



VIA EMAIL

November 23, 2011  
File No. 18.0171123.00



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Mr. William H. Sheehan III, Esq  
Feoffees of the Grammar School  
c/o MacLean Holloway Doherty Ardoff & Morse, P.C.  
8 Essex Center Drive  
Peabody, MA 01960

Re: Opinion Report  
Little Neck Embankment Stabilization Project  
Cliff and River Roads, Ipswich, MA

Dear Attorney Sheehan:

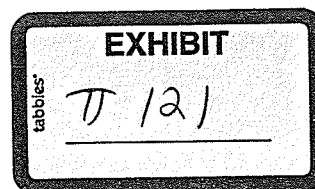
In accordance with our Agreement dated November 17, 2011, Vine Associates, A Division of GZA GeoEnvironmental, Inc. (VA) has prepared this opinion Report regarding the proposed Embankment Stabilization Project at Little Neck, Ipswich, MA. The opinions presented are based on our work at the site since 2007 and our experience at other similar sites in Massachusetts. VA's prior work for the Embankment Stabilization Project has involved the evaluation of potential stabilization methods, the development of a slope stabilization design, acquisition of regulatory approvals and the preparation of construction documents for the slope stabilization work along Cliff and River Roads.

## BACKGROUND

The Little Neck Embankment Stabilization Project involves the stabilization of two sections of eroding embankment on the eastern and southern sides of Little Neck. Little Neck is located at the confluence of the Ipswich River and Plum Island Sound as illustrated by **Figure 1**. Little Neck is a drumlin which was formed during the glacial periods and is comprised of glacial till.

The ground elevation along the embankments of Little Neck, ranges from +0 feet (datum North American Vertical Datum 1988 - NAVD) to a maximum elevation of approximately + 60 feet NAVD. The Mean High Water (MHW) tide elevation is +4.2 feet NAVD. The eastern and southern shorelines of Little Neck are located within the Federal Emergency Management Agency (FEMA) coastal flood zone with velocity hazard due to wave action, as illustrated by **Figure 2**.

The River Road Area is located on the southern side of Little Neck near the mouth of the Ipswich River and is comprised of a vertical timber wall that extends about 315 linear feet to the east from the entrance to the boat ramp parking area, as illustrated by **Figure 3**. The embankment in this area ranges in height from approximately five to 15 feet. The embankment is protected by a vertical timber retaining wall as illustrated by **Photographs 1 and 2**. The toe of the timber retaining wall is protected by a toe revetment that extends approximately eight feet seaward of the wall. The area directly behind the timber retaining wall consists of a deteriorated concrete cap, gravel shoulder or steep vegetated slope. A public water main and a sanitary sewer line are located within the roadway. For over half the length of the River Road site the paved roadway surface is less than ten feet from the deteriorated timber retaining wall.





The River Road and Cliff Road Areas are separated by approximately 900 feet of embankment. The embankment in this area consists of a stone revetment which in the upper sections is overgrown with vegetation, as illustrated by **Photograph 3**. The embankment in this area ranges in height from approximately 20 to 55 feet.

The Cliff Road Area is located on the east side of Little Neck adjacent to Plum Island Sound. The Cliff Road embankment extends from the terminus of the Revetment Area approximately 600 linear feet to the northwest to Pavilion Beach. The embankment is comprised of a steep naturally vegetated slope and is backed by lawn areas, Cliff Road and several houses, as illustrated by **Photographs 4 and 5**. Both a public water main and sanitary sewer are located within the paved roadway. A single catch basin is located at the north end of Cliff Road. The catch basin drains onto the adjacent embankment.

### 2007 NORTHEASTER STORM IMPACTS

During the "Patriots Day Northeaster" of 2007 Little Neck was subject to severe storm winds and waves from Atlantic Ocean and higher than normal tides over a three day period from April 16<sup>th</sup> through April 18<sup>th</sup>. On April 23, 2007 VA visited Little Neck to observe damage to the shoreline embankment and seawall areas resulting from the Northeaster. The areas of significant damage were located along the eastern and southern shorelines of Little Neck. The following paragraphs provide a general description of the conditions observed during the post storm site visit by project area.

Within the River Road Area the observed storm damage consisted of sinkholes behind the timber bulkhead and erosion of River Road. The damage was likely the result of the high water conditions which washed out the backfill along the timber bulkhead during receding tides. At the time of the inspection the erosion and sinkholes had been partially and temporarily stabilized by the placement of stone material to fill in the voids.

The stone revetment within the embankment between the two project areas appeared to have weathered the storm conditions well and no apparent areas of damage due to the storm waves were observed.

The Cliff Road Area embankment was observed to have general sloughing of the embankment slope. This condition appears to be due to the high tide and wave action saturating and eroding the toe area, which caused subsequent instability and sloughing of the slope. This type of condition appeared in four locations extending for a total length of approximately 400 to 500 feet. The sloughing extending up about 2/3 of the approximate 30 foot height of the embankment. **Photographs 6, 7, 8 and 9** illustrate the general conditions observed after the 2007 Northeaster.

### SLOPE STABILIZATION ALTERNATIVE ANALYSIS

The following presents a summary of the alternatives analysis that was performed by VA in April, 2008 to develop and evaluate potential alternatives to repair and stabilize the areas damaged by the April 2007 northeaster.

River Road -Five repair/stabilization alternatives were evaluated for the River Road project area. These alternatives included: Do Nothing; Steel Sheet Pile Bulkhead; Modular Concrete Block Wall; a cast in place Concrete Seawall; and Stone Revetment. The Do Nothing alternative was deemed unacceptable since it would allow the eventual erosion of the public



roadway and loss of the water main and sanitary sewer line located within the roadway. The Steel Sheet Pile Bulkhead, Modular Concrete Block and the Concrete Seawall alternatives were not considered for the project because of their high construction costs, their potential for scouring and undermining, and the potential for wave reflection impacts. The Stone Revetment alternative was chosen because of its superior cost to benefit ratio, the lower potential for scouring and wave reflection, and the ability to blend the revetment into the adjacent revetment.

Cliff Road -Five repair/stabilization alternatives were evaluated for the Cliff Road project site. These alternatives included: Do Nothing; Vegetated Slope; Full Height Revetment; Concrete Wall/Revetment; and Partial Height Revetment. The Do Nothing alternative was deemed unacceptable since it would allow the eventual erosion of the public roadway and loss of the sanitary sewer line located within the roadway. The second alternative, the Vegetated Slope, was not selected because of its high potential for failure that could lead to damage at Cliff Road. Vegetated stabilization methods are only suitable for slopes that are not subject to wave action since the high energy and velocity effects of breaking waves can readily erode even well vegetated slopes. This concern is evidenced by the recent failure of the embankment which was heavily vegetated prior to its collapse. The site is exposed to ocean waves which during storm surges can over saturate the soils and severely undermine the slope and cause catastrophic sloughing of the embankment and damage to the road. The third alternative at Cliff Road considered building a stone revetment to the top of the embankment. The Full Height Revetment alternative was not considered further due to its high cost and because the upper slope is suitable for vegetative stabilization. The fourth alternative considered the installation of a concrete seawall at the base of the slope with a stone revetment placed above the seawall to elevation 25 NAVD and vegetation planted to the top of the slope. This method was deemed unacceptable because of its high cost.

The fifth alternative, the Partial Height Revetment, was selected as the proposed method for Cliff Road since it is the most cost effective solution and minimizes potential impacts to the bank and wetland resource areas. The potential for wave reflection will be minimized with the stone revetment. The advantage of a stone revetment is that it has the capacity to absorb and dissipate incident wave energy while protecting the underlying soil. The stone revetment also has the advantage that it can easily be designed to blend smoothly into the adjacent existing stone revetment.

## **EMBANKMENT STABILIZATION DESIGN**

The following presents a summary of the analyses performed to evaluate the design parameters for the proposed slope stabilization at Cliff Road. The wave conditions at the River Road project area were not evaluated due to its relatively sheltered location.

As illustrated by Figure 1, the Cliff Road project site is directly exposed to ocean waves from the Atlantic Ocean to the east. However, review of the offshore bathymetry revealed that the shoals at the entrance to the Ipswich River currently limit the height of the waves that can reach the site. It was estimated that at the 100-year water level, the shoals will limit wave heights entering Plum Island Sound to 12 feet in height.

Since the proposed revetment is above the mean high water line at Cliff Road, breaking wave conditions were assumed for the design of the revetment. The breaking wave heights were evaluated using the procedures outlined in Volume II, Chapter 7, Part I, Section 4 of the US Army Corps of Engineers Shore Protection Manual 1984 (SPM). A range of wave periods were



evaluated resulting in breaking wave heights varying from 7.6 to 8.3 feet. A breaking wave height of eight feet was selected for the design of the revetment.

Armor stone sizing calculations and revetment layer design were performed using the Hudson Equation and methodology's presented in the SPM and the U.S Army Corps of Engineers Coastal Engineering Manual EM -1110-2-1100 2006 (CEM). The calculation indicated that a four ton armor stone should be used for the revetment. Armor stone observed on the adjacent revetment generally ranged in size from three to seven tons with the majority of the stones in the three to four ton size. A four ton armor stone size was selected and to ensure stability of the revetment toe, the proposed design includes a six ton toe stone.

Wave runup calculations were performed to determine the height of the stone revetment on the embankment. The runup calculations were performed using the methodologies presented in Volume II, Chapter 7, Part II, Section 1 of the SPM and Part VI, Chapter 5 of the CEM. The wave runup calculations were performed for wave periods ranging from eight to 14 seconds. The SPM wave runup results ranged from elevation 22 to 40 NAVD. The CEM wave runup results ranged from elevation 19 to 26 NAVD. The FEMA flood elevation at the site is 15, which appears to underestimate the wave runup. The SPM results are based on model test with an impervious under layer and tend to overestimate the wave runup. Based on the preceding results and field observations, a top elevation of 25 was selected for the Cliff Road revetment.

#### **PROPOSED EMBANKMENT STABILIZATION PROJECT**

The proposed project at the River Road site consists of the removal of approximately 315 linear feet of the existing vertical timber wall and stone toe protection and the installation of a new stone revetment and cap stone. The existing wall and toe stones will be removed and replaced with the new revetment. The proposed stone revetment will be constructed of two foot thick armor stone layer with bedding stone placed on 1 vertical to 1.5 horizontal and 1 vertical to 1 horizontal slopes. A two foot thick capstone will be placed at the top of the slope to provide further wave protection and curbing. The existing stones will utilized within the new revetment. The new stone revetment will be located within the footprint of the existing toe stones, timber wall and concrete cap.

The gravel area between the existing timber wall and River Road will be replaced with loam, and will be seeded with salt tolerant grass species. This will aid in absorption of stormwater runoff and help prevent future embankment erosion.

The proposed project at Cliff Road site involves an approximately 600 foot extension of the adjacent stone revetment to the north. The upper eroded areas of the slope will be loamed and vegetated. The proposed stone revetment will extend from the toe of the existing bank to elevation 25 NAVD. In areas where the top of the bank is below elevation 25, the revetment will only extend to the existing top of slope. The eroded portions of the bank above elevation 25 NAVD will be re-graded to match the grade of the new revetment, and then planted with erosion control/salt tolerant grass.

Cliff Road within the project area drains to a low point at the north end of the road where a catch basin is located. The catch basin discharges to the embankment below. The proposed work will also involve the replacement of the existing bituminous curbing with a bituminous berm on the seaward side of Cliff Road, replacement of the existing catch basin with a deep sump catch basin with outlet tee, replacement of the outlet pipe and installation of a mortared stone swale to prevent erosion of the slope.

## INITIATION OF SLOPE STABILIZATION WORK



As discussed in the prior paragraphs the April 2007 Northeaster caused significant damage to the Cliff Road and River Road embankments. At Cliff Road the large collapsed slope area is within 30 feet of the sewer line in road. Similarly, at River Road there is a sewer line located within 10 feet of the deteriorated timber bulkhead. Based on the potential for further loss and damage to the Cliff Road and River Road, it is VA's opinion that the embankment stabilization work should be started as soon as practical, since another severe storm event could result in the loss of more embankment area and damage to the existing roads and utilities.

## ESTIMATED CONSTRUCTION COST

As part of VA's previous efforts on the Little Neck Embankment Stabilization Project, construction cost estimates were prepared for the proposed work at Cliff and River Roads. The cost estimates were based on our experience with similar projects in eastern Massachusetts. VA's initial construction cost estimates were updated in November of 2010. The construction cost estimates presented below reflect the November 2010 costs with a 5% increase for inflation.

PROJECT AREA	ESTIMATE COST
CLIFF ROAD	\$750,000
RIVER ROAD	\$200,000
<b>TOTAL ESTIMATED COST</b>	<b>\$950,000</b>

It should be noted that the above construction costs are estimated and that actual construction cost will be dependent upon contractor availability and fuel and material costs at the time of construction.

## ANTICIPATED FUTURE EROSION AND STORM IMPACTS

As with most of the open coastlines of Massachusetts long term erosion rates are dependent upon the frequency and intensity of coastal storms that impact the shoreline. The predominant type of storm that impacts the Ipswich coastline is a northeaster. Due to its location within Ipswich Bay, Little Neck is partially sheltered from the storm waves generated by northeasters. However, as evidenced by the 2007 Northeaster, Little Neck is susceptible to storm damage from severe northeasters.

If the Little Neck Embankment Stabilization Project is implemented and maintained, erosion of the embankments should be minimal. Incidental erosion due to foot traffic or severe rain events could cause erosion along the top of the embankments. The occurrence of a 500 year storm event or other cataclysmic storm could damage the existing or proposed stone revetments and cause embankment erosion.

Without the proposed Project, the sloughing and erosion of the Cliff Road embankment will continue to occur and may occur more frequently. Predicting long term erosion rates for these types of shorelines is difficult since erosion of the embankment is highly dependent upon the frequency of severe storm events. Over the long term the continued erosion of the Cliff Road embankment will eventually impact Cliff Road and the utilities located within the Road. In addition, the continued erosion will soon start to impact the stability of the adjacent existing stone revetment to the south.



If the proposed improvements are not implemented along the River Road embankment, the structural deterioration of the existing timber will continue and there will be further loss of back fill due to structural failure and erosion by high tides and storm events. The continued structural deterioration of the bulkhead and the loss of backfill will make the structure more susceptible to a catastrophic failure. Consequently the occurrence of a storm of the magnitude of the 2007 Northeaster could result in the loss of a much larger section of River Road and the loss of the sewer line in River Road with the associated environmental impacts.

We hope that the information presented in this letter is helpful. Please contact Peter Williams at 781-749-2530 x201 or [peter.williams@gza.com](mailto:peter.williams@gza.com) if you have any questions or require any additional information.

Sincerely,

VINE ASSOCIATES

A DIVISION OF GZA GEOENVIRONMENTAL, INC.

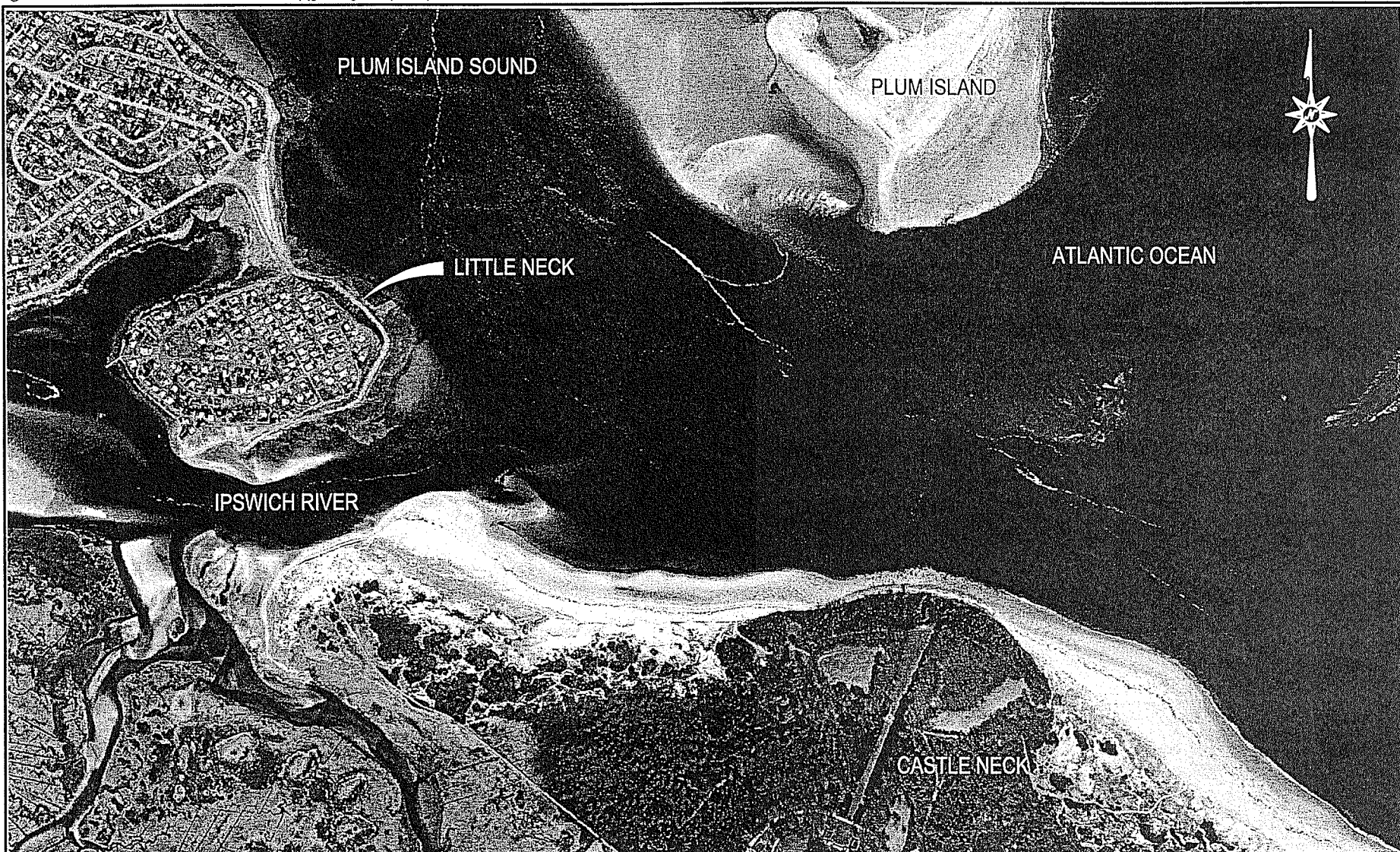
A handwritten signature in black ink, appearing to read "Peter Williams".

Peter Williams, P.E.  
Senior Project Manager

A handwritten signature in black ink, appearing to read "David B. Vine".

David B. Vine, P.E.  
Principal-In-Charge

Attachments: Figures (4)  
Photographs (5)



**NOTE:**

IMAGE UTILIZED IN BASE MAP WAS TAKEN FROM 2008 COLOR ORTHO IMAGERY PUBLISHED BY OFFICE OF GEOGRAPHIC INFORMATION (MassGIS), COMMONWEALTH OF MASSACHUSETTS INFORMATION TECHNOLOGY DIVISION.

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**LOCUS PLAN**

PREPARED BY:



GZA GeoEnvironmental, Inc.  
Engineers and Scientists  
www.gza.com

PREPARED FOR:

FEOFFEES OF THE  
GRAMMAR SCHOOL

PROJ MGR: PJW

DESIGNED BY: PJW

DATE: NOV. 2011

REVIEWED BY:

DRAWN BY: DMG/MAG

PROJECT NO. 18.0171123

CHECKED BY:

SCALE: N.T.S.

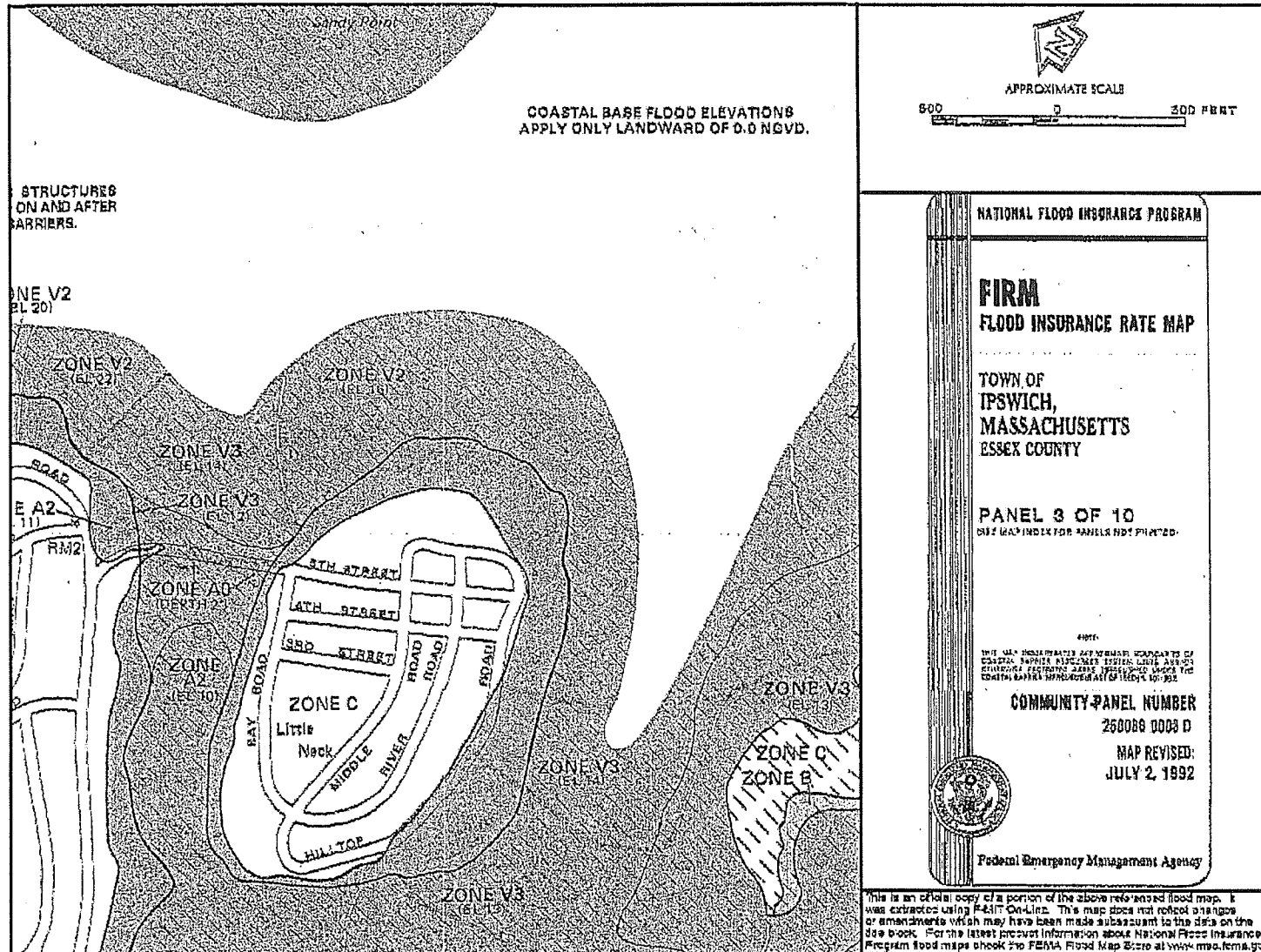
REVISION NO.

**FIGURE**

**1**

SHEET NO. 1 OF 4





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FEMA FLOOD ZONES

PREPARED BY:

Vine Associates  
A DIVISION OF GZA GeoEnvironmental, Inc.  
Engineers and Scientists  
www.gza.com

PREPARED FOR:

FEOFFEEES OF THE GRAMMAR SCHOOL

PROJ MGR: PJW	REVIEWED BY: DBV	CHECKED BY: DBV
DESIGNED BY: PJW	DRAWN BY: DMG/MAG	SCALE: N.T.S.
DATE: NOV. 2011	PROJECT NO. 18.0171123	REVISION NO.

FIGURE

2

SHEET NO. 2 OF 4



**NOTE:**

IMAGE UTILIZED IN BASE MAP WAS TAKEN FROM 2008 COLOR ORTHO IMAGERY PUBLISHED BY OFFICE OF GEOGRAPHIC INFORMATION (MassGIS), COMMONWEALTH OF MASSACHUSETTES INFORMATION TECHNOLOGY DIVISION.

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**EMBANKMENT AREA DELINEATION**

PREPARED BY:



GZA GeoEnvironmental, Inc.  
Engineers and Scientists  
www.gza.com

PREPARED FOR:

FEOFFEEES OF THE GRAMMAR SCHOOL

PROJ MGR: PJW

DESIGNED BY: PJW

DATE:

NOV. 2011

REVIEWED BY:

DRAWN BY: DMG/MAG

PROJECT NO.

18.0171123

CHECKED BY:

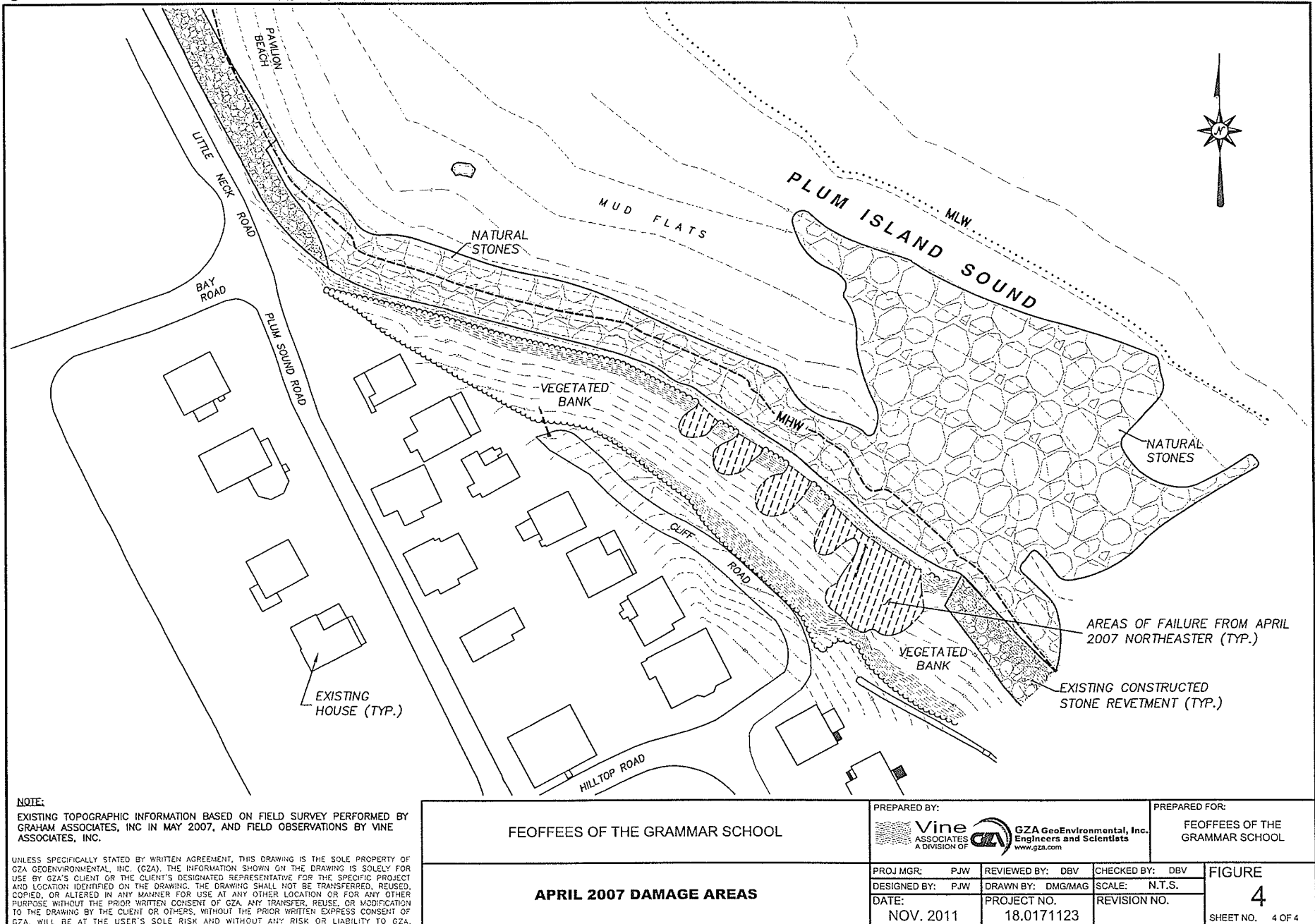
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REVISION NO.

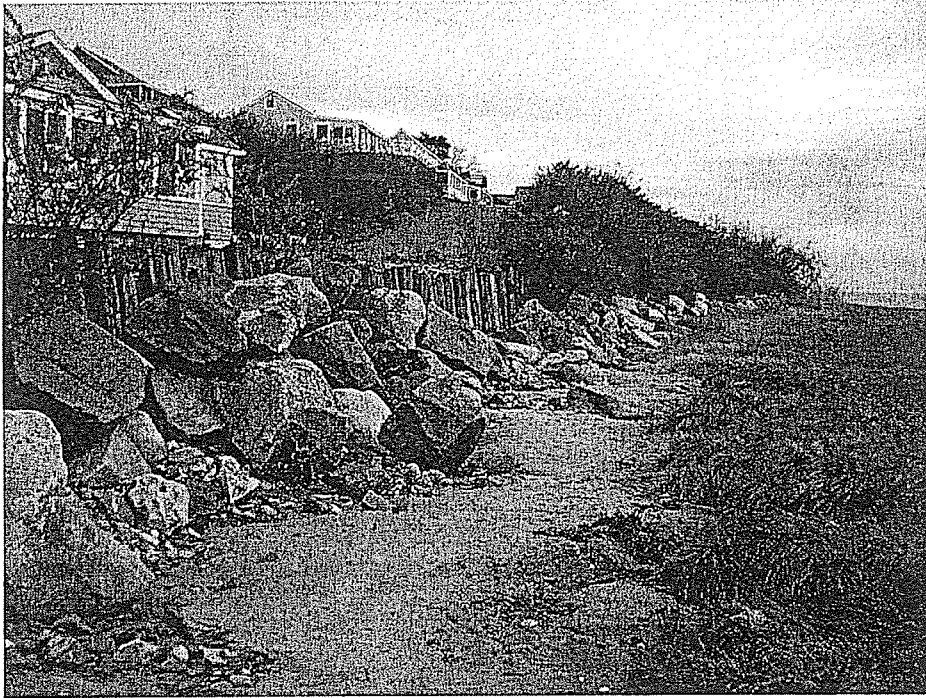
FIGURE

3

SHEET NO. 3 OF 4



**SITE PHOTOGRAPHS**  
**LITTLE NECK, IPSWICH, MA**



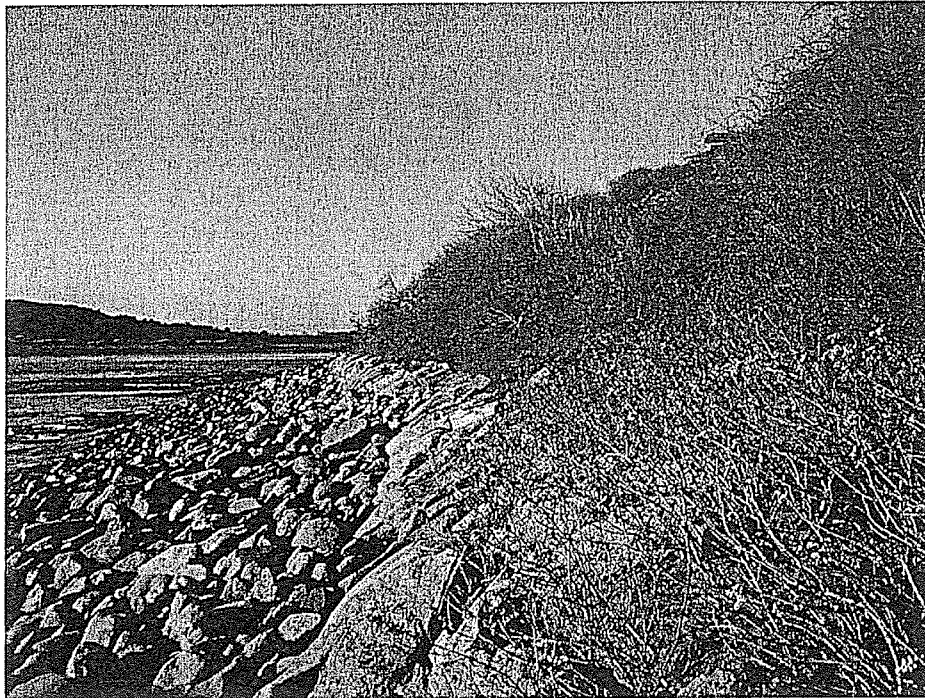
**Photograph #1:** View of River Road embankment looking east.



**Photograph #2:** View of River Road embankment looking west.



**SITE PHOTOGRAPHS**  
**LITTLE NECK, IPSWICH, MA**



**Photograph #3:** View of existing revetment looking south.



**Photograph #4:** View of Cliff Road embankment in winter looking south.

**SITE PHOTOGRAPHS**  
**LITTLE NECK, IPSWICH, MA**



**Photograph #5:** View of Cliff Road embankment from Pavilion Beach.



**Photograph #6:** View of storm damage along Cliff Road embankment.

**SITE PHOTOGRAPHS**  
**LITTLE NECK, IPSWICH, MA**

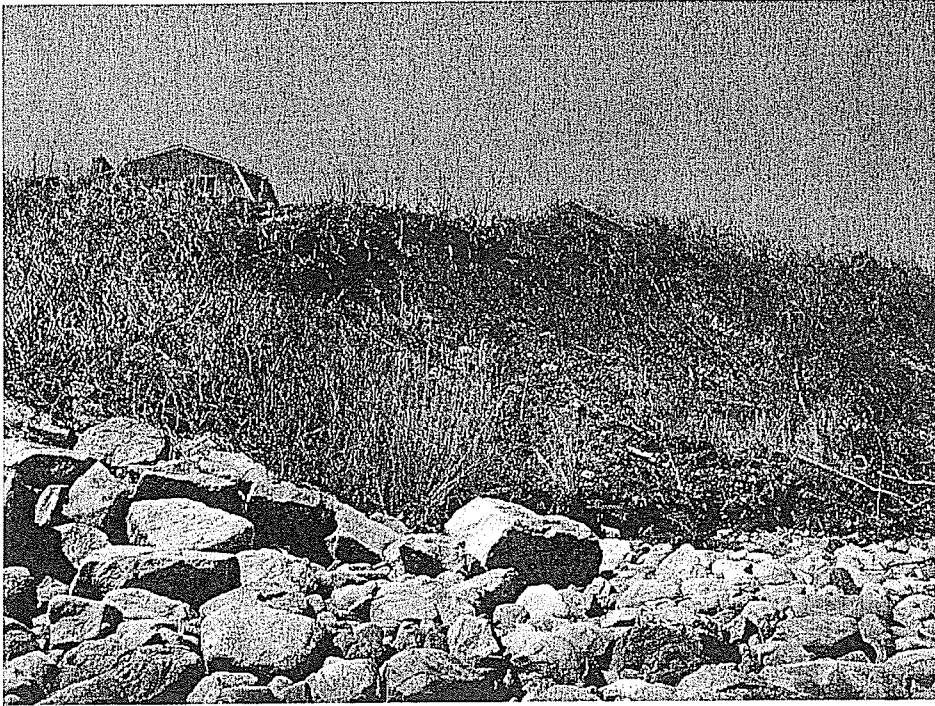


**Photograph #7:** View of storm damage at toe of Cliff Road embankment.



**Photograph #8:** Close up view of storm damage along Cliff Road embankment.

**LITTLE NECK, IPSWICH, MA**



**Photograph #9:** View of Cliff Road embankment storm damage adjacent to the existing revetment.