Proactive by Design

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

35 Nutmeg Drive
Suite 325
Trumbull, CT 06611
203-380-8188
www.gza.com

June 23, 2017
File No. 05.0045937.00

Mr. Stephen M. Savarese, P.E., L.S.
Civil Engineer
City of New London
34 Middletown Avenue
New London, CT 06513

Re: Letter Condition Survey Report for the Shaw's Cove Bulkhead
Shaw's Cove, New London, CT

Dear Mr. Savarese:

GZA GeoEnvironmental, Inc. (GZA), performed an investigation of the Shaw's Cove bulkhead located on the north side of Shaw's Cove. The investigation consisted of a visual review of the above and below water steel surfaces, ultrasonic thickness readings, and a cathodic protection review.

This letter report presents the results of GZA's investigation of approximately 290 linear feet of steel bulkhead and provides several options and order of magnitude cost for the repair of the bulkhead substructure. This investigation was conducted at the request of the City of New London upon the Army Corp of Engineer's (ACOE) identification and report of existing conditions. The ACOE reported that the existing conditions of the bulkhead were suspect and requested that an evaluation and possible repairs be performed.

EXISTING PROJECT INFORMATION

GZA reviewed existing documentation relative to the subject bulkhead. These included design plans and specifications dated February 1982 and titled Hurricane Protection Project New London. These plans presented the bulkhead configuration and results of several test borings previously completed for the project.

STRUCTURE DESCRIPTION

This site is composed of approximately 290 linear feet of steel sheetpile bulkhead that was constructed in the early 1980s (See Photograph 1). Review of the original construction drawings found the bulkhead was constructed of PZ-38 sheeting approximately forty (40) feet long with a C15x33.9 channel along the cap. A continuous 12x12 timber curb is mounted to the top of the steel channel cap. The drawings indicate that the bulkhead is restrained laterally, by tie rods that are anchored to a pile supported, reinforced concrete floodwall wall located some 26 feet inland of (behind) the bulkhead. Lateral forces are transmitted from the bulkhead, to the tie rods,

through a horizontal double channel wale that extends along and is bolted to the inboard (buried) face of the sheetpiles.

Caissons (two earth filled sheet pile cells) were installed near the eastern end of the bulkhead around 1982. This extended the footprint of the berthing structure seaward. Stone slope revetments abut the eastern and western ends of the existing bulkhead. The exposed height of the bulkhead varies from 6.0 feet to 18.4 feet, with the top of the bulkhead at approximately elevation +6.0 Mean Low Water (MLW) datum.

The bulkhead supports earth fill and protects a slab-on-grade concrete deck and floodwall landward of the bulkhead. An impressed current, cathodic protection system was observed in the backland area of the bulkhead as well as along the face of the bulkhead. GZA was unable to determine if the system is active. The status of maintenance or upkeep of the cathodic protection system is also unknown however, spare sacrificial anodes were observed piled along the base of the concrete floodwall. Drains were observed along the face of the bulkhead but it is unclear as to the point of origin of the drains. A large diameter rubber fender is located along the bulkhead east of the caissons. A timber fendering system is attached to both main caissons. Remnants of the mounting brackets for the original timber fendering system along the face of the bulkhead were also observed during the inspection.

For the purposes of this inspection, the bulkhead has been separated into three zones: bulkhead west of caissons, the caissons, and bulkhead east of caissons. It should be noted that the inspection was limited to approximately 188 linear feet of the full 290 linear feet of the main bulkhead due to the bulkhead sheeting being fronted by the caissons and the revetment.

INSPECTION PROGRAM

Structural Condition Assessment

Prior to conducting the field inspection work, GZA personnel reviewed available site information associated with the structure. The same stationing system used in prior documents was used to locate features and document conditions in our field inspection notes.

The above-water and below-water inspection included visual and tactile inspection of the accessible portions of the steel sheetpile bulkhead. The inspection procedure included documentation of the existing conditions by field notes, photography, videography and Ultrasonic Thickness (UT) measurements of the steel sheetpiles. Access to the structure was from the top of the existing bulkhead and from the GZA-owned 20-foot survey/dive vessel.

The underwater inspection was performed in accordance with OSHA Subpart T – Commercial Diving Directives and the American Society of Civil Engineers, Underwater Investigations, ASCE Waterfront Facilities Inspection and Assessment Manual No. 130. Underwater dive operations were performed during the day in approximately 0 to 15-foot water depths with 38-degree water temperature and approximately 5 to 10-foot visibility.

Underwater dive operations were performed by experienced divers utilizing Self Contained Underwater Breathing Apparatus (SCUBA) equipment. Inspection limitations are indicated in **Appendix A.**

The underwater inspection included a Level I, Level II and Level III inspection as defined in the Waterfront Inspection Manual No. 103. The Level I inspection is generally referred to as a "swim-by" inspection, performed to the level of detail necessary to detect obvious major damage or deterioration due to overstressing or other severe deterioration. For this inspection 100 percent of the steel sheetpile bulkhead was included in the Level I inspection. A Level II inspection involved the removal of marine growth on portions of the bulkhead face at three elevations and focused on typical areas of weakness such as connections, attachment points, and welds. The Level II inspection is intended to detect and identify damaged and deteriorated areas that may be hidden by surface biofouling, coating, or corrosion. A Level III inspection is a detailed inspection, typically involving nondestructive or partially destructive testing to detect hidden or interior damage or to evaluate material homogeneity. The Level III inspection included additional cleaning and limited removal of coating to perform UT measurements along the face of the bulkhead. UT measurements were recorded at approximately 15-foot intervals along the bulkhead with four measurements at each interval: at the mudline, below the approximate low water mark, within the intertidal zone, and in the upper splash zone. See the cross section in **Appendix A** for the approximate locations of the UT measurements.

The bulkhead was 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	Limited 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 are 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.
2 - Serious	Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components.

Table 1 - Condition Rating Assessment	
Rating	**Description**
	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 2-14 Condition Assessment Ratings. From the Waterfront Facilities Inspection and Assessment Manual, as published in the ASCE Manuals and Reports on Engineering Practice No.130, Copyright 2015.

Documentation

The documentation of the 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 A**.

Non-Destructive Testing

Based on the observed conditions of the underwater and above-water portions of the steel sheetpile bulkhead, normal cleaning of the steel associated with a Level II inspection was performed. Additionally, non-destructive testing was performed on the steel sheetpile bulkhead using an ultrasonic thickness (UT) meter to measure the thickness of the steel at the locations and frequency described above. The UT meter used during this inspection was a Krautkramer Branson DMS 2 unit with a 0.5-inch, 2.25 MHz duel element transducer. The UT measurement readings are presented below. The UT measurement readings are presented in **Appendix A**.

Cathodic Protection

GZA hired HMI Technical Solutions to review the existing cathodic protection system and provide recommendations and design of a repair or replacement system. HMI's report, analysis and cost estimate are provided in **Appendix B**.

EXISTING CONDITIONS

The observations below are based on above-water and underwater inspection on the steel sheetpile bulkhead. Refer to Figure No. 1 for stationing and photograph locations.

BULKHEAD WEST OF CAISSON

The bulkhead to the west of the caissons is approximately 150 linear feet and varies in exposed height from approximately 6.0 to 10.0 feet. This portion of the bulkhead was observed to be in **Fair** condition. The face of the bulkhead was sounded with a hammer during the Level I and II inspection. Hollow sounds were heard during the sounding at the following locations: Station 20+46 approximately 5 feet below the timber curb and at Station 20+69 approximately 4.5 feet below the timber curb on the web and 5.5 feet below the timber curb on the outer flange. The hollow sound at approximate Station 20+46 near the corner of the bulkhead was located just below a steel plate and possible patch of the sheetpile.

Iron oxide was observed along the face of the steel sheetpiles between the mudline and approximate Mean Low Water elevation (subtidal). In general, scraping at the iron oxide locations revealed smooth steel with minor pitting (See Photograph 7 through 9). Minor marine growth was observed in the subtidal zone along the bulkhead. The tidal and splash zones were observed to be corroded with loss of coating and delamination and corrosion of steel. It should be noted that readings and observations along the western end of the bulkhead was limited along the length due to shallow water.

CAISSONS

The caissons along the bulkhead extend approximately 30 feet seaward from the face of the bulkhead, and measure approximately 125 linear feet from the end of the eastern end of the bulkhead to the western end of the bulkhead. The caissons vary in exposed height from approximately 10 to 18.4 feet. The caissons were observed to be in **Satisfactory** condition. Little to no iron oxide was observed along the caisson sheeting in the subtidal zone. Minor marine growth was observed within the subtidal zone. The sheeting was observed to be smooth with generally intact coating. Removal of coating during the Level III inspection revealed smooth steel with no pitting observed. A timber fender system bolted to the steel sheeting was observed along the seaward face of the caissons, approximately 25 feet in length, and extends to approximately 1 foot below approximate low water level (See Photograph 4). The tidal and splash zones were observed to be somewhat corroded with loss of coating and steel. See Photograph 6 for typical tidal and splash zone conditions.

BULKHEAD EAST OF CAISSONS

The bulkhead to the east of the caissons is approximately 60 linear feet long and varies in exposed height from approximately 8.5 to 11.0 feet. This portion of the bulkhead was observed to be in **Fair** condition. Minor areas of iron oxide were observed within the subtidal zone along this portion of the bulkhead however, heavier marine growth was present as compared to the bulkhead west of the caissons. Scraping and removal of the coating during the Level III inspection revealed smooth steel with minor pitting. The tidal and splash zones were observed to be corroded with loss of coating and delaminated and corroded steel. See Photograph 6 for typical tidal and splash zone conditions.

ULTRASONIC THICKNESS (UT) READINGS

The original construction drawings from the U.S. Army Corps of Engineers sheet titled "New London Hurricane Protection, Shaw Cove, Dike and Appurtenant Structures, Flood Wall Details" with a revision date of April 16, 1979 shows the bulkhead was constructed with PZ-38 steel sheetpiles. The flange thickness and web thickness of this section of sheet pile is 0.5 inches and 0.375 inches respectively, per the USS Steel Sheet Piling Design Manual dated July 1984.

During the recent investigations, ultrasonic thickness (UT) readings were performed at the mudline, below approximate low water, within the tidal zone, and within the upper splash zone. Steel thickness was measured at these four vertical locations at approximately 15 feet on center along the face of the bulkhead. The approximate locations on the vertical bulkhead profile are shown in the typical section in **Appendix A**. The results of the testing program indicated an average flange thickness of 0.506 inches, a minimum flange thickness of 0.404 inches, an average web thickness of 0.306 inches and a minimum web thickness of 0.248 inches. The average caisson wall thickness was found to be 0.366 inches with a minimum thickness of 0.342 inches. The minimum flange thickness reading was taken at the hollow sounded location at Station 20+46 of the bulkhead west of the caissons. The results and approximate station location along the bulkhead are presented in the table in **Appendix A**.

The overall condition of the steel sheetpile bulkhead is **Satisfactory**. A portion at the corner of the bulkhead west of the caissons was observed to be in **Fair** condition at the location of a previous repair. UT readings in this location revealed section loss in the intertidal zone to be approximately 0.1 inches. A hollow sound was heard when this location was sounded with a hammer during the Level I and II inspection.

RECOMMENDATIONS

GZA has completed our evaluation of the existing steel sheetpile bulkhead. The evaluation included wall stability calculations for several loading conditions. These were based on subsurface information contained in the original project plans and observations made during our site visits. In general, the evaluations indicate that there has been minimal corrosion and that the bulkhead is stable.

GZA also evaluated the results of these stability analyses with consideration towards future material loss due to corrosion and benefits of proactive maintenance, now or scheduled for future actions. Three mitigation/maintenance options were developed as appropriate actions for the bulkhead. Order of magnitude cost estimates were developed for each option developed. These costs are based on the engineering work completed to date and should be consider for planning level efforts.

The options are as follows:

Option 1

The overall condition of the sheetpile wall is **in Fair** condition. Analysis (refer to Appendix C) indicates that the wall has significant excess capacity to continue to support current load conditions, regardless of the measured

minor loss of steel section, therefore, Option 1 would be to leave the wall as is and develop an inspection program to evaluate conditions on a periotic basis. This program should include above and below water inspection of the bulkhead with UT readings in the same areas as described in this letter report. We recommend that the wall be reevaluated every 5 years. Comparison of future readings with the December 2016 readings would enable the City to better determine the rate of corrosion and the point at which repairs should be undertalen.

Option 2

In this option, the goal would be to extend the service life beyond Option 1 by approximately 10 years. This option involves performing minor localized repairs at approximately eight locations throughout the length of the bulkhead at areas of reduced steel section. The repairs would involve the welding of new coated steel plates over the areas of reduced steel section to strengthen the sheets. GZA also recommends the City implement an inspection program similar to Option 1. Routine inspection should occur every five years to review further corrosion and coating damage.

Option 3

Option 3 is the more proactive program and is expected to prolong the life of the bulkhead by 20 or more if the system is maintained. This option calls for the repairs in Option 2, the addition of galvanic cathodic protection, and cleaning and recoating of the existing sheets above mean low water. The cathodic protection would include the addition of 64 Standard Aluminum anodes and 12 Shallow Water Aluminum anodes. All the anodes would weight 120 lbs.

The recoating of the sheets would require the sheets be cleaned and the existing coating removed above the mean low water line. Once the sheets are cleaned, they would be recoated with a marine grade epoxy coating.

GZA recommends that the City implement a Routine Inspection Program that will review the condition of the sheets including the coatings and cathodic protection. Providing the additional protection described in Option 3 should allow for a less frequent inspection interval, possibly 7 years rather than 3 to 5.

GZA GEOENVIRONMENTAL, INC.

Rodney J. Van Deusen, Jr.
Project Manager

Russel Morgan, P.E.
Senior Principal

Dino Fiscaletti, P.E.
Senior Consultant / Consultant Reviewer

Attachments: Figure 1 Existing Site Plan and Typical Section
Appendix A: Limitations
Appendix B: ….
Appendix C:…

APPENDIX A - CONDITION ASSESMENT

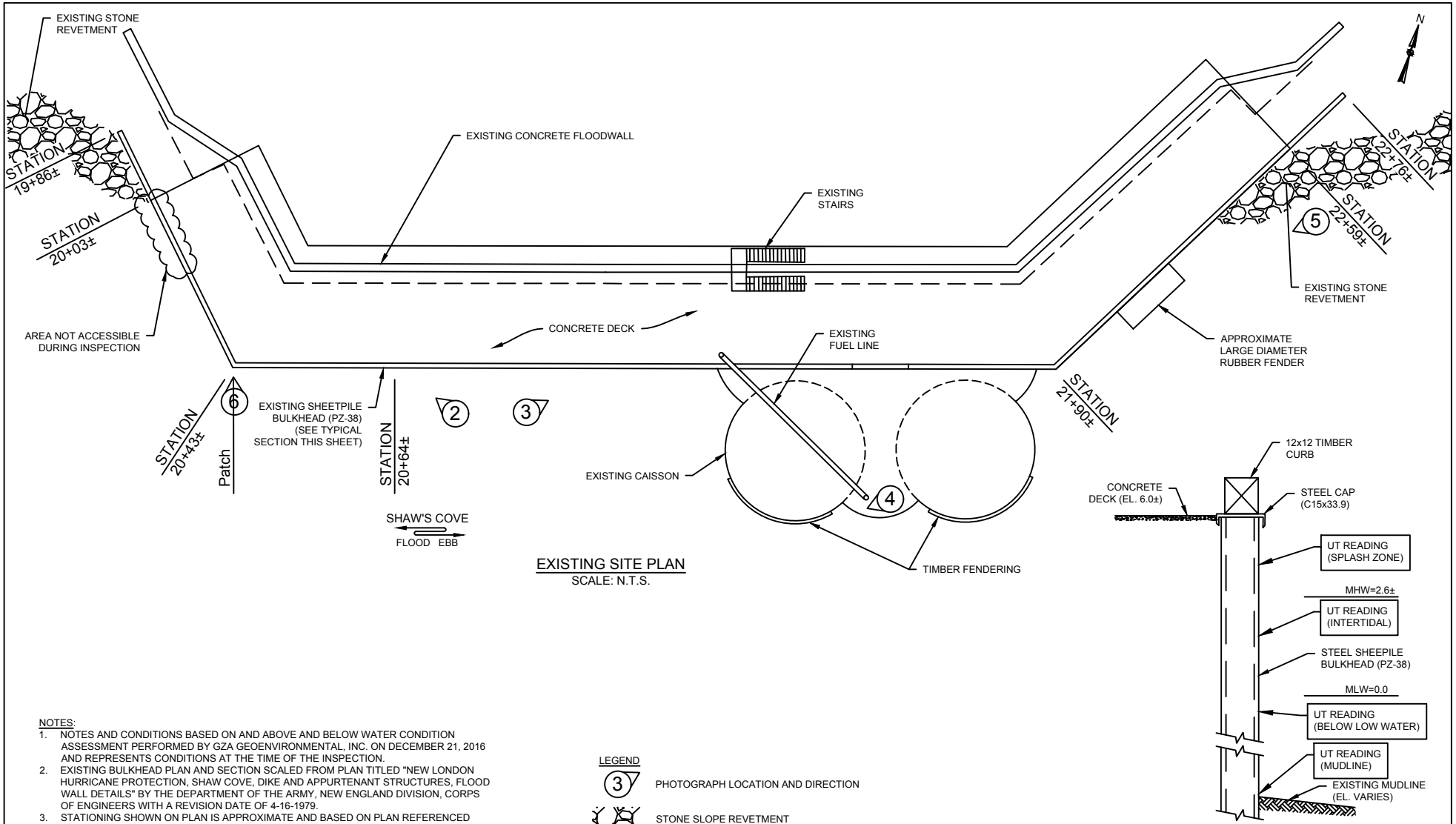
VISUAL INSPECTION LIMITATIONS

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 Memorandum, 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.

3. This memorandum has been prepared for the exclusive use of the City of New London for specific evaluation purposed in accordance with generally accepted inspection practices. No other warranty, expressed or implied, is made.

4. This inspection memorandum has been prepared for this project by GZA. This memorandum is for the City of New London's evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.



EXISTING SITE PLAN
SCALE: N.T.S.

TYPICAL BULKHEAD SECTION / APPROXIMATE LOCATION OF ULTRASONIC THICKNESS (UT) READINGS
SCALE: N.T.S.

NOTES:
1. NOTES AND CONDITIONS BASED ON AND ABOVE AND BELOW WATER CONDITION ASSESSMENT PERFORMED BY GZA GEOENVIRONMENTAL, INC. ON DECEMBER 21, 2016 AND REPRESENTS CONDITIONS AT THE TIME OF THE INSPECTION.
2. EXISTING BULKHEAD PLAN AND SECTION SCALED FROM PLAN TITLED "NEW LONDON HURRICANE PROTECTION, SHAW COVE, DIKE AND APPURTENANT STRUCTURES, FLOOD WALL DETAILS" BY THE DEPARTMENT OF THE ARMY, NEW ENGLAND DIVISION, CORPS OF ENGINEERS WITH A REVISION DATE OF 4-16-1979.
3. STATIONING SHOWN ON PLAN IS APPROXIMATE AND BASED ON PLAN REFERENCED ABOVE IN NOTE 2.
4. REFER TO APPENDIX C IN INSPECTION MEMORANDUM FOR PHOTOGRAPHIC LOG.

LEGEND
3 PHOTOGRAPH LOCATION AND DIRECTION
STONE SLOPE REVETMENT

NO.	ISSUE/DESCRIPTION	BY	DATE

SHAW'S COVE BULKHEAD INSPECTION
410 BANK STREET
NEW LONDON, CONNECTICUT

EXISTING SITE PLAN & TYPICAL SECTION

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

PREPARED FOR:
CITY OF NEW LONDON, CT

PROJ MGR: RVD	REVIEWED BY: DAS	CHECKED BY: RVD	FIGURE 1
DESIGNED BY: JJZ	DRAWN BY: JJZ	SCALE: N.T.S.	
DATE: JUNE, 2017	PROJECT NO. 05.0045937.00	REVISION NO.	SHEET NO. 1 OF 1

Appendix D - Ultrasonic Thickness Readings

Station	Mudline	Low Water	Intertidal	Splash Zone
20+23 ±	0.489	-	*0.360*	0.421
20+33 ±	0.491	-	0.470	-
20+43 ±	*0.249*	-	0.459	0.535
20+46 ±	0.449	-	0.404	0.480
20+58 ±	0.456	0.559	0.597	0.520
20+73 ±	*0.323*	*0.374*	0.505	0.565
20+88 ±	0.501	0.487	0.484	0.461
21+03 ±	0.488	0.511	0.507	*0.259*
21+18 ±	0.509	0.522	0.515	*0.248*
21+33 ±	0.531	0.521	0.557	*0.329*
21+48 ±	0.491	0.491	0.513	0.481
Caisson 12	0.364	0.361	-	0.373
Caisson 13	0.371	0.342	-	0.375
Caisson 14	0.371	0.369	0.365	0.368
21+90 ±	0.560	0.508	0.539	0.523
22+24 ±	0.597	0.510	0.494	0.521
	Thickness measurement in inches			

Notes:

1 Blank cells were locations that were inaccessible for reading.
2 Red numbers indicate lowest reading for each location.
3 Italic numbers represent readings obtained on sheetpile web.

Appendix C
Photographic Log

Client Name: City of New London	**Site Location:** Shaw's Cove, New London, CT	**Project No.** 05.0045937.00

Photo No.	**Date:**
1	May 2015

Direction Photo Taken:
Aerial Image (Google Earth)

Description:
Aerial image of site.

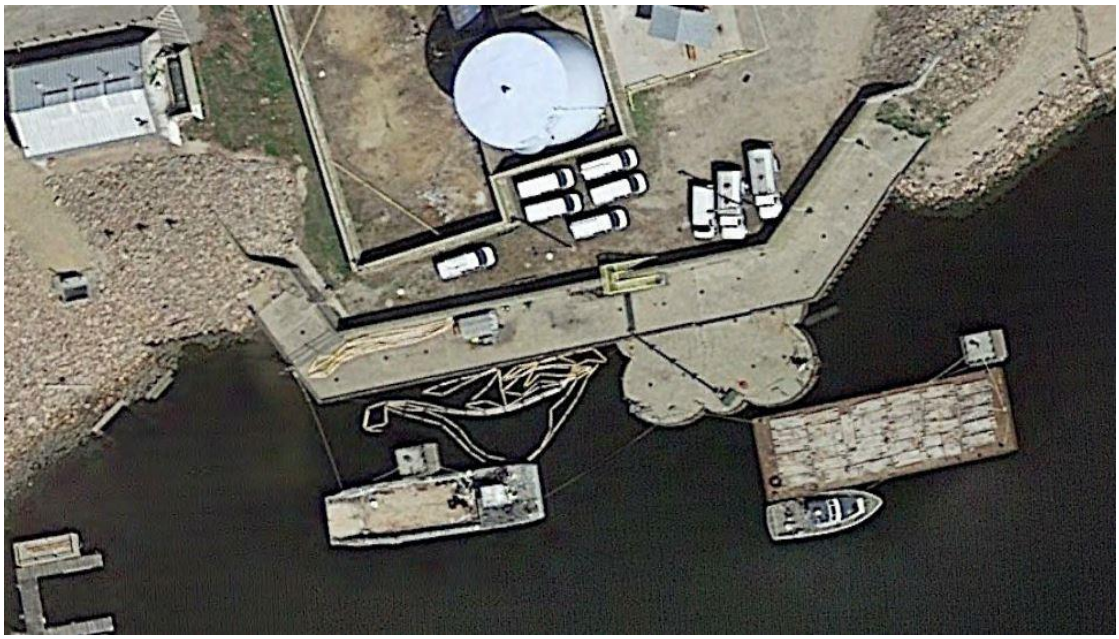


Photo No.	**Date:**
2	12-21-16

Direction Photo Taken:
Looking West

Description:
Existing conditions of bulkhead splash zone west of the caissons.

Appendix C
Photographic Log

Client Name: City of New London	**Site Location:** Shaw's Cove, New London, CT	**Project No.** 05.0045937.00

Photo No.	**Date:**
3	12-21-16

Direction Photo Taken:
Looking Northeast

Description:
Existing conditions of bulkhead splash zone west of the caissons. Note beginning of caissons.

Photo No.	**Date:**
4	12-21-16

Direction Photo Taken:
Looking Southwest

Description:
Typical condition at top of caisson.

Appendix C
Photographic Log

Client Name: City of New London	**Site Location:** Shaw's Cove, New London, CT	**Project No.** 05.0045937.00

Photo No.	**Date:**
5	12-21-16

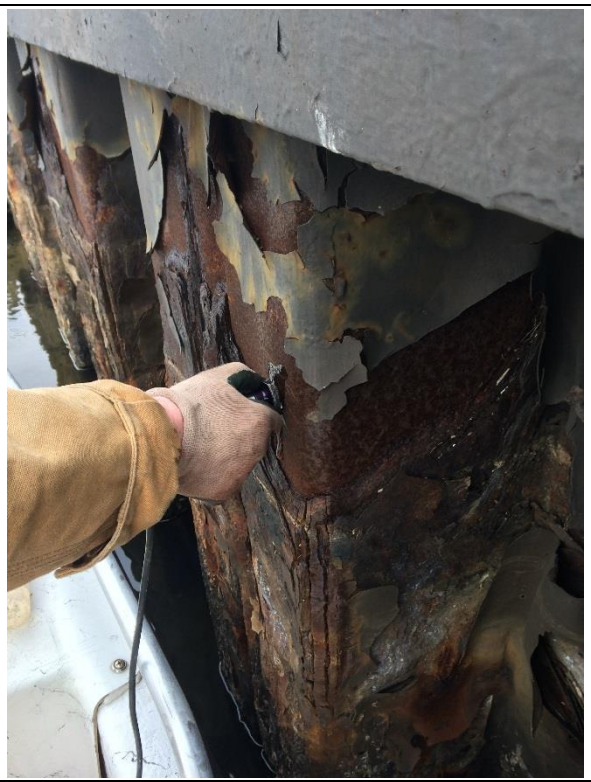
Direction Photo Taken:
Looking West

Description:
Existing condition of bulkhead splash zone east of the caissons.

Photo No.	**Date:**
6	12-21-16

Direction Photo Taken:
Looking North

Description:
Existing condition in upper splash zone at approximate Station 20+43. Splash zone UT reading being performed.



Appendix C
Photographic Log

Client Name: City of New London	**Site Location:** Shaw's Cove, New London, CT	**Project No.** 05.0045937.00

Photo No.	**Date:**
7	12-21-16

Direction Photo Taken:
Looking North

Description:
Observed iron oxide along bulkhead west of caissons and exposed steel. Photographs taken before and after cleaning.

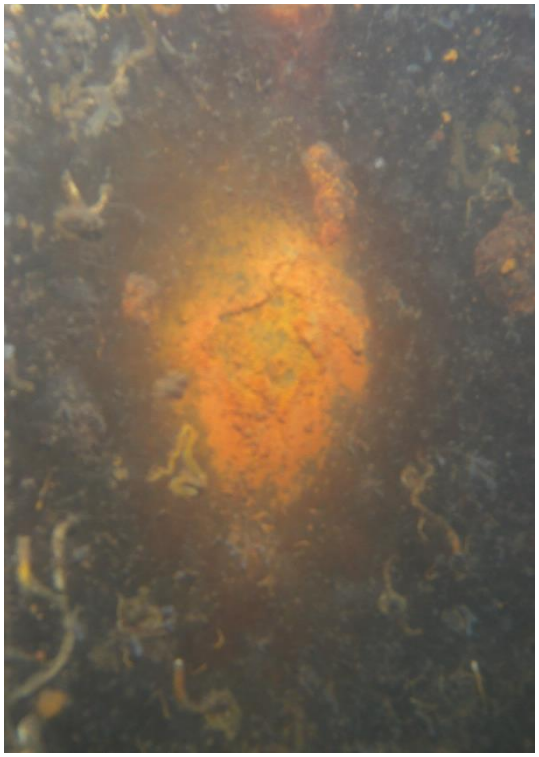


Photo No.	**Date:**
8	12-21-16

Direction Photo Taken:
Looking North

Description:
Observed iron oxide along bulkhead west of caissons and exposed steel. Photographs taken before and after cleaning.

Appendix C
Photographic Log

Client Name: City of New London	**Site Location:** Shaw's Cove, New London, CT	**Project No.** 05.0045937.00

Photo No.	**Date:**
9	12-21-16

Direction Photo Taken:
Looking North

Description:
Observed iron oxide at mudline.

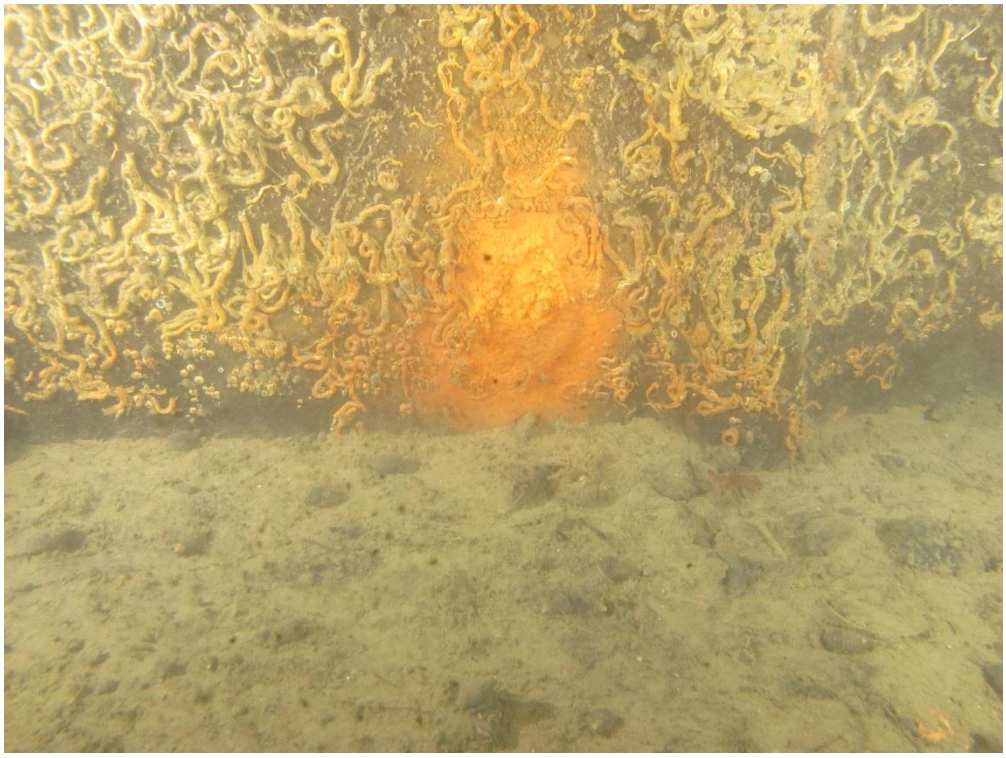
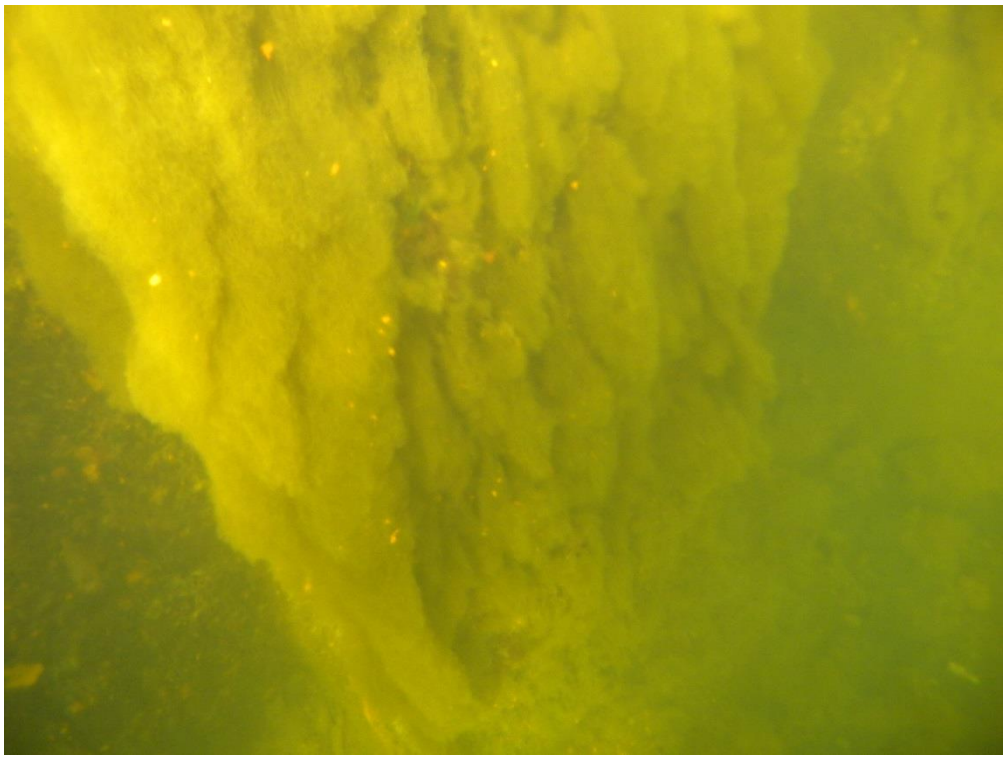


Photo No.	**Date:**
10	12-21-16

Direction Photo Taken:
Looking North

Description:
Typical marine growth along bulkhead east of caissons.



Appendix C
Photographic Log

Client Name: City of New London	**Site Location:** Shaw's Cove, New London, CT	**Project No.** 05.0045937.00

Photo No.	**Date:**
11	12-21-16

Direction Photo Taken:
Looking North

Description:
Minor pitting of steel observed after removing coating.

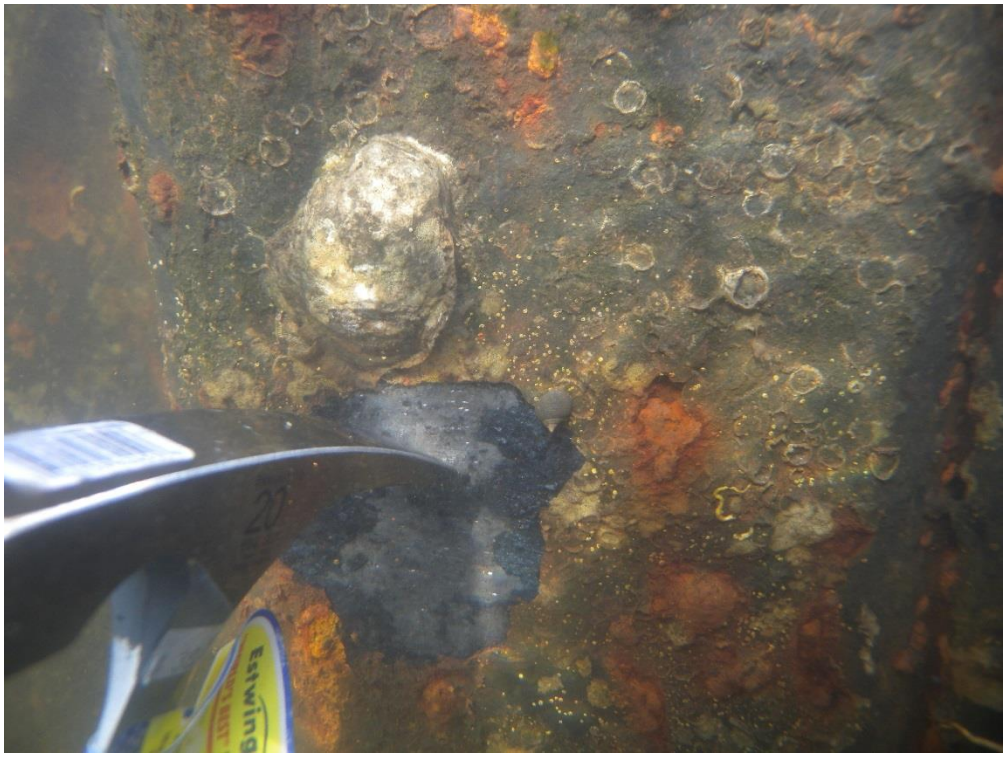


Photo No.	**Date:**
12	12-21-16

Direction Photo Taken:
Looking North

Description:
Cathodic protection system member along face of bulkhead.

APPENDIX B – CATHODIC PROTECTION

GZA GEOENVIRONMENTAL, INC.

CATHODIC PROTECTION SYSTEM
BASIS OF DESIGN
COST ESTIMATE

SHAW'S COVE BULKHEAD
410 BANK ST
NEW LONDON, CT

MARCH 2017

PREPARED BY:

HMI TECHNICAL SOLUTIONS, LLC.
1395 ATWOOD AVE.
JOHNSTON, RI O2919

CATHODIC PROTECTION SYSTEM – DESIGN & COST ESTIMATE

BACKGROUND

Upon examination of the bulkhead and the existing cathodic protection system, it was determined that the previous system had completely used up its useful life, and a complete redo of the system is necessary.

On the land side of the bulkhead, soil resistivity measurements taken were found to be 13,000 ohm-cm. This falls in the "slightly corrosive" range. Based on the configuration of the dock, it is also very likely that the soil in that area has a very low oxygen content. With low oxygen content, the corrosion rate would be further diminished.

With the limited access points to the soil on the land side (only accessible at the 29 existing anode locations from the previous cathodic protection system) as well as the relatively high soil resistivity of the soil, a galvanic cathodic protection system would not provide adequate current to protect the land side of the bulkhead. Due to the nature and configuration of the dock, an impressed current system would be very expensive and difficult to install. In addition, it would require monthly inspections to ensure the system was still operating properly.

In the overall scheme of corrosion on the bulkhead, the vast majority of the corrosion is occurring on the water side of the bulkhead. The water resistivity was found to be 44 ohm-cm (slightly higher resistivity than standard sea water, which is usually around 30 ohm-cm). An impressed current system or a galvanic system could adequately protect the water side of this wall. Based on conversations with GZA, due to the maintenance involved with an impressed current system, a galvanic system is strongly preferred.

ASSUMPTIONS

- 100% coating loss on the exterior wall of the bulkhead
- 30 foot tip elevation on all piles

SURFACE AREA

The exposed steel on both the Z-pile bulkhead and the flat web sheet piles require cathodic protection. The Z-pile bulkhead are PZ-38 piles. The flat web sheet piles are assumed to be PS28 piles.

The total length of exposed Z-piles is approximately 164 feet. This does not include the Z-pile that has been encapsulated within the flat web sheet piles. The total length of the exposed flat web sheet piles is 180 feet. The following is a table that breaks down the surface area calculations for the bulkhead. Each pile type is broken down into submerged surface area (above the mudline) and buried surface area (below the mudline).

Z Piles			PZ38	2.53 ft2/ft		**Total Z Pile Current Req (A)**
Submerged						
Station #	Approx Water Depth (ft)			Average Depth (ft)	Number of Piles	Surface Area (ft2)
20+15	2		20+15 - 20+43	3.25	22	180.895
20+43	4.5		20+43 - 21+00	8.25	46	960.135
21+00	12		21+00 - 21+29	12.45	24	755.964
21+29	12.9					
21+86	14.6		21+86 - 22+00	14.8	9	336.996
22+00	15		22+00 - 22+36	12.5	25	790.625
22+36	10					
						Total Submerged SA (ft2)
						3025
Buried	Pile Tip Elevation (ft)	Total # Piles				Total Buried SA (ft2)
	30	126				9563

Flat Web Cells			PS28	1.43 ft2/ft		**Total Cell Current Req (A)**
Submerged						
	Approx Water Depth (ft)	Total # Piles				Total Submerged SA (ft2)
	15	102				2188
Buried	Pile Tip Elevation (ft)	Total # Piles				Total Buried SA (ft2)
	30	102				4376

CURRENT REQUIREMENT

The current requirement for this project is based on actual testing in seawater on a number of isolated structural steel over the last 20 years. A current requirement of 6 mA per square foot of uncoated steel was used for submerged surfaces (above the mudline) and 2 mA per square foot of uncoated steel was used for buried surfaces (below the mudline).

Z-pile Bulkhead

Above Mudline – 3,025 ft^2 * 6mA/ft^2 = 18.15 A
Below Mudline – 9,563 ft^2 * 2mA/ft^2 = 19.12 A
Total Current Requirement = 37.27Amps

Flat Web Bulkhead

Above Mudline – 2,188 ft^2 * 6mA/ft^2 = 13.13 A
Below Mudline – 4,376 ft^2 * 2mA/ft^2 = 8.75 A
Total Current Requirement = 21.88 A

NUMBER OF ANODES REQUIRED AND DESIGN LIFE

Galvanic cathodic protection system

Design calculations are based on utilizing (4.5" x 4.5" x 60") 121.5 lb high potential aluminum anodes.

The following equation is utilized to calculate the output current for each anode:

$$I_{out} = \frac{[\Delta(E) \times L]}{[(0.0626)P\{\ln(4L/r)-1\}]}$$

Where:

Iout	=	Anode output current in amps
Delta(E)	=	Voltage difference between anode and steel
L	=	Length of anode in inches
r	=	Equivalent radius of anode in inches
P	=	Electrolyte resistivity in ohm-cm
0.0626	=	cm to inches conversion factor

Example: Pile 1

Waterside Values:

Delta(E)	=	0.45 volts (pre-polarization)
		0.15 volts (after-polarization)
L	=	60 inches
r	=	2.54 inches
P	=	44 ohm-cm

I max. Output = 2.31 A (before polarization) --- 0.77 A (after polarization)

Amount of current necessary to achieve polarization is typically approximately 3 times that of the current requirement, or 18mA/ft^2.

Number of anodes to achieve polarization = 177.15 Amps / 2.31 Amps = 76 Anodes

Number of anodes to maintain polarization = 59.05 A / 0.77 A = 76 Anodes

DESIGN LIFE

In order to determine if the proposed 76 anodes will meet the minimum 20 year design life, the following equation is used to calculate the life of each anode:

$$\text{Life} = \frac{(\text{F.C.})(\text{Eff.})(\text{Wgt.})}{(\text{Ireq})(8760)}$$

Where:

F.C.	=	Faradays constant amp-hrs/lb
Eff.	=	Anode efficiency factor
Wgt.	=	Anode weight in lbs.
Ireq	=	Anode output current in amps
8760	=	Conversion factor, hours/year

Waterside Values:

F.C.	=	1345 amp-hrs/lb
Eff.	=	0.85
Wgt.	=	121.5 lb. * 76 anodes
Ireq	=	59.05 amps

Life = 20.4 years

This is an underestimate of the design life, because it assumes 100% coating loss on the bulkhead. This is seen as the "worst case scenario" and it still exceeds the 20 year minimum design life set in the scope of work for this project.

RESULTS: ANODE LAYOUT

The anodes shall be placed as according to the drawings to maximize the current distribution to the entire bulkhead. The twelve westernmost Z-pile anodes are in an area where the water is too shallow to mount the anodes to the wall vertically. Therefore, those anodes should be installed with the shallow-water configuration shown in the drawings. All other anodes should be installed mounted vertically with an offset bracket. In the case of the Z-piles, the anodes should be mounted on the outer bellies of the piles. All vertically mounted anodes should be placed with the bottom of the anode bracket no more than 6 inches above the mudline.

COST ESTIMATE

Attached is a cost estimate to install the seventy-three galvanic aluminum anodes on the Z-pile and flat web sheet pile bulkhead at Shaw's Cove:

TOTAL	*$106,100*

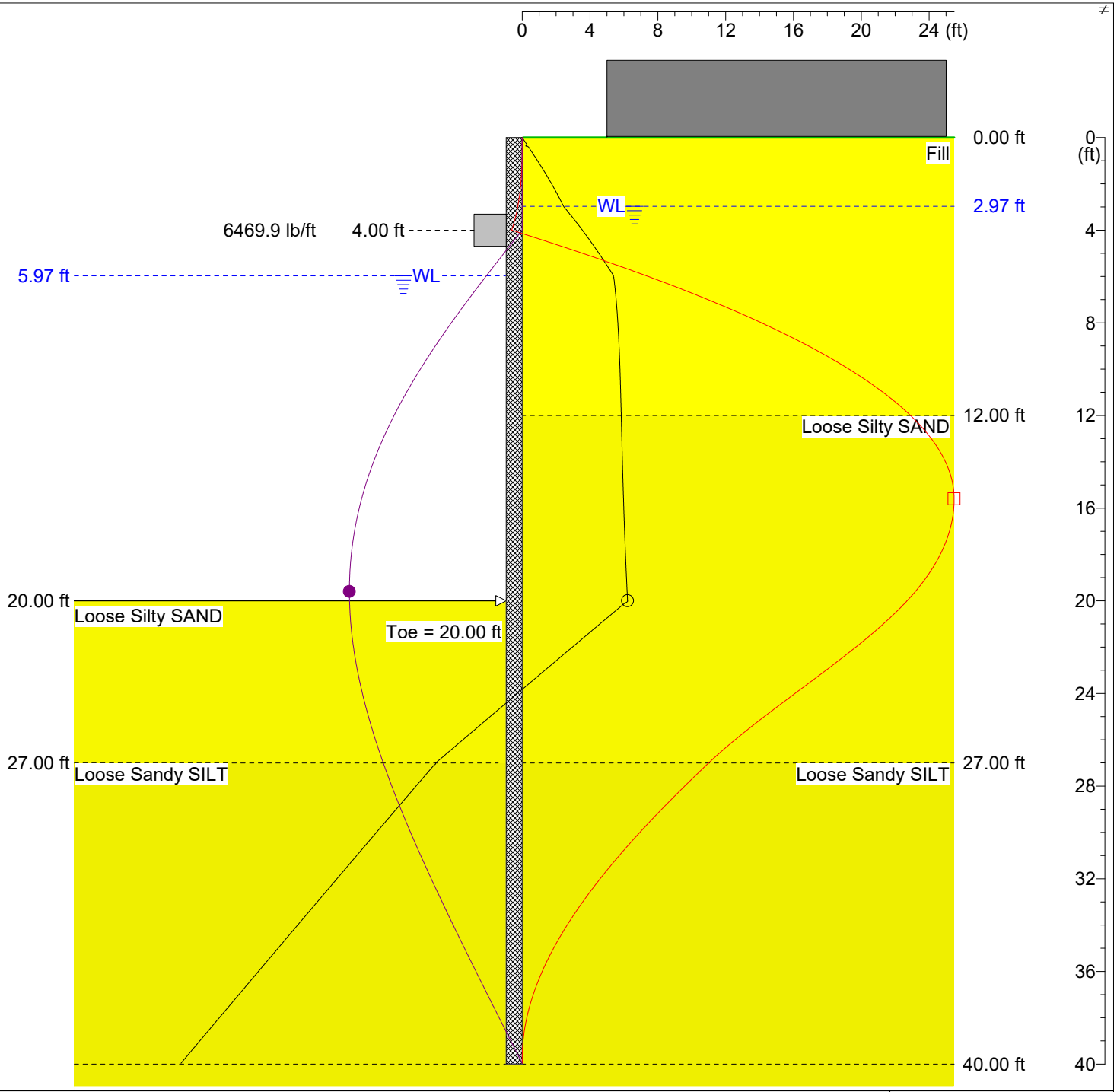
This is a budgetary estimate only and should in no way be considered a quotation by HMI Technical Solutions, LLC to perform this work.

APPENDIX C – CALCULATIONS

Page: 1
Date: 2.24.17

Sheet: PZ38
Works: Permanent
Pressure: Coulomb
Analysis: Net Pressure
Toe: Free Earth Support

Maximum	d (ft)
○ 563.9 psf	20.00
□ 34560.8 ftlb/ft	15.60
● 0.5 in	19.60



Your Company Name

SupportIT, v2.31

Tel/Fax: +44 (0)1292 477754
Email: GTSoftLtd@aol.com
Web: www.GTSoft.org

Sheet: PZ38
Works: Permanent
Pressure: Coulomb
Analysis: Net Pressure
Toe: Free Earth Support

Input Data

Depth Of Excavation = 20.00ft
Surcharge = 0.0psf

Depth Of Active Water = 2.97ft
Depth Of Passive Water = 5.97ft

Water Density = 62.43pcf
Minimum Fluid Density = 31.82pcf

Soil Profile — Active Side

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Fill	100.00	37.60	0.0	0.0	28.0	15.1	0.32	0.00	4.22	0.00
12.00	Loose Silty SAND	100.00	37.60	0.0	0.0	28.5	14.0	0.32	0.00	4.44	0.00
27.00	Loose Sandy SILT	90.00	27.60	0.0	0.0	30.0	11.0	0.31	0.00	4.05	0.00
42.00	Dense Gravel	109.46	65.55	0.0	0.0	40.0	0.0	0.22	0.00	4.61	0.00

Soil Profile — Passive Side

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Fill	100.00	37.60	0.0	0.0	28.0	15.1	0.32	0.00	4.21 (2.81)	0.00 (0.00)
12.00	Loose Silty SAND	100.00	37.60	0.0	0.0	28.0	14.0	0.33	0.00	4.10 (2.73)	0.00 (0.00)
27.00	Loose Sandy SILT	90.00	27.60	0.0	0.0	30.0	11.0	0.31	0.00	4.05 (2.70)	0.00 (0.00)
42.00	Dense Gravel	109.46	65.55	0.0	0.0	40.0	0.0	0.22	0.00	4.61 (3.07)	0.00 (0.00)

( ) indicates factored value used in embedment calculation. Factor(s): $K_p \div 1.5$; $C_{pas} \div 1.5$

Surcharges

Position (ft)	Width (ft)	Length (ft)	Depth (ft)	Magnitude	Type
5.00	20.00		0.00	500.0psf	Strip

Solution

Sheet

Sheet Name	E (psi)	I (in⁴/ft)	f (psi)	Z (in³/ft)	Allowed M_{max} (ftlb/ft)	b (in)	A (in²/ft)	W (lb/ft)	Upstand (ft)	Toe (ft)	Length (ft)
PZ38	3.04E+07	421.20	18000.0	46.80	70200.0	12.01	16.77	57.0	0.00	20.00	40.00

Load Model: Area Distribution

Supports

d (ft)	Type	Load (lb/ft)
4.00	Brace	6469.9

Maxima

	Maximum	Depth (ft)
Pressure	563.9 psf	20.00
Bending Moment	34560.8 ftlb/ft	15.60
Deflection	0.5 in	19.60
Shear Force	5838.4 lb/ft	4.00

Your Company Name

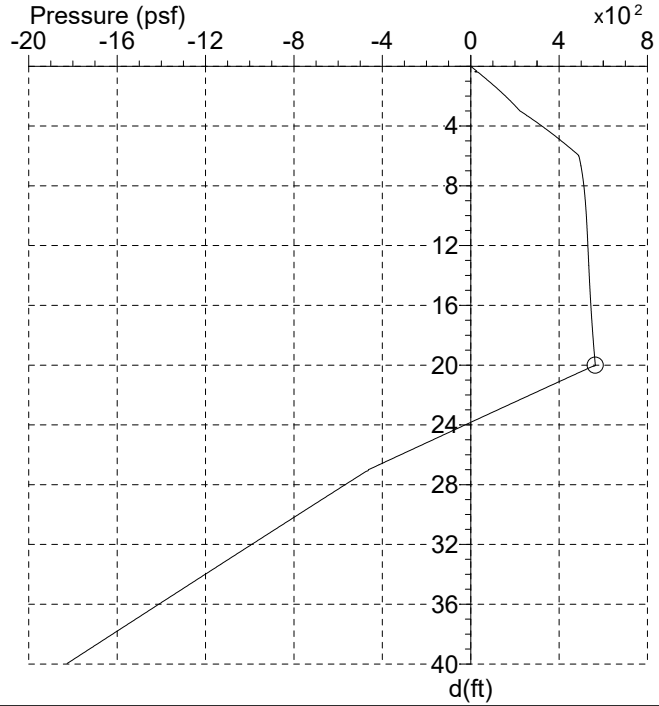
SupportIT, v2.31

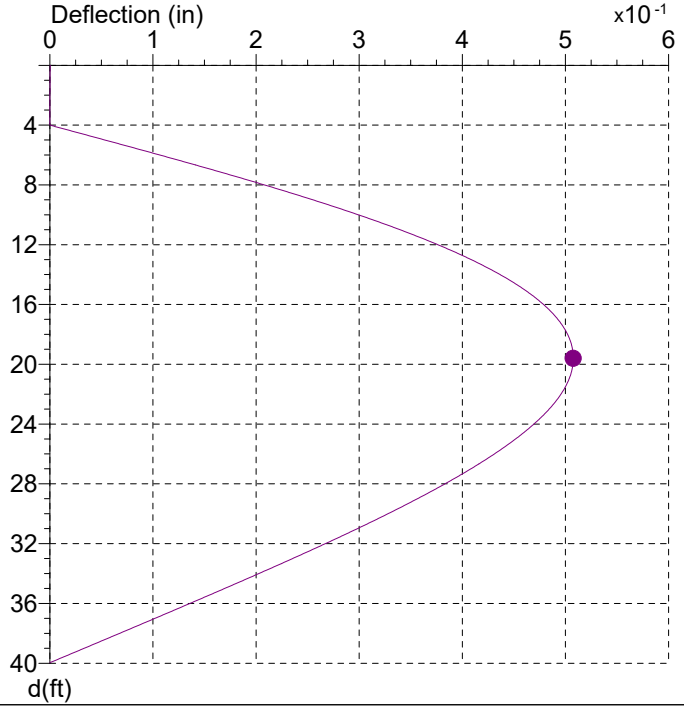
Tel/Fax: +44 (0)1292 477754
Email: GTSoftLtd@aol.com
Web: www.GTSoft.org

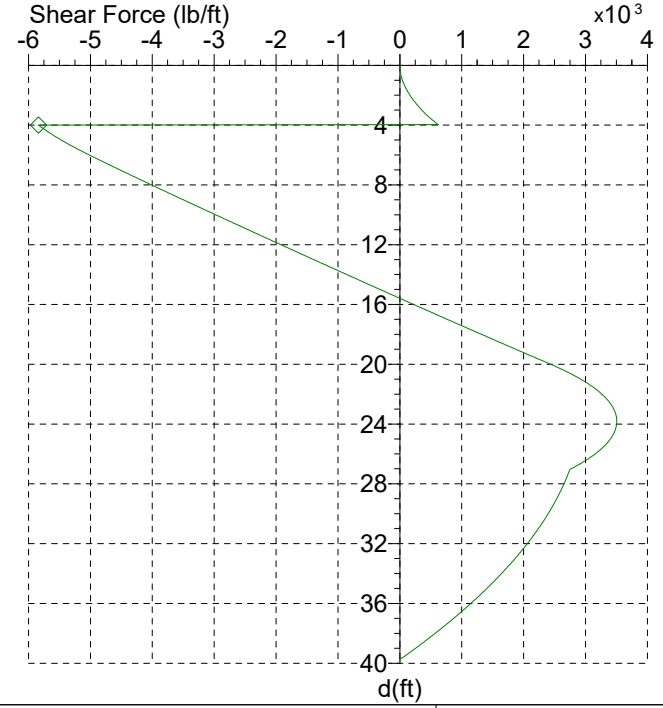
Page: 3
Date: 2.24.17

Sheet: PZ38
Works: Permanent
Pressure: Coulomb
Analysis: Net Pressure
Toe: Free Earth Support

Maximum	d (ft)
○ 563.9 psf	20.00
□ 34560.8 ftlb/ft	15.60
◇ 5838.4 lb/ft	4.00
● 0.5 in	19.60







Your Company Name

SupportIT, v2.31

Tel/Fax: +44 (0)1292 477754
Email: GTSoftLtd@aol.com
Web: www.GTSoft.org

Sheet: PZ38
Works: Permanent
Pressure: Coulomb
Analysis: Net Pressure
Toe: Free Earth Support

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	0.0	-0.1	0.0	0.0
0.29	24.8	0.3	0.0	4.1
0.57	46.8	2.3	0.0	13.7
0.86	71.1	8.7	0.0	31.8
1.14	92.3	19.6	0.0	53.9
1.43	115.6	39.8	0.0	85.5
1.71	135.6	66.5	0.0	119.4
2.00	157.3	108.0	0.0	163.7
2.29	178.2	163.7	0.0	214.4
2.57	195.9	226.7	0.0	264.6
2.86	214.9	314.2	0.0	326.5
3.14	237.9	408.1	0.0	386.9
3.43	267.9	534.2	0.0	463.3
3.71	293.7	666.4	0.0	538.6
4.00	322.0	840.0	0.0	-5838.4
4.29	349.4	-898.2	0.0	-5737.2
4.57	373.1	-2417.0	0.0	-5640.5
4.86	399.1	-4093.8	0.0	-5524.2
5.14	421.6	-5554.2	0.1	-5414.4
5.43	446.3	-7161.3	0.1	-5283.8
5.71	467.8	-8556.2	0.1	-5161.5
6.00	487.4	-10085.6	0.1	-5017.3
6.29	494.0	-11571.1	0.1	-4869.7
6.57	497.6	-12854.3	0.1	-4737.4
6.86	501.2	-14255.5	0.2	-4587.5
7.14	504.2	-15463.2	0.2	-4453.4
7.43	507.1	-16779.1	0.2	-4301.7
7.71	509.5	-17910.4	0.2	-4166.1
8.00	511.9	-19139.8	0.2	-4012.8
8.29	514.1	-20323.1	0.2	-3858.8
8.57	515.9	-21336.1	0.2	-3721.5
8.86	517.7	-22431.9	0.2	-3566.4
9.14	519.2	-23366.8	0.3	-3428.1
9.43	520.7	-24374.4	0.3	-3272.1
9.71	521.9	-25230.8	0.3	-3133.1
10.00	523.2	-26149.8	0.3	-2976.3
10.29	524.4	-27021.7	0.3	-2819.1
10.57	525.4	-27757.1	0.3	-2679.1
10.86	526.5	-28539.8	0.3	-2521.3
11.14	527.4	-29195.8	0.3	-2380.7
11.43	528.4	-29888.9	0.4	-2222.3
11.71	529.2	-30465.1	0.4	-2081.3
12.00	530.2	-31068.3	0.4	-1922.4
12.29	531.1	-31623.8	0.4	-1763.2
12.57	531.9	-32077.4	0.4	-1621.4
12.86	532.8	-32542.6	0.4	-1461.7
13.14	533.7	-32915.8	0.4	-1319.5
13.43	534.6	-33290.3	0.4	-1159.2
13.71	535.4	-33582.7	0.4	-1016.6
14.00	536.4	-33866.3	0.4	-855.8
14.29	537.4	-34101.5	0.4	-694.7
14.57	538.3	-34270.1	0.5	-551.2
14.86	539.4	-34413.9	0.5	-389.6
15.14	540.3	-34501.0	0.5	-245.6
15.43	541.5	-34553.0	0.5	-83.3
15.71	542.5	-34559.0	0.5	61.2
16.00	543.7	-34530.6	0.5	224.2
16.29	544.9	-34467.4	0.5	387.5
16.57	546.1	-34382.1	0.5	533.0
16.86	547.4	-34253.2	0.5	697.0
17.14	548.6	-34109.2	0.5	843.2
17.43	550.0	-33914.2	0.5	1008.0
17.71	551.3	-33711.4	0.5	1154.9
18.00	552.8	-33450.0	0.5	1320.5
18.29	554.3	-33153.3	0.5	1486.6
18.57	555.7	-32859.9	0.5	1634.6
18.86	557.3	-32496.3	0.5	1801.6
19.14	558.8	-32143.2	0.5	1950.4
19.43	560.5	-31712.3	0.5	2118.4
19.71	562.1	-31299.2	0.5	2268.1
20.00	563.9	-30800.6	0.5	2437.0
20.29	519.4	-30266.5	0.5	2599.0
20.57	480.0	-29763.7	0.5	2731.6
20.86	435.6	-29169.3	0.5	2868.3
21.14	396.3	-28617.5	0.5	2978.5
21.43	352.0	-27972.9	0.5	3090.0
21.71	312.7	-27381.0	0.5	3178.0
22.00	268.5	-26696.4	0.5	3264.4
22.29	224.4	-25994.6	0.5	3337.6
22.57	185.1	-25358.6	0.5	3391.6
22.86	141.1	-24632.1	0.5	3439.8
23.14	101.9	-23978.7	0.5	3471.5
23.43	57.9	-23237.6	0.5	3494.8
23.71	18.8	-22575.6	0.5	3504.3
24.00	-25.1	-21829.9	0.5	3502.7
24.29	-69.0	-21085.7	0.5	3487.8
24.57	-108.0	-20427.8	0.5	3463.5
24.86	-151.9	-19694.3	0.5	3423.8
25.14	-190.8	-19050.4	0.4	3377.5
25.43	-234.6	-18337.6	0.4	3312.9
25.71	-273.5	-17716.5	0.4	3244.5
26.00	-317.3	-17034.3	0.4	3155.2
26.29	-361.0	-16372.4	0.4	3052.7
26.57	-399.8	-15803.2	0.4	2950.6
26.86	-443.5	-15187.2	0.4	2823.4
27.14	-475.9	-14662.3	0.4	2738.3
27.43	-507.9	-14082.3	0.4	2710.2
27.71	-536.2	-13571.8	0.4	2683.7
28.00	-568.1	-13003.7	0.4	2652.2
28.29	-600.0	-12442.5	0.4	2618.9
28.57	-628.3	-11949.7	0.4	2587.7
28.86	-660.1	-11402.5	0.4	2551.0
29.14	-688.4	-10922.7	0.4	2516.8
29.43	-720.2	-10391.0	0.3	2476.6
29.71	-748.4	-9925.6	0.3	2439.4
30.00	-780.1	-9410.6	0.3	2395.8
30.29	-811.9	-8905.0	0.3	2350.5
30.57	-840.1	-8463.9	0.3	2308.6
30.86	-871.7	-7977.2	0.3	2259.8
31.14	-899.9	-7553.4	0.3	2215.0
31.43	-931.5	-7087.0	0.3	2162.8
31.71	-959.7	-6681.9	0.3	2114.9
32.00	-991.3	-6237.1	0.3	2059.3
32.29	-1022.9	-5804.3	0.3	2001.9
32.57	-1051.0	-5430.0	0.2	1949.4
32.86	-1082.6	-5020.9	0.2	1888.6
33.14	-1110.6	-4668.2	0.2	1833.1
33.43	-1142.2	-4284.2	0.2	1768.9
33.71	-1170.2	-3954.4	0.2	1710.3
34.00	-1201.7	-3596.8	0.2	1642.8
34.29	-1233.2	-3253.8	0.2	1573.4
34.57	-1261.2	-2961.4	0.2	1510.3
34.86	-1292.7	-2646.9	0.2	1437.5
35.14	-1320.7	-2380.4	0.2	1371.4
35.43	-1352.2	-2095.8	0.2	1295.3
35.71	-1380.1	-1856.5	0.1	1226.1
36.00	-1411.5	-1603.1	0.1	1146.6
36.29	-1443.0	-1366.7	0.1	1065.3
36.57	-1470.9	-1171.3	0.1	991.6
36.86	-1502.3	-968.3	0.1	906.9
37.14	-1530.2	-803.1	0.1	830.1
37.43	-1561.6	-634.7	0.1	742.1
37.71	-1589.5	-500.9	0.1	662.4
38.00	-1620.9	-368.6	0.1	571.0
38.29	-1652.2	-255.9	0.1	477.8
38.57	-1680.1	-172.5	0.0	393.4
38.86	-1711.4	-97.9	0.0	296.9
39.14	-1739.3	-48.9	0.0	209.5
39.43	-1770.6	-13.7	0.0	109.6
39.71	-1798.5	-0.5	0.0	19.3
40.00	-1826.3	0.0	0.0	0.0

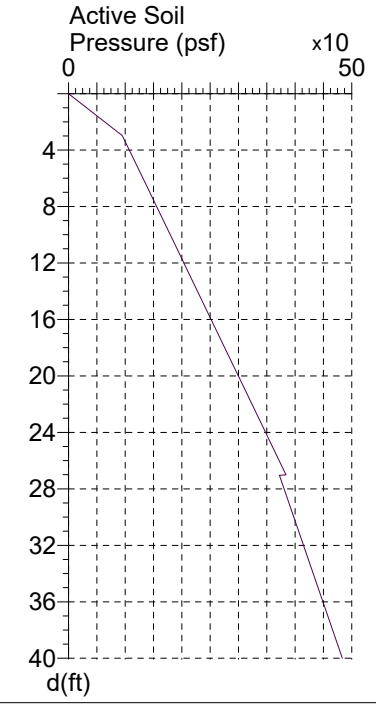
Your Company Name

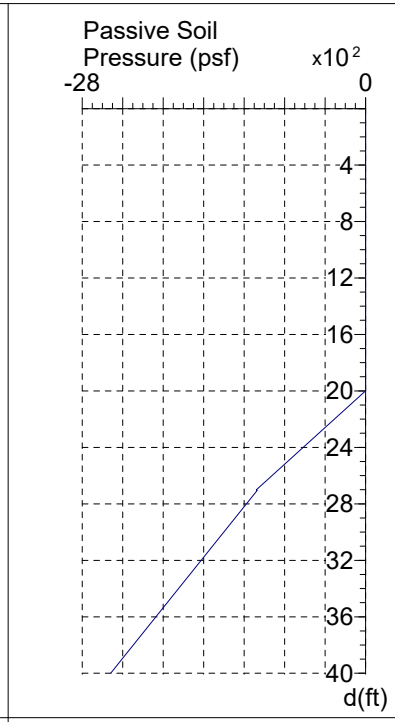
SupportIT, v2.31

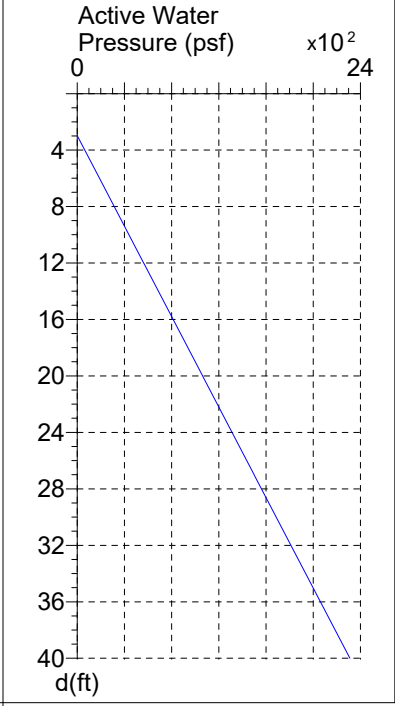
Tel/Fax: +44 (0)1292 477754
Email: GTSoftLtd@aol.com
Web: www.GTSoft.org

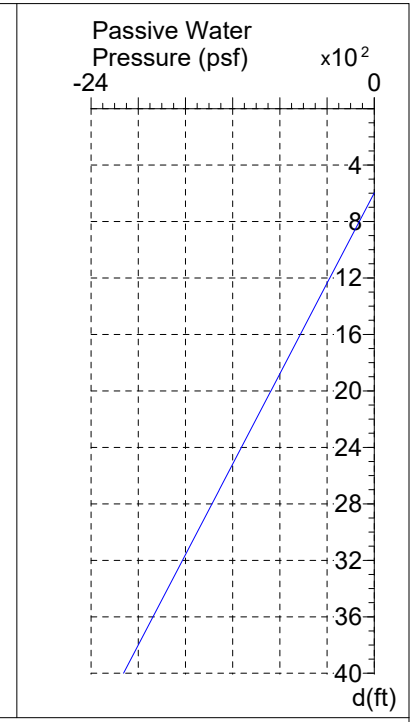
Page: 5
Date: 2.24.17

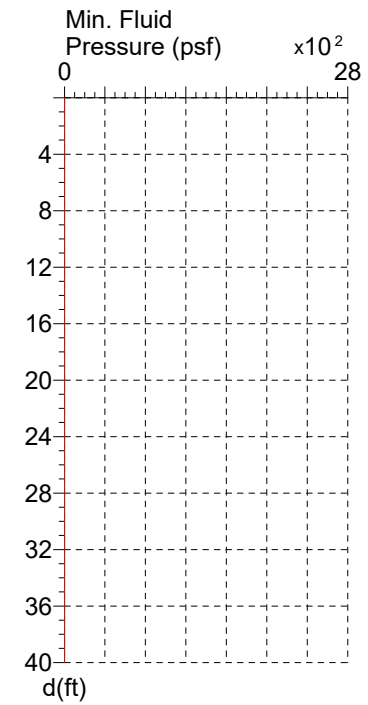
Sheet: PZ38
Works: Permanent
Pressure: Coulomb
Analysis: Net Pressure
Toe: Free Earth Support

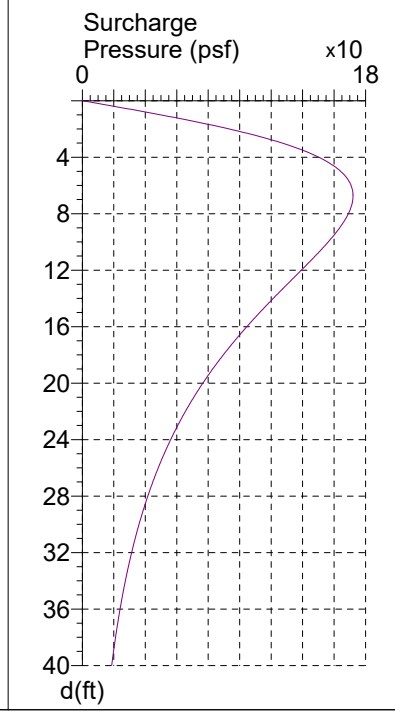


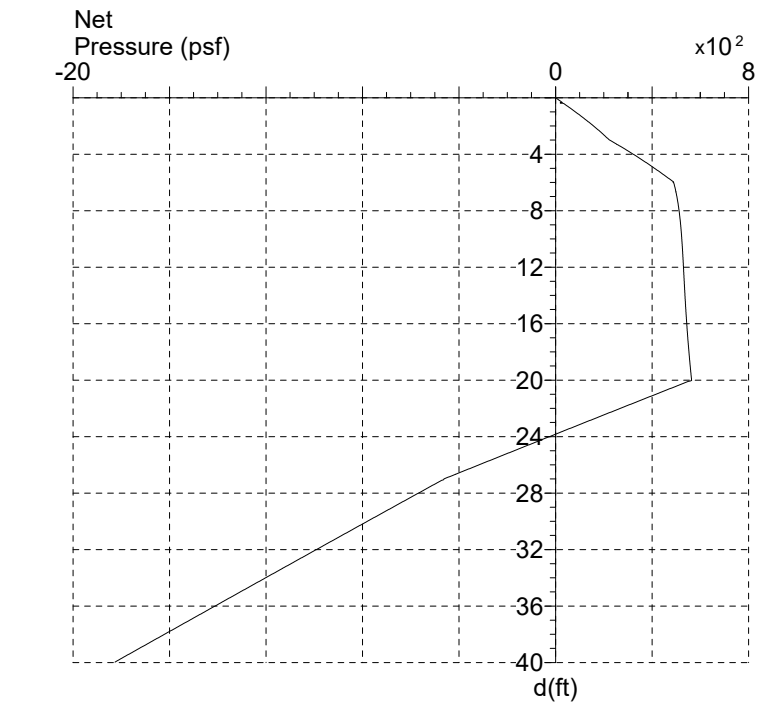










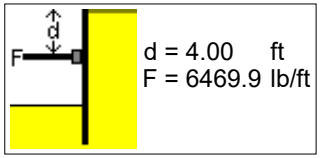


Your Company Name

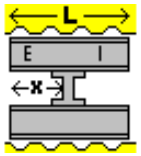
SupportIT, v2.31

Tel/Fax: +44 (0)1292 477754
Email: GTSoftLtd@aol.com
Web: www.GTSoft.org

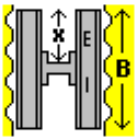
Sheet: PZ38
Works: Permanent
Pressure: Coulomb
Analysis: Net Pressure
Toe: Free Earth Support



d = 4.00 ft
F = 6469.9 lb/ft



Waler/brace inadequately specified.
(Define L, E and I.)



Waler/brace inadequately specified.
(Define B, I and E.)

Your Company Name

SupportIT, v2.31

Tel/Fax: +44 (0)1292 477754
Email: GTSoftLtd@aol.com
Web: www.GTSoft.org

Sheet: PZ38
Works: Permanent
Pressure: Coulomb
Analysis: Net Pressure
Toe: Free Earth Support

Design Report

1. The standard surcharge is 0.0psf. The Piling Handbook recommends a minimum surcharge of 200.0psf. Other surcharges have been defined, but ensure that this is sufficient.

2. Factor(s) applied to soil parameter(s) in the 'Wall' page, and used in the embedment calculation.
   Factor(s) used: Kp ÷1.5; C (passive) ÷1.5

3. Maximum bending moment = 34560.8ftlb/ft and f = 18000.0psi. MINIMUM required sheet section modulus is: Z = 23.04in³/ft (= M/f).
   Sheet section modulus in this design is Z = 46.80in³/ft, and is satisfactory.

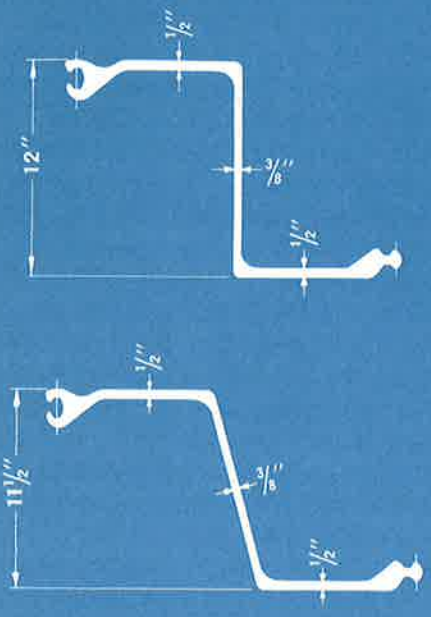
4. Frame primary axis bending moments checked. Users should manually check the axial load capacities and the effects of combined axial and bending stresses to confirm frames are suitable.

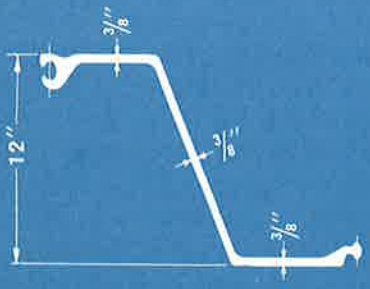
5. FOS = 5.48 (Net Pressure)
   This is the factor of safety against rotation about the lowest frame. It is calculated using the factored soil parameters (see above).
   The FOS can be changed using 'Defined FOS' or 'Manual' in the 'Wall' page.

Tel/Fax: +44 (0)1292 477754
Email: GTSoftLtd@aol.com
Web: www.GTSoft.org

Z Piles

PROFILE



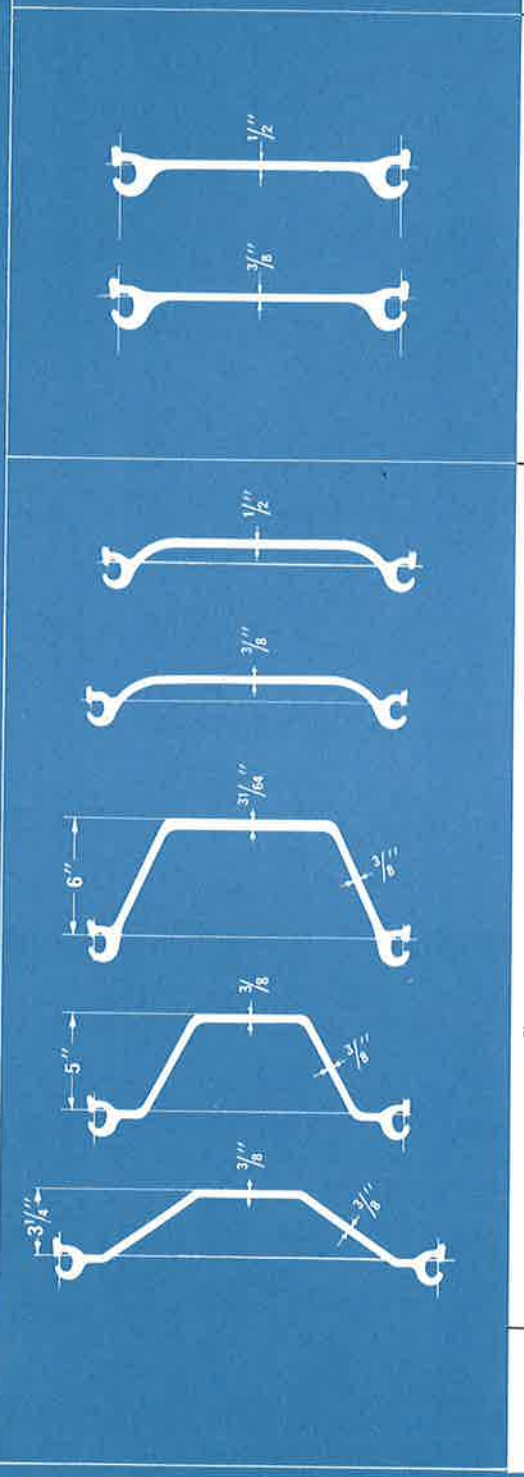


Section Index	Driving Distance Per Pile	Weight		Web Thickness	Section Modulus	
		Per Foot	Per Square Foot of Wall		Per Pile	Per Foot of Wall
	Inches	Pounds	Pounds	Inches	Inches³	Inches³
MZ-38 AND MZ-32 INTERLOCK WITH EACH OTHER AND WITH MP-112 OR MP-113 SECTIONS — MZ-38	18	57.0	**38.0**	3/8	70.2	**46.8**
MZ-32	21	56.0	**32.0**	3/8	67.0	**38.3**
MZ-27 INTERLOCKS WITH MP-112 OR MP-113 ONLY — MZ-27	18	40.5	**27.0**	3/8	45.3	**30.2**

For details—See pages 10 to 25, inc.

Straight and Arch Web Piles

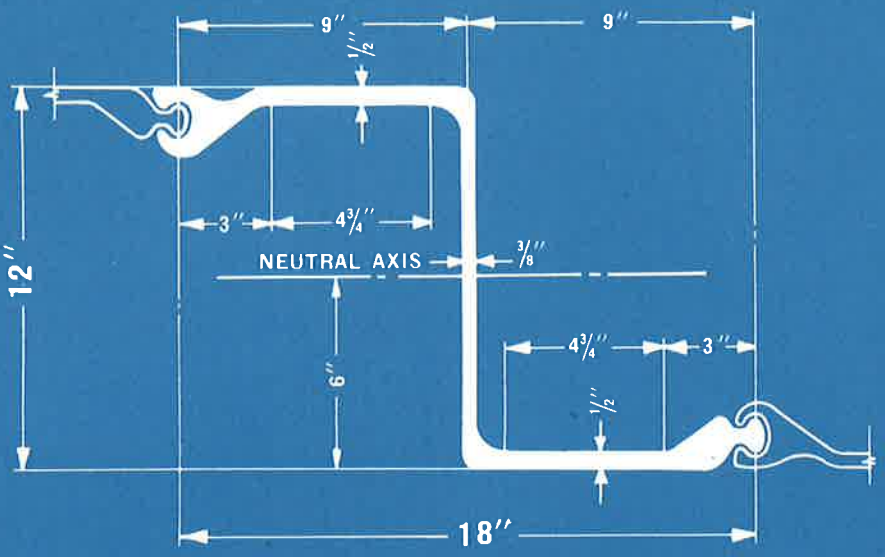
PROFILE



	Section Index	Driving Distance Per Pile	Weight		Web Thickness	Section Modulus	
			Per Foot	Per Square Foot of Wall		Per Pile	Per Foot of Wall
		Inches	Pounds	Pounds	Inches	Inches³	Inches³
INTERLOCK WITH EACH OTHER	MP-102	15	40.0	**32.0**	½	2.4	**1.9**
	MP-101	15	35.0	**28.0**	⅜	2.4	**1.9**
INTERLOCK WITH EACH OTHER	MP-113	16	37.3	**28.0**	½	3.3	**2.5**
	MP-112	16	30.7	**23.0**	⅜	3.2	**2.4**
	MP-110	16	42.7	**32.0**	31/64	20.4	**15.3**
	MP-116	16	36.0	**27.0**	⅜	14.3	**10.7**
	MP-115	19⅝	36.0	**22.0**	⅜	8.8	**5.4**

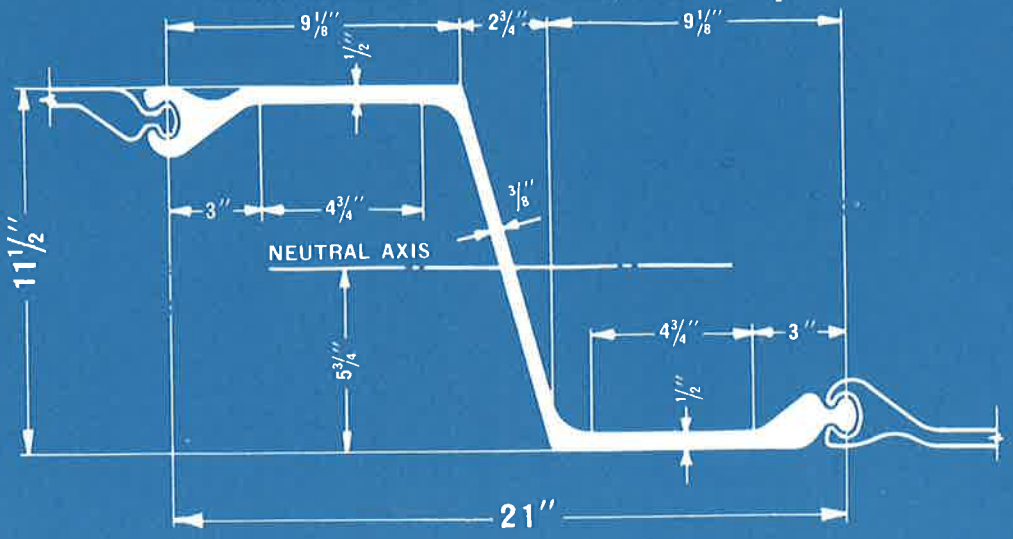
For details—See pages 26 to 47, inc.

Section MZ-38 — 18″ Wide, 12″ Deep



WEIGHT PER LINEAL FOOT OF PILE - - - 57.0 POUNDS
WEIGHT PER SQUARE FOOT OF WALL - - 38.0 POUNDS

Section MZ-32 — 21″ Wide, 11½″ Deep



WEIGHT PER LINEAL FOOT OF PILE - - - 56.0 POUNDS
WEIGHT PER SQUARE FOOT OF WALL - - 32.0 POUNDS

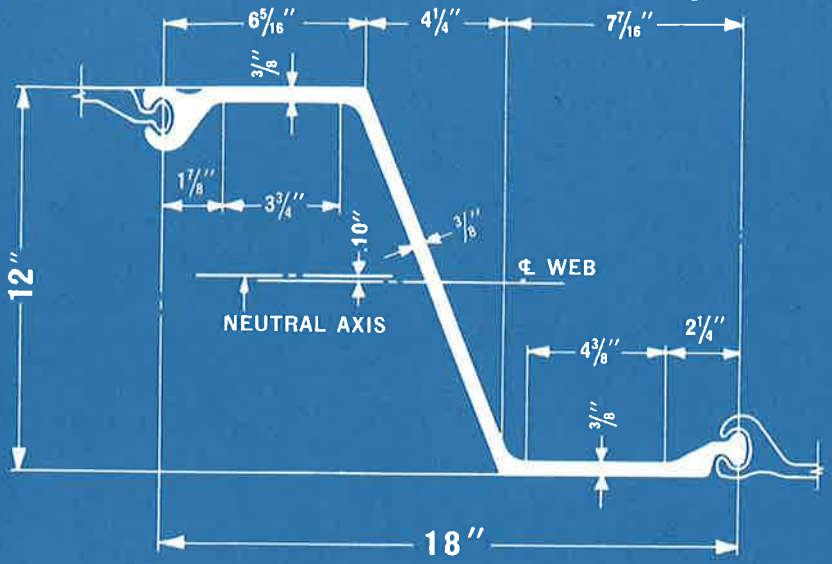
Section Number	Driving Distance Per Pile	Thickness		Weight		Section Modulus		Area	Moment of Inertia
		Web	Flange	Per Lineal Foot of Pile	Per Square Foot of Wall	Per Pile	Per Foot of Wall		
	Inches	Inches	Inches	Pounds	Pounds	Ins.³	Ins.³	Sq. In.	Ins.⁴
MZ-38	18	3/8	½	57.0	**38.0**	70.2	**46.8**	16.77	421.2
MZ-32	21	3/8	½	56.0	**32.0**	67.0	**38.3**	16.47	385.7

USS Piling Sections MZ-38 and MZ-32 interlock with each other.

To obtain number of pieces required see tables on pages 18 and 19.

For standard fabricated connections see pages 12 and 13.
For cofferdam combinations see page 16.
For standard handling and pulling holes see page 59.

Section MZ-27 — 18″ Wide, 12″ Deep

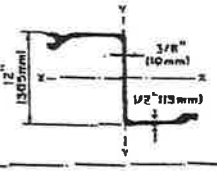
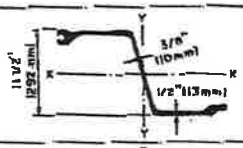
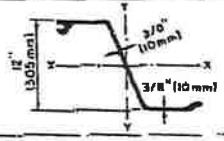
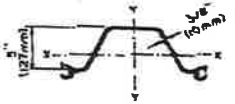
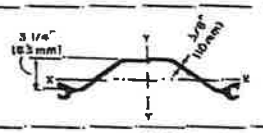
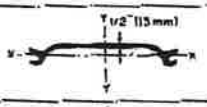
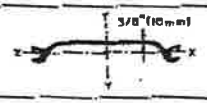
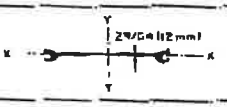
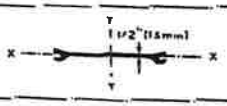


WEIGHT PER LINEAL FOOT OF PILE - - - 40.5 POUNDS
WEIGHT PER SQUARE FOOT OF WALL - - 27.0 POUNDS

Section Number	Driving Distance Per Pile	Thickness		Weight		Section Modulus		Area	Moment of Inertia Per Pile
		Web	Flange	Per Lineal Foot of Pile	Per Square Foot of Wall	Per Pile	Per Foot of Wall		
	Inches	Inches	Inches	Pounds	Pounds	Ins.^{3}	Ins.^{3}	Sq. In.	Ins.^{4}
MZ-27	18	3/8	3/8	40.5	**27.0**	45.3	**30.2**	11.91	276.3

To obtain number of pieces required see table on page 18.

For standard fabricated connections see pages 14 and 15.
For cofferdam combinations see page 17.
For standard handling and pulling holes see page 59.

DESIGNATION	PROFILE	INTERLOCK	WEIGHT PER LINEAR FT	WEIGHT PER SQ FT OF WALL	AREA A	DRIVING WIDTH	SECTION MODULUS PER FT WALL	SECTION MODULUS PER PILE
			LB	LB	INCH²	INCH	INCH³	INCH³
PZ38		INTERLOCK WITH EACH OTHER AND PSA 23, PSA 28	57.0	38.0	16.8	18	46.8	70.2
PZ32			56.0	32.0	16.5	21	38.3	67.0
PZ27		INTERLOCKS WITH ITSELF AND PSA 23, PSA 28	40.5	27.0	11.9	18	30.2	45.3
PDA27		INTERLOCK WITH EACH OTHER	36.0	27.0	10.6	16	10.7	14.3
PMA22			36.0	22.0	10.6	19⅝	5.4	8.8
PSA28			37.3	28.0	11.0	16	2.5	3.3
PSA23			30.7	23.0	9.0	16	2.4	3.2
PSX32		INTERLOCK WITH EACH OTHER	44.0	32.0	13.0	16½	2.4	3.3
PS32			40.0	32.0	11.8	15	1.9	2.4
PS28			35.0	28.0	10.3	15	1.9	2.4

APPENDIX D - COSTING

PRELIMINARY ORDER OF MAGNITUDE
SHAW'S COVE BULKHEAD COST ESTIMATE
City of New London Department of Public Works
111 Union Street, New London, CT

May 2017

WORK ITEM	QUANTITY		MATERIAL COST		LABOR COST		TOTAL SCHEMATIC COST
	UNITS	NUMBER	UNIT COST	TOTAL UNIT COST	UNIT COST	TOTAL UNIT COST	
Option 1 - Do nothing and Monitor the Wall in 5 years							
Mobilization - Above and Below Water Inspection Teams	L.S.	1			$500.00	$500.00	$500.00
Routine Inspection	L.S.	1			$3,500.00	$3,500.00	$3,500.00
Cathodic Protection Inspection	L.S.	1			$3,000.00	$3,000.00	$3,000.00
Letter Report	L.S.	1			$800.00	$800.00	$800.00
20 Percent Contingency		20%					$1,000.00
Total for Option 1							$8,800.00
Option 2 - Repair Localized Deterioration							
Contractor Mobilization	L.S.	1			$15,000.00	$15,000.00	$15,000.00
Steel Plate - 12"x5/8"x1'6" - 8 Pieces	LBS	306	$4.00	$1,300.00		$0.00	$1,300.00
Above Water Repairs	Day	3			$1,500.00	$4,500.00	$4,500.00
Diving to repair below water areas	Crew/Day	4			$6,000.00	$24,000.00	$24,000.00
Routine Inspection in 5 years	L.S.	1			$7,800.00	$7,800.00	$7,800.00
20 Percent Contingency		20%					$7,300.00
Total for Option 2							$59,900.00
Option 3 - Localized Repairs, Cathodic Protection and Epoxy Coating the Steel Sheets							
Contractor Mobilization	L.S.	1			$20,000.00	$20,000.00	$20,000.00
Steel Plate - 12"x5/8"x1'6" - 8 Pieces	LBS	306	$4.00	$1,300.00		$0.00	$1,300.00
Above Water Repairs	Day	3		$0.00	$1,500.00	$4,500.00	$4,500.00
Diving to repair below water areas	Day	4		$0.00	$6,000.00	$24,000.00	$24,000.00
Cathodic Protection				$0.00		$0.00	$0.00
- Standard Aluminum anodes - 4.5" x 4.5" x 60" - 120 LBS	EA	64	$162.00	$10,400.00	$600.00	$38,400.00	$48,800.00
- Shallow Water Aluminum anodes (and assembly) - 4.5" x 4.5" x 60" -	EA	12	$310.00	$3,800.00	$700.00	$8,400.00	$12,200.00
- Post Install Survey	EA	1		$0.00	$1,800.00	$1,800.00	$1,800.00
- Final Test Report and as-built	EA	1		$0.00	$1,600.00	$1,600.00	$1,600.00
Clean Sheets	S.F.	250		$0.00	$1,740.00	$435,000.00	$435,000.00
Primer Coat Sheets	S.F.	30		$0.00	$1,740.00	$52,200.00	$52,200.00
Epoxy Coat Sheets	S.F.	50		$0.00	$1,740.00	$87,000.00	$87,000.00
20 Percent Contingency		20%		$0.00			$114,900.00
Total for Option 3							$803,300.00

PRELIMINARY ORDER OF MAGNITUDE
SHAW'S COVE BULKHEAD COST ESTIMATE
City of New London Department of Public Works
111 Union Street, New London, CT

May 2017

NOTES:

1 COSTS ARE BASED ON FY 2017

2 NO SALES AND USE TAX IS INCLUDED.

3 CT STATE LABOR PREVAILING WAGE RATES
RESOURCES USED FOR PRICING:
A. THE AED GREEN BOOK , 56th EDITION, 2005 RENTAL RATES & SPECIFICATIONS FOR CONSTRUCTION EQUIPMENT
B. R.S.MEANS 2017 BUILDING CONSTRUCTION COST DATA, 63rd ANNUAL EDITION
C. R.S.MEANS 2017 HEAVY CONSTRUCTION COST DATA, 19th ANNUAL EDITION
D. ENGINEER'S PAST EXPERIENCE IN WATERFRONT CONSTRUCTION
E. ENGINEER'S PAST EXPERIENCE IN WATERFRONT CONSTRUCTION

4 UNLESS OTHERWISE STATED, OUR OPINIONS OF COST MAY INVOLVE APPROXIMATE QUANITIES AND ARE NOT INTENDED TO BE SUFFICIENTLY ACCURATE TO DEVELOP CONSTRUCTION BIDS, OR TO PREDIT THE ACTUAL COST OF WORK. GZA HAS NO CONTROL OVER THE TIMING OF THE WORK, LABOR COST, OR MATERIAL COST FOR THE ANITICPATED WORK, THESE OPINIONS WERE MADE BY RELYING ON EXPERIENCE, THE EXPERIENCE OF OTHERS, AND OTHER RESOURCES OF READILY AVAILABLE INFORMATION.