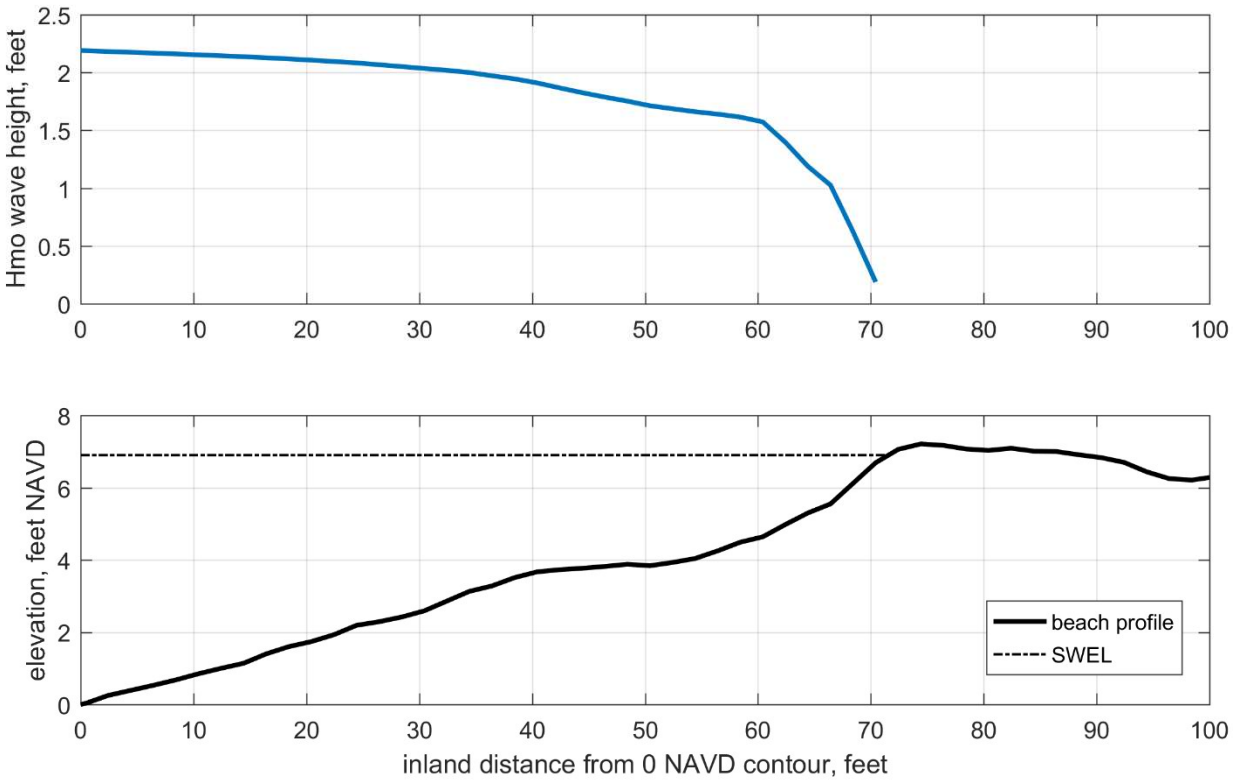

Figure 6. Significant wave height (top plot) across the surf zone at 13 Marginal Road during 100-year storm conditions at the study site. The bottom plot shows the cross-shore profile and still water elevation (SWEL) used for the wave height calculations.

C. References

Battjes, J.A., and Janssen, J.P.F.M. (1978). “Energy loss and set-up due to breaking of random waves.” *Proc. 16th Coastal Engineering Conf*., ASCE, Reston, VA, 569-587.

FEMA (2016). Flood Insurance Study, Suffolk County, Massachusetts. Federal Emergency Management Agency.

ATTACHMENT 2.
SHELLFISH
SURVEY

MEGALODON
ENVIRONMENTAL LLC

Shellfish Habitat Assessment Report

To:	Town of Hull Conservation Commissioners	From:	Pamela Neubert, Megalodon Environmental LLC
	Applied Coastal		P.O. Box 329 Woods Hole MA 02543
File:	13 Marginal Road, Hull, Massachusetts	Date:	December 2, 2020

Megalodon Environmental LLC (Megalodon), performed a shellfish habitat assessment on November 13, 2020 at a proposed project location adjacent to 13 Marginal Road, Hull, Massachusetts (**Figure 1**). The proposed project is within the estuarine waters of the Hull Bay. This area is surrounded by year-round and seasonal residential development.

The purpose of this survey was to investigate the shellfish resources in the area and to determine abundances as part of a feasibility study and to assist with project design. The proposed Project location is within an area determined by Massachusetts Division of Marine Fisheries (MADMF) to be conditionally restricted for shellfish growing and is designated as suitable habitat for blue mussels (*Mytilus edulis*) and soft shell clams (*Mya Arenaria*) (**Figures 2 and 3**). Massachusetts Department of Environmental Protection (MADEP) has not mapped the Project area for eelgrass (*Zostera marina*).

This shellfish survey provides an accurate description of the shellfish resources at the proposed Project location. This information will assist the Conservation Commission as well as other regulatory agencies with their responsibility to protect the Town of Hull wetlands and coastal resources. The resource areas within 100 feet of the project site include: land under the ocean, land containing shellfish, coastal bank, salt marsh and land subject to coastal storm flowage.

Survey Methodology

Megalodon's survey methodology followed those approved and utilized for shellfish studies within a variety of Massachusetts coastal cities and towns, including Scituate, Marblehead, Nahant, New Bedford, and the Towns of Cape Cod, Nantucket, and Martha's Vineyard. Shellfish stations at the Project location were arranged in a grid pattern. The study area was 240 ft by 190 ft. Transects were established at ten-foot intervals parallel and perpendicular to the shoreline. The 24 parallel and 19 perpendicular transects resulted in a total of 456 sampling points throughout the survey area. (**Figure 4 and 5**). A random number generator was used in selecting 125 sample locations from the 456 sampling points. Samples were hand raked to obtain 1 foot (ft.) squared of substrate and processed through a 0.25-inch mesh basket at each of the station locations. General sediment texture, shellfish abundance, and other observations were recorded (**Figures 4 and 5**).

Figure 1. Shellfish survey area, 13 Marginal Road, Hull, Massachusetts

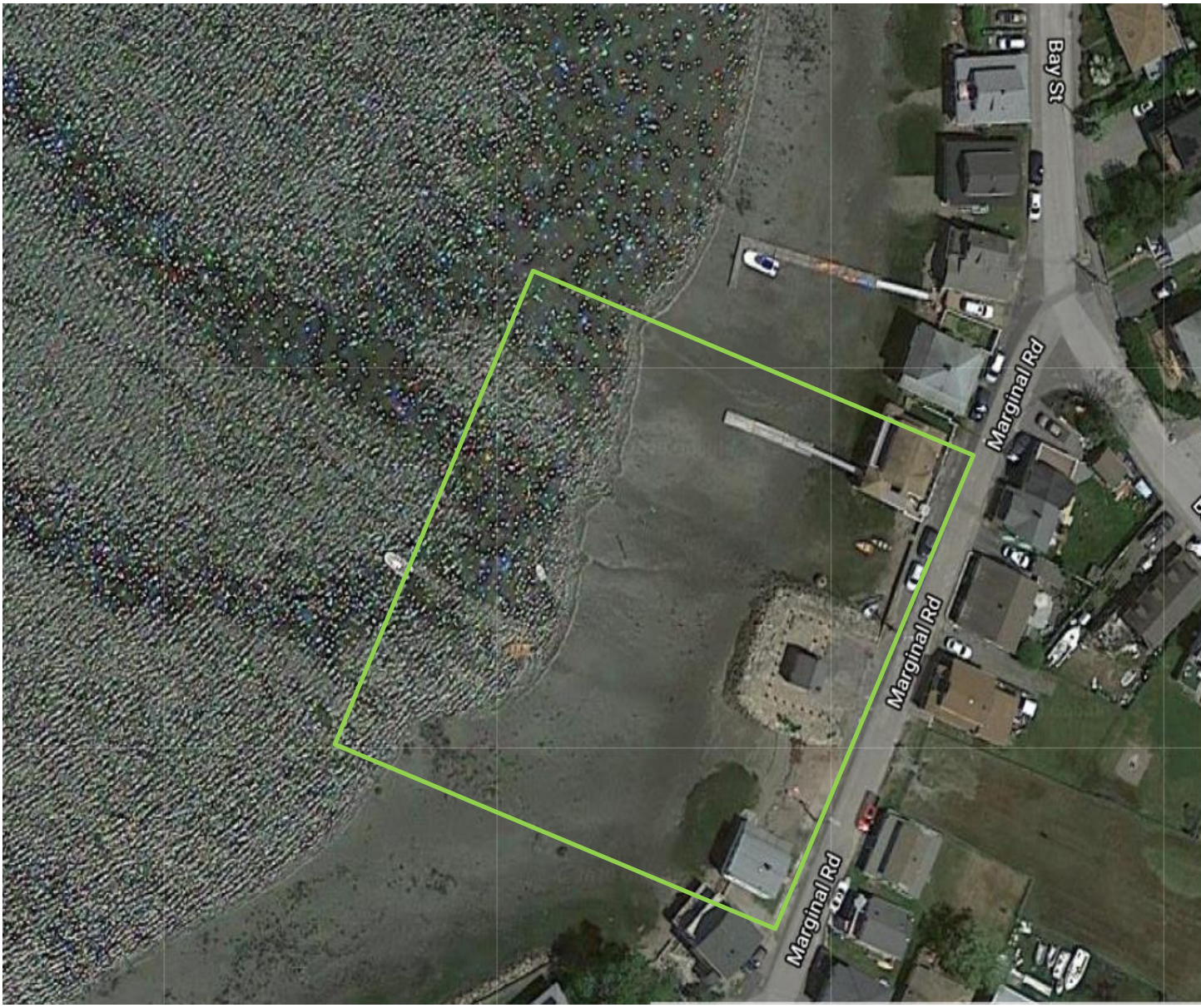

Figure 2. MADMF Shellfish Suitability.(June 10, 2020).

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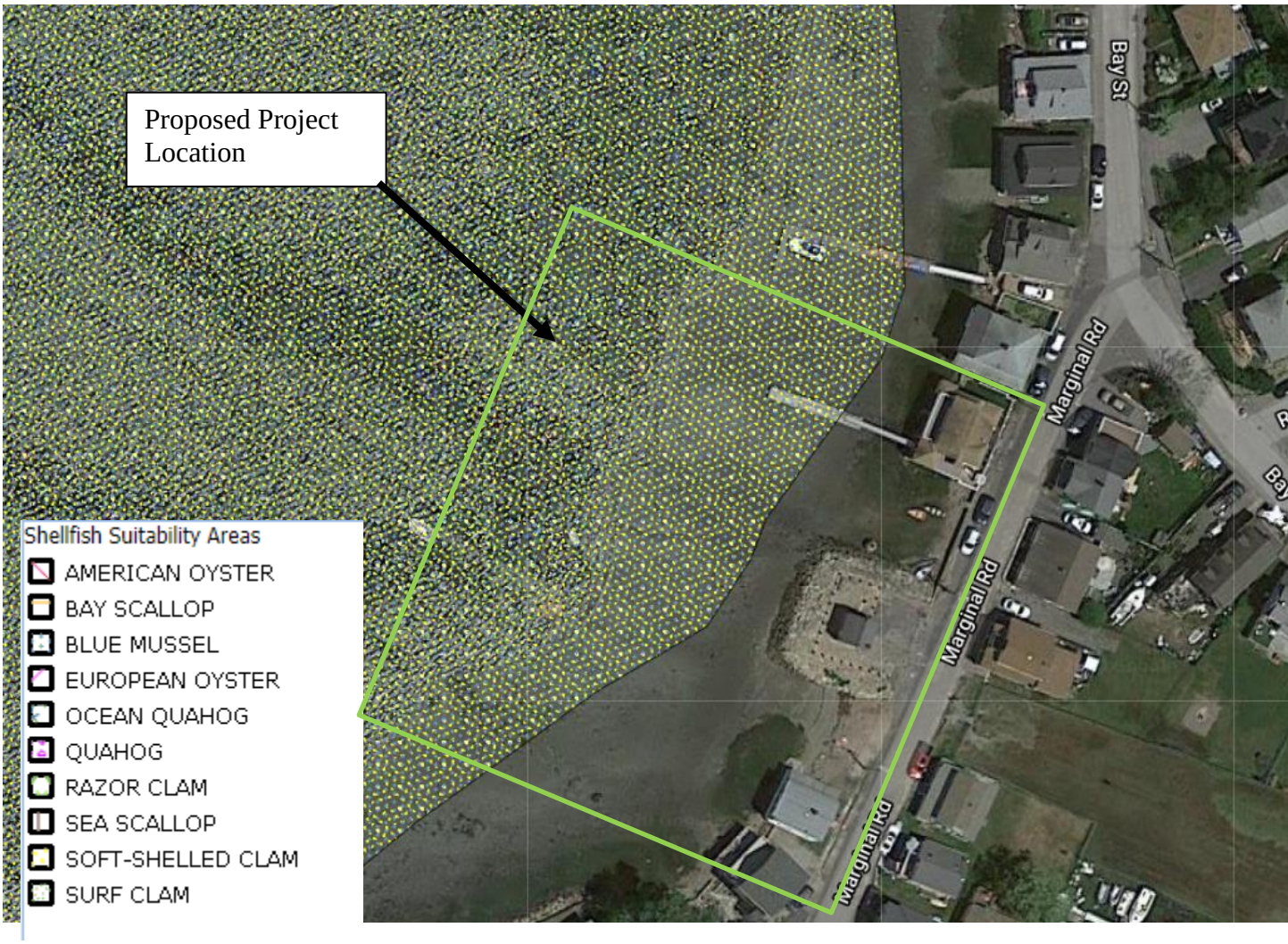
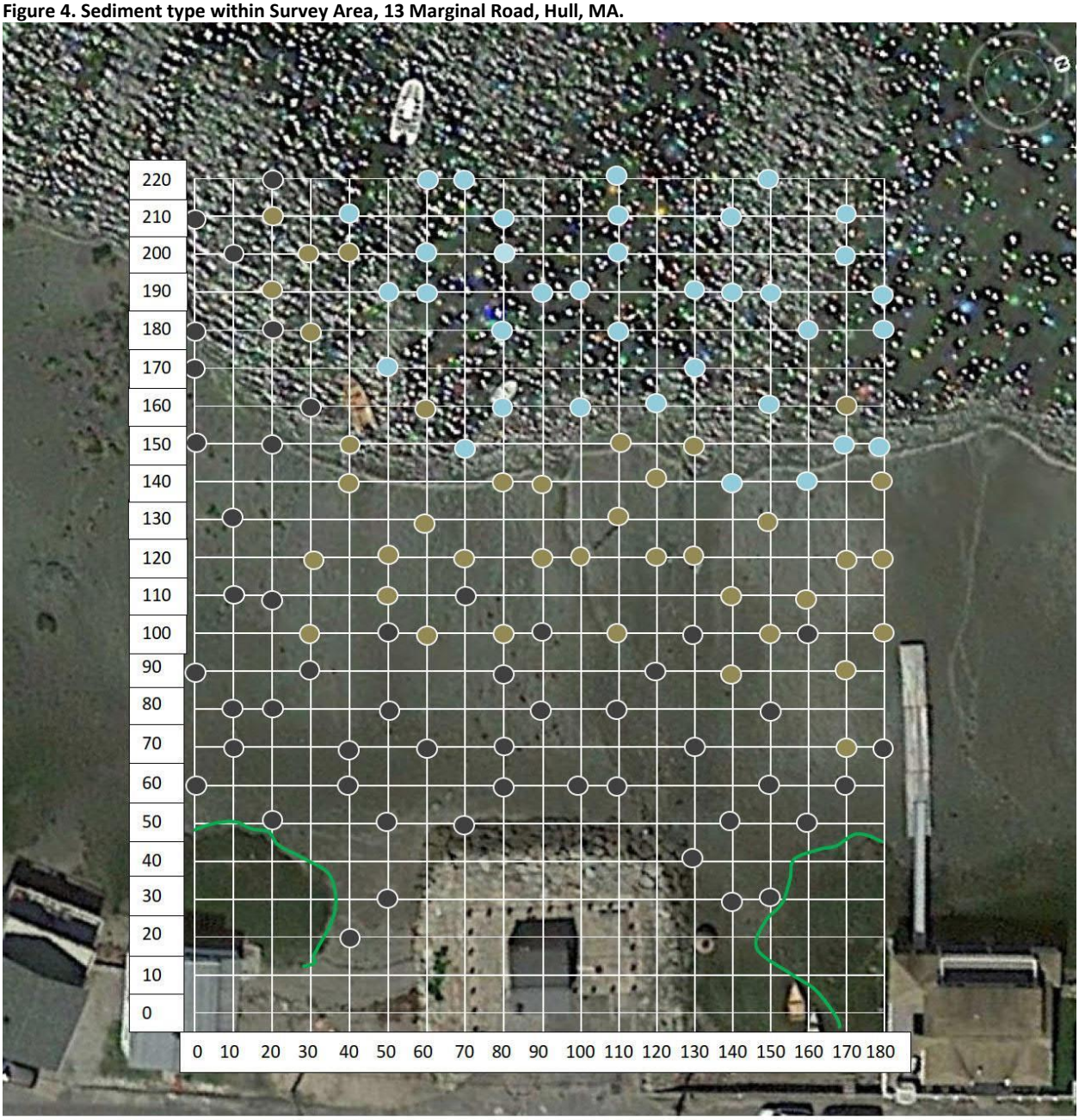


Figure 3. MADMF Shellfish Growing Areas (June 10, 2020).

Figure 4. Sediment type within Survey Area, 13 Marginal Road, Hull, MA.



13 Marginal Rd Hull, MA 02045 Sediment Characterization Map

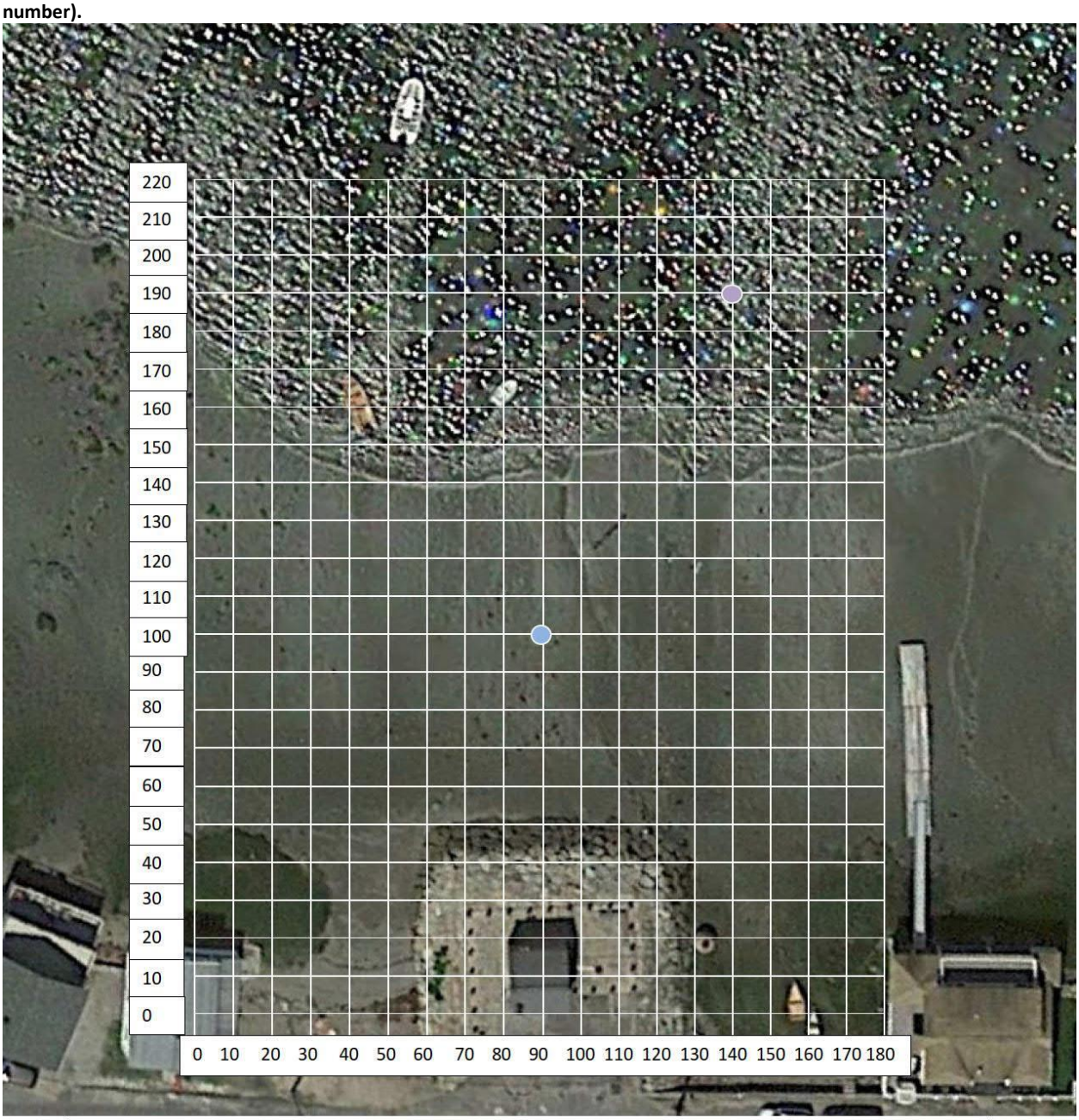
=Gravel

=Marsh grass

=Gravel and sand

=Silt and sand over gravel

Figure 5. Shellfish abundance within Survey Area, 13 Marginal Rd, Hull, MA (S-# indicates unique sample identification number).



13 Marginal Rd Hull, MA 02045 Shellfish Abundance Map

= Blue mussels (*Mytilus edulis*)

= Quahog (*Mercenaria mercenaria*)

Survey Results

Megalodon's survey found no eelgrass within the project area, which was consistent with MADEP figures provided within the MassGIS OLIVER website. A fringing saltmarsh was observed above mean low water and the sediment consistency was observed to be sand mixed with occasional gravel by visual inspection. The sediment consistency transitioned from sand mixed with gravel to organic, muddy silt and sand over buried gravel in the subtidal area (**Figure 4**). One (1) quahog and one (1) cluster of three (3) blue mussels were observed from two (2) of the one hundred twenty-five (125) sample stations (**Figure 5**). No other shellfish were found within the sampled area.

Conclusions

The shellfish survey was performed using a methodology that accurately maps shellfish abundance in the area of the proposed project. No eelgrass was observed within the surveyed area. Sediment transitioned from nearshore sand to silty mud in deeper water.

Pertinent Resource Areas as defined by Commonwealth of Massachusetts 310 Code of Massachusetts Regulations (CMR) include:

- Land Under the Ocean Massachusetts 310 CMR 10.25
- Salt Marsh Massachusetts 310 CMR 10.32
- Land Containing Shellfish 310CMR 10.34
- There are no designated coastal dunes, mud flats and/or rocky intertidal natural resources associated with the proposed project

Massachusetts 310CMR 10.25 Land Under the Ocean Performance Standards

Massachusetts 310CMR 10.25 states: "When land under the ocean or nearshore areas of land under the ocean are found to be significant to the protection of marine fisheries, protection of wildlife habitat, storm damage prevention or flood control, 310CMR 10.25(3) through (7) shall apply". These include as summarized below:

(5) Project not included in 310CMR 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, erosion, coastal banks, dunes or salt marshes.

(6) Projects not included in 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) alterations in water circulation;

(b) destruction of eelgrass (*Zostera marina*) or widgeon grass (*Ruppia maritima*) 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.

(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 established under 310 CMR 10.37.

Pertaining to Massachusetts 310CMR 10.25 Land Under the Ocean:

As alternatives are developed for the project area, highest priority will be given to those that will not adversely affect sediment transport, destroy or pollute fisheries and shellfish habitat or add nutrients to the area. There is no eelgrass or widgeon grass in the Project area, there are no rare vertebrates or invertebrate species identified that would be affected by this project.

Massachusetts 310CMR 10.32 Salt Marsh Performance Standards

Salt marsh is defined as a coastal wetland that extends landward up to the highest high tide line, that is the highest spring tide of the year and is characterized by plants that are well adapted to prefer living in saline soils. Dominant plants within saltmarshes typically include salt meadow cord grass (*Spartina patens*), and/or salt marsh cord grass (*Spartina alterniflora*).

Pertaining to Massachusetts 310CMR 10.32 Salt Marshes

As alternatives are developed for the project area, highest priority will be given to those that avoid marsh habitat..

Massachusetts 310CMR 10.34 Land Containing Shellfish Performance Standards

Massachusetts 310CMR 10.34 defines land containing shellfish as follows:

"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. Significance. Land containing shellfish shall be found significant to the protection of land containing shellfish and to the protection of marine fisheries when it has been identified and mapped as follows:

(a) by the conservation commission or the Department in consultation with the Division of Marine Fisheries and based upon maps and designations of the Division of Marine Fisheries;

or

(b) by the conservation commission or the Department, based upon maps and written documentation of the shellfish constable or the Department. In making such identification and maps the following factors shall be taken into account and documented: the density of shellfish, the size of the area and the historical and current importance of the area to recreational or commercial shellfishing.

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.

(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 Environmental 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.

(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.

(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".

Pertaining to Massachusetts 310CMR 10.34 Land Containing Shellfish:

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ENVIRONMENTAL LLC

According to 310 CMR 10.34(5) Notwithstanding the provisions of 310 CMR 10.34(4), "projects which temporarily have an adverse effect on shellfish productivity but which do not permanently destroy the habitat maybe permitted if the land containing shellfish can and will be returned substantially to its former productivity in less than one 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".

As alternatives are developed for the project area, highest priority will be given to those that:

- do not adversely change water circulation. Tidal currents in the area are small and would not be altered by the placement of the sediment associated with the proposed project.
- do not significantly change sediment grain size. Any material placed would be similar in consistency to the existing material and will provide overall benefit to the homeowners and municipal infrastructure by providing increased resilience to storm and wave damage.
- benefit natural drainage and protect the area from storm and wave damage.
- has minimal to no effect on water quality, including, salinity, dissolved oxygen, nutrients, temperature or turbidity, or the addition of pollutants.
- has minimal to no effect on rare vertebrate or invertebrate species as the proposed Project is not within an area considered as habitat for rare wildlife for coastal wetlands.

Alternatives developed for the project area will benefit the local community and the Town of Hull's roadways and existing pump-house infrastructure by providing protection from sea-level rise, wave and storm damage. Given only 1 quahog and 3 mussels were found in the sampled area, this project will have no significant impact to shellfish or shellfish habitat.

Please do not hesitate to contact me if you have any questions.

Sincerely yours,

Pamela Neubert, Ph.D.
Principal
Megalodon Environmental, LLC
megalodonev@gmail.com