Proactive by Design

SEAWALL CONDITION ASSESSMENT

LESLEY MANAGEMENT HARBORSIDE CONDOMINIUM
24 Lee Street
Marblehead, Massachusetts

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PREPARED FOR:
LESLEY MANAGEMENT HARBORSIDE CONDOMINIUM
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Marblehead, Massachusetts

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A. GENERAL

1. INTRODUCTION

On August 3 and 9, 2016 GZA GeoEnvironmental, Inc. (GZA) performed a limited topographic survey and an above and underwater visual and tactile inspection of the existing granite stone seawall and adjacent associate site features fronting the existing harbor side condominiums at 24 Lee Street in Marblehead, Massachusetts (See **Figure 1 – Locus Plan**). The inspection was performed in accordance with the signed agreement received by GZA on February 26, 2016. The work was performed as a result of Owner's concerns with the seawall including but not limited to the following; voids along the face of the seawall, missing mortar joints, deteriorated concrete, possible movement of the seawall stones and sinkholes forming in the parking area behind the seawall.

The topographic survey on August 3, 2016 included features of the property within the area of the granite stone seawall including but not limited to; existing buildings, parking area, seawall, riprap slope, adjacent structures and general shoreline features.

The inspection was limited to the accessible above- and underwater portions of the existing seawall and was performed by swimming at the surface during periods of low tide and by observing the seawall from the parking lot located directly landward of the seawall. The underwater portion of the inspection took place during a dive on August 9th. The main purpose was to assess the above-and below-water existing conditions of the granite stone seawall to determine existing conditions and establish baseline criteria for future inspections and/or rehabilitation. No utilities/building structures, floats or gangways, or any other ancillary structures associated with the condominiums were included in the inspection scope of work.

The seawall elements observed were assessed a condition rating based on the following table:

Table 1 - Condition Rating Assessment

Rating	Description
6 - Good	No visible damage, or only minor damage is noted. Structural elements may show very minor deterioration, but no overstressing is observed. No repairs are required.
5 - Satisfactory	Limit minor to moderate defects or deterioration are observed, but no overstressing is observed. No repairs are required.
4 - Fair	All primary structural elements are sound, but minor to moderate defects or deterioration is observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repair is low
3 - Poor	Advanced deterioration or overstressing is observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may need to be carried out with moderate urgency.

Table 1 - Condition Rating Assessment	
Rating	**Description**
2 - Serious	Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components. Local failures are possible and loading restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency.
1 – Critical	Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high priority basis with strong urgency.

Note: Rating system taken from Table 2-4. From Routine Underwater Condition Assessment Ratings, Page 21, Underwater Investigations Standard Practice Manual, as published in the ASCE Manuals and Reports on Engineering Practice No.101, Copyright 2001.

2. INSPECTION PROCEDURES

Prior to conducting the field inspection work, GZA personnel reviewed available site information associated with the site to familiarize ourselves with the existing structures and to establish an inspection baseline.

The above-water and underwater inspections included visual and tactile inspections of the accessible portions of the granite stone seawall. The inspection procedures included documentation of existing conditions of the seawall by field notes, photography, videography. Access to the structures during the inspection was from the existing floating docks.

The underwater inspections were performed in accordance with OSHA Subpart T – Commercial Diving directives and the American Society of Civil Engineers, Underwater Investigations, Standard Practice Manual, No. 101 (Manual 101). Underwater dive operations were performed during the day in approximately 0 to 6-foot water depths with 65-degree water temperature and approximately 10 to 15-foot visibility. Inspection limitations are indicated in **Appendix A.**

The underwater inspection included a Level I inspection effort that involved visual and tactile inspections of the seawall face and a modified limited Level II inspection as defined in Manual 101. The Level I inspection was a "swim-by" inspection, performed to the level of detail necessary to detect obvious major damage or deterioration. The modified Level II inspection involved the removal of marine growth on portions of the seawall face. This inspection was directed towards detecting and identifying damage and deterioration that was hidden by surface biofouling.

a. Documentation

The documentation resulting from the above-water and underwater inspection included field notes, photographs, video and underwater photographs that were taken of the general conditions encountered. Select site inspection

photographs are presented in **Appendix B** of this report. **Appendix C** of the report provides a drawing describing the conditions encountered.

b. Non-Destructive Testing

No destructive or non-destructive testing was performed on the existing seawall face aside from minor cleaning of marine growth. Cleaning associated with the Level II underwater inspection was performed without damage to the seawall.

3. EXISTING SITE CONDITIONS & STRUCTURES

The site is composed of several condominiums buildings, a small grassed area and paved parking lot/driveway located landward of the granite block seawall fronting Marblehead Harbor. The seawall provides foreshore protection and support to the landside structures and features. Two seasonal aluminum gangways are connected to the seawall and provide access to two, 20-foot by 40-foot timber floats within the Harbor. The site was previously a boatyard in the late 1800s with seawalls and a marine railway, as observed in historic photographs.

Based on a site visit conducted on August 20, 2015 and August 3 and 9, 2016, the seawall appears to have been constructed and reconstructed at different periods in time using different materials. The seawall is generally composed of granite stones of varying sizes from the exposed base of the seawall to approximately mean high water elevation. Above mean high water the seawall varies in construction type, composed of large granite blocks, mortared stones, cast-in-place concrete or cement block construction that all vary in height. A stone masonry planter was observed on the top of the seawall at the northern end of the parking lot in addition to a potted planter at the southeastern corner of the parking lot.

The overall length of the inspected structures fronting Marblehead Harbor is approximately 310 linear feet, and consists of seawalls and stone revetment slope. The seawall portion of the site can be divided into different segments based on height and upper seawall construction type. The seawall length from the northern property limit to southeastern end of the paved parking lot is approximately 205 linear feet. South of the parking lot an approximate 45-foot-long stone riprap slope with a low height masonry seawall above provides protection to the parking lot and the southern condominium building. The remaining portion of the seawall is located beneath the southern condominium building and deck and extends approximately 40 linear feet and then 20 linear feet toward shore to the southern property limit (See Figure 2 in Appendix C for Existing Conditions Plan and general site photographs in Appendix B).

Four chains connect the existing timber floats to the granite block seawall, two per float. It appears that the two chains connecting the southernmost float to the existing seawall are cast into a mortared section and the two chains connecting the northernmost float to the seawall are bolted through the top concrete section (See Figure 2 in Appendix C and Photographs 15-16 in Appendix B). These appear to be mooring connections for dingy outhauls attached to the seawall.

B. EXISTING CONDITIONS

1. GENERAL

The observations below are based on above-water and underwater inspection of the existing seawall. A plan of the site and associated features is included in **Appendix C** of this report.

2. EXISTING SEAWALL

The existing seawall structures at 24 Lee Street was divided into seven different segments based on the various seawall construction types. The Site Plan in Appendix C differentiates the locations of these seawall segments and **Table 2** below describes the lengths and seawall construction types of each segment.

Table 2 - Seawall Segment Descriptions

Seawall Type Designation	***Length***	***Construction Type (Bottom to Top)***	***Top of Seawall El. (NAVD88)***	***Observed Bottom of Seawall at Mudline El. (NAVD88)***
1	±65 LF	Stone, Granite Block, Mortared Stone, Poured Concrete	±6.2’	Varies -7’ to -8’
2	±12 LF	Stone, Granite Block, Mortared Stone, Concrete Block, Stone Planter	±12’	-7’
3	±7 LF	Stone, Granite Block, Mortared Stone, Poured Concrete (for Gangway connection)	±7.5’	-7’
4	±100 LF	Stone, Granite Block, Stone Planter	Varies ±10.5’ to ±11.8’	Varies -6’ to -7.5’
5	±21 LF	Stone, Granite Block	Varies ±7.8’ to ±8.2’	Varies -6.8’ to -7.7’
6	±45 LF	Rip Rap Slope, Poured Concrete, Stone Planter	±10.6’	Bottom of rip rap slope varies
7	±60 LF	Stone, Granite Block, Poured Concrete (for Building Foundation)	±8.0’ (top of stone)	-

In general, the upper portion of the seawall with the stone and mortar planter was observed to be in **Fair** condition. The mortar in the lower courses of the seawall, splash zone and near the Mean High Water (MHW) line was observed to have deteriorated mortar and be in **Satisfactory** to **Poor** condition. The lower portions of the seawall with stones without mortar was observed to range from **Satisfactory** to **Poor** condition due to voids throughout and limited bulging in areas possibly due to past movement of the seawall.

The drawing in **Appendix C** shows the existing site and observed seawall conditions by an assigned observation number. Notes are included within the table on the site plan.

Seawall Type 1

The overall condition of the existing seawall Type 1 was observed to range from **Fair** to **Satisfactory**, with two locations with observed **Poor** condition. The Type 1 seawall extends approximately 65 linear feet south from the northern property line (See **Photograph 2**). The seawall consists of irregularly shaped stone extending from the mudline to approximately MHW. Two courses of cut granite block were observed above the irregular stone; the lower course of a smaller size than the upper course. Above that was an approximate two-foot thick layer of stone and mortar with an approximate three-foot high concrete cap. A steel railing is mounted to the top of the cap. No weep holes were observed along this portion of the seawall, although gaps exist between stones. Approximately 15 feet of the seawall is fronted by a mound of placed stone at an apparent bow in the seawall (See **Photograph 2**). Smaller stone located at the base of the seawall appeared to follow the natural slope of the mudline.

Seawall Type 1 was observed to be in **Poor** condition in two locations. Voids in the seawall near the mudline were observed near both the northern and southern limits of the placed stone. The northern void was observed to be approximate 1 foot wide by 1 foot high by 4 feet deep. The southern void was observed to be approximately 2.5 feet wide by 1 foot high by 1.5 feet deep. The bottom of the wall behind the placed stone was inaccessible during the inspection. Therefore, it is unclear whether or not there are additional voids within this portion of the wall. In general, the lower portion of the seawall was observed to have gaps between the various stones. It appeared that these gaps had been filled in the past with chinking stone, however not all larger gaps were observed to be currently filled. A course of cut granite block was observed to have been leveled using chinking stone. It should be noted that around the placed stone, the course of cut granite block appears to have settled in the past, possibly resulting in the placed stone seaward of the seawall (see **Photograph 2**). Additionally, the observed base of the seawall appears to have bulged out and is located more seaward at this location than in other portions of the seawall, possibly a result of past settlement or isolated failure. Areas of exposed aggregate were observed along the face of the concrete cap, and the form ties from the construction remain in place and have corroded and rusted. Heavy marine growth was located along the face of the seawall from the mudline to a few feet below MHW.

Seawall Type 2

The overall condition of the existing seawall Type 2 was observed to be **Satisfactory**, with an isolated section of the upper planter in **Poor** condition. The Type 2 seawall extends from the end of the Type 1 seawall construction for approximately 12 linear feet. The seawall is constructed similarly to Type 1 with the lower portion of the seawall composed of granite stones, two courses of cut granite block and then a layer of stone and mortar. Above this layer, the seawall consists of an approximate three-foot-high portion of concrete blocks and then an approximate three-foot-high mortared stone planter (See **Photograph 3**). A large rosa rugosa plant is and irrigation system are located within this planter. Stone located at the base of the seawall appeared to follow the natural slope of the mudline. No weep holes were observed along this portion of the seawall, although gaps exist between stones. In general, the lower portion of the seawall was observed to have gaps between the various stones and had been partially filled with chinking stones. Heavy marine growth was located along the face of the seawall from the mudline to a few feet below MHW. An approximate ¾-inch to 1-inch crack was observed through the top of the stone planter at the northern end of the planter (See **Photograph 3** inlay).

Seawall Type 3

The overall condition of the existing seawall Type 3 was observed to range from **Fair** to **Satisfactory**. The Type 3 seawall extends from the end of the Type 2 seawall construction for approximately 7 linear feet. The northern gangway is attached to a concrete pad at this location by a face-mounted bracket. The top of the concrete pad is located approximately 1.5 feet below the elevation of the parking area behind the seawall and only approximately 2.5 feet above MHW. The concrete was observed to be in fair condition. While the gangway was not included in the scope of the inspection, the gangway bracket was observed to be moderately corroded. In general, the lower portion of the seawall was observed to have gaps between the various stones and had been partially filled with chinking stones. Stone located at the base of the seawall appeared to follow the natural slope of the mudline. Heavy marine growth was located along the face of the seawall from the mudline to a few feet below MHW.

Seawall Type 4

The overall condition of the existing seawall Type 4 was observed to be **Fair**. The Type 4 seawall extends from the end of the Type 3 seawall construction for approximately 100 linear feet to the location of the southern gangway. Isolated areas of depressed pavement were observed in the parking area landward of this section of the seawall (See **Photograph 11**). Various voids were observed near the mudline at the face of the seawall ranging in size from 1.5 feet high by 0.75 feet wide by 3 feet deep to 1.5 feet high by 1.5 feet wide by 4 feet deep (See **Photograph 20**). No weep holes were observed along this portion of the seawall, although gaps exist between stones. In general, the lower portion of the seawall was observed to have gaps between the various stones and had been partially filled with chinking stones. Heavy marine growth was located along the face of the seawall from the mudline to a few feet below MHW.

Seawall Type 5

The overall condition of the existing seawall Type 5 was observed to be **Fair** to **Poor**. The Type 5 seawall extends from the end of the Type 4 seawall construction for approximately 21 linear feet around the corner to the rip rap slope (See **Photograph 7**). The seawall is constructed similarly to the Type 4 seawall with smaller irregularly shaped stones from the mudline to approximately MHW and one course of cut granite block mortared in place at the top. The southern gangway is mounted to the top of the stone at this location. A pipe railing and a round planter is located along the length of this portion of the seawall, as there is no mortared stone planter. Two larger voids were observed near the mudline below the gangway in this location (See **Photographs 17 through 19**). Additionally, a small void was probed and was observed to be greater than 6 feet into the seawall. In general, the lower portion of the seawall was observed to have gaps between the various stones and had been partially filled with chinking stones. Heavy marine growth was located along the face of the seawall from the mudline to a few feet below MHW. The base stones at the corner of the seawall appear to have shifted seaward in the past (See **Photograph 7**). Review of archive drawings and permit plans show a concrete overlay seawall was proposed to be installed around the corner of the seawall in 2004, likely to prevent additional movement. It appears this proposed work was not performed.

Seawall Type 6

The overall condition of the existing seawall Type 6 was observed to be **Fair** to **Poor**. The seawall in the location consists of an observed concrete seawall of unknown depth that appears to have been poured directly on the stones of the existing rip rap slope or possibly on ledge (See **Photographs 7 and 10**). A mortared stone planter is

located above the concrete seawall. Weep holes were observed at approximately 8 feet on center located at the intersection of the poured concrete and the stone planter, presumably to drain the planters. After review of archive drawings and permits, it remains unclear if an additional lower seawall exists behind the rip rap slope. The eastern end of the rip rap slope, adjacent to Seawall Type 5, appears to have raveled and created larger voids between the stones in the rip rap. The voids extend landward along the edge of the stone planter.

Seawall Type 7

The overall condition of the existing seawall Type 7 was observed to range from **Fair** to **Poor**. The Type 7 seawall construction extends from the rip rap slope to the southern corner of the property, and then returns landward along the southern property line. The seawall is constructed similarly to the Type 1 seawall construction; however, this portion of the seawall was observed to be founded on an existing ledge outcrop (See **Photograph 14**). The lower portion of the seawall extending up from the ledge consists of irregular stones to an elevation of approximately MHW. Two courses of cut granite block extend up from MHW and are set in mortar. An approximately three-foot high concrete foundation for the condominium structure above is cast directly onto the cut granite blocks. The lower stones appear to have been dry laid and were observed to have gaps in the joints between stones. In portions of the seawall, these gaps appear to have been filled with chinking stones. The concrete foundation was observed to be in Fair condition with minor efflorescence throughout and minor horizontal cracks at the northern end. Efflorescence and spalling was observed in the mortared course near the MHW line. The lower portion of the seawall was observed to have numerous voids between stones and a large void at the corner of the seawall (see **Photograph 14**). The corner of the wall and the return landward was observed to be in **Poor** condition. Numerous gaps and voids were observed between adjacent stones. One stone along the bottom of the return wall appears to have shifted.

3. PARKING AREA

The parking facility for the condominium association is located seaward of the condominium buildings. It consists of asphalt pavement and can accommodate parking for approximately fourteen vehicles. Ten of the fourteen spaces are directly adjacent to the existing granite block seawall (See **Photograph 11**).

Sinkholes and depressed locations approximately 12 to 15 feet landward of the landward side of the planters (See **Photographs 21** and **22**). In the late 1800s, the site was the home of a boat yard with a marine railway. Historic photographs show the railway roughly parallel with the wall at that time. It is possible that the current location of the seawall is seaward of this prior marine railway. Remnants of the railway and other site features from the past boat yard may be increasing the occurance of sinkholes and depressions.

4. PRIOR PERMITS

GZA performed a review of the status of prior permits or licenses associated with the existing seawalls and floats. This review was limited to Massachusetts Department of Environmental Protection Chapter 91 License Number 8472, issued in 2001, provided by the Owner. According to License Number 8472, the structures and fill were authorized with past licenses including Chapter 21 Acts of 1858, Harbor and Lands License No 3109 issued September 14, 1906, DPW License No. 1710 issued August 20, 1935, and DPW License No. 3283 Issued November 28, 1950. The rip rap slope and seawall in the area of Seawall Type 6, as well as a portion of the fill behind the rip rap, was not authorized under this License. The text of License No. 8472, from 2001, states that “the applicant has one year from the date of issuance of this license to submit an application to authorize the existing seawall, fill and rip rap depicted on the associated license plan, sheet 1 of 3.” Based on the information that was provided,

it is unclear that this application was submitted. Permitting for future work at the site would likely need to include the permitting for this area as well as proposed improvements to the seawall.

C. SUMMARY AND RECOMMENDATIONS

1. SUMMARY OF CONDITIONS

The condition of the seawall was observed to be in overall **Fair** condition with isolated areas of the structures in **Poor** condition. GZA's evaluation is based on the visible conditions observed as per our scope of services. A description of the Condition Ratings is presented in the Condition Rating Assessment – **Table 1**, provided on page 1 of this report.

Voids observed in the seawall face along with missing or deteriorated mortared joints and concrete and the observation of minor sinkholes and settlement along the landside of the seawall are conditions that were observed at the site, that if not addressed in the future, will lead to further deterioration and possibly could result in compromising the integrity and stability of the seawall.

Factors that are typically considered with the design/evaluation of a gravity seawall include the conditions of the seawall structure, soil types behind and below the seawall, the water levels in front and behind the seawall, and any surcharge or loading conditions that exist near the seawall. These considerations are typically evaluated to assess the seawalls ability to resist overturning and sliding conditions. Unfortunately, the subsurface conditions, depths to bedrock, seawall geometry or thickness, depth of seawall or any information associated with construction of the original seawall are unknown at the site. It should be noted that no calculations were performed as a part of this condition assessment and that additional information such as soil conditions and seawall construction may be needed to perform these calculations.

Tidal conditions can also create differential loading conditions acting on the seawall due to the tidal lag where the water behind the seawall drains more slowly than the water along the face of the seawall as the tide recedes. Due to the many voids and open joints in the seawall, tidal lag may not be of significant concern, however with the rise and fall of the tide and possible groundwater flow conditions, soil behind the seawall can move and migrate through the seawall joints and can cause settlement of landside surfaces and seawall stone instability over time.

The information contained within this report is based on the conditions observed at the time of inspection. The report is for general condition assessment purposes only and is not sufficient, in and of itself, to prepare construction documents for rehabilitation/repair work. Existing conditions are subject to change.

2. RECOMMENDATIONS

In accordance with our scope of services, we have developed two levels of seawall repair/improvement for consideration which would address some of the major conditional issues observed during our inspection. The Seawall Maintenance Repair, Level 1 work, considers the necessary, short-term maintenance repair work on the existing seawalls to reduce further deterioration of the seawall structure. Level 2 work involves a concrete overlay work outside of the existing seawall footprint to help reinforce and stabilize the existing seawall structures. Level 1 and 2 work involve cost-effective repairs based on conditions observed with consideration toward disruption to the site, permitting requirements and budgetary costs. Level 1 and 2 repairs would be performed from both the

landside and waterside with relatively minimal impact to the site. It is estimated that if ongoing maintenance is performed on a continuing, programmatic basis, the seawall should provide many more years of favorable service. It is recommended that Level 1 and 2 work are performed together, however at a minimum, Level 1 work should be performed in the near future.

In addition, we have considered options involving major seawall improvements/reconstruction work that would provide long term foreshore protection and longevity for the seawall structures. Major seawall stabilization/improvement options for consideration include the installation of a stone revetment fronting the existing seawall. Parking lot drainage improvements and seawall overlay for Seawall 7 could be performed in conjunction with the revetment work. A second option would be for total seawall reconstruction which could include in-kind replacement and consideration for design improvements and use of alternate materials, such as concrete.

These recommendations are, in general, typical of repairs and reconstruction improvements for a structure of this assumed construction and age. Older stone masonry seawalls which were designed for use in the marine-related industry a couple hundred years ago, are under-designed for current conditions which include increased seawall height, increased landside drainage flow, and increased landside loading conditions. Deterioration conditions typically observed include sinkholes/settlement along the landside, shifting stone and loss of mortar and/or chinking stones. Typical historic stone masonry seawalls constructed along the waterfront require periodic maintenance and repairs and often time reconstruction to account for today's changed conditions. We also recommend continued periodic monitoring of the existing structures, both pre- and post-repairs for potential future movement both horizontally and vertically.

The two levels of recommendations for short-term and long term repair and major rehabilitation/reconstruction work includes the following:

a. SEAWALL MAINTENANCE REPAIRS

The following items include recommended maintenance and repair concepts that could be performed to increase the longevity of the seawall. These have been broken down into two levels of repair: Level 1 and Level 2. Descriptions of the levels and estimated construction costs are included below.

1) Level 1 Repairs:

Level 1 repairs could be performed on the existing seawall either by hand or with small machinery. The repairs would help to maintain and restore the seawall to provide increased service life to the structure. A contractor would likely require smaller machinery and possibly a small work barge. Contractor mobilization costs for these work items would likely range between approximately **$20,000** and **$35,000**. Items iv and v below are not necessary due to issues associated with our inspection, however performing those repairs may increase the longevity of the seawall and help to protect the parking lot and condominiums during storm events.

i. *Chinking of joints and voids along face of seawall*. Portions of the seawall, especially locations where voids were observed could be filled with additional stone and chinking stone. This would be performed during periods of low tide by hand and would likely have minimal impact to day-to-day activities at the site. Chinking of the seawall voids will still allow for potential drainage from behind the seawall. Underwater voids could be repaired with additional stone and chinking stone

or grout-filled bags installed by divers. The seawall chinking and void repair work will help to stabilize stones and reduce possible settlement and additional movement of stones.

The preliminary budgetary cost estimate for this level of repair would range between approximately **$25,000** and **$35,000**. Contractor mobilization costs would be in addition to this estimate.

ii. *Concrete and mortar repairs*. The upper portion of a majority of the seawall structures was observed to have either poured concrete or mortared stone. In the intertidal and splash zones, the mortar was observed to be spalled and/or missing. These areas could be cleaned and prepared for new mortar to be installed. Similarly, the lower portions of the concrete in the intertidal and splash zones could be cleaned, chipped to sound concrete and patched/repaired. Seawall drainage would still need to be maintained by installing weepholes at select locations within the existing seawall joints.

The preliminary budgetary cost estimate for this level of repair would range between approximately **$30,000** and **$40,000**. Contractor mobilization costs would be in addition to this estimate.

iii. *Repairs to existing revetment*. The existing revetment at Seawall Type 6 was observed to have raveled stones along the eastern end adjacent to Seawall Type 5. The raveled stone would be reset and stabilized. This work could be performed by land with an excavator or by a barge-mounted crane or excavator combined with other work.

The preliminary budgetary cost estimate for this level of repair would range between approximately **$5,000** and **$9,000**. Contractor mobilization costs would be in addition to this estimate.

iv. *Remove float anchorage from face of seawall.* The north and south gangways are connected to the float and the seawall with 5th wheel connections. To reduce loading on the seawall, the 5th wheel float connection could be replaced with a roller system on the float end of the gangway. This would reduce additional loading to the seawall from movement of the floats. The existing anchorage system should be analyzed prior to this repair to assess the need for additional bottom-anchors.

The preliminary budgetary cost estimate for this level of repair would range between approximately **$7,000** and **$10,000**. Contractor mobilization costs would be in addition to this estimate.

v. *Flood protection at gangway locations*. The top of the seawall at the two gangway locations are the lowest portions of the seawall, and leave the possibility for overtopping during periods of storm surges. The top of the seawall at the southern gangway location is at approximately elevation 8.0 North American Vertical Datum of 1988 (NAVD88) and the northern gangway location is at approximately 7.5 NAVD88. The FEMA 100-year flood elevation at the site is elevation 16.0 NAVD88. Improvements should be made in these gangway locations to install stop logs or other types of temporary flood protection during periods of storms as needed. This would help to limit the amount of water behind the seawall that must filter through the seawall without weep holes to pass through.

The preliminary budgetary cost estimate for this level of repair would range between approximately **$3,000** and **$4,000**. Contractor mobilization costs would be in addition to this estimate.

vi. *Repairs to Seawall Type 7.* The length of Seawall Type 7 from the southern corner to the return wall along the property line was observed to be in Poor condition. Repairs to this corner and return wall could be performed to increase the longevity of this portion of the wall that supports the building above. Repairs for this section of wall would include power washing of the existing wall and removal of marine growth and other deleterious material. The existing voids along the face of the wall would be filled by the placement of chinking stone and supplemental stone. The joints between stones would then be filled and packed with mortar. Grout would be injected to fill voids in the interior of the wall that may not be visible from the exterior, and other deleterious material.

An additional site visit was held on January 12, 2017 to look further at this section of wall. North Shore Marine, Inc, (NSM) a local marine contractor, was also present during the site visit. After observing the wall and discussing the recommended repairs, NSM agreed to to provide a preliminary budgetary cost estimate for this work. GZA estimates that the preliminary budgetary cost estimate for this level of repair would range between approximately **$70,000** and **$80,000**. Contractor mobilization costs would be in addition to this estimate. A budgetary cost estimate of $74,190 was received from NSM on February 1, 2017 for performing this Level 1 work.

2) Level 2 Repairs

The corners of the seawall at Seawall Type 5 and 7 were observed to be in poor condition. Level 2 repairs involve advanced concrete overlay work outside of the existing seawall footprint to help reinforce and stabilize the existing seawall structures at the localized areas described below. A contractor would likely require accessing these locations by land or by water-based equipment. Water-based equipment (crane and barge) would most likely be required for work at Seawall Type 7. Contractor mobilization costs for these work items would likely range between approximately **$35,000** and **$45,000**. The Level 2 repairs would likely be performed in conjunction with the Level 1 repairs which may reduce the combined mobilization costs.

i. *Seawall Type 5 Corner Overlay*. The corner of the seawall at Seawall Type 5 was observed to be in poor condition with voids and potentially displaced stones observed. In this corner, a reinforced concrete overlay seawall could be installed to provide additional lateral support at the base of the seawall. The corner of the seawall at Seawall Type 5 could include a two-foot wide by four-foot high seawall for approximately 20 linear feet; 8 feet to the west of the corner and 12 feet to the north of the corner. The repair would encompass the area of the seawall directly below the southern gangway. This would include dowels to the face of the existing seawall and dowels down into the presumed existing ledge below the mudline.

The preliminary budgetary cost estimate for this level of repair would range between approximately **$20,000** and **$30,000**. Contractor mobilization costs would be in addition to this estimate.

ii. *Seawall Type 7 Overlay*. The seawall at Seawall Type 7 provides support for the existing condominium building above. A reinforced concrete overlay footing could be installed at this

location. The overlay footing would extend from the landward end at the west to the corner of the existing wall and then approximately 25 feet to the north. The overlay footing would vary in height, as the existing ledge varies in elevation, however the average height would be approximately 3 feet and would be stepped as the elevation of the ledge changes. The overlay footing would include dowels to the face of the existing seawall and dowels down to the existing ledge below. The existing ledge in the area of the proposed footing would be cleaned to remove marine growth and other deleterious material.

GZA estimates the preliminary budgetary cost estimate for this level of repair would range between approximately **$40,000** and **$50,000**. Contractor mobilization costs would be in addition to this estimate. A budgetary cost estimate of $44,250 was received from North Shore Marine on February 1, 2017 for this Level 2 work. In accordance with NSM's preliminary cost estimate, the combined Level 1 and Level 2 repairs for Seawall 7 repairs would be $118,440.

b. MAJOR SEAWALL STABILIZATION/RECONSTRUCTION OPTIONS

The following items are recommendations that would be performed in the long term. These would be permanent repairs to the seawall. This work would require large machinery, and like both land and barge-based equipment. Contractor mobilization costs and other incidental costs for these work items would likely range between approximately **$150,000** and **$200,000**.

1) *Revetment along face of seawall and Sinkhole Repairs/Improve Drainage behind seawall*. A stone slope revetment could be placed along the face of the entire length of the seawall. This would help to provide passive loading support to the seawall as well as act as an additional buffer to waves. This may limit the ability to dock certain sized vessels at the existing floats, depending on the size and extent of the revetment. Additional investigations would need to be performed to design the revetment cross section and stone size.

   Weep holes would be installed through the existing seawall to improve the drainage behind the seawall. The seaward elevation of the weep holes should be located within the tidal zone. An area of crushed stone and filter fabric should be installed at the landward face of the seawall at the weep hole locations. This will limit the migration of fine grained material through the seawall and weep holes. This would likely be accomplished by excavating at each location. Additionally, drainage containment/settlement treatment basins would need to be installed to address the parking lot runoff before exiting through weep holes in the seawall. At the time of the installation of the crushed stone and filter fabric, test pits could be performed to assess the approximate elevation of the bedrock for future seawall re-build options. The area of the sink holes could also be excavated at this time as well. Repairs to the sinkholes could include replacement of existing soil with a more permeable soil with less fine grained material as well as installation of filter fabric. Archive photographs show a marine railway along the face of the wall in the late 1800s. The presence of abandoned railway structures may limit or impede excavation work within this area.

   The preliminary budgetary cost estimate for this level of repair would range between approximately **$250,000** and **$350,000,** however difficulty of excavation due to the presence of abandoned railway structures may increase this cost. Contractor mobilization costs would be in addition to this estimate.

2) *Concrete Fill Behind Existing Seawall.* At the time of the excavation for the drainage improvements, assessments could be made to place concrete behind the existing seawall. Reinforcing dowels would be drilled and grouted into the landward face of the seawall stones to create a monolithic structure with the concrete. This would be in conjunction with the drainage improvements and sinkhole repairs. Additional investigations would be required to assess soil conditions and quality of the landward face of the existing stone. A preliminary budgetary cost estimate for this level of repair would range between approximately **$450,000** and **$650,000**. Contractor mobilization costs would be in addition to this estimate.

3) *Total Seawall Reconstruction*. This option would involve reconstruction of the seawall to provide protection and supports to the landside features based on today's use. Preliminary investigations would be required as the original seawall construction, the elevation of bedrock, and the material used behind the seawall remain unknown. There are two options for rebuilding the seawall: removing and rebuilding the seawall in its current location or build a new seawall seaward of the existing seawall. Both options would include the design of a new improved seawall and improving drainage behind the seawall. A new seawall should consider climate change and sea level rise to provide additional protection to the condominium structures and residents.

   The preliminary budgetary cost estimate for this level of repair would range between approximately **$750,000** and **$1,100,000**.

Budgetary cost estimates for repairs and major rehabilitation/reconstruction are further summarized as follows:

Recommended Repairs/Major Improvement Options	Preliminary Budgetary Cost Estimate Range
Seawall Maintenance Repairs	
A. Level 1 Repairs	
1. *Mobilization/Demobilization*	$20,000 to $35,000
2. *Seawall Chinking*	$25,000 to $35,000
3. *Mortar/Concrete Repairs*	$30,000 to $40,000
4. *Revetment Repairs*	$ 5,000 to $ 9,000
5. *Float Anchorage*	$ 7,000 to $10,000
6. *Opening Improvements*	$ 3,000 to $ 4,000
7. *Repairs to Seawall Type 7*	$70,000 to $80,000
Total Level 1 Repairs	**$160,000 to $213,000**
B. Level 2 Repairs	
1. *Mobilization/Demobilization*	$35,000 to $45,000
2. *Seawall 5 Overlay*	$20,000 to $30,000
3. *Seawall 7 Overlay*	$40,000 to $50,000
Total Level 2 Repairs	**$95,000 to $125,000**
Total Level 1 and 2 Repairs	**$255,000 to $338,000**

Major Seawall Rehabilitation/Reconstruction Options (includes Mobilization/Demobilization Cost)	
A. Revetment/Drainage/Overlay Improvements	**$400,000 to $550,000**
B. Concrete Fill Behind Existing Seawall	**$600,000 to $850,000**
C. Seawall Reconstruction	**$900,000 to $1,300,000**

c. PERMITTING

Regulatory authorization from the Department of Environmental Protection (DEP), Marblehead Conservation Commission, Massachusetts DEP Chapter 91, and the U.S. Army Corps of Engineers (USACE) would likely be required to perform work or improvements to the waterfront structures at the site. Depending on the type of work, this may involve filing for new permits/authorizations or coordination with regulatory agencies prior to the start of the work. Generally, work involving Level 1 and 2 repairs are permittable due to maintenance and repairs to existing structures with minimal impacts to resource areas.

Permitting new structures outside of the existing footprint, seaward of existing permitted and licensed structures, may be challenging. Oftentimes the regulatory agencies strongly discourage new intertidal impacts due to further encroachments into the water without alternate analysis performed to demonstrate the hardships from other options and minimization of impacts. Further inquiry with the regulatory agencies would be advised for major intertidal impact work prior to filing permits.

Appendix A – Limitations

APPENDIX A

VISUAL INSPECTION LIMITATIONS

1. The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints. Engineering and design calculations were not performed as a part of the assessment of the existing conditions.

2. In reviewing this Report, it should be realized that the reported condition of the waterfront structures is based on observations of field conditions during the course of this study along with data made available to GZA GeoEnvironmental, Inc. (GZA). The observations of conditions reflect only the situation present at the specific moment in time the observations were made, under the specific conditions present. It may be necessary to reevaluate the recommendations of this report when subsequent phases of evaluation or repair and improvement provide more data.

3. This report has been prepared for the exclusive use of the Lesley Management Harborside Condominium for specific evaluation purposed in accordance with generally accepted inspection practices. No other warranty, expressed or implied, is made.

4. This inspection report has been prepared for this project by GZA. This report is for the Lesley Management Harborside Condominium's evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.

Appendix B – Photographs

Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
1	2016

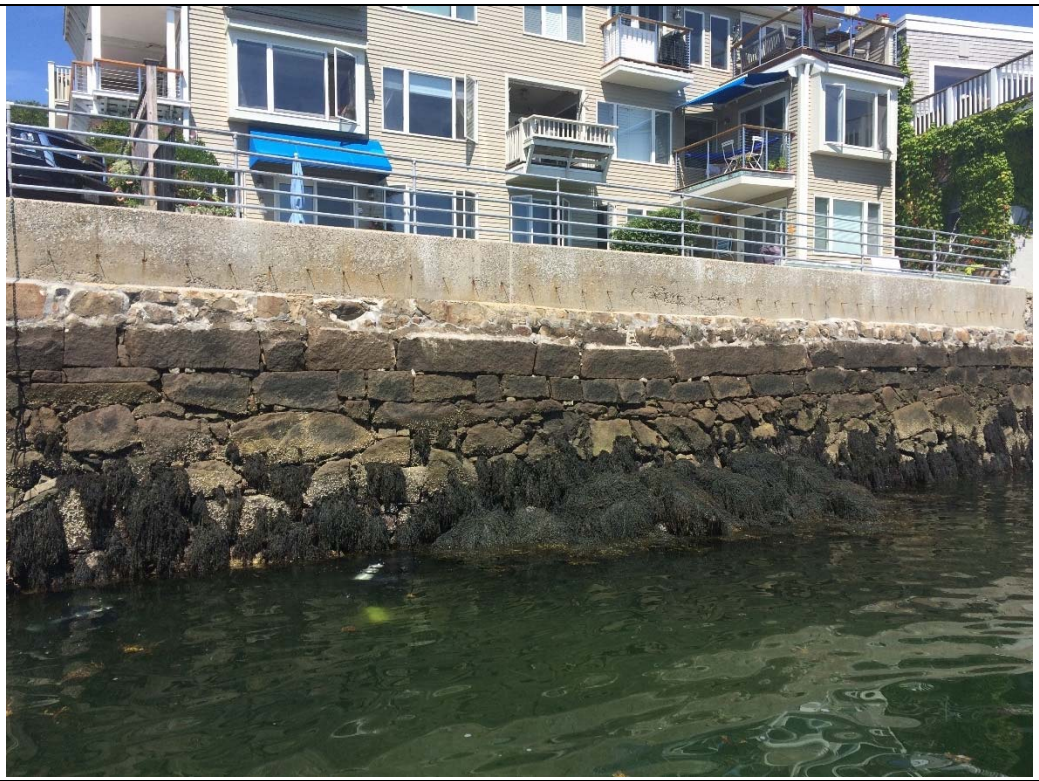
Direction Photo Taken:
Aerial

Description:
Aerial image of the site (Bing Maps).

Photo No.	**Date:**
2	08/09/16

Direction Photo Taken:
North

Description:
Existing (wall type 1) at northern end of property. Note prior settlement in upper stone layers and added stone fronting the wall.



Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
3	08/09/16

Direction Photo Taken:
Northeast

Description:
Existing seawall (wall types 1, 2, 3 and 4 from right to left) at northern gangway. Note crack in top of planter.

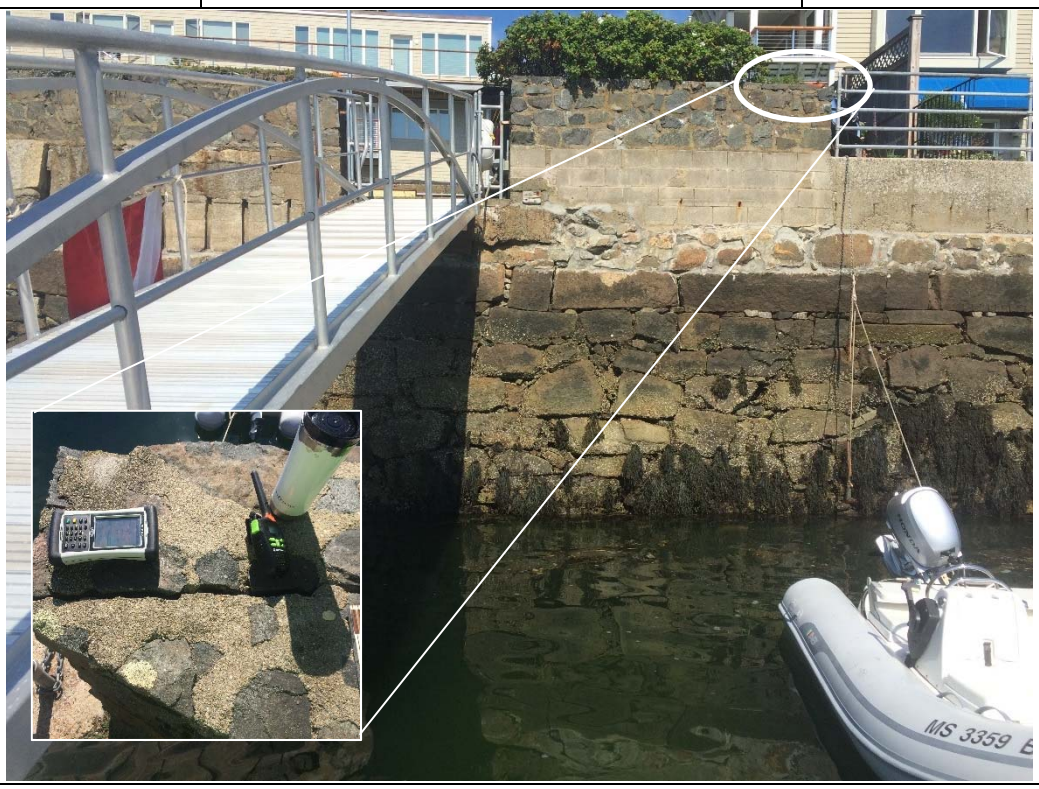
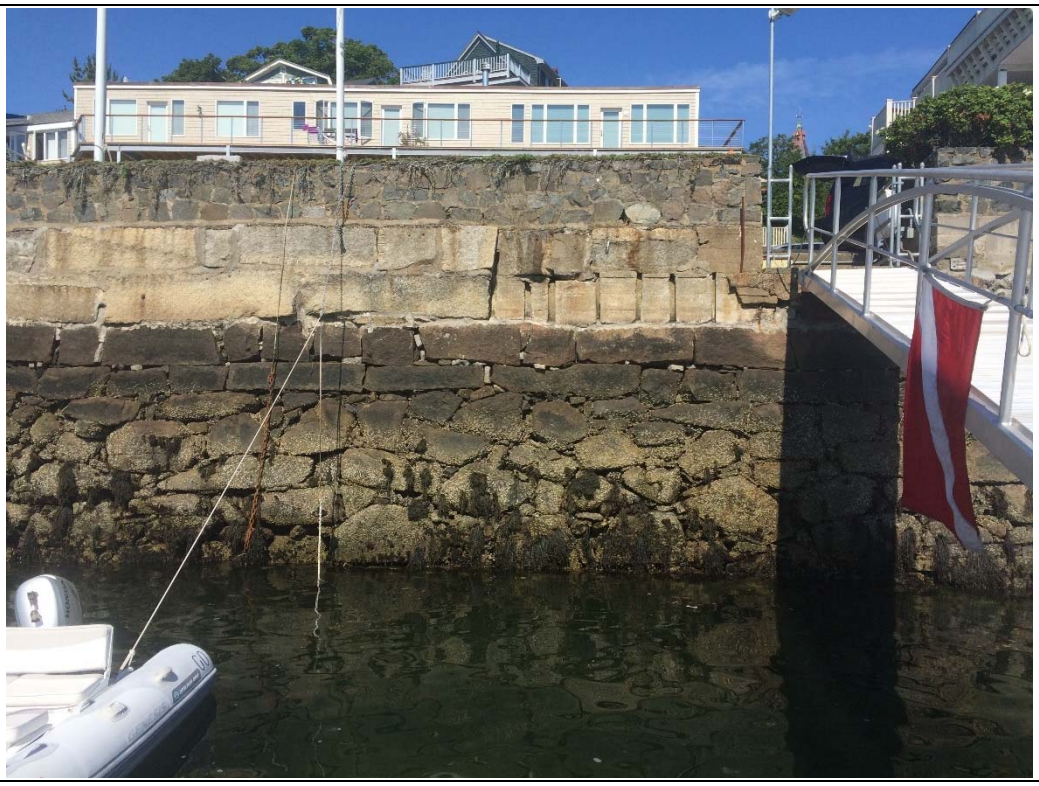


Photo No.	**Date:**
4	08/09/16

Direction Photo Taken:
Northeast

Description:
Existing seawall (wall types 3 and 4 from right to left) seaward of parking lot.



Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
5	08/09/16

Direction Photo Taken:
East

Description:
Existing seawall (wall type 4) seaward of parking lot.

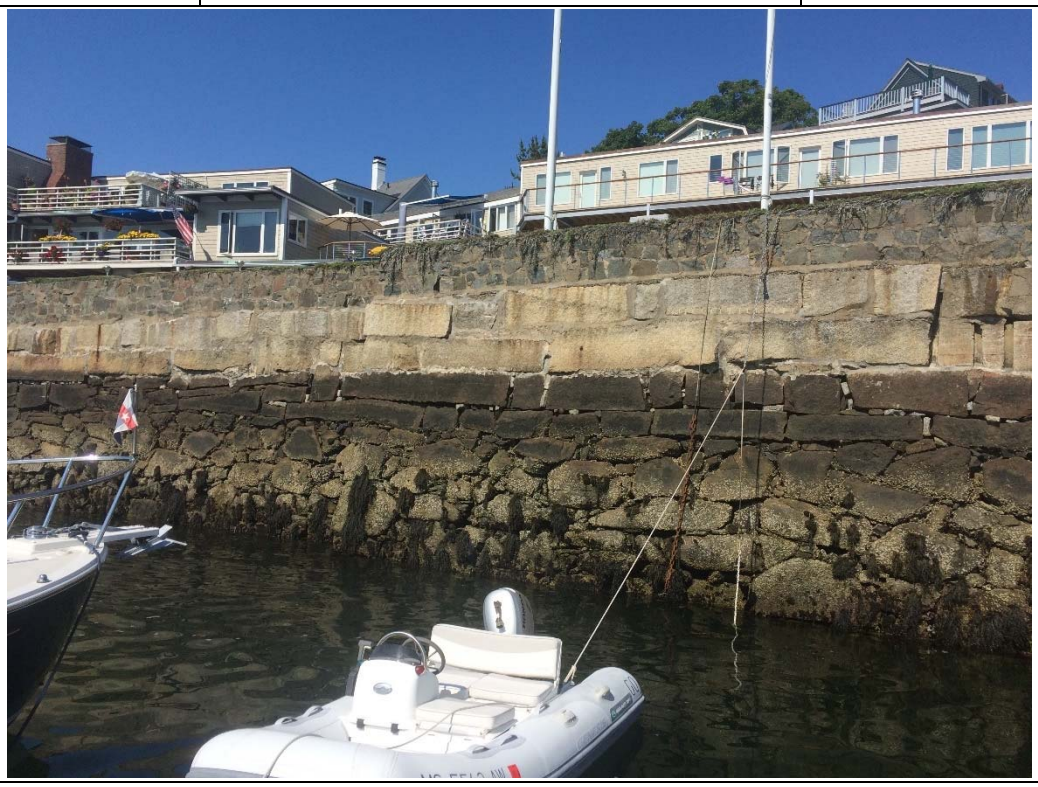
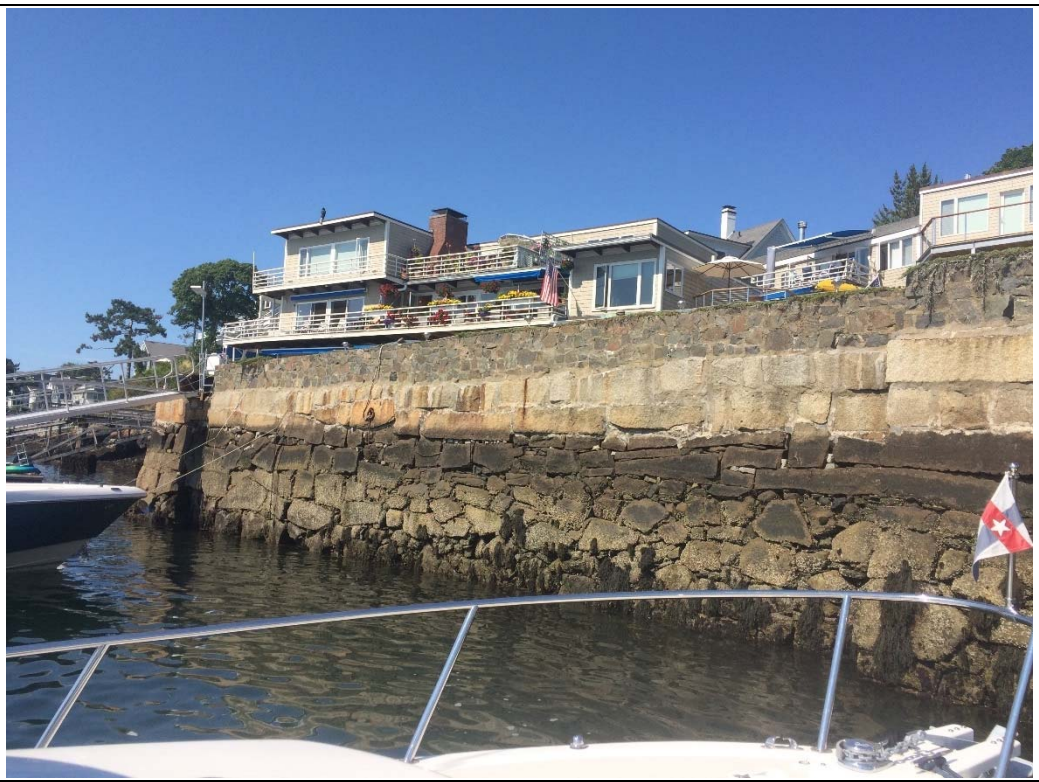


Photo No.	**Date:**
6	08/09/16

Direction Photo Taken:
Southeast

Description:
Existing seawall (wall types 4 and 5 from right to left) seaward of parking lot.



Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
7	08/09/16

Direction Photo Taken:
Northeast

Description:
Existing seawall and revetment (wall types 5 and 6 from right to left) at corner.

Photo No.	**Date:**
8	08/09/16

Direction Photo Taken:
Southeast

Description:
Existing stone riprap and seawall (wall types 6 and 7 from right to left).

Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
9	08/03/16

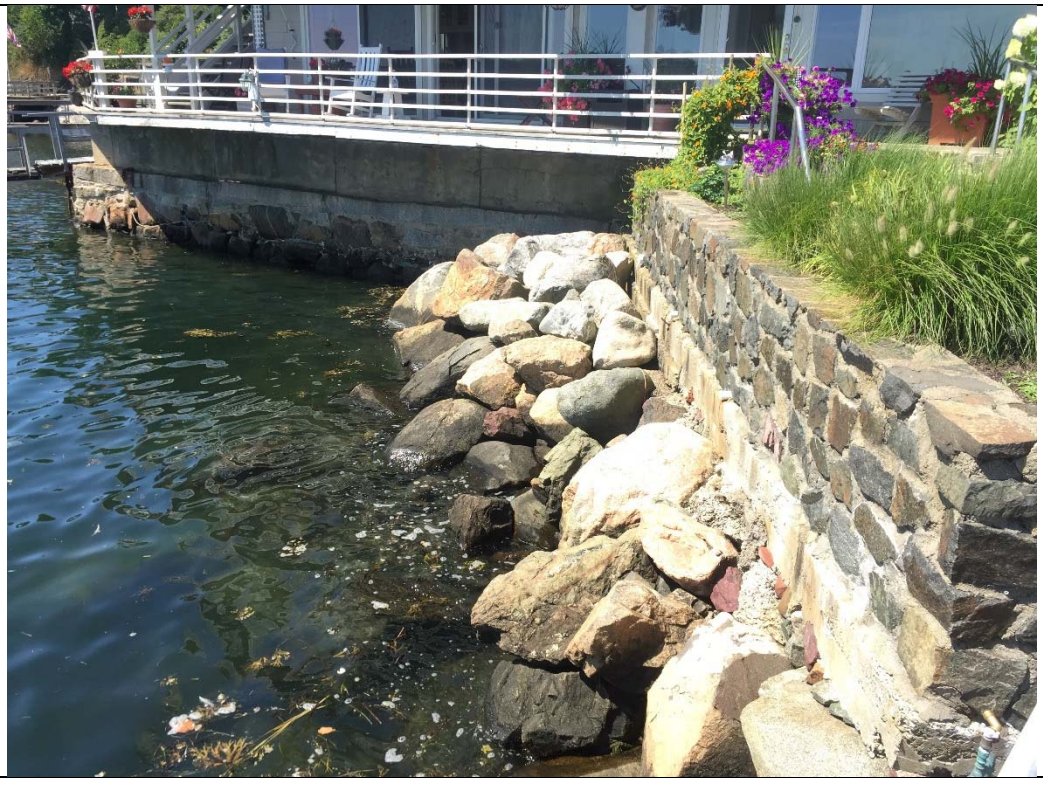
Direction Photo Taken:
North

Description:
Existing seawall (wall type 4) seaward of parking lot.

Photo No.	**Date:**
10	08/03/16

Direction Photo Taken:
Southeast

Description:
Existing stone and concrete with large stone riprap (wall types 6 and 7 from right to left).



Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
11	08/03/16

Direction Photo Taken:
South

Description:
Existing seawall planter with landscaping and parking lot (wall type 4).

Photo No.	**Date:**
12	08/09/16

Direction Photo Taken:
South

Description:
View of granite and stone wall face from water.

Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
13	08/09/16

Direction Photo Taken:
North

Description:
View of granite and stone wall face at bump out.

Photo No.	**Date:**
14	08/09/16

Direction Photo Taken:
-

Description:
View of underside of condominium deck and concrete foundation/wall beneath.

Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
15	08/03/16

Direction Photo Taken:
North

Description:
Apparent northern float connection into concrete section of existing wall.

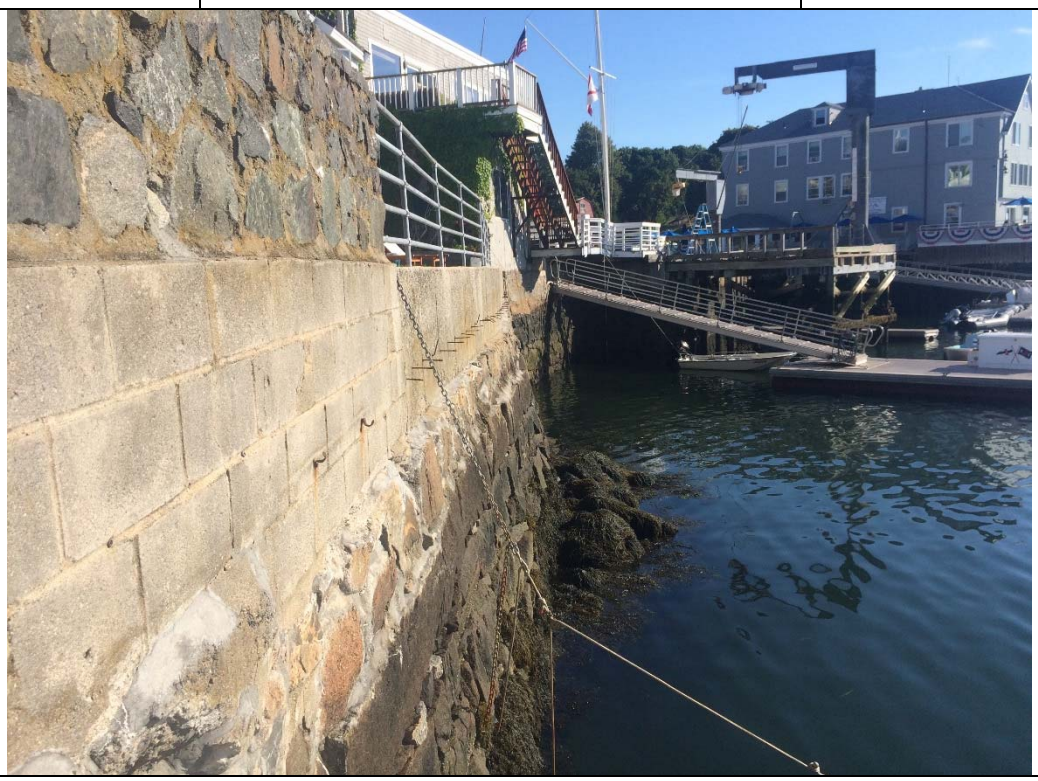
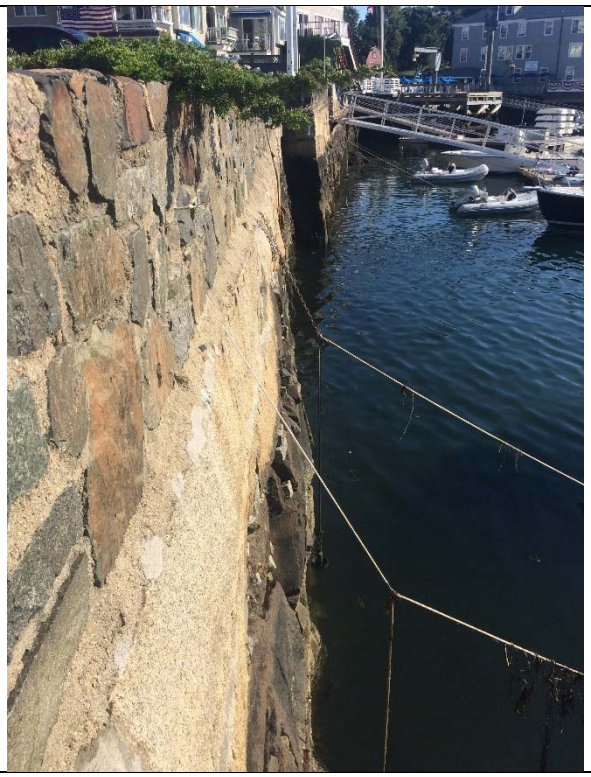


Photo No.	**Date:**
16	08/03/16

Direction Photo Taken:
North

Description:
Apparent southern float connection into mortared section of existing wall.



Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
17	08/09/16

Direction Photo Taken:
West

Description:
Area below southern gangway connection. Note aligned vertical joints in adjacent courses of stone and void at bottom.

Photo No.	**Date:**
18	08/09/16

Direction Photo Taken:
West

Description:
Void near bottom of wall below southern gangway connection.

Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
19	08/09/16

Direction Photo Taken:
West

Description:
Void near bottom of wall below southern gangway connection. (Same void as Photograph 18, different angle).

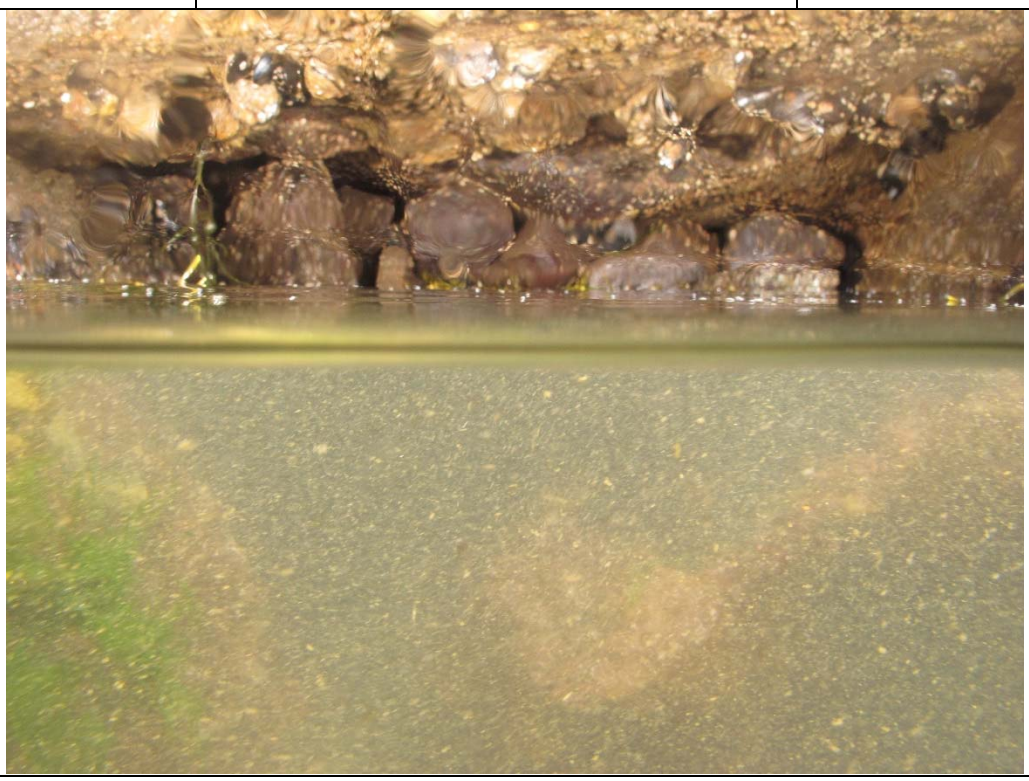


Photo No.	**Date:**
20	08/09/16

Direction Photo Taken:
West

Description:
Void between courses near MLW approximately 10 feet south of the northern gangway.

Photographic Log

Client Name: Lesley Management	**Site Location:** 24 Lee Street Marblehead, MA	**Project No.** 18.0172708.00

Photo No.	**Date:**
21	08/03/16

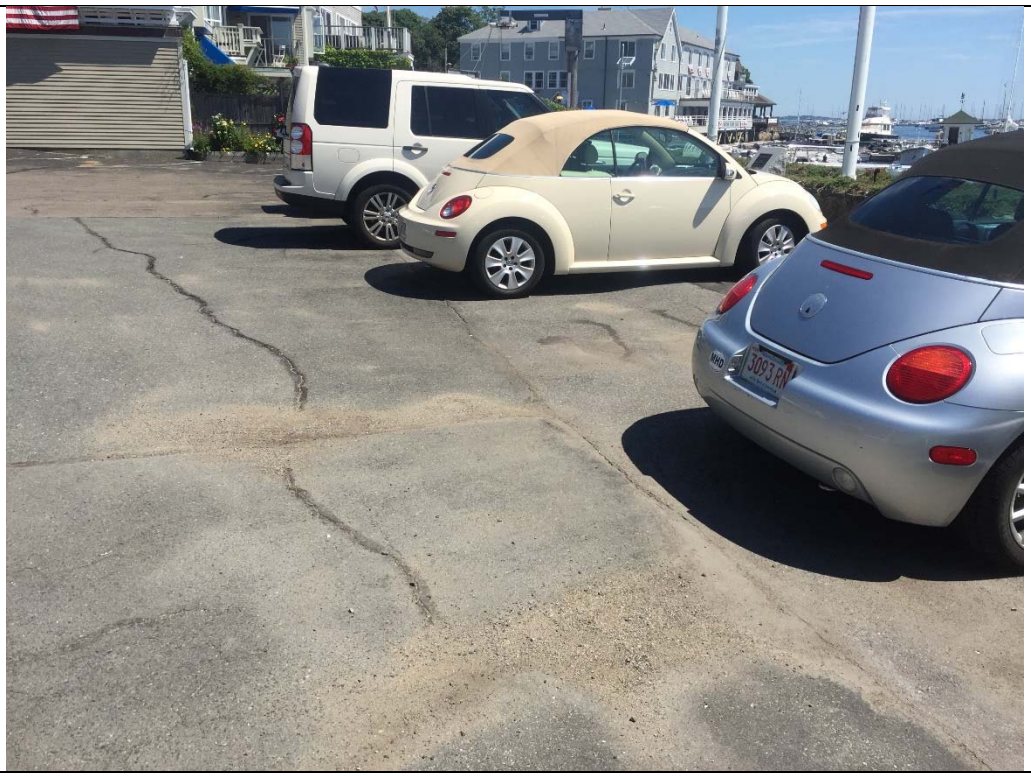
Direction Photo Taken:
South

Description:
Depressions, sinkholes and cracking of pavement in parking area.

Photo No.	**Date:**
22	08/03/16

Direction Photo Taken:
North

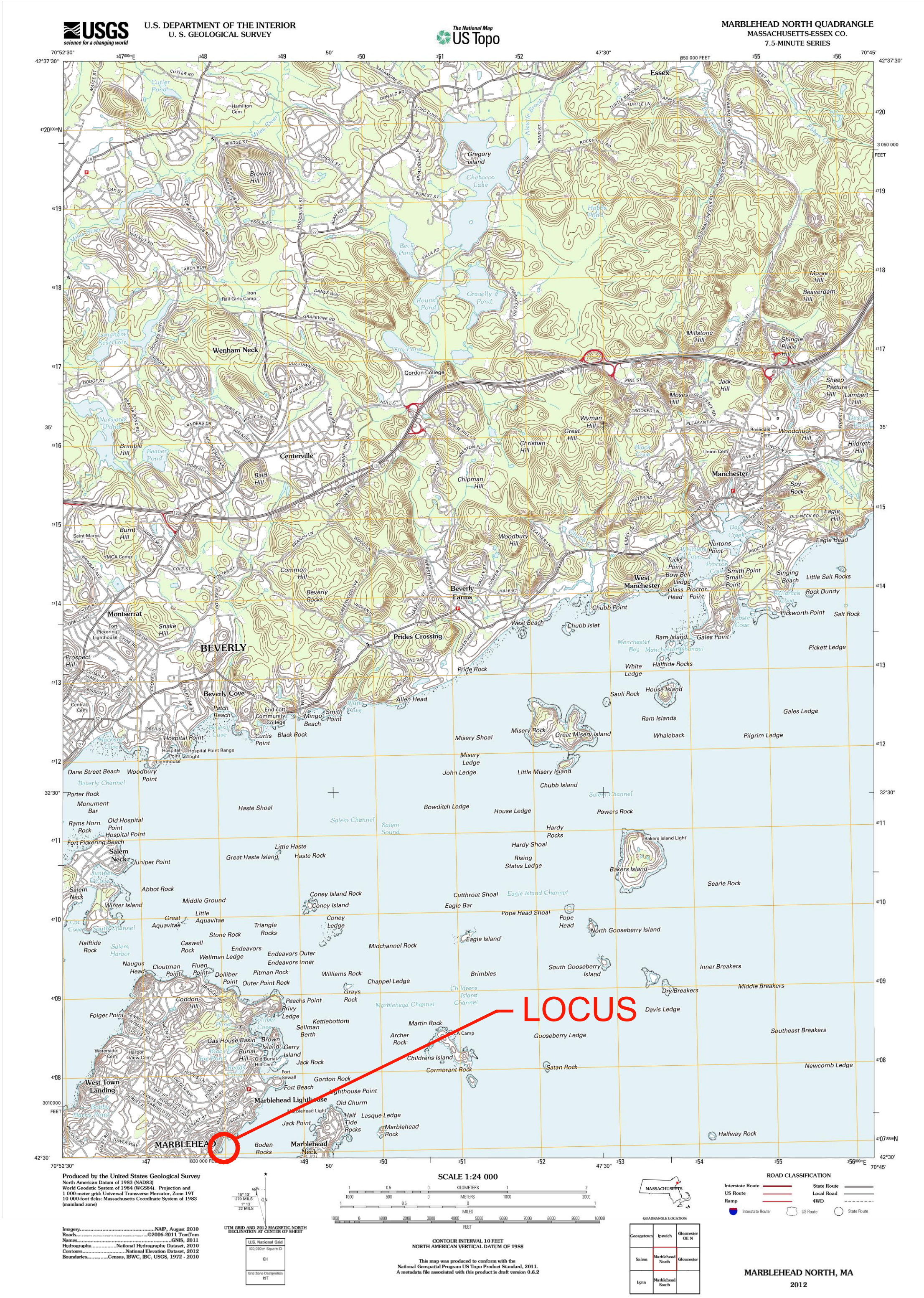
Description:
Depressions, sinkholes and cracking of pavement in parking area.



Appendix C – Figure

Figure 1. Locus Plan

Figure 2. Existing Conditions Plan



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NO.	ISSUE/DESCRIPTION	BY	DATE

LESLEY MANAGEMENT HARBORSIDE CONDOMINIUMS
24 LEE STREET
MARBLEHEAD, MASSACHUSETTS

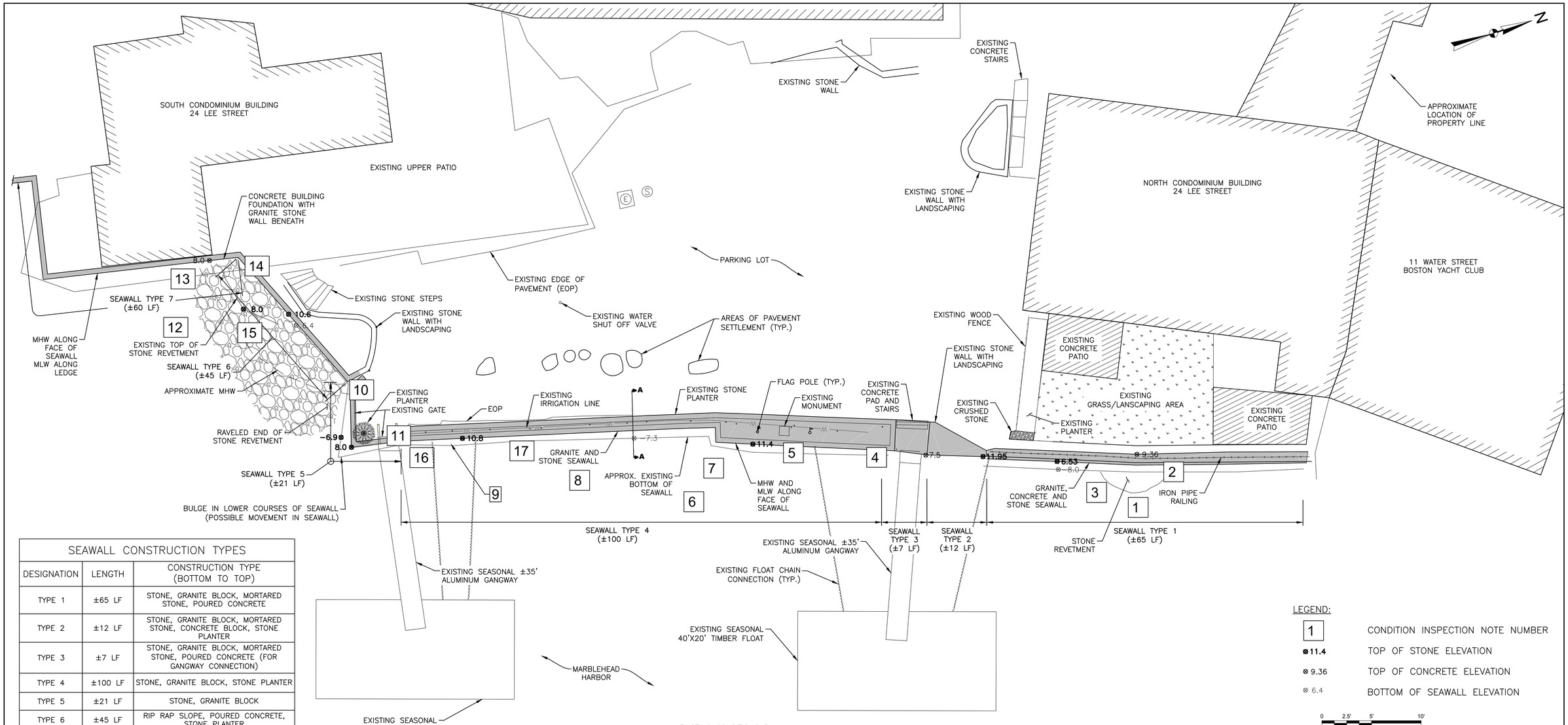
PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
LESLEY MANAGEMENT
24 LEE STREET
MARBLEHEAD, MASSACHUSETTS 01945

LOCUS PLAN

PROJ MGR: DAS	REVIEWED BY: PJW	CHECKED BY: ABB	FIGURE
DESIGNED BY: DAS	DRAWN BY: LT/RKT	SCALE: AS SHOWN	1
DATE: FEBRUARY, 2017	PROJECT NO. 18.0172708.00	REVISION NO.	SHEET NO. 1 OF 2

© 2016 – GZA GeoEnvironmental, Inc. GZA-J:\172700's\18.0172708.00 Harborside Condo\Figures-CAD\18.0172708.00 – Lesley Management_Seawall_recover.dwg [FIG 1 – LOCUS PLAN] February 15, 2017 – 2:01pm josh



SEAWALL CONSTRUCTION TYPES		
DESIGNATION	LENGTH	CONSTRUCTION TYPE (BOTTOM TO TOP)
TYPE 1	±65 LF	STONE, GRANITE BLOCK, MORTARED STONE, POURED CONCRETE
TYPE 2	±12 LF	STONE, GRANITE BLOCK, MORTARED STONE, CONCRETE BLOCK, STONE PLANTER
TYPE 3	±7 LF	STONE, GRANITE BLOCK, MORTARED STONE, POURED CONCRETE (FOR GANGWAY CONNECTION)
TYPE 4	±100 LF	STONE, GRANITE BLOCK, STONE PLANTER
TYPE 5	±21 LF	STONE, GRANITE BLOCK
TYPE 6	±45 LF	RIP RAP SLOPE, POURED CONCRETE, STONE PLANTER
TYPE 7	±60 LF	STONE, GRANITE BLOCK, POURED CONCRETE (FOR BUILDING FOUNDATION)

CONDITIONS INSPECTION NOTES	
1	REVETMENT EXTENDS APPROX. 10' FROM FACE OF SEAWALL
2	1'X1'X4' DEEP VOID, APPROX. 1' ABOVE MUDLINE
3	2.5'X1'X1.5' DEEP VOID AT MUDLINE
4	1.5'X0.75'X3' DEEP VOID AT ±2' FROM MUDLINE (HEAVY MARINE GROWTH)
5	1.5'X0.75'X3' DEEP VOID AT MUDLINE
6	±9' OF WATER DEPTH AT SEAWARD END OF REVETMENT
7	±3' DIAMETER MOORING BLOCK APPROX. 4' OFFSET FROM WALL WITHIN REVETMENT
8	4'X4'X2' THICK MOORING BLOCK
9	1.5'X1.5'X4' DEEP VOID APPROX. 1' ABOVE MUDLINE
10	APPROX. 5' OF WATER DEPTH AT SEAWARD END OF REVETMENT
11	2'X1.5'X3' DEEP VOID (SOME LARGER STONES, BUT MOSTLY 12" MINUS)
12	MOORING BLOCK VISIBLE ABOVE LOW TIDE
13	SEAWALL SET ON BEDROCK ABOVE MUDLINE LOW TIDE
14	1'X2'X2' DEEP VOID AT TOP OF BEDROCK
15	4'X4' MOORING BLOCK
16	1'X1'X6'+ VOID AT MUDLINE
17	PROBE 4' INTO SEAWALL AT MUDLINE

LEGEND:

1	CONDITION INSPECTION NOTE NUMBER
⊗11.4	TOP OF STONE ELEVATION
⊗ 9.36	TOP OF CONCRETE ELEVATION
⊗ 6.4	BOTTOM OF SEAWALL ELEVATION

0 2.5' 5' 10'
SCALE IN FEET 1" = 5'

0 5' 10' 20'
SCALE IN FEET 1" = 10'

REPORT FIGURE
NOT FOR CONSTRUCTION

NOTES:

1. DATUM: ELEVATIONS SHOWN REFER TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88): NAVD88=0.0, MLW=-5.06, MHW=3.84, FEMA 100-YR FLOOD=16.0.
2. LIMITED TOPOGRAPHIC SURVEY AND ABOVE WATER INSPECTION PERFORMED BY GZA GEOENVIRONMENTAL, INC. ON AUGUST 3, 2016 AND REPRESENTS CONDITIONS AT THE TIME OF THE SURVEY.
3. UNDERWATER INSPECTION PERFORMED BY GZA GEOENVIRONMENTAL, INC ON AUGUST 9, 2016 AND REPRESENTS CONDITIONS AT THE TIME OF THE INSPECTION.
4. UNDERGROUND UTILITIES ARE NOT SHOWN ON THIS PLAN.
3. AERIAL IMAGE TAKEN FROM MASSGIS ORTHOPHOTOS (2013/2014)
4. LIMITED SITE FEATURES TRACED FROM AERIAL IMAGE.
5. PLAN TO ACCOMPANY SEAWALL CONDITION ASSESSMENT FINAL REPORT, DATED FEBRUARY 2017.

NO.	ISSUE/DESCRIPTION	BY	DATE
1	FINAL REPORT	JJZ	2/13/17

LESLEY MANAGEMENT HARBORSIDE CONDOMINIUMS
24 LEE STREET
MARBLEHEAD, MASSACHUSETTS

EXISTING CONDITIONS PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
LESLEY MANAGEMENT HARBORSIDE CONDO
24 LEE STREET
MARBLEHEAD, MASSACHUSETTS 01945

PROJ MGR: DAS	REVIEWED BY: PJW	CHECKED BY: ABB	FIGURE 2
DESIGNED BY: DAS	DRAWN BY: LT/RKT	SCALE: AS SHOWN	SHEET NO. 2 OF 2
DATE: NOVEMBER 2016	PROJECT NO. 18.0172708.00	REVISION NO. FEBRUARY 2017	

GZA GeoEnvironmental, Inc.