Final General Reevaluation Report
and
Final Environmental Impact Statement

on

Hurricane Protection and Beach Erosion Control

WEST ONSLOW BEACH AND NEW RIVER INLET (TOPSAIL BEACH), NORTH CAROLINA

Appendix E

Sand Compatibility Analysis

Appendix E: Sand Compatibility Analysis

Table of Contents

1. Introduction	E-1
2. Definitions	E-1
3. Grain Size Nomenclature	E-3
4. Native Beach Sampling and Results	E-3
5. Borrow Material Sampling and Results	E-5
6. Overfill Ratio	E-7
7. Compatibility and Borrow Sources	E-7

List of Figures

Figure E-1 - Mean Grain Size @ Dune Toe	E-9
Figure E-2 – Mean Grain Size @ Berm Crest	E-9
Figure E-3 – Mean Grain Size @ Mean High Water	E-10
Figure E-4 – Mean Grain Size @ Mean Sea Level	E-10
Figure E-5 - Mean Grain Size @ Mean Low Water	E-11
Figure E-6 - Mean & Standard Deviation of All Foreshore Samples	E-11

List of Tables

Table E-1 - Native Beach Samples	E-12
Table E-2 - Composite Characteristics of the Native Beach Sands	E-15
Table E-3 - Borings for Borrow Area A	E-16
Table E-4 – Borings for Borrow Area B	E-20
Table E-5 – Borings for Borrow Area C	E-21
Table E-6 – Borings for Borrow Area D	E-23
Table E-7 – Borings for Borrow Area E	E-24
Table E-8 – Borings for Borrow Area F	E-25
Table E-9 - Composite Characteristics for Borrow Area A	E-26
Table E-10 - Composite Characteristics for Borrow Area B	E-26
Table E-11 - Composite Characteristics for Borrow Area C	E-27
Table E-12 - Composite Characteristics for Borrow Area D	E-27
Table E-13 - Composite Characteristics for Borrow Area E	E-28
Table E-14 - Compatibility Characteristics of Borrow Area F	E-28
Table E-15 – Compatibility of Native and Borrow Sand	E-29

Appendix E: Sand Compatibility Analysis

1. **Introduction.** Sands making up the native beach are generally hydraulically sorted with the coarser grain sizes concentrated in the foreshore region, where wave energy is the greatest, and the finer grain sizes located in the offshore areas seaward of the surf zone. In order for the borrow material to be compatible with the native beach sand, the borrow material must contain essentially all of the same grain sizes that exist on the active beach profile of the project area. In this regard, the active beach profile is generally defined in engineering terms as the portion of the profile from the top of the beach berm seaward to depths where significant sand transport by wave energy is negligible. At Topsail Island, the active beach profile appears to end in a water depth of approximately 23 feet below National Geodetic Vertical Datum (NGVD). Note that sediment movement in water depths greater than 23 feet below NGVD is known to occur. However, the rate of sediment movement in these deeper depths is relatively small compared to rate of movement in the shallower depths and are therefore of minor importance in the day to day and year to year behavior of the beach profile.

2. **Definitions.** Definitions are included to provide better understanding of the terminology used in this appendix.

   Active zone. The zone that extends from the top of the beach berm seaward to depths where sediment transport induced by waves is negligible.

   Beach berm. A nearly horizontal part of the beach or backshore formed by the deposit of material by wave action.

   Datum. Any permanent line, plane, or surface, used as a reference to which elevations are referred.

   Foreshore. The part of the shore, lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the ordinary low water mark, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall.

   Grain size. Refers to the mean or effective diameter of individual mineral grains or particles. Grain size analysis passes particles through a series of sieves with known mesh sizes to determine the grain size based on the amount of particles retained or passing a sieve.

Mean high water (MHW). The average height of high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value.

Mean low water (MLW). The average height of low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value.

Mean sea level (MSL). The average height of the surface of the sea for all the stages of the tide over a 19-year period, usually determined from hourly height readings. Not necessarily equal to mean tide level. It is also the average water level that would exist in the absence of tides.

Offshore. The zone extending from the shoreface to the edge of the continental shelf.

Overfill ratio. Used to evaluate the compatibility of sediments and to relate the volume of borrow site sediment required for a project to perform comparably with native beach sand.

Phi scale. A common method to represent grain size distribution. The scale is a logarithmic transformation of the Wentworth grade scale for size classifications of sediment grains based on the negative logarithm to the base 2 of the particle diameter. A phi value is dimensionless and has equivalent millimeter values.

Vibracore. A drill machine driven by a vibrating head assembly to collect sediment samples. Ocean sediment samples are collected by lowering the machine from a floating vessel to the ocean floor.

3. **Grain Size Nomenclature.** Note that the mean grain sizes of the native and borrow area materials are reported in both millimeters (mm) and phi (N) units in this report where phi is related to the grain size as follows:

$$N = -\log_2(d)$$

where:
d = grain size in millimeters (mm)
$\log_2$ = logarithm to the base 2

Since the distribution of the sand samples can generally be represented as log-normal distributions, the standard deviations and variances of the particle size distributions are reported in phi units.

4. **Native Beach Sampling and Results.** The characteristics of the native beach material at Topsail Island were determined through an extensive sampling program. The details and results of the sampling are discussed below. The sampling of the native beach material was concentrated in two areas. The foreshore, which extends from mean low water (approximately 1.9 feet below NGVD in the study area) landward to the seaward toe of the dune and the offshore area, which extends seaward from mean low water to a depth of 23 feet below NGVD. The foreshore and offshore samples were collected at approximately 5,000-foot intervals along the study area in order to evaluate grain size differences along the study area. The samples collected at each interval or profile line (see Appendix A, Figure A-2) were combined to develop the composite characteristics of the native beach material to be used in the compatibility analysis of the borrow material. The composite characteristics of the native beach material refers to a singular grain size distribution, in terms of percent passing a particular sieve size, that contains all of the sand grain sizes on the active beach profile.

<u>**Foreshore Zone**</u>

Samples of the native beach material were collected from the seaward toe of the dune (TOE), center of the berm (CREST), mean high water (MHW), mean sea level (MSL), and mean low water (MLW) at the aforementioned 5,000-foot profile lines (Appendix A, Figure A-2) along the study area shoreline. The grain size distribution of each sample was determined by standard sieve analysis, from which the mean and standard deviation of the grain size distribution of each sample were determined.

Plots of the variation in the mean grain size of the 5 foreshore samples collected at each sample profile line along the study area shoreline are shown on Figures E-1 through E-5. The mean grain size of the samples collected at the toe of the dune and the crest of the berm (Figures E-1 and E-2) do not follow a large trend. The mean grain size of these samples does decrease in size slightly from south to north in the study area. The mean grain size of the samples collected at mean high water (Figure E-3) do not follow any trend and decrease and increase several times between profile lines. The samples collected from the mean sea level and mean low water point (Figures E-4 and E-5) increase in size slightly from south to north in the study area but do not show a large trend.

The average grain size of the foreshore samples were computed from the 5 samples collected at each sample profile line and plotted. This plot is shown on Figure E-6. This average mix of the foreshore samples is similar to the individual foreshore sample figures and shows very little to no trend for changes in size of the foreshore material throughout the study area. Also shown on Figure E-6 is the composite standard deviation of the 5 foreshore samples. The foreshore samples appear to be well sorted, i.e.; the distribution of grain sizes is relatively small throughout the study area.

Active Beach Profile Zone

While the foreshore samples provide some insight into the local shore processes in the area, the success of any beach nourishment project depends on the ability to find borrow material that is compatible with all of the material on the active beach profile, not just the foreshore. In the case of Topsail Island, this active littoral zone appears to extend to a depth of 23 feet below NGVD. Accordingly, samples were obtained from the 5,000-foot profile lines (Appendix A, Figure A-2) along the study area with samples collected in 2-foot depth increments along each profile, extending to a 24-foot depth. Sampling based on water depth accounts for the natural hydraulic sorting of sand grain sizes that occurs as a result of wave and tide action.

Composite Characteristics for Project Areas

The size distributions of all of the beach samples collected from each of the profiles are given in Table E-1. The composite characteristics of the native beach sands along the Topsail Beach study area were computed by mathematically mixing all of the samples collected from the active beach profile to obtain a singular mean and standard deviation representative of all of the sediment on the active beach profile. The composite characteristics for Topsail Beach are summarized in Table E-2. The composite mean for Topsail Beach is 2.18 phi (0.22 mm) with a standard deviation of 1.50 phi. As stated earlier, the standard deviation is relatively the same for all profile lines indicating that the sediments are well sorted throughout the project area.

5. Borrow Material Sampling and Results. The search for borrow material was concentrated in Banks Channel behind Topsail Island and in the ocean waters off Topsail Island beginning in water depths of 30 feet below NGVD and extending seaward to approximately 6.5 miles offshore. Details of this offshore search for beach compatible material is described in Appendix C, Geotechnical Analyses, and consisted of a combination of seismic surveys followed by the collection of vibracores at 369 locations. Boring logs were developed for each vibracore based on visual classifications of the material in the cores. The sand layers in each vibracore were sampled for grain size analysis. The results of the grain size analysis of the vibracore material combined with the seismic bottom profile data, was used to delineate the boundaries of six (6) potential offshore borrow areas. Composite grain size characteristics of the material in each of these potential borrow areas were computed for comparison with the composite characteristics of the native beach material.

Borrow Material Vibracores

The investigation was conducted in two major phases. Phase one consisted of the collection of over 142 miles of seismic subbottom profiles while phase two involved the collection of 167 vibracores for the Topsail Beach project. The search area and the seismic lines surveyed in this effort for the entire Topsail Island are displayed in Attachment 1 to Appendix C, Geotechnical Analyses. The seismic survey data was analyzed to determine areas where beach quality material of sufficient depth appeared likely.

Based on the interpretation of the seismic data, a vibracore drilling plan was developed to determine the characteristics of the subbottom material. In this regard, the seismic data only provides information on the layering of material and does not provide information of the granular characteristics of the material. The vibracores consist of vibrating a 20-foot long plastic core into the ocean bottom. The plastic core is then split and the material characteristics in the core visually classified. Material collected in the core was sampled and the size distribution of that material was determined through standard sieve analysis. In general, the cores were sampled in two-foot intervals or more frequently if a significant difference in the character of the material was visually apparent. The locations of the vibracores collected for the Topsail Beach study area are shown on Figure A-2 in Appendix A. Logs of each of the vibracores are provided in Attachment 2 to Appendix C, Geotechnical Analyses.

Borrow Site Vibracore Analysis

The results of the grain size analysis was used to delineate the potential borrow areas. The six defined borrow areas (designated as A, B, C, D, E, and F) and the vibracores taken within each of the areas are shown on Figure A-2 in Appendix A. The grain size characteristics of all of the samples collected from each of the cores within the six potential borrow areas are given in Tables E-3 through E-8. The grain size characteristics of the borrow area samples were used to develop weighted composite grain size distribution representative of all of the material in each of the borrow areas. The weighting was based on the thickness of the core represented by a particular sample in each core from which a weighted composite distribution for each core was determined. The weighted core distributions were used to compute the overall composite characteristics for the entire borrow area.

Included in the analysis was an estimate of the amount of fine-grained sediments in each core, that is sediment finer than the 200 sieve (0.074-mm). With regard to the percentage of fine-grained sediments, borrow areas containing more than 10 percent fines are generally considered to be incompatible for placement on the beach due to potential problems with increased turbidity and siltation during placement. The final weighted composite characteristics for each of the six borrow areas are given in Tables E-9 to E-15. As illustrated in these tables, the borrow areas are have acceptable levels of silt content (less than 10 percent).

6. Overfill Ratio. The suitability of the borrow material for placement on the beach is based on the overfill ratio. The overfill ratio is computed by numerically comparing the size distribution characteristics of the native beach sand with that in the borrow area and includes an adjustment for the percent of fines in the borrow area. The overfill ratio is primarily based on the assumption that the borrow material will undergo sorting and winnowing once exposed to waves and currents in the littoral zone, with the resulting sorted distribution approaching that of the native sand.

Since borrow material will rarely match the native material exactly, the amount of borrow material needed to result in a net cubic yard of beach fill material will generally be greater than one cubic yard. The excess material needed to yield one net cubic yard of material in place on the beach profile is the overfill ratio. The overfill ratio is defined as the ratio of the volume of borrow material needed to yield one net cubic yard of fill material. For example, if 1.5 cubic yards of fill material is needed to yield one net yard in place, the overfill factor would equal 1.5. The numerical procedure for computing the overfill ratio is contained in a suite of computer programs contained in the Automated Coastal Engineering System (ACES) produced by the U.S. Army Coastal Engineering Research Center. The procedure is also described in the U.S. Army Coastal Engineering Manual EM-1110-2-1100 Part V (July 2003). A summary of beach and borrow characteristics, as well as, the computed overfill ratios is shown in Table E-15.

7. Compatibility and Borrow Sources. The compatibility analysis compares the grain size of the “native beach” or the “reference beach” with the material in the proposed borrow material. The overfill ratio is the primary indicator of the compatibility of the borrow material to the beach material, with a value of 1.00 indicating that one cubic yard of borrow material is needed to match one cubic yard of beach material. An overfill ratio of up to 1.5 is generally considered acceptable as a match of compatibility. As shown in Table E-15, the overfill ratios for all of the potential borrow areas were below 1.5 indicating they are compatible for the Topsail Beach project.

The volume of borrow material available in borrow areas A, B, C, D, E, and F is approximately 21.1 million cubic yards. Borrow area A is the largest of the 7 potential sites with a total available volume of approximately 13.2 million cubic yards.

The volume of material in A is sufficient to satisfy the initial construction and a portion of most of the periodic nourishment cycles for the full 50-year economic life of the project. The composite mean grain size of material in borrow area A is 2.35 phi (0.20 mm) which is slightly smaller than the composite mean grain size of the native beach sand of 2.18 phi (0.22 mm). As a result the overfill factor for borrow area A is 1.35.

Additional material for the periodic nourishment cycles can be accomplished from 4 other borrow sites (B, D, E, and F) for various cycles. The composite mean grain size of the material from these borrow areas is relatively the same as the native beach sands. Relative to all of the borrow areas, borrow area C is the greatest distance from the project area (approximately 5.5 to 6.5 miles) and therefore is the least cost effective. Therefore, as stated in section 7.04.1.1, borrow area C would be reserved for contingency purposes. The composite mean grain size of the material in borrow area C is 2.32 (0.20 mm) which is slightly smaller than the composite mean grain size of the native beach sand. The overfill ratio for borrow area C is 1.45. Based on preliminary evaluation, borrow site F may be incompatible with the native material at Topsail Beach. However, additional characterization of the borrow areas will be conducted prior to use to confirm compatibility.

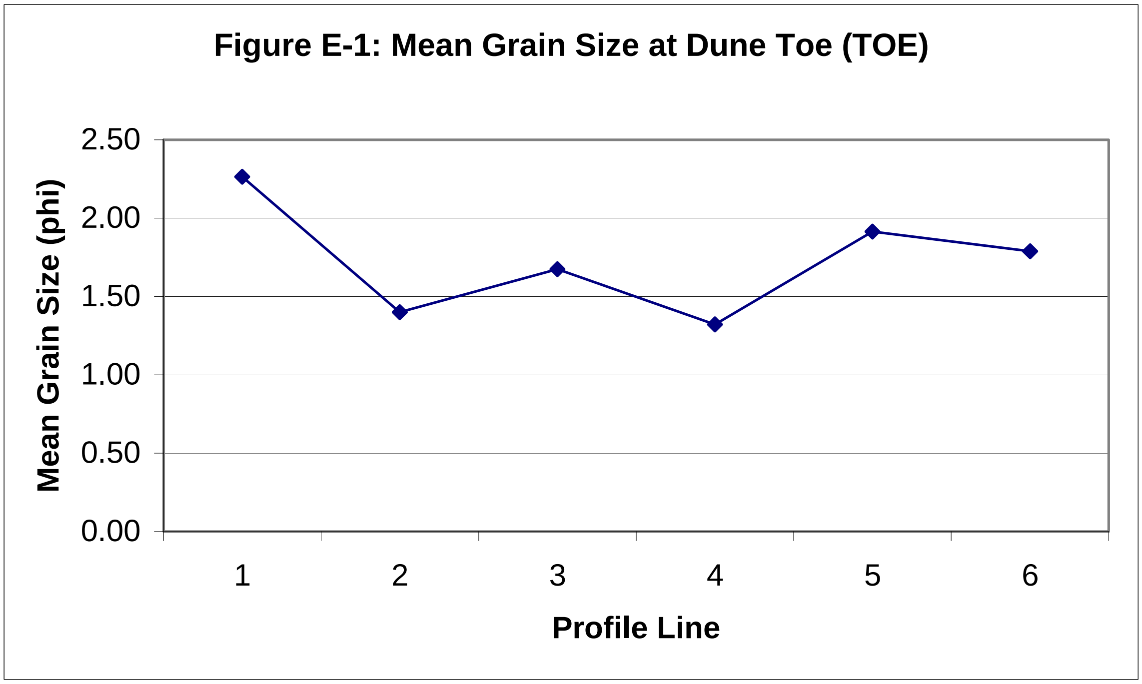
Figure E-1: Mean Grain Size at Dune Toe (TOE)
2.50
2.00
1.50
1.00
0.50
0.00
Mean Grain Size (phi)
1
2
3
4
5
6
Profile Line

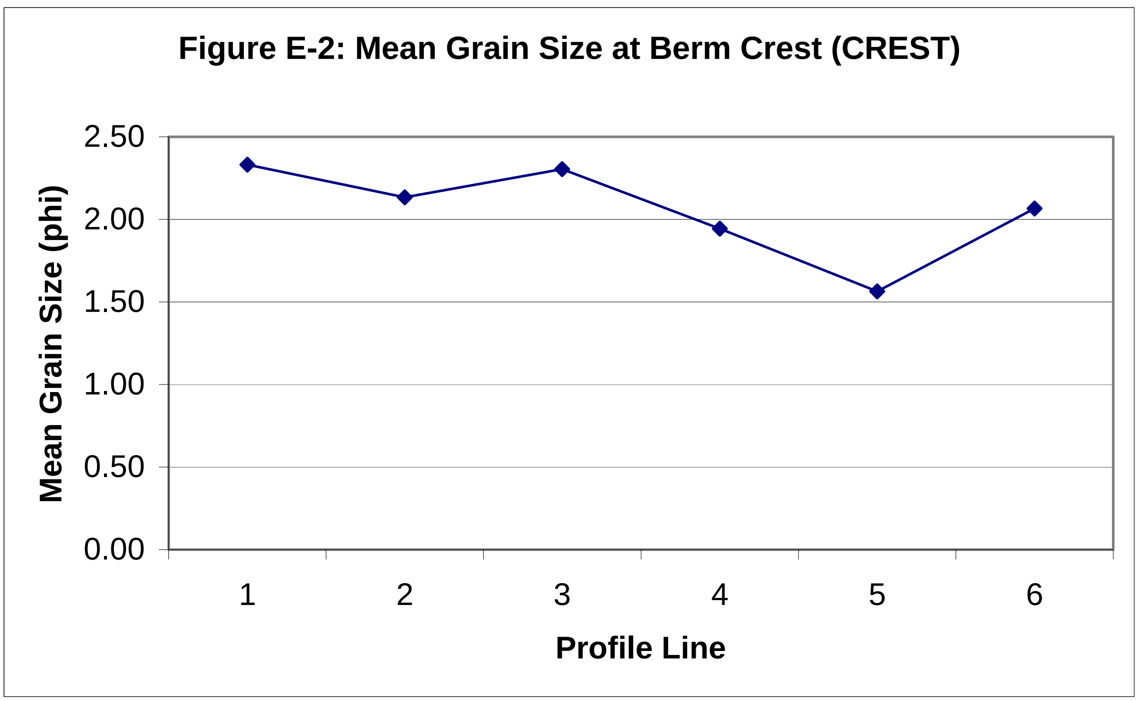
Figure E-2: Mean Grain Size at Berm Crest (CREST)
2.50
2.00
1.50
1.00
0.50
0.00
Mean Grain Size (phi)
1
2
3
4
5
6
Profile Line

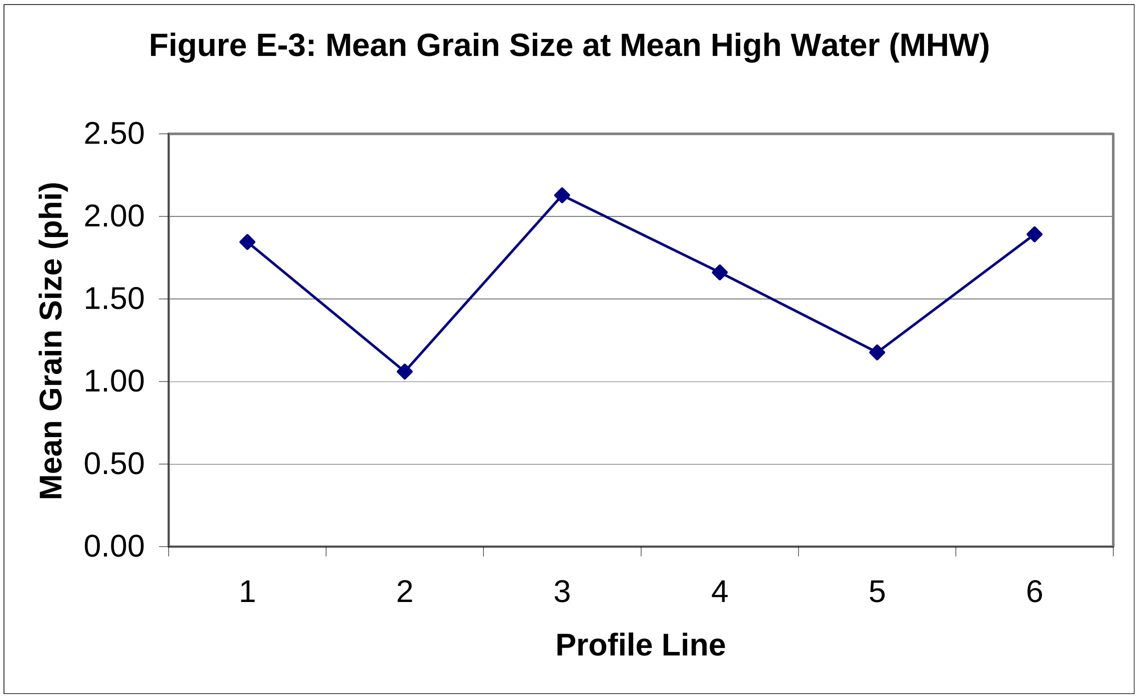
Figure E-3: Mean Grain Size at Mean High Water (MHW)
Mean Grain Size (phi)
2.50
2.00
1.50
1.00
0.50
0.00
1
2
3
4
5
6
Profile Line

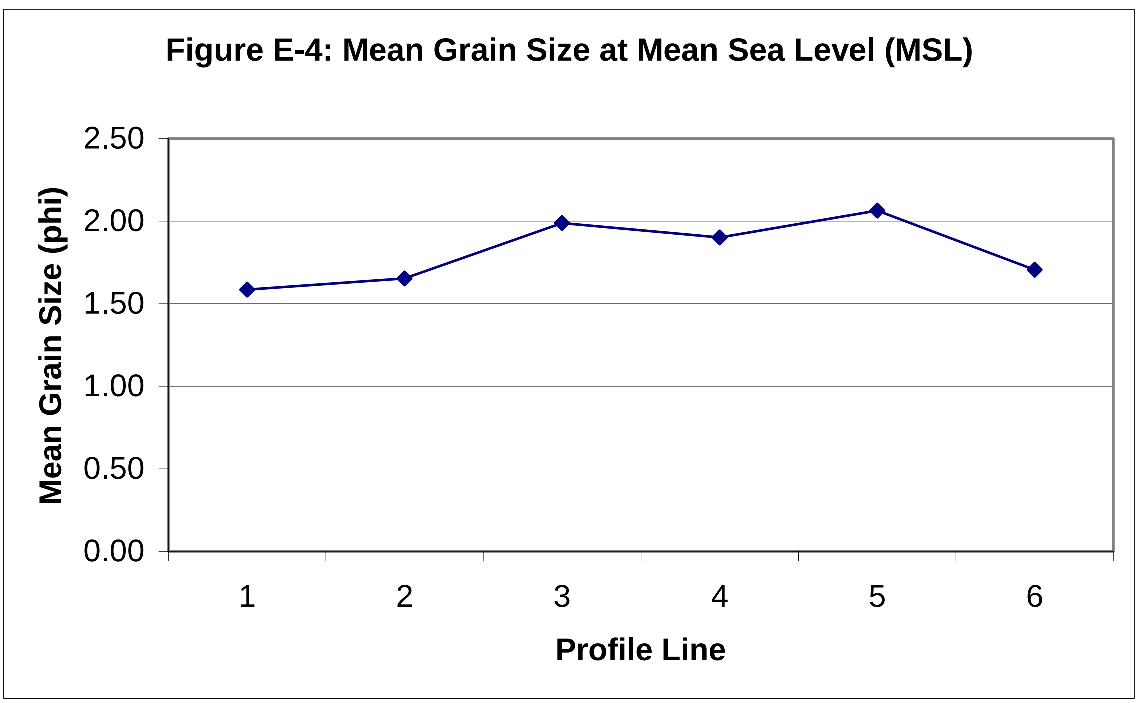
Figure E-4: Mean Grain Size at Mean Sea Level (MSL)
Mean Grain Size (phi)
2.50
2.00
1.50
1.00
0.50
0.00
1
2
3
4
5
6
Profile Line

Figure E-5: Mean Grain Size at Mean Low Water (MLW)

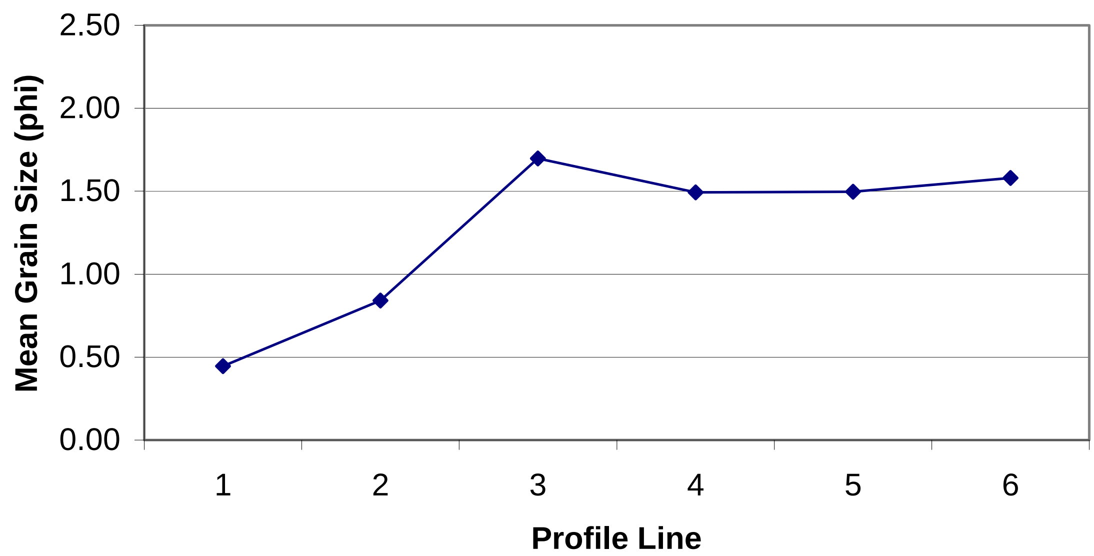

Figure E-6: Mean and Standard Deviation of All Foreshore Samples

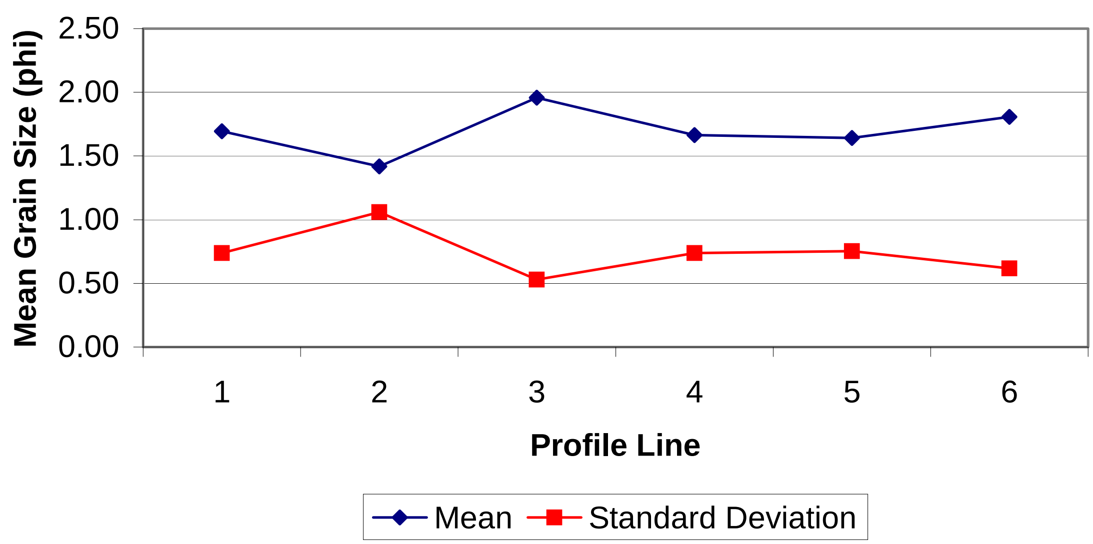

Table E-1
Native Beach Samples

Sample Description	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell
PROFILE LINE TB-1				
TB-1-TOE	2.27	0.23	0.1	3
TB-1-CREST	2.33	0.29	0.5	3
TB-1-MHW	1.84	0.69	0.9	14
TB-1-MLW	0.44	1.53	2.2	54
TB-1-MSL	1.59	0.95	1.1	23
TB-1-3	1.74	0.45	0.4	2
TB-1-4	1.43	1.16	0.8	28
TB-1-6	2.53	0.38	1.1	2
TB-1-8	2.49	0.39	1.3	2
TB-1-10	2.48	0.38	1.1	2
TB-1-12	2.44	0.37	1.3	3
TB-1-14	2.54	0.38	1.3	3
TB-1-16	2.42	0.37	1.1	3
TB-1-18	2.50	0.38	1.4	3
TB-1-20	2.44	0.38	1.4	3
TB-1-22	2.46	0.37	1.8	5
TB-1-24	2.45	0.36	1.1	5
PROFILE LINE TB-2				
TB-2-TOE	1.40	1.23	1.0	30
TB-2-CREST	2.13	0.40	0.8	7
TB-2-MHW	1.06	1.32	0.4	39
TB-2-MLW	0.84	1.40	1.0	42
TB-2-MSL	1.65	0.95	1.2	23
TB-2-3	0.89	1.81	0.5	35
TB-2-4	2.34	0.43	0.9	9
TB-2-6	2.44	0.38	1.2	4
TB-2-8	2.52	0.43	1.5	6
TB-2-10	2.52	0.45	1.6	8
TB-2-12	2.49	0.41	1.4	7
TB-2-14	2.60	0.38	1.3	3
TB-2-16	2.55	0.39	1.8	3
TB-2-18	2.58	0.39	1.9	4
TB-2-20	2.58	0.41	2.3	4
TB-2-22	2.50	0.42	2.0	6
TB-2-24	2.52	0.43	2.9	8

Table E-1
Native Beach Samples (continued)

Sample Description	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell
PROFILE LINE TB-3				
TB-3-TOE	1.67	0.64	0.4	17
TB-3-CREST	2.31	0.31	0.2	6
TB-3-MHW	2.13	0.38	0.1	10
TB-3-MLW	1.70	0.83	1.3	21
TB-3-MSL	1.99	0.50	1.2	14
TB-3-3	0.96	1.32	0.6	43
TB-3-4	2.16	0.57	0.5	14
TB-3-6	1.75	1.09	0.9	20
TB-3-8	2.47	0.39	0.5	7
TB-3-10	2.46	0.38	0.7	4
TB-3-12	2.48	0.44	2.3	7
TB-3-14	2.44	0.41	1.7	6
TB-3-16	2.48	0.39	1.6	5
TB-3-18	2.51	0.39	1.6	5
TB-3-20	2.59	0.39	2.4	7
TB-3-22	2.56	0.39	2.6	5
TB-3-24	2.40	0.41	1.8	10
PROFILE LINE TB-4				
TB-4-TOE	1.32	0.88	1.0	25
TB-4-CREST	1.94	0.59	0.1	16
TB-4-MHW	1.66	0.77	0.1	21
TB-4-MLW	1.49	0.94	1.0	26
TB-4-MSL	1.90	0.51	0.3	14
TB-4-3	-0.36	1.23	0.8	55
TB-4-4	2.13	0.42	1.1	10
TB-4-6	2.40	0.40	0.4	8
TB-4-8	2.26	0.59	1.1	11
TB-4-10	2.56	0.42	1.4	6
TB-4-12	1.57	1.35	1.3	25
TB-4-14	2.55	0.43	2.7	6
TB-4-16	2.48	0.40	1.3	6
TB-4-18	2.46	0.39	2.1	6
TB-4-20	2.56	0.42	2.9	8
TB-4-22	2.54	0.42	3.1	6
TB-4-24	2.56	0.42	3.2	6

Table E-1
<u>Native Beach Samples (continued)</u>

Sample Description	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell
PROFILE LINE TB-5				
TB-5-TOE	1.91	0.49	6.6	15
TB-5-CREST	1.56	0.83	1.4	27
TB-5-MHW	1.18	1.08	0.1	31
TB-5-MLW	1.50	0.92	1.1	26
TB-5-MSL	2.06	0.44	0.9	12
TB-5-3	1.10	1.01	1.1	42
TB-5-4	2.33	0.48	0.9	11
TB-5-6	2.34	0.47	1.1	9
TB-5-8	2.34	0.51	1.0	10
TB-5-10	2.31	0.71	2.8	15
TB-5-12	2.48	0.43	2.6	6
TB-5-14	2.45	0.42	2.2	7
TB-5-16	2.49	0.42	2.4	5
TB-5-18	2.53	0.42	2.5	4
TB-5-20	2.55	0.39	2.9	8
TB-5-22	2.60	0.41	3.6	4
TB-5-24	2.59	0.44	5.7	5
PROFILE LINE TB-6				
TB-6-TOE	1.79	0.55	0.5	14
TB-6-CREST	2.07	0.42	0.7	11
TB-6-MHW	1.89	0.55	0.9	13
TB-6-MLW	1.58	0.85	1.0	23
TB-6-MSL	1.71	0.72	1.3	18
TB-6-3	1.23	1.11	1.2	30
TB-6-4	2.16	0.54	0.7	9
TB-6-6	1.91	0.75	0.9	14
TB-6-8	2.25	0.66	1.4	13
TB-6-10	2.39	0.58	2.2	10
TB-6-12	2.54	0.43	3.1	6
TB-6-14	2.57	0.48	3.4	6
TB-6-16	2.56	0.41	2.9	4
TB-6-18	2.56	0.40	2.9	3
TB-6-20	2.62	0.37	3.5	4
TB-6-22	2.60	0.39	5.2	4
TB-6-24	2.66	0.41	6.6	2

Table E-2
Composite Characteristics for Native Beach Sands

Profile Line	Cumulative Depth	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean	Weighted Std Dev
TB-1	17	2.24	0.57	1.1	9	38.09	9.72
TB-2	17	2.17	0.75	1.4	14	36.95	12.80
TB-3	17	2.23	0.59	1.2	12	37.92	10.11
TB-4	17	2.04	0.87	1.4	15	34.66	14.74
TB-5	17	2.15	0.75	2.3	14	36.56	12.68
TB-6	17	2.22	0.67	2.3	11	37.72	11.34

Native Beach Sands Composite Data

Mean	**2.18**
Std Dev	**0.70**
%Silt	**1.6**
% Shell	**12**

Table E-3
Borings for Borrow Area A

Boring Number	Layer Number	Layer Depth (ft) Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-124	**1**	**-38.5**	**-40.5**	**2**	**1.72**	**1.59**	**9.6**	**22**	**3.45**	**3.17**
	2	-40.5	-42.5	2	2.37	0.54	19.2	11	4.75	1.07
	3	-42.5	-45	2.5	2.79	0.42	6.9	3	6.97	1.06
	4	-45	-48	3	2.84	0.58	14.1	1	8.51	1.74
	5	-48	-51	3	2.73	0.67	14.9	1	8.19	2.01
	6	-51	-53.5	2.5	2.61	0.47	12.6	1	6.52	1.19
		EL -38.5 to -40.5		**D= 2**	**1.72**	**1.59**	**9.6**	**22**	**3.45**	**3.17**
TI-03-V-125	**1**	**-38.9**	**-40.9**	**2**	**2.31**	**0.98**	**9.2**	**17**	**4.62**	**1.95**
	2	-40.9	-43	2.1	2.71	0.58	12.2	9	5.69	1.21
	3	-43	-46	3	2.94	0.42	13.1	1	8.81	1.27
	4	-46	-48	2	2.93	0.44	13.0	1	5.85	0.87
	5	-48	-50.5	2.5	2.95	0.55	14.8	1	7.37	1.38
	6	-50.5	-51	0.5	2.88	0.67	15.1	1	1.44	0.33
		EL -38.9 to -40.9		**D=2**	**2.31**	**0.98**	**9.2**	**17**	**4.62**	**1.95**
TI-03-V-126	**1**	**-38.7**	**-41**	**2.3**	**1.00**	**2.20**	**9.3**	**43**	**2.31**	**5.05**
	2	**-41**	**-43.5**	**2.5**	**2.77**	**0.38**	**7.4**	**3**	**6.92**	**0.94**
	3	-43.5	-45.5	2	3.06	0.64	16.4	2	6.12	1.28
	4	-45.5	-47.5	2	2.75	0.57	12.7	2	5.49	1.15
	5	-47.5	-49.2	1.7	3.28	1.32	21.7	1	5.57	2.24
	6	-49.2	-49.7	0.5	2.81	0.61	14.2	2	1.40	0.30
		EL -38.7 to -43.5		**D=4.8**	**1.76**	**1.79**	**8.3**	**22**	**8.43**	**8.58**
TI-03-V-127	**1**	**-39.8**	**-42.3**	**2.5**	**1.41**	**1.91**	**4.4**	**28**	**3.52**	**4.77**
	2	**-42.3**	**-44**	**1.7**	**2.86**	**0.36**	**8.4**	**1**	**4.86**	**0.61**
	3	**-44**	**-44.7**	**0.7**	**2.90**	**0.36**	**8.2**	**1**	**2.03**	**0.25**
		EL -39.8 to -44.7		**D=4.9**	**2.19**	**1.11**	**6.3**	**15**	**10.74**	**5.42**

Table E-3

Borings for Borrow Area A (cont.)

Boring Number	Layer Number	Layer Depth (ft) Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-129	**1**	**-40.9**	**-42.5**	**1.6**	**1.48**	**1.25**	**1.3**	**24**	**2.38**	**1.99**
	2	**-42.5**	**-43.4**	**0.9**	**2.41**	**0.54**	**2.3**	**9**	**2.17**	**0.49**
	3	-43.4	-44.3	0.9	>4.0	NA	37.6	7	NA	NA
	4	-44.3	-47.6	3.3	1.59	1.16	7.7	6	5.24	3.83
	5	-47.6	-49.2	1.6	>4.0	NA	71.2	1	NA	NA
		EL -40.9 to -43.4		**D=2.5**	**1.84**	**1.09**	**1.7**	**19**	**4.61**	**2.73**
TI-03-V-130	**1**	**-42.6**	**-45.1**	**2.5**	**2.62**	**0.51**	**8.9**	**7**	**6.56**	**1.27**
	2	**-45.1**	**-47**	**1.9**	**2.82**	**0.32**	**6.2**	**2**	**5.36**	**0.60**
	3	**-47**	**-49**	**2**	**2.82**	**0.29**	**5.0**	**1**	**5.64**	**0.57**
	4	**-49**	**-50.9**	**1.9**	**2.65**	**0.44**	**5.2**	**1**	**5.03**	**0.83**
		EL -42.6 to -50.9		**D=8.3**	**2.71**	**0.42**	**6.5**	**3**	**22.52**	**3.46**
TI-03-V-182	**1**	**-44.7**	**-46**	**1.3**	**2.30**	**0.63**	**2.9**	**7**	**2.99**	**0.82**
	2	**-46**	**-47**	**1**	**1.88**	**1.26**	**2.6**	**11**	**1.88**	**1.26**
	3	**-47**	**-49**	**2**	**2.90**	**0.44**	**12.6**	**1**	**5.81**	**0.89**
	4	-49	-52.3	3.3	2.93	0.42	12.2	0	9.66	1.38
		EL -44.7 to -49		**D=4.3**	**2.55**	**0.49**	**7.3**	**5**	**10.97**	**2.12**
TI-03-V-187	**1**	**-42.5**	**-44.5**	**2**	**2.40**	**0.65**	**3.8**	**11**	**4.81**	**1.29**
	2	**-44.5**	**-46.5**	**2**	**2.81**	**0.55**	**11.0**	**7**	**5.63**	**1.09**
	3	-46.5	-49	2.5	2.92	0.40	10.8	1	7.29	1.00
	4	-49	-52	3	2.92	0.42	11.4	1	8.77	1.26
	5	-52	-54	2	2.81	0.56	12.5	1	5.63	1.13
	6	-54	-55.5	1.5	3.37	1.27	21.6	1	5.06	1.91
		EL -42.5 to -46.5		**D=4**	**2.63**	**0.56**	**7.4**	**9**	**10.51**	**2.23**

Table E-3
Borings for Borrow Area A (cont.)

Boring Number	Layer Number	Layer Depth (ft) Top	Layer Depth (ft) Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-188	**1**	**-44.2**	**-47.8**	**3.6**	**1.74**	**1.51**	**3.7**	**19**	**6.28**	**5.45**
	2	**-47.8**	**-50**	**2.2**	**2.97**	**0.46**	**14.1**	**2**	**6.54**	**1.02**
	3	**-50**	**-52**	**2**	**3.07**	**0.52**	**14.8**	**0**	**6.13**	**1.05**
	4	-52	-54.2	2.2	2.93	0.48	13.7	1	6.44	1.05
		EL -44.2 to -52		**D=7.8**	**2.69**	**0.65**	**9.5**	**9**	**21.01**	**5.05**
TI-03-V-189	**1**	**-45.5**	**-47.5**	**2**	**2.36**	**0.60**	**3.3**	**8**	**4.72**	**1.20**
	2	**-47.5**	**-51**	**3.5**	**2.06**	**1.16**	**8.2**	**16**	**7.22**	**4.05**
	3	**-51**	**-54.8**	**3.8**	**2.81**	**0.60**	**12.9**	**8**	**10.67**	**2.28**
	4	-54.8	-57	2.2	2.91	0.46	12.3	5	6.41	1.01
	5	-57	-59	2	3.04	0.55	15.0	3	6.09	1.10
	6	-59	-59.5	0.5	2.92	0.47	13.4	2	1.46	0.24
		EL -45.5 to -54.8		**D=9.3**	**2.46**	**0.77**	**9.1**	**11**	**22.91**	**7.17**
TI-03-V-197	**1**	**-45.5**	**-47**	**1.5**	**2.23**	**0.64**	**1.9**	**8**	**3.35**	**0.96**
	2	**-47**	**-49.5**	**2.5**	**2.88**	**0.43**	**11.4**	**3**	**7.20**	**1.06**
	3	-49.5	-52	2.5	3.35	0.77	26.7	1	8.38	1.93
	4	-52	-52.9	0.9	>4.0	NA	73.5	0	NA	NA
	5	-52.9	-55	2.1	3.61	1.03	40.5	1	7.58	2.16
	6	-55	-56.7	1.7	3.71	1.18	42.0	1	6.30	2.00
	7	-56.7	-57.5	0.8	>4.0	NA	72.4	0	NA	NA
		EL -45.5 to -49.5		**D=4**	**2.61**	**0.51**	**7.9**	**5**	**10.43**	**2.03**
TI-03-V-202	**1**	**-46.3**	**-48**	**1.7**	**2.24**	**0.75**	**2.2**	**9**	**3.81**	**1.27**
	2	**-48**	**-50**	**2**	**2.70**	**0.79**	**13.8**	**9**	**5.39**	**1.58**
	3	-50	-52	2	2.99	1.09	18.3	18	5.99	2.19
	4	-52	-53.9	1.9	2.92	0.69	15.3	9	5.54	1.30
		EL -46.3 to -50		**D=3.7**	**2.44**	**0.77**	**8.5**	**9**	**9.02**	**2.85**

Table E-3
Borings for Borrow Area A (cont.)

Boring Number	Layer Number	Layer Depth (ft) Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-203	1	-43.4	-45.5	2.1	0.93	2.03	2.5	25	1.96	4.26
	2	-45.5	-46.6	1.1	2.28	0.64	2.3	10	2.51	0.70
		EL -43.4 to -46.6		D=3.2	1.34	1.78	2.4	20	4.30	5.69

Boring Number	Layer Number	Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-208	1	-49	-51	2	2.61	0.42	5.4	6	5.22	0.83
	2	-51	-52.2	1.2	2.88	0.41	10.9	3	3.45	0.49
		EL -49 to -52.2		D=3.2	2.70	0.44	7.4	5	8.63	1.39

Boring Number	Layer Number	Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-216	1	-48.2	-49	0.8	1.15	2.12	2.2	23	0.92	1.70
	2	-49	-50.3	1.3	1.75	1.94	13.2	18	2.27	2.52
		EL -48.2 to -50.3		D=2.1	1.45	1.95	9.0	20	3.05	4.09

Table E-4
Borings for Borrow Area B

Boring Number	Layer Number	Layer Depth (ft) Top	Layer Depth (ft) Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-132	**1**	**-42.2**	**-43.8**	**1.6**	**0.58**	**2.04**	**1.7**	**44**	**0.93**	**3.27**
	2	**-43.8**	**-46**	**2.2**	**2.64**	**0.44**	**6.6**	**5**	**5.81**	**0.96**
	3	**-46**	**-47.6**	**1.6**	**2.86**	**0.37**	**8.7**	**2**	**4.58**	**0.59**
		EL -42.2 to -47.6		**D= 5.4**	**2.09**	**1.16**	**5.8**	**16**	**11.28**	**6.24**

Boring Number	Layer Number	Layer Depth (ft) Top	Layer Depth (ft) Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-205	**1**	**-43.2**	**-45.2**	**2**	**2.39**	**0.56**	**2.8**	**6**	**4.79**	**1.12**
	2	-45.2	-47.2	2	>4.0	NA	70.6	0	NA	NA
	3	-47.2	-50	2.8	3.73	1.02	42.1	1	10.44	2.85
	4	-50	-53	3	3.74	1.09	43.5	1	11.21	3.27
	5	-53	-55.2	2.2	3.32	0.84	25.9	1	7.30	1.84
		EL -43.2 to -45.2		**D=2**	**2.39**	**0.56**	**2.8**	**6**	**4.79**	**1.12**

Table E-5
Borings for Borrow Area C

Boring Number	Layer Number	Layer Depth (ft) Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-174	**1**	**-45.5**	**-47.8**	**2.3**	**2.43**	**0.53**	**2.9**	**9**	**5.60**	**1.22**
	2	-47.8	-49.5	1.7	>4.0	NA	69.1	3	NA	NA
	3	-49.5	-50.5	1	>4.0	NA	81.3	3	NA	NA
	4	-50.5	-51.3	0.8	3.53	1.27	26.3	2	**2.83**	**1.02**
		EL -45.5 to -47.8		**D= 2.3**	**2.43**	**0.53**	**2.9**	**9**	**5.60**	**1.22**

Boring Number	Layer Number	Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-178	**1**	**-46.3**	**-48.5**	**2.2**	**2.58**	**0.53**	**7.9**	**9**	**4.62**	**1.95**
	2	-48.5	-50.5	2	2.95	0.43	11.6	2	5.91	0.85
	3	-50.5	-52	1.5	2.52	0.81	9.7	11	3.79	1.21
	4	-52	-54.5	2.5	2.59	0.49	8.1	2	6.48	1.22
	5	-54.5	-57	2.5	2.50	0.44	4.2	3	6.26	1.10
	6	-57	-60	3	2.06	0.87	4.2	9	6.19	2.61
	7	-60	-62.5	2.5	2.01	0.87	2.5	2	5.03	2.17
	8	-62.5	-63.3	0.8	2.69	0.31	3.9	1	2.16	0.25
		EL -46.3 to -48.5		**D=2.2**	**2.58**	**0.53**	**7.9**	**9**	**4.62**	**1.95**

Boring Number	Layer Number	Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-185	**1**	**-46.5**	**-48.5**	**2**	**2.38**	**0.53**	**1.6**	**5**	**4.75**	**1.05**
	2	**-48.5**	**-51**	**2.5**	**2.73**	**0.63**	**12.7**	**8**	**6.83**	**1.57**
	3	-51	-53	2	3.12	0.68	17.8	8	6.25	1.36
	4	-53	-55	2	>4.0	NA	52.1	1	NA	NA
	5	-55	-58	3	>4.0	NA	87.9	0	NA	NA
	6	-58	-61	3	>4.0	NA	89.1	0	NA	NA
	7	-61	-64.3	3.3	3.32	0.81	28.2	1	10.97	2.66
	8	-64.3	-64.8	0.5	3.06	0.72	17.5	1	1.53	0.36
		EL -46.5 to -51		**D=4.5**	**2.54**	**0.49**	**7.8**	**7**	**11.43**	**2.21**

Table E-5
Borings for Borrow Area C (cont.)

Boring Number	Layer Number	Layer Depth (ft) Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-186	**1**	**-47.7**	**-49.5**	**1.8**	**2.42**	**0.49**	**3.0**	**7**	**4.36**	**0.88**
	2	**-49.5**	**-51**	**1.5**	**2.48**	**0.43**	**5.0**	**7**	**3.72**	**0.65**
	3	-51	-53.9	2.9	2.73	0.51	9.3	2	7.92	1.47
	4	-53.9	-56	2.1	>4.0	NA	60.3	2	NA	NA
	5	-56	-57	1	>4.0	NA	73.5	0	NA	NA
	6	-57	-60	3	3.28	0.84	27.2	2	9.85	2.52
	7	-60	-63	3	2.93	0.45	12.7	2	8.79	1.36
	8	-63	-65.5	2.5	3.18	0.76	18.7	1	7.96	1.90
		EL -47.7 to -51		**D=3.3**	**2.46**	**0.44**	**3.9**	**7**	**8.12**	**1.47**
TI-03-V-192	**1**	**-47**	**-49**	**2**	**2.10**	**0.69**	**1.7**	**7**	**4.21**	**1.38**
	2	-49	-50	1	>4.0	NA	35.7	1	NA	NA
		EL -47 to -49		**D=2**	**2.10**	**0.69**	**1.7**	**7**	**4.21**	**1.38**
TI-03-V-198	**1**	**-46.5**	**-48.5**	**2**	**1.35**	**1.75**	**1.6**	**20**	**2.71**	**3.51**
	2	**-48.5**	**-49.5**	**1**	**2.33**	**0.56**	**2.7**	**7**	**2.33**	**0.56**
	3	-49.5	-50.5	1	3.29	1.05	27.9	1	3.29	1.05
	4	-50.5	-52.5	2	2.43	0.60	7.3	0	4.87	1.21
	5	-52.5	-54.5	2	3.05	0.48	12.8	0	**6.11**	**0.96**
		EL -46.5 to -49.5		**D=3**	**1.84**	**1.14**	**2.0**	**16**	**5.52**	**3.42**
TI-03-V-199	**1**	**-46.6**	**-48.8**	**2.2**	**2.14**	**0.70**	**1.7**	**7**	**4.70**	**1.53**
	2	-48.8	-51.1	2.3	3.11	0.68	18.3	2	7.16	1.55
	3	-51.1	-51.6	0.5	2.97	0.73	16.4	2	1.49	0.36
		EL -46.6 to -48.8		**D=2.2**	**2.14**	**0.70**	**1.7**	**7**	**4.70**	**1.53**

Table E-6
Borings for Borrow Area D

Boring Number	Layer Number	Layer Depth (ft) Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-223	**1**	**-43.5**	**-45**	**1.5**	**2.12**	**0.63**	**1.1**	**8**	**3.19**	**0.95**
	2	**-45**	**-46.5**	**1.5**	**1.85**	**0.90**	**1.4**	**16**	**2.77**	**1.35**
	3	-46.5	-47.2	0.7	3.00	1.15	23.7	8	**2.10**	**0.80**
		EL -43.5 to -46.5		**D= 3**	**2.00**	**0.75**	**1.3**	**12**	**5.99**	**2.26**

Boring Number	Layer Number	Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-224	**1**	**-46.4**	**-48.4**	**2**	**2.23**	**0.54**	**1.5**	**7**	**4.62**	**1.95**
	2	-48.4	-50.5	2.1	3.63	1.46	32.5	2	7.63	3.06
	3	-50.5	-52.6	2.1	3.38	0.86	28.0	1	7.10	1.81
		EL -46.4 to -48.4		**D=2**	**2.23**	**0.54**	**1.5**	**7**	**4.62**	**1.95**

Boring Number	Layer Number	Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-228	**1**	**-46.9**	**-47.9**	**1**	**2.10**	**0.68**	**1.7**	**6**	**2.10**	**0.68**
	2	**-47.9**	**-50.6**	**2.7**	**1.29**	**2.08**	**8.7**	**18**	**3.49**	**5.62**
	3	**-50.6**	**-52.5**	**1.9**	**2.93**	**0.44**	**13.0**	**3**	**5.57**	**0.84**
	4	**-52.5**	**-53.6**	**1.1**	**2.92**	**0.46**	**12.7**	**5**	**3.21**	**0.51**
		EL -46.9 to -53.6		**D=6.7**	**2.16**	**1.23**	**9.5**	**2**	**14.44**	**8.21**

Table E-7
Borings for Borrow Area E

Boring Number	Layer Number	Layer Depth (ft) Top	Layer Depth (ft) Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-240	**1**	**-50**	**-52**	**2**	**1.78**	**0.74**	**1.1**	**9**	**3.55**	**1.48**
	2	**-52**	**-52.8**	**0.8**	**2.56**	**0.42**	**5.9**	**3**	**2.05**	**0.33**
		EL -50 to -52.8		**D= 2.8**	**2.00**	**0.82**	**2.5**	**7**	**5.61**	**2.29**

Boring Number	Layer Number	Layer Depth (ft) Top	Layer Depth (ft) Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-241	**1**	**-49**	**-51.2**	**2.2**	**2.01**	**0.50**	**0.8**	**4**	**4.43**	**1.10**
	2	**-51.2**	**-53**	**1.8**	**2.55**	**0.45**	**8.2**	**3**	**4.59**	**0.81**
	3	-53	-54	1	3.87	1.27	48.0	1	3.87	1.27
	4	-54	-56.1	2.1	3.62	1.39	40.2	1	7.60	2.91
		EL -49 to -53		**D=4**	**2.25**	**0.61**	**4.1**	**4**	**9.00**	**2.43**

Table E-8
Borings for Borrow Area F

Boring Number	Layer Number	Layer Depth (ft) Top	Bottom	Layer Thickness (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean (phi)	Weighted Std Dev (phi)
TI-03-V-245	1	-47.2	-48.5	1.3	0.50	1.47	2.0	18	0.65	1.92
	2	-48.5	-49.7	1.2	1.55	1.37	1.5	18	1.87	1.64
		EL -47.2 to -49.7		D= 2.5	0.96	1.64	1.7	18	2.41	4.10
TI-03-V-369	1	-48	-49	1	1.73	1.25	8.0	2	1.73	1.25
	2	-49	-51	2	0.82	2.34	5.2	3	1.65	4.69
	3	-51	-53	2	-0.08	2.64	6.9	1	-0.17	5.28
		EL -48 to -53		D=5	0.72	2.31	6.4	2	3.61	11.55

Table E-9
Composite Characteristics for Borrow Area A

Boring Number	Depth (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	%Shell	Weighted Mean	Weighted Std Dev
TI-03-V-124	2.0	1.72	1.59	9.6	22	3.45	3.17
TI-03-V-125	2.0	2.31	0.98	9.2	17	4.62	1.95
TI-03-V-126	4.8	1.76	1.79	8.3	22	8.43	8.58
TI-03-V-127	4.9	2.19	1.11	6.3	15	10.74	5.42
TI-03-V-129	2.5	1.84	1.09	1.7	19	4.61	2.73
TI-03-V-130	8.3	2.71	0.42	6.5	3	22.52	3.46
TI-03-V-182	4.3	2.55	0.49	7.3	5	10.97	2.12
TI-03-V-187	4.0	2.63	0.56	7.4	9	10.51	2.23
TI-03-V-188	7.8	2.69	0.65	9.5	9	21.01	5.05
TI-03-V-189	9.3	2.46	0.77	9.1	11	22.91	7.17
TI-03-V-197	4.0	2.61	0.51	7.9	5	10.43	2.03
TI-03-V-202	3.7	2.44	0.77	8.5	9	9.02	2.85
TI-03-V-203	3.2	1.34	1.78	2.4	20	4.30	5.69
TI-03-V-208	3.2	2.70	0.44	7.4	5	8.63	1.39
TI-03-V-216	2.1	1.45	1.95	9.0	20	3.05	4.09

Borrow Area A Composite Data

Mean	**2.35**
Std Dev	**0.88**
%Silt	**7.6**
%Shell	**11**

Table E-10
Composite Characteristics for Borrow Area B

Boring Number	Depth (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	%Shell	Weighted Mean	Weighted Std Dev
TI-03-V-132	5.40	2.09	1.16	5.8	6	11.28	6.24
TI-03-V-205	2.0	2.39	0.56	2.8	16	4.79	1.12

Borrow Area B Composite Data

Mean	**2.17**
Std Dev	**0.99**
%Silt	**5.0**
%Shell	**13**

Table E-11
Composite Characteristics for Borrow Area C

Boring Number	Depth (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	% Shell	Weighted Mean	Weighted Std Dev
TI-03-V-174	2.3	2.43	0.53	2.9	9	5.60	1.22
TI-03-V-178	2.2	2.58	0.53	7.9	9	5.69	1.16
TI-03-V-185	4.5	2.54	0.49	7.8	7	11.43	2.21
TI-03-V-186	3.3	2.46	0.44	3.9	7	8.12	1.47
TI-03-V-192	2.0	2.10	0.69	1.7	7	4.21	1.38
TI-03-V-198	3.0	1.84	1.14	2.0	16	5.52	3.42
TI-03-V-199	2.2	2.14	0.70	1.7	7	4.70	1.53

Borrow Area C Composite Data

Mean	**2.32**
Std Dev	**0.63**
% Silt	**4.4**
% Shell	**9**

Table E-12
Composite Characteristics for Borrow Area D

Boring Number	Depth (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	%Shell	Weighted Mean	Weighted Std Dev
TI-03-V-223	3.0	2.00	0.75	1.3	12	5.60	1.22
TI-03-V-224	2.0	2.23	0.54	1.5	7	5.69	1.16
TI-03-V-228	6.7	2.16	1.23	9.5	2	11.43	2.21

Borrow Area D Composite Data

Mean	**2.13**
Std Dev	**0.99**
% Silt	**6.0**
% Shell	**6**

Table E-13
Composite Characteristics for Borrow Area E

Boring Number	Depth (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	%Shell	Weighted Mean	Weighted Std Dev
TI-03-V-240	2.8	2.00	0.82	2.5	7	5.61	2.29
TI-03-V-241	4.0	2.25	0.61	4.1	4	9.00	2.43

Borrow Area E Composite Data

Mean	**2.15**
Std Dev	**0.69**
% Silt	**3.4**
% Shell	**5**

Table E-14
Composite Characteristics for Borrow Area F

Boring Number	Depth (ft)	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	%Shell	Weighted Mean	Weighted Std Dev
TI-03-V-245	2.5	0.96	1.64	1.7	18	2.41	4.10
TI-03-V-369	5.0	0.72	2.31	6.4	2	3.61	11.55

Borrow Area F Composite Data

Mean	**0.80**
Std Dev	**2.09**
% Silt	**4.9**
% Shell	**7.3**

Table E-15
Compatibility of Native and Borrow Sand

Native Beach Material

	Mean (phi)	Std Dev (phi)	% Silt (#200 sieve)	%Shell
Topsail Beach	2.18	0.70	1.6	12

Borrow Site	Borrow Material (phi) Mean	Std Dev	% Silt (#200 sieve)	%Shell	Overfill Ratio	Silt Correction Factor	Final Overfill Ratios Corrected for Silt Content
A	2.35	0.86	7.6	11	1.25	1.08	1.35
B	2.17	0.99	5.0	13	1.17	1.05	1.23
C	2.32	0.63	4.4	9	1.39	1.05	1.45
D	2.13	0.99	6.0	6	1.15	1.06	1.22
E	2.15	0.69	3.4	5	1.00	1.04	1.04
F	0.80	2.09	4.9	7	1.14	1.05	1.20