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12 December 2012
Project No. 750513310

Mr. Ed Sommerauer
City of Alameda Public Works Department
950 West Mall Square, Room 110
Alameda, California 94501

Subject: Geotechnical Evaluation of Erosion at Alameda Shoreline Park
Alameda, California

Dear Mr. Sommerauer:

This letter report presents the results of our geotechnical evaluation of shoreline erosion occurring along the north shore of Alameda Shoreline Park on Bay Farm Island in Alameda, California. Our services were provided as part of the City of Alameda Geotechnical Investigative Services contract. This consultation is in fulfillment of our proposal dated 21 August 2008. In preparing this report, we have 1) reviewed the conceptual design report 2) discussed the project with you, and 3) performed field exploration.

PROJECT DESCRIPTION

Alameda Shoreline Park is located along the northern and western shorelines of Bay Farm Island in Alameda, California, as shown on Figure 1. The park was constructed in the early 1980s and includes an asphalt-paved bike path with an adjoining decomposed granite jogging path. A second decomposed granite footpath is present between the jogging path and the water line. Some areas of the park shoreline are protected with rock riprap, particularly along the western shoreline. Where riprap is not present, the soil at the shoreline consists of sand.

Estimated ground surface elevations at the park generally range from about Elevation 100 feet[1] at the water line to about Elevation 106 feet near the existing asphalt-paved path. Based on the original grading plans for the park, the shoreline embankment is sloped at a maximum inclination of about 2:1 (horizontal to vertical), though typical slopes are more gradual.

Some erosion of the shoreline embankment has occurred at localized areas along the north shore of Shoreline Park at the San Leandro Channel, at areas not protected with riprap. We understand the City of Alameda (City) is concerned that if the shoreline erosion continues, the nearby decomposed granite and asphalt paths may be undermined. The City is considering implementing shoreline protection measures to reduce the potential for further erosion.

SCOPE OF SERVICES

Our scope of services, outlined in our proposal dated 21 August 2012, consisted of the following tasks:

- evaluating the subsurface conditions at one area of erosion by drilling three borings and performing three dynamic cone penetromenter tests (DPTs)
- providing conclusions and recommendations for shoreline protection measures to reduce the potential for further erosion.

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1 Elevations discussed in this report are based on grading plans included in the original project drawings titled "Alameda Shoreline Park, Alameda, California," prepared by CHNMB Associates, 14 October 1980; the vertical datum is unspecified.

FIELD INVESTIGATION AND LABORATORY TESTING

Subsurface conditions at one area of erosion were explored by drilling three borings, designated B-1 through B-3, and performing three DPTs, designated DPT-1 through DPT-3. The approximate locations of the borings and DPTs are shown on Figure 2.

Prior to performing our field investigation we contacted Alameda County Public Works Agency (ACPWA) to obtain a drilling permit; however, ACPWA indicated a permit was not required for this project. The City obtained a permit from the San Francisco Bay Conservation and Development Commission (BCDC) for this project. We notified Underground Service Alert prior to our field work to check that the planned boring and DPT locations were clear of existing utilities.

The borings were drilled by our field engineers on 31 October 2012 using hand auger equipment. The borings were advanced to depths ranging from about 2 to 5 feet below the existing ground surface (bgs). During drilling, our field engineers logged the soil encountered and obtained representative samples of the soil for classification and laboratory testing. The boring logs are presented in Appendix A on Figures A-1 through A-3. The soil encountered in the borings was classified in accordance with the soil classification system presented on Figure A-4.

To evaluate the strength of the soil, a DPT was performed near each of the borings. The DPT consists of driving a 1.4-inch-diameter, cone-tipped probe into the ground with a 35-pound hammer falling 15 inches. The blows used to drive the probe are converted to Standard Penetration Test (SPT) N-values for use in evaluating the soil conditions. The DPTs were advanced to depths between 9.5 to 23 feet bgs. The SPT N-values resulting from the DPTs are presented in Appendix B.

We re-examined the soil samples obtained from our borings to confirm the field classifications and select representative samples for geotechnical laboratory testing. Soil samples were tested to measure moisture content and gradation. The geotechnical laboratory test results are presented on the boring logs and in Appendix C.

SITE AND SUBSURFACE CONDITIONS

On the basis of our field investigation and our review of the subsurface information available for the site vicinity, the site is underlain by up to about 8 feet of loose to dense sandy fill, which decreases in thickness toward the shoreline. Between the jogging path and the shoreline, erosion has occurred in the sand fill; in localized areas, scarps on the order of 2 to 2-1/2 feet high have developed in the fill.

The fill is underlain by weak, compressible marine clay, known locally as Bay Mud, which may be on the order of 40 feet thick; evaluating the thickness of the Bay Mud was not included in the scope of our investigation. The Bay Mud is likely underlain by layers of stiff sandy and silty clay and dense sand and gravel.

Groundwater was encountered in borings at a depth of approximately 0.7 feet bgs near the shoreline in boring B-3 and about 5 feet bgs near the existing asphalt-paved bike path in boring B-1. These depths correspond to approximate Elevations 101 and 99 feet, respectively. The groundwater measurements during our field investigation were not stabilized. The groundwater level fluctuates with the tides; because Bay Mud is virtually impervious, the water level does not drop below the Bay Mud surface.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of our investigation, we conclude the project is feasible from a geotechnical standpoint. Recommendations for temporary and long-term shoreline protection are provided in this section.

Causes of Erosion

The north shore of Alameda Shoreline Park at San Leandro Channel is a tidal marsh. Tidal marshes are typically exposed to low-energy wave action; however, periods of high wave energy can occur during storm events, when high water and wind pushes waves beyond the marsh plants and erodes the bank, which is comprised of sandy fill, near the water line. Other likely causes of the shoreline erosion are tidal water level fluctuation, overbank drainage of surface water during storms, and occasional high waves resulting from boats passing nearby.

After erosion occurs, the eroded soil is washed away by subsequent waves. We judge that additional erosion of the sandy fill at the shoreline will occur unless an erosion mitigation measure is implemented and maintained.

Temporary Shoreline Protection

We judge temporary measures can be implemented to protect the shoreline from further erosion on a short-term basis. Temporary measures should be anticipated to provide erosion protection for a time period of several months to one year. Two options for temporary shoreline protection are as follows:

1) Biodegradable coconut (coir) fiber rolls and coir erosion protection mats: Erosion protection mats can be spread on the ground surface between the water line and up the erosion scarp. The mats should be staked to the ground a distance of at least two feet beyond the erosion scarp (toward the jogging path) to reduce the potential for further loosening the soil at the top of the scarp. The mats should also be staked at the bottom of the scarp and near the water line. The coir fiber rolls can be stacked along the base of the erosion scarp to provide further protection from wave action.

2) Biodegradable hay bales: The hay bales can be placed side-to-side along the base of the erosion scarps to protect the scarps from wave action. The bales should be staked to the ground with long wood stakes. The bales can be used alone; however, additional protection would be provided by using the bales in conjunction with the erosion protection mat previously described under Option 1.

Long-Term Shoreline Protection

For long-term protection of the shoreline, the primary geotechnical issues are the presence of the sand fill and underlying weak Bay Mud. The Bay Mud may undergo consolidation settlement due to placement of new fill, depending on the weight of the fill and the thickness and properties of the underlying Bay Mud. In addition, the Bay Mud will not provide a stable base upon which to construct a typical retaining wall; deep foundations would likely be needed to support the wall. Likewise, any new fill or surface protection placed on the shoreline will need to be gently sloped to reduce the potential for slope failure.

Detailed static and seismic slope stability analyses and recommendations for soil improvement and retaining walls were not part of our scope of services. However, we judge there could be some lateral movement of the shoreline slopes should a major earthquake occur near the site.

On the basis of the available site information, we judge the following options can be used to provide long-term erosion protection for the shoreline slopes:

1) Rock slope protection (rock or rubble riprap): Rock slope protection consists of layers of rock placed along a shoreline to reduce the potential for erosion, scour, and sloughing of the embankment. The slope protection may include materials other than rock, such as concrete rubble or broken concrete slabs. A typical rock slope protection system consists of an outside layer of large-sized rock or rubble, an inner layer of small-size rock or rubble, and a filter fabric placed on the regraded bank. This type of slope protection is considered a flexible revetment, with individual rocks working independently within the rock mass. Rock slope protection should be designed in accordance with the recommendations provided in the Caltrans document, "California Bank and Shore Rock Slope Protection Design, Final Report No. FHWA-CA-TL-95-10, Caltrans Study No. F90TL03," dated October 2000. However, because of the presence of Bay Mud at the site, we recommend the toe of the riprap be feathered onto the Bay Mud rather than keyed into the Bay Mud. The final surface of the riprap should be sloped at a maximum inclination of 3:1 (horizontal to vertical), with the thickest section of rock near the toe of the slope to provide confinement. If needed, we can provide an example riprap detail that has been used successfully on previous Bay Mud sites.

2) Coconut fiber mats with vegetation plugs: This option is similar to the temporary shoreline protection measure previously described; however, for long-term erosion protection, it would include regrading the embankment slope, anchoring a biodegradable coir erosion blanket on the slope with stakes, and planting plugs of vegetation through the mat. An alternative to the vegetation plugs would be to hydroseed under the erosion blanket. The purpose of the planting is to create a dense zone of vegetation to buffer the shoreline embankment from high waves after the coir mat has degraded. Vegetation appropriate for a marine environment would need to be selected. Because the embankment is comprised of sand, it may be necessary to fertilize the slopes for the first two years to facilitate vegetation growth. Advantages of this option are that it is likely more cost effective than riprap, could be more aesthetic than riprap, and it may be possible to implement it over smaller areas to repair localized erosion. A disadvantage of this option, as compared to the riprap option described above, is that periodic maintenance including slope regrading and replanting will likely be necessary to maintain a thick zone of vegetation.

Site Preparation for Long-Term Shoreline Protection Options

Areas to be improved should be stripped of concrete/asphalt pavement (if any), loose surface soil, vegetation, and topsoil (if any). If present, topsoil and organics may be stockpiled for later use elsewhere (e.g. landscaped areas), if approved by the architect.

If any fill or backfill is needed to repair eroded areas, the fill should be placed in lifts not exceeding eight inches in loose thickness, moisture-conditioned to near optimum moisture content, and compacted to at least 90 percent relative compaction. If the fill consists of on-site sand or imported sand or gravel with less than 10 percent fines (material passing the No. 200 sieve), it should be compacted to at least 95 percent relative compaction. If the subgrade is too soft to achieve this compaction, a reinforcing fabric and at least 8 inches of crushed rock overlain by filter fabric can be placed to provide a stable subgrade. The crushed rock should be angular and uniformly graded, with particle sizes between 1/2 and 3/4 inch. From a geotechnical standpoint, crushed concrete can be used instead of crushed rock provided it meets the requirements for crushed rock.

Materials to be used as fill and backfill should consist of imported soil that is free of organic matter and contain no rocks or lumps larger than four inches in greatest dimension. Imported fill, if needed, should also meet these criteria and have a low expansion potential as defined by a liquid limit (LL) of less than 40 and a plasticity index (PI) of 12 or less. We judge that the excavated on-site sand is suitable to be used as fill and backfill provided it meets the requirements given above. However, Bay Mud is typically not recommended to be used as fill because of its high moisture content and high expansion potential.

Samples of imported material should be submitted to the geotechnical engineer for approval and testing at least 72 hours before delivery to the site. The grading subcontractor should provide analytical test results or other suitable environmental documentation indicating the imported fill is free of hazardous materials at least three days before use at the site. If this data is not available, up to two weeks should be allowed to perform analytical testing on the proposed import material.

GEOTECHNICAL SERVICES DURING CONSTRUCTION

During final design, we should be retained to consult with the design team as geotechnical issues arise. Prior to construction of permanent erosion protection measures, we should review the project plans and specifications to check their conformance with the intent of our recommendations. During construction, we should observe subgrade preparation, fill placement and compaction, and placement of the erosion protection system. These observations will allow us to compare the actual with the anticipated soil conditions and to check that the contractors' work conforms to the geotechnical aspects of the plans and specifications.

LIMITATIONS

The conclusions and recommendations presented in this letter result from limited subsurface investigation and engineering studies based on our interpretation of the existing geotechnical conditions. Actual subsurface conditions may vary. If any variations or undesirable conditions are encountered during construction, or if the proposed construction will differ from that described in this report, Treadwell & Rollo, A Langan Company should be notified to make supplemental recommendations, as necessary.

We trust this letter provides the information you require at this time. If you have any questions, please call.

Sincerely yours,
TREADWELL & ROLLO, A LANGAN COMPANY

Elena M. Ayers

REGISTERED PROFESSIONAL ENGINEER ELENA M. AYERS NO. GE2916 Exp. 12/31/13 GEOTECHNICAL STATE OF CALIFORNIA

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Lori A. Simpson, G.E. #2396
Senior Associate/Vice President

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Attachments: Figure 1 – Site Location Map
Figure 2 – Site Plan
Appendix A – Figures A-1 through A-3: Log of Borings B–1 through B-3
Figure A-4: Classification Chart
Appendix B – Dynamic Cone Penetrometer Test Log
Appendix C – Figure C-1: Particle Size Analysis

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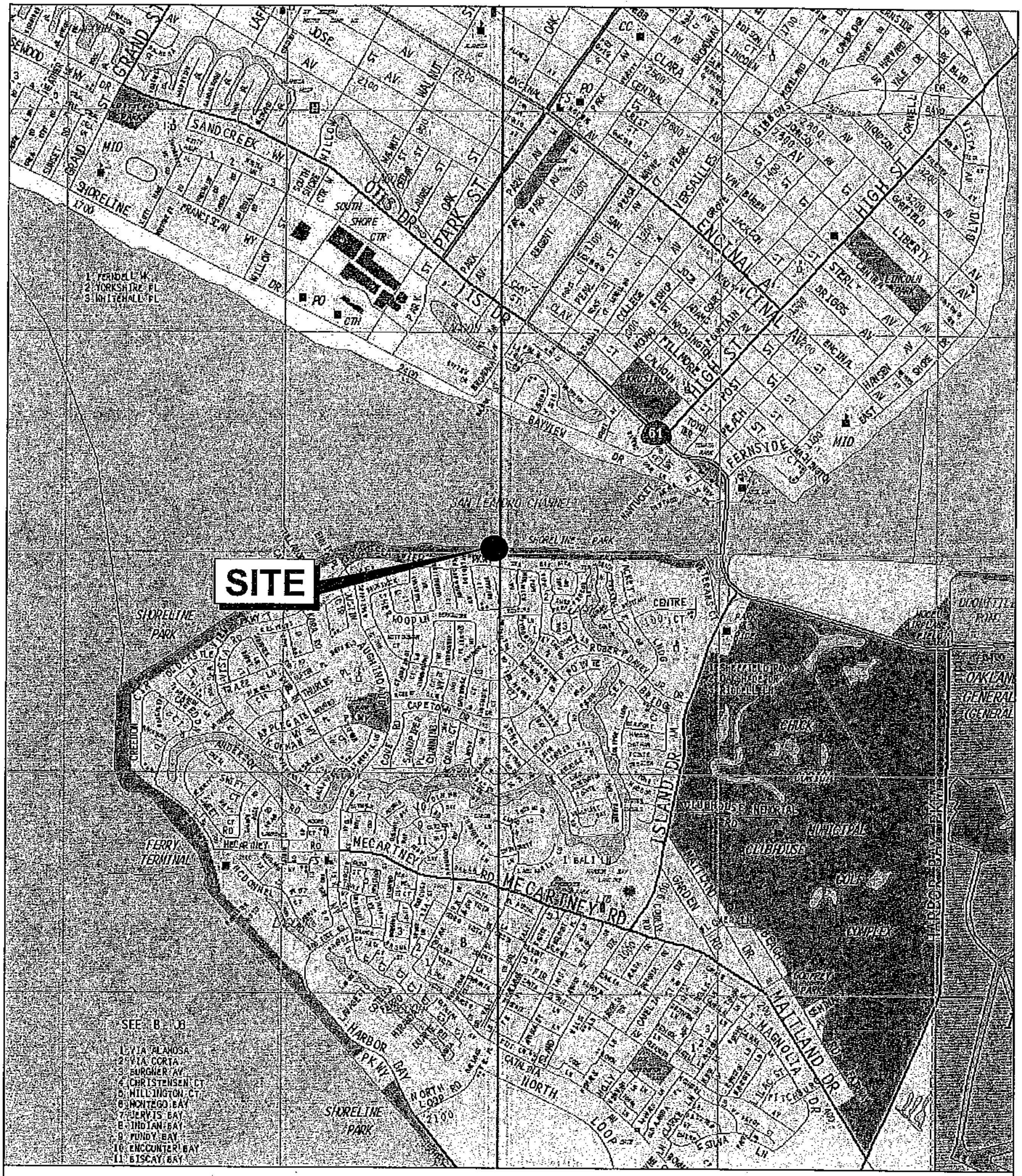
FIGURES



Base map: The Thomas Guide
San Francisco County
2002

0 2000 Feet
Approximate scale

EROSION AT ALAMEDA SHORELINE PARK
Alameda, California

SITE LOCATION MAP

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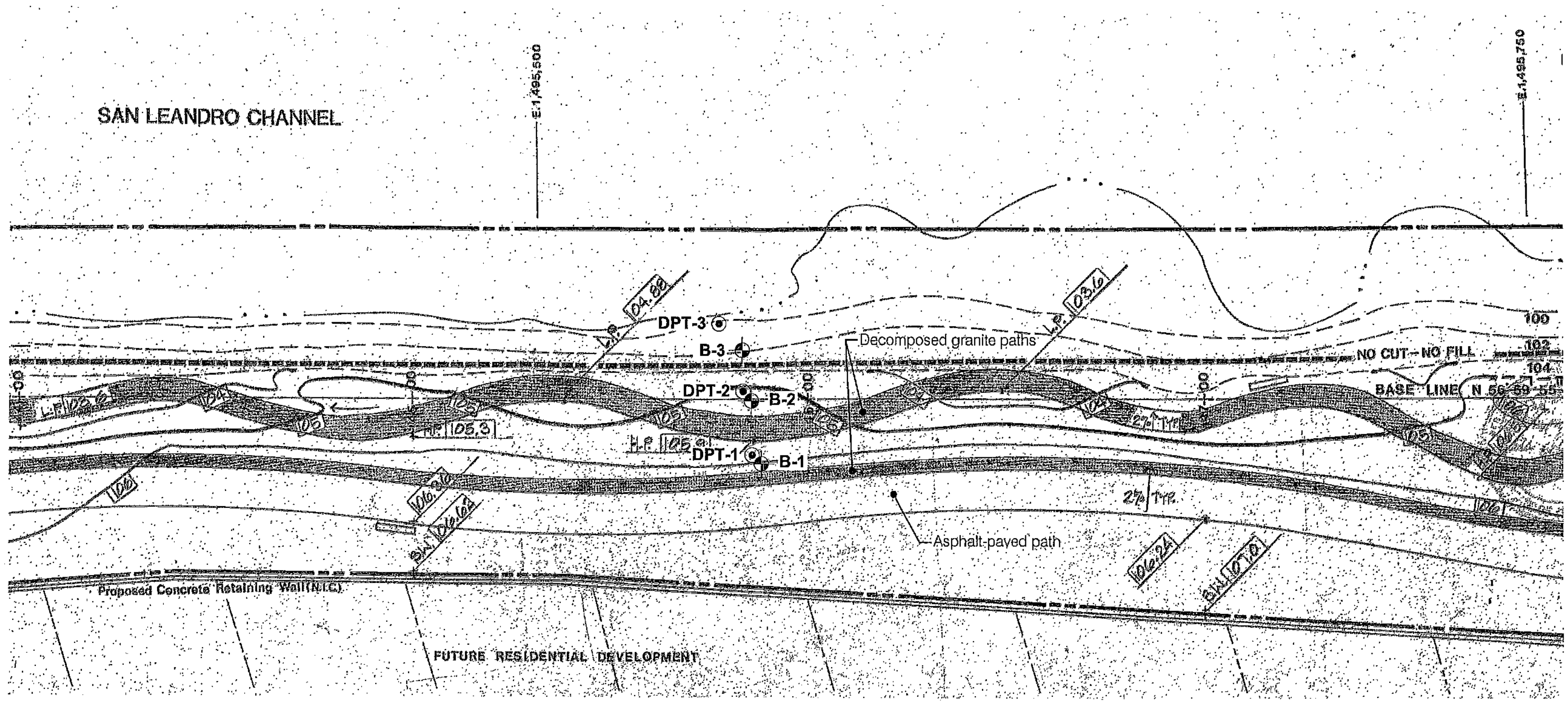
Date 12/10/12	Project No. 750513310	Figure 1



EXPLANATION

B-1 — Approximate location of boring by Treadwell & Rollo, October 2012

DPT-1 — Approximate location of dynamic cone penetrometer test by Treadwell & Rollo, October 2012

0 30 Feet

Approximate scale

EROSION AT ALAMEDA SHORELINE PARK
Alameda, California

SITE PLAN

Date 12/10/12	Project No. 750513310	Figure 2

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Reference: Base map from a drawing titled "Grading Plan," by CHNMB, dated 10/14/80.

APPENDIX A
Logs of Borings and Classification Chart

Log of Boring B-1

PAGE 1 OF 1

PROJECT: EROSION AT ALAMEDA SHORELINE PARK
Alameda, California

Boring location:	See Site Plan, Figure 2
Date started:	10/31/12
Date finished:	10/31/12
Drilling method:	Hand Auger
Hammer weight/drop:	NA
Hammer type:	NA
Sampler:	Bulk
Logged by:	E. Toth/K. Johnson

Ground Surface Elevation: 106 feet[1]

DEPTH (feet)	Sampler Type	Sample	Blows/ 6"	SPT N-Value[1]	LITHOLOGY	MATERIAL DESCRIPTION	Type of Strength Test	Confining Pressure Lbs/Sq Ft	Shear Strength Lbs/Sq Ft	Fines %	Natural Moisture Content, %	Dry Density Lbs/Cu Ft
0–2	BULK	X			SP-SM	SAND with SILT (SP-SM) olive-brown, moist, fine-grained sand, with trace organic rootlets, and occasional gravel and rock fragments up to 1 inch in diameter, and asphalt fragments. Sieve Analysis, see Figure C-1 (FILL)				11.8	3.4	
2–4.5	BULK, BULK, BULK	X			SP	SAND (SP) olive-brown, moist, fine-grained sand, with trace fines and shells, occasional organics (plant fibers), organic odor (FILL)						
4.5–5					SP-SM	SAND with SILT (SP-SM) olive-brown, moist to wet, fine-grained sand, trace shell fragments and organics (plant fibers), organic odor. Groundwater (10/31/12, 10:20 a.m.) (FILL)						

Boring terminated at a depth of 5 feet below ground surface.
Boring backfilled with soil cuttings.
Groundwater encountered at 5 feet below ground surface during hand augering.

[1] Elevations based on project datum (Grading Plan, Sheet L19, Alameda Shoreline Park, by CGNMB, 14 October 1980).

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Project No.: 750513310
Figure: A-1

TEST GEOTECH LOG 750510310.GPJ TR.GDT 12/12/12

PROJECT:	EROSION AT ALAMEDA SHORELINE PARK Alameda, California	Log of Boring B-2

Boring location:	See Site Plan, Figure 2		
Date started:	10/31/12	Date finished:	10/31/12
Drilling method:	Hand Auger		
Hammer weight/drop:	NA	Hammer type:	NA
Sampler:	Bulk		

Logged by: E. Toth/K. Johnson

DEPTH (feet)	Sampler Type	Sample	Blows/ 6"	SPT N-Value[1]	LITHOLOGY	MATERIAL DESCRIPTION Ground Surface Elevation: 103 feet[1]		Type of Strength Test	Confining Pressure Lbs/Sq Ft	Shear Strength Lbs/Sq Ft	Fines %	Natural Moisture Content, %	Dry Density Lbs/Cu Ft
	BULK	X			SC	CLAYEY SAND with GRAVEL (SC) brown, moist, fine- to coarse-grained sand, gravel fragments up to 1 inch in diameter	FILL						
1	BULK	X			SP	SAND (SP) olive-gray, moist to wet, fine-grained sand, trace fines, trace organics (rootlets) ▽ (10/31/12, 10:39 a.m.) Sieve Analysis, see Figure C-1	FILL				4.2	25.6	
2					CH	CLAY (CH) gray, soft, wet, trace organics	BAY MUD						
3													
4													
5													
6													
7													
8													
9													
10													

LABORATORY TEST DATA

Boring terminated at a depth of 2 feet below ground surface.
Boring backfilled with soil cuttings.
Groundwater encountered at 1 foot below ground surface during hand augering.

[1] Elevations based on project datum (Grading Plan, Sheet L19, Alameda Shoreline Park, by CGNMB, 14 October 1980).

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Project No.: 750513310

Figure: A-2

TEST GEOTECH LOG 750510310.GPJ TR.GDT 12/12/12

PROJECT: **EROSION AT ALAMEDA SHORELINE PARK**
Alameda, California

Log of Boring B-3

Boring location:	See Site Plan, Figure 2
Date started:	10/31/12
Date finished:	10/31/12
Drilling method:	Hand Auger
Hammer weight/drop:	NA
Hammer type:	NA
Sampler:	Bulk
Logged by:	E. Toth/K. Johnson

LABORATORY TEST DATA

DEPTH (feet)	Sampler Type	Sample	Blows/ 6"	SPT N-Value[1]	LITHOLOGY	MATERIAL DESCRIPTION (Ground Surface Elevation: 101 feet[1])	Type of Strength Test	Confining Pressure Lbs/Sq Ft	Shear Strength Lbs/Sq Ft	Fines %	Natural Moisture Content, %	Dry Density Lbs/Cu Ft
0					CH	CLAY (CH) gray, very soft, wet, abundant organics (10/31/12, 11:10 a.m.) ▽ — BAY MUD (0 to 3.5 feet)						
1	BULK	X										
2	BULK	X										
3												
4												
5												
6												
7												
8												
9												
10												

Boring terminated at a depth of 3.5 feet below ground surface.
Boring backfilled with soil cuttings.
Groundwater encountered at 0.7 feet below ground surface during hand augering.

[1] Elevations based on project datum (Grading Plan, Sheet L19, Alameda Shoreline Park, by CGNMB, 14 October 1980).

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Project No.: 750513310
Figure: A-3

TEST GEOTECH LOG 750510310.GPJ TR.GDT 12/12/12

UNIFIED SOIL CLASSIFICATION SYSTEM

Major Divisions		Symbols	Typical Names
Coarse-Grained Soils (more than half of soil > no. 200 sieve size	Gravels (More than half of coarse fraction > no. 4 sieve size)	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	Sands (More than half of coarse fraction < no. 4 sieve size)	SW	Well-graded sands or gravelly sands, little or no fines
		SP	Poorly-graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
Fine -Grained Soils (more than half of soil < no. 200 sieve size)	Silts and Clays LL = < 50	ML	Inorganic silts and clayey silts of low plasticity, sandy silts, gravelly silts
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays
		OL	Organic silts and organic silt-clays of low plasticity
	Silts and Clays LL = > 50	MH	Inorganic silts of high plasticity
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic silts and clays of high plasticity
Highly Organic Soils		PT	Peat and other highly organic soils

GRAIN SIZE CHART

Classification	Range of Grain Sizes: U.S. Standard Sieve Size	Range of Grain Sizes: Grain Size in Millimeters
Boulders	Above 12"	Above 305
Cobbles	12" to 3"	305 to 76.2
Gravel	3" to No. 4	76.2 to 4.76
coarse	3" to 3/4"	76.2 to 19.1
fine	3/4" to No. 4	19.1 to 4.76
Sand	No. 4 to No. 200	4.76 to 0.075
coarse	No. 4 to No. 10	4.76 to 2.00
medium	No. 10 to No. 40	2.00 to 0.420
fine	No. 40 to No. 200	0.420 to 0.075
Silt and Clay	Below No. 200	Below 0.075

▽ Unstabilized groundwater level

▼ Stabilized groundwater level

SAMPLE DESIGNATIONS/SYMBOLS

Sample taken with Sprague & Henwood split-barrel sampler with a 3.0-inch outside diameter and a 2.43-inch inside diameter. Darkened area indicates soil recovered

Classification sample taken with Standard Penetration Test sampler

Undisturbed sample taken with thin-walled tube

Disturbed sample

Sampling attempted with no recovery

Core sample

Analytical laboratory sample

Sample taken with Direct Push sampler

SAMPLER TYPE

C Core barrel

CA California split-barrel sampler with 2.5-inch outside diameter and a 1.93-inch inside diameter

D&M Dames & Moore piston sampler using 2.5-inch outside diameter, thin-walled tube

O Osterberg piston sampler using 3.0-inch outside diameter, thin-walled Shelby tube

PT Pitcher tube sampler using 3.0-inch outside diameter, thin-walled Shelby tube

S&H Sprague & Henwood split-barrel sampler with a 3.0-inch outside diameter and a 2.43-inch inside diameter

SPT Standard Penetration Test (SPT) split-barrel sampler with a 2.0-inch outside diameter and a 1.5-inch inside diameter

ST Shelby Tube (3.0-inch outside diameter, thin-walled tube) advanced with hydraulic pressure

EROSION AT ALAMEDA SHORELINE PARK
Alameda, California

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CLASSIFICATION CHART

Date 11/07/12 | Project No. 750513310 | Figure A-4

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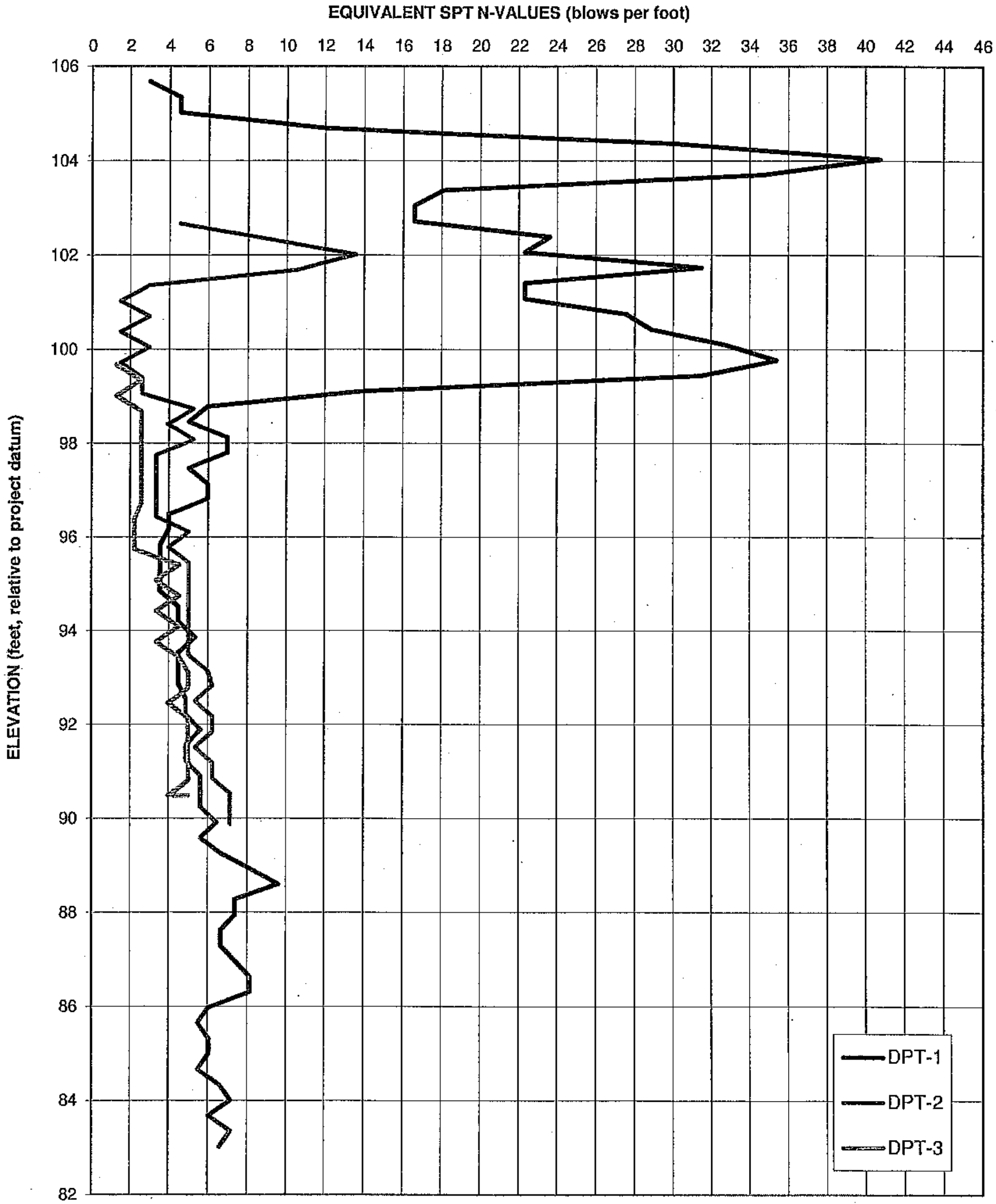
APPENDIX B
Dynamic Cone Penetrometer Test Log

Appendix B
Dynamic Cone Penetrometer Test Log
Erosion at Alameda Shoreline Park
Alameda, California



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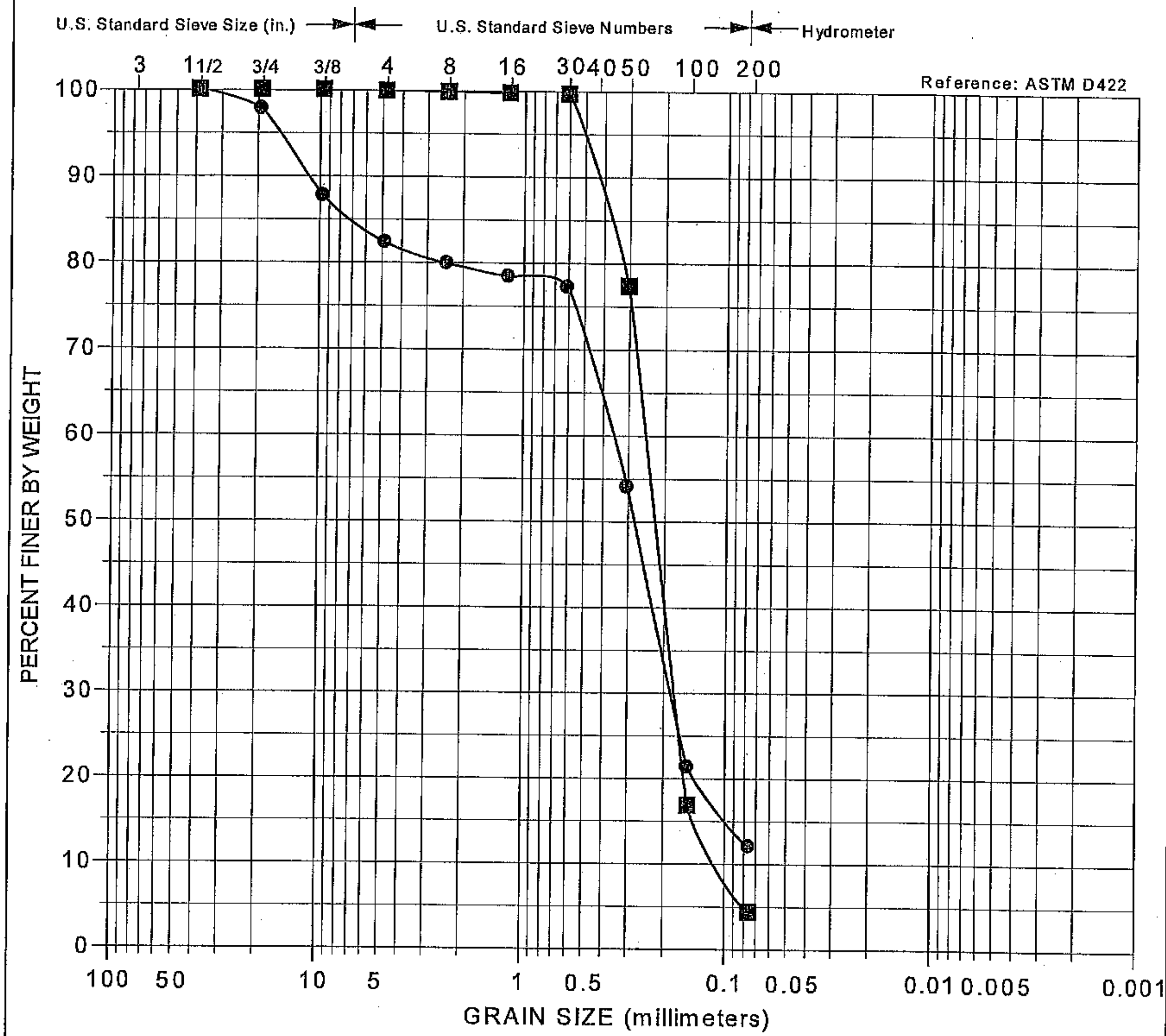
APPENDIX C
Particle Size Analysis



Sample	% Gravel		%Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay

Symbol	Sample Source	Classification
●	B-1 at 1foot	SAND with SILT (SP-SM), olive-brown
■	B-2 at 1 foot	SAND (SP), olive-gray

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PARTICLE SIZE ANALYSIS

Date 12/10/12	Project No. 750513310	Figure C-1