APPENDIX C – GEOTECHNICAL DATA

US ARMY CORPS OF ENGINEERS

US DEPARTMENT OF INTERIOR
NATIONAL PARK SERVICE

CAPE HATTERAS NATIONAL SEASHORE
NORTH CAROLINA

ENVIRONMENTAL ASSESSMENT

BEACH RESTORATION TO PROTECT NC HIGHWAY 12
CLEAN WATER ACT 404 AND NPS SPECIAL USE PERMITS
AT BUXTON, DARE COUNTY, NORTH CAROLINA

SEPTEMBER 2015

APPENDIX C

GEOTECHNICAL DATA REPORT

Beach Restoration to Protect NC Highway 12 at Buxton, Dare County, North Carolina

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PREFACE

This report contains geotechnical data on potential borrow sediments for a proposed beach nourishment project along ~3 miles of shoreline in Buxton, North Carolina, extending north into Cape Hatteras National Seashore. The primary borrow source is a shoal ~1.7 miles offshore of the old Cape Hatteras Lighthouse site. Other borrow areas considered included Oregon Inlet (limited evaluation herein), Pamlico Sound (rejected due to environmental considerations) and upland sand pits (rejected due to insufficient volume available within economic distances or high transportation costs due to distance from the project site). The report presents detailed results of beach sampling and borrow area sampling via cores. Sediment quality analyses demonstrate the similarity between native sediment on the beach and the quality of sand in a designated offshore area within the broader sand search area.

This report is prepared at the direction of the Dare County Board of Commissioners (Bob Woodward, Chairman) in support of planning and permitting for the Buxton project in close cooperation with the National Park Service.

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1.0 INTRODUCTION

This report provides sediment data for the Buxton, North Carolina, project area based on sampling and analysis in 2013–2014. Samples were obtained along the beach and inshore zone in accordance with North Carolina Technical Standards for Beach Fill Projects (15A NCAC 07H .0312) and National Park Service Beach Nourishment Guidance (NPS 2012). Ten stations (transects) were established along the Buxton project area and adjacent shoreline at 1,000 to 4,000-foot (ft) spacing (stations 1760+00 to 1980+00) for sampling at 14 cross-shore positions. An offshore sand search area encompassing ~450 acres was sampled by 3-inch borings at core spacing of ~1,000 ft (Fig 1.1). The borings were subsampled and analyzed for grain-size distribution and comparison with the existing beach sand.

Nourishment success depends on finding a source of sand that is similar in character to the native beach. The degree to which a particular borrow sediment matches the native beach sediments strongly influences project longevity and environmental impacts. Three outcomes are possible (Fig 1.2) (cf, Dean 1991, 2002):

- ***Borrow sediment is finer than native*** – The majority of fill will shift offshore and yield a more gently sloping profile. Dry beach will be narrowest.
- ***Borrow sediment is coarser than native*** – The majority of fill will tend to "perch" on the visible beach and yield a steeper profile through the surf zone. Dry beach will be widest.
- ***Borrow sediment matches the native sediment*** – The fill will tend to follow the natural contours of the profile and retain similar slopes and morphology.

It is generally accepted that environmental impacts of nourishment are most likely to be minimized if the borrow sediment "matches" the native (NRC 1995). However, the question of what constitutes "native" is still debatable. In some settings, such as many South Carolina beaches, sediments exist over a very narrow size range between the foredune and inshore zone [eg, mean = 0.18–0.22 millimeters (mm) with well-sorted sand at Isle of Palms SC]. In these cases, it is relatively easy to distinguish between "coarser" and "finer" than native. Most North Carolina beaches, by contrast, exhibit more variable sediment size distributions. Fine sand may dominate in the dunes and offshore while coarse sand dominates the inner surf zone.

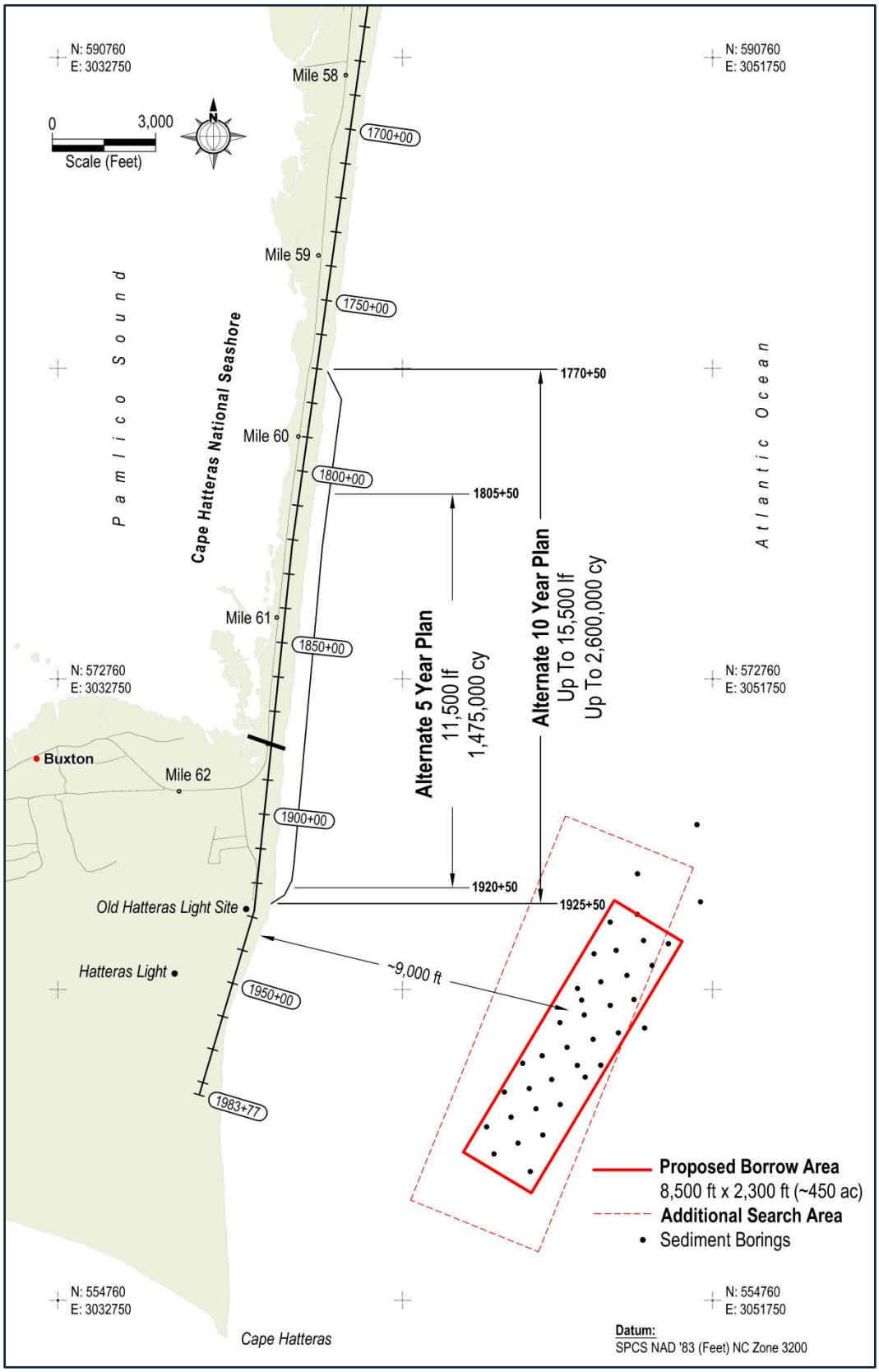


FIGURE 1.1. Map showing the Buxton project area, stationing along the beach, and offshore sand search area (location of borings).

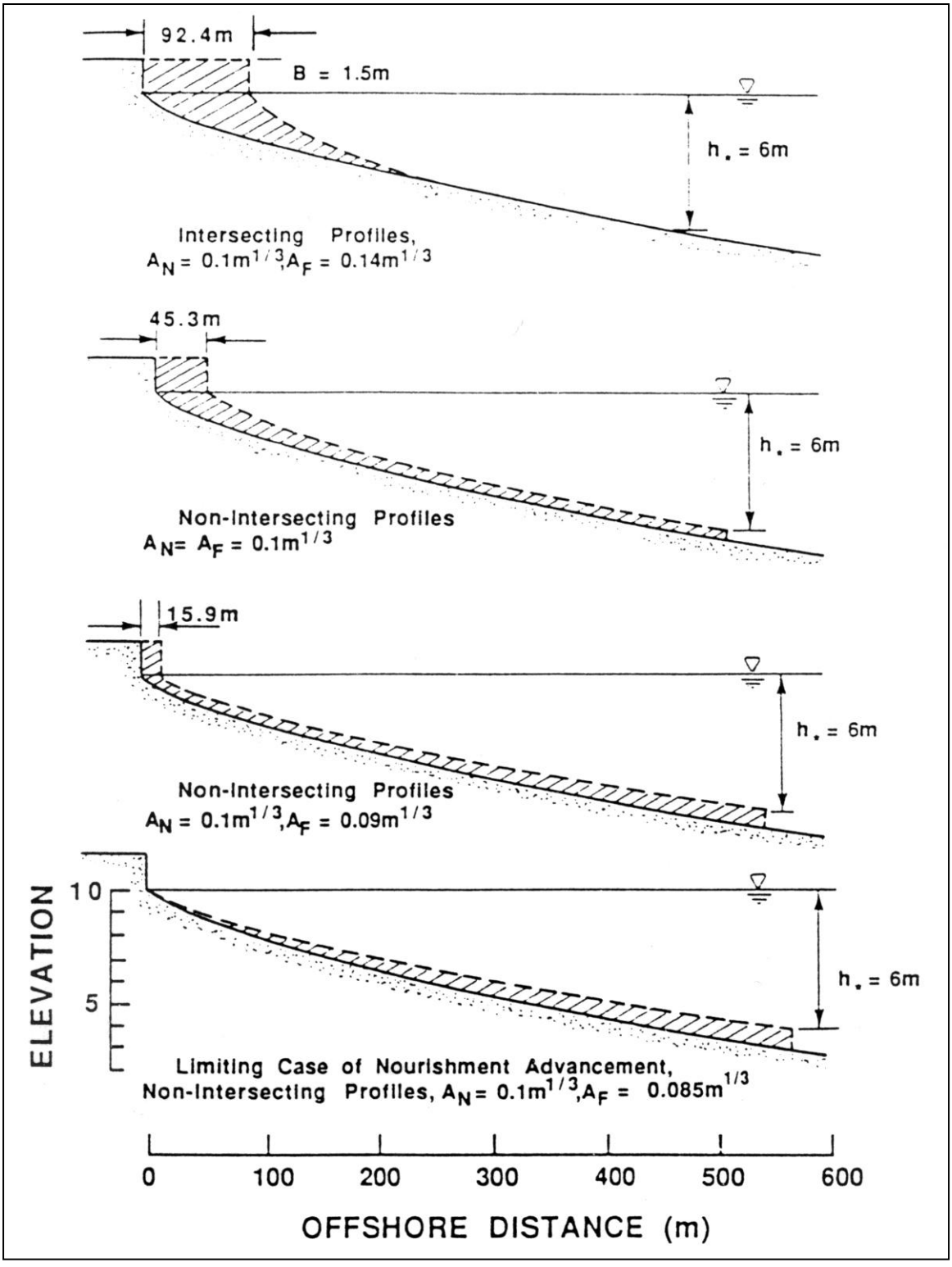


FIGURE 1.2. Effect of borrow material grain size (nourishment scale parameter, A_F) on the width of the dry beach for a fixed volume of nourishment sand added per unit beach length (from Dean 1991, Fig 25). In simple terms, coarser sand relative to the native sediment produces a wider visible beach than finer sand. [Note: 1 m ≈ 3.28 ft]

North Carolina beaches are typically composed of quartz sand in the medium size range [0.25–0.5 millimeter (mm) mean diameter]. Northern Outer Banks beaches tend to be coarser than southern North Carolina beaches with a wider range of sediment grain sizes (USACE 2000, 2010).

Waves and nearshore currents as well as winds sort the sediments of the littoral zone and introduce characteristic topography across the profile. Coarsest material tends to concentrate at the inshore "plunge" point of breaking waves where energy dissipation is focused (Miller & Ziegler 1958, Greenwood & Davidson-Arnott 1972, Komar 1998). Finer sands are winnowed and shifted offshore, leaving coarser sediments near the low watermark (Fig 1.3). Sands washed up the profile across the berm at high tide dry out and become sorted by winds, leading to accumulation of finer sand in the dunes.

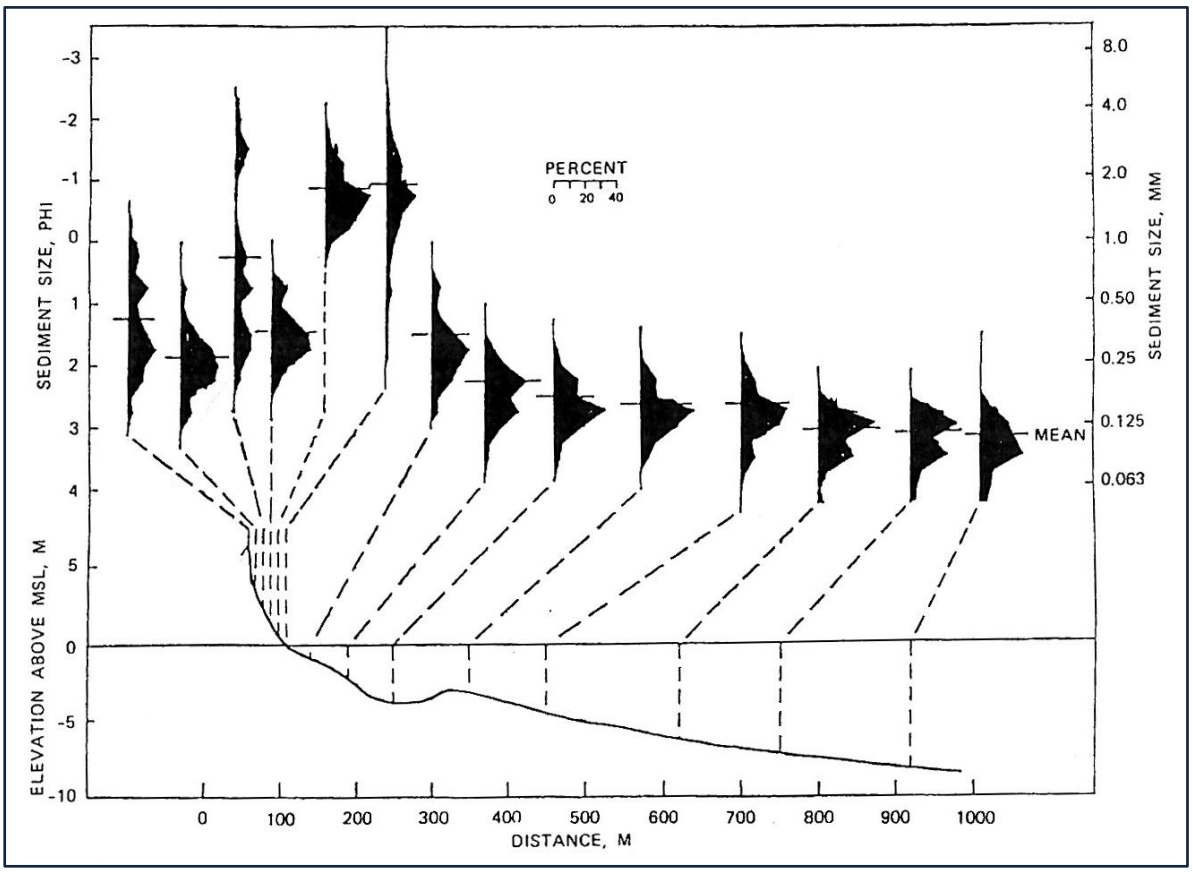


FIGURE 1.3. Grain size distributions along a profile at Duck, North Carolina, ~70 miles north of the Buxton project area, illustrating the variation in grain sizes as a function of position (from Birkemeier et al 1985).

Each sand size typically finds its equilibrium position across the profile with accumulations developing a particular slope and geometry. The longshore bar is often composed of fine sand (<0.25 mm diameter) which equilibrates at a gentler slope than the swash zone. Any suite of sediment sizes introduced to a beach by natural or artificial means will similarly sort under waves and migrate across the profile.

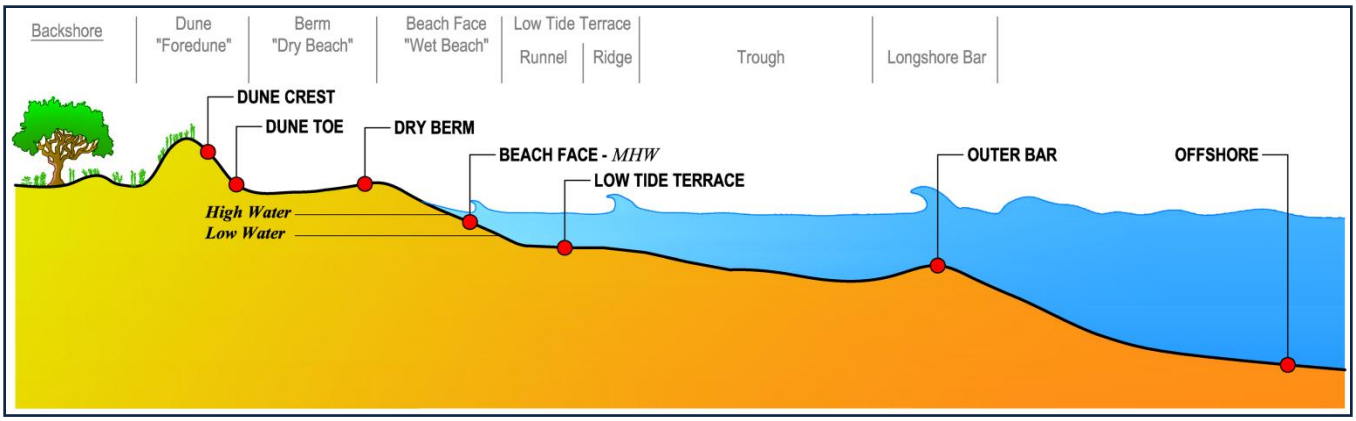
Figure 1.4 illustrates a typical profile across the littoral zone showing primary morphologic features such as the foredune, dry beach (berm), beach face, trough, and outer bar. A composite mean grain size of samples from each position for Nags Head (NC) (~50 miles north of the Buxton project area) is shown at the bottom of Figure 1.4. At Nags Head (pre-nourishment), the dune sands were typically ~0.3 mm mean diameter, whereas the swash zone samples were coarse (0.5–1.0 mm) or very coarse sand (1.0–2.0 mm). Seaward of the inner surf zone, sediments are consistently fine sand (0.12–0.25 mm).

The visible beach (ie, above low water) along most coasts tends to exhibit well-sorted (poorly graded) sands of some dominant size class. If such sand is desirable for aesthetics and other environmental reasons, prospective borrow areas should contain high proportions of those grain sizes (NPS 2012). Nourishment sediments within the size distribution that are finer than those of the dry-sand beach are likely to shift offshore during initial fill adjustment and erosion events, or be transported by winds toward the foredune, winnowing from the coarser sands.

Under North Carolina rules and standards for beach fill projects, any sediments within the sand-size range (0.0625–2.0 mm) are considered acceptable for use in nourishment projects. However, borrow areas must meet three important criteria:

1) Borrow sediments must not contain more than 5 percent mud (<0.0625 mm) by distribution above ambient conditions.
2) Borrow sediments must not contain more than 5 percent gravel (>2 mm) by distribution above ambient conditions.
3) Shell content (percent $CaCO_3$ material) may not exceed 15 percent by distribution above ambient conditions (ref — 15A NCAC 07H .0312).

The following sections provide detailed results of sampling and analyses performed to identify potential borrow sediments meeting state standards for beach fill. The potential borrow sediments are also evaluated in terms of their likely performance in widening the beach.



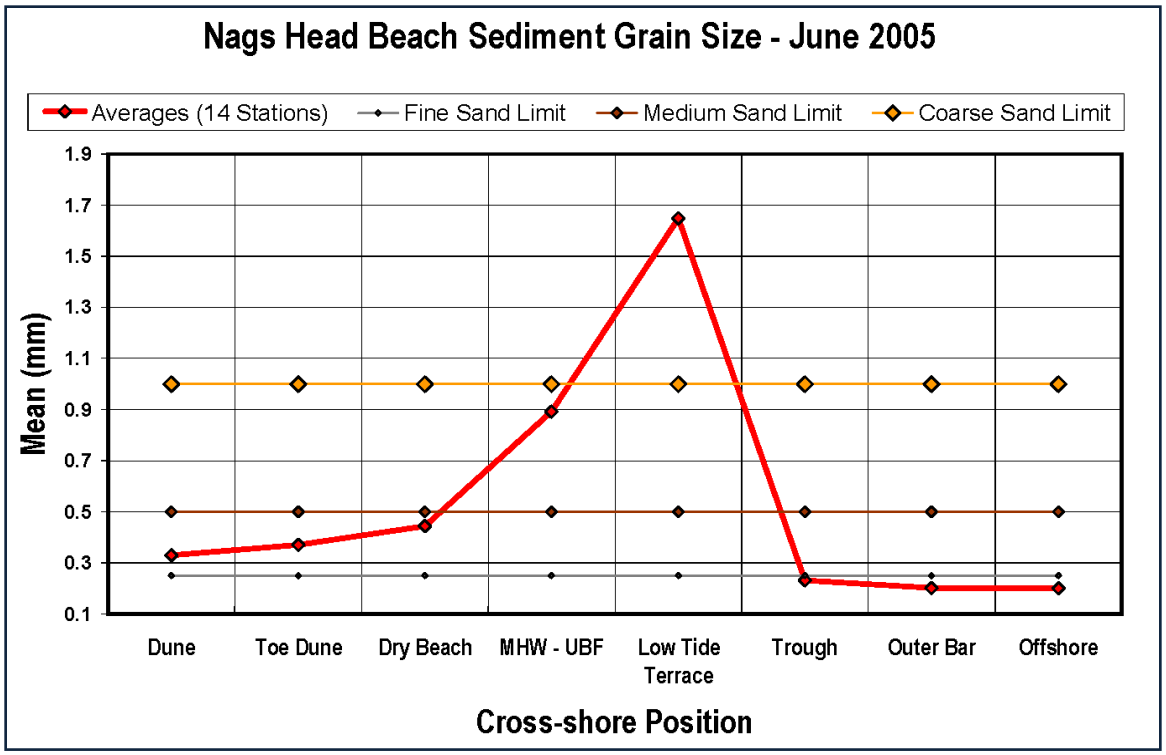


FIGURE 1.4. **[UPPER]** Littoral profile showing eight sediment sampling positions based on morphology. **[LOWER]** Overall trends in mean grain size by position across the profile based on 14 transects at Nags Head. Note predominance of finer sands in the foredune and underwater zone and coarsest sand in the active surf zone (after CSE 2005, USACE 2010).

2.0 METHODS

2.1 Beach Samples

CSE collected beach samples along the Buxton project area in August 2013 (summer beach conditions) across the subaerial beach and in October 2014 (fall beach conditions) encompassing the entire littoral profile to a water depth of −24 ft NAVD. Six transects (24 samples total) were sampled in 2013 (CSE 2013), and ten transects (140 samples total) were sampled in 2014. Figure 2.1 shows the cross-shore sample locations, and Figure 2.2 shows the sampling tool used for surface grabs in the upper 15 centimeters (cm) (6 inches) of substrate. Station locations for the 2014 samples are illustrated in Figure 2.3.

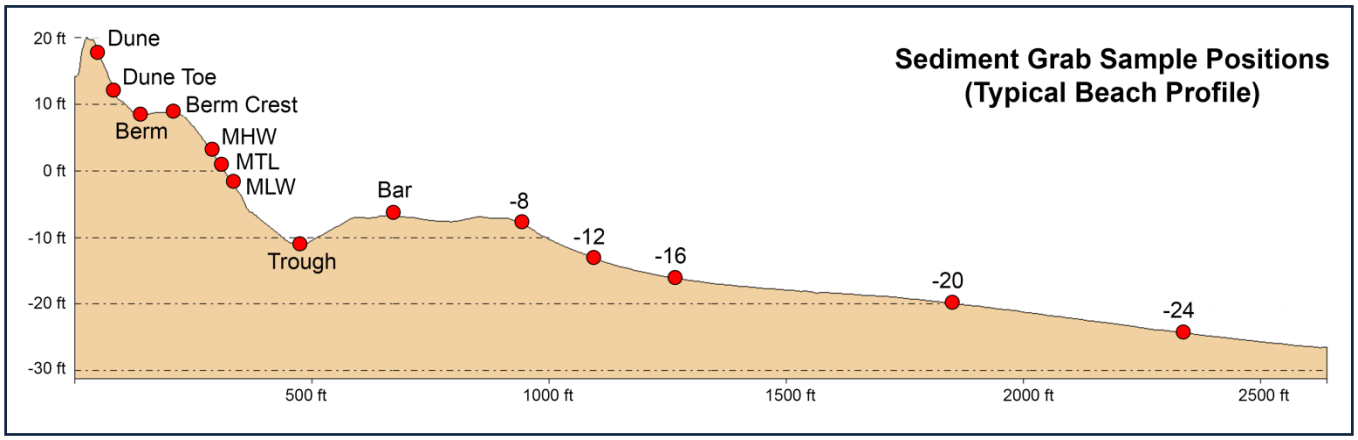


FIGURE 2.1. Sample positions for "beach" grab samples along Buxton following North Carolina sediment sampling criteria rules. The Buxton littoral profile exhibits a narrow berm (dry-sand beach) and deep trough separating the outer bar from the beach.

FIGURE 2.2. Uniform sediment samples were collected on the beach in the upper 6 inches (15 centimeters), mixed, and subsampled for laboratory testing.

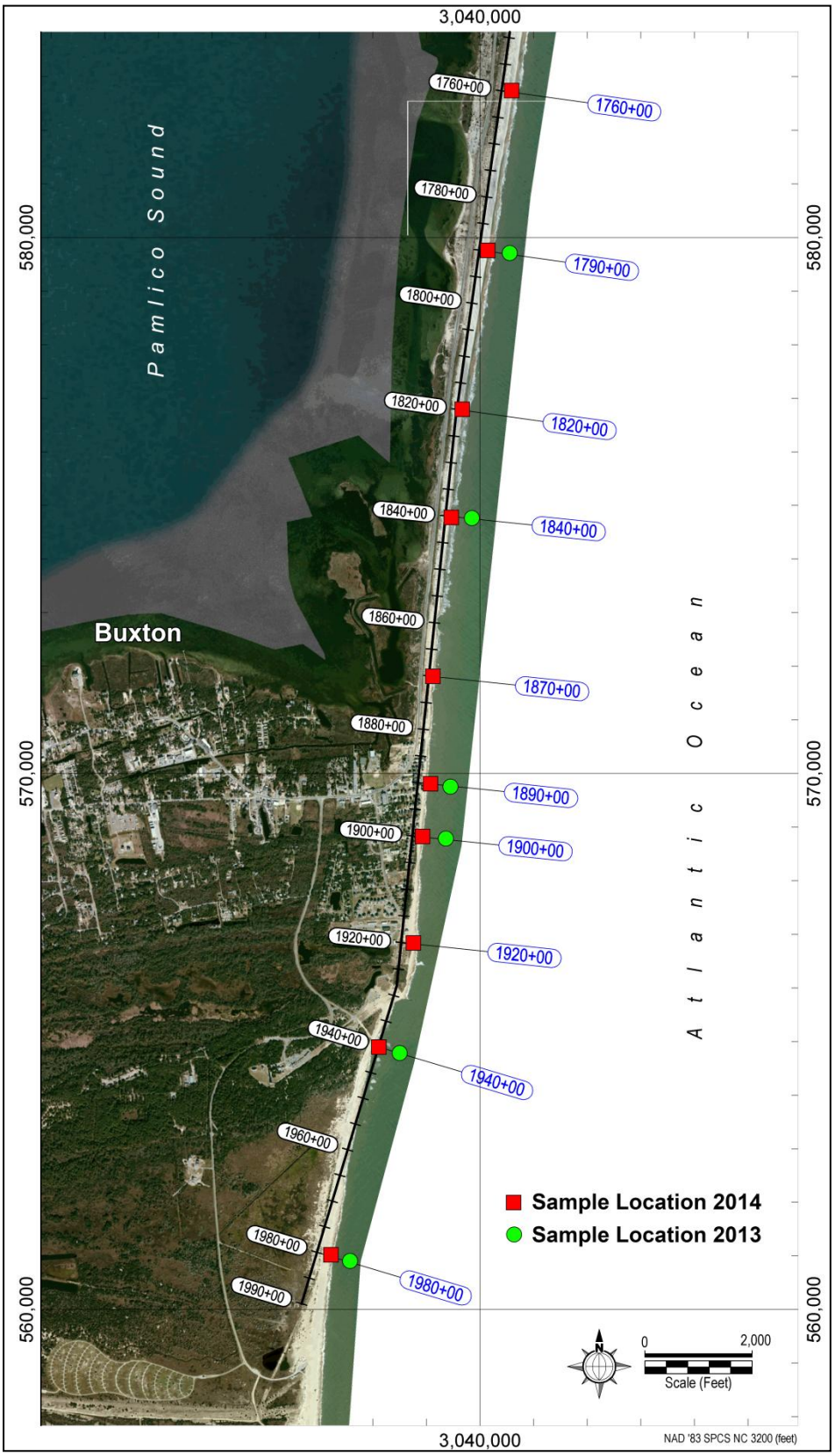


FIGURE 2.3. Location of sediment sample transects (14 samples per transect) along the Buxton project area. Samples collected in October 2014.

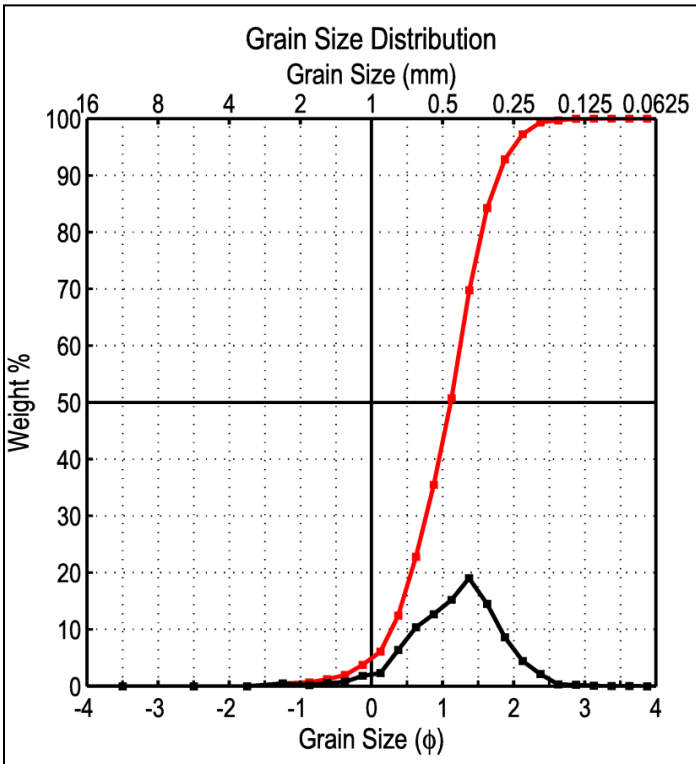
Samples were inspected for mud then washed, dried, weighed in splits for analysis of grain size, gravel, and shell content. The split for grain size (~100 gram sample) was mechanically sieved at 0.25-phi intervals (ie, ~21 sieves in the sand size range) and each subsample was split, weighed, and recorded on lab sheets. The split for shell analysis (~20-gram sample) was immersed in diluted muriatic acid (ie, nearly pure hydrochloric acid–HCl). After ~24 hours or once there was no evidence of bubbling, the remainder was rinsed, dried, and reweighed to the nearest 0.01 gram. The difference represented the proportion of shell in the sample.

Summary tables of results, including sediment size distribution statistics, shell percentages, and fines percentages, are given in Section 3.0 (Results). Fines are defined here as material passing the US Standard Sieve #230 (ie, <0.0625 mm) and generally consists of minute fractions of silt. No beach samples were observed to contain measurable quantities of clays or organics. Gravel percentage was determined from the split retained on the US Standard Sieve #5 (>0.2 mm). In some cases, additional coarse sieves were used in the analysis for a breakdown of the small gravel sizes.

Sample splits were converted to percentages and graphed as frequency and cumulative frequency distributions. Standard statistical measures were computed including true-moment measures, graphic means, and standard deviations (ie, Inman 1952, Folk and Ward 1957). Results were reported in millimeters as well as standard phi units. Figure 2.4 shows a typical data sheet for one sample; the set of laboratory data sheets is given in Attachment 1.

Statistical composites of groups of samples were determined mathematically by averaging results for each individual size class for a given group of samples, then calculating moment measures for the composite. Composites were developed for each morphological unit sampled (ie, all dune samples combined, all toe-of-dune samples combined, etc). Groups of morphological units, such as dune and toe-of-dune, were also composited mathematically.

Results of composite size distributions are given after the individual sample results in Attachment 1. In general, they are identified on the data sheets as a morphological group or all samples. Multiple groups include a numerical value in the name corresponding to the applicable number of samples represented by the result (ie, All Samples–Comp 140, Subaerial Samples–Comp 60). Percent fines are given on the sample data sheets, and summary tables provide all key statistics including mean, standard deviation, skewness, percent shell, and percent gravel.



Project	**2403**
Location	**Hatteras NC**
Date	**August 2013**
Station	**1940+00**
Interval	**Berm**
Mean	**0.442 mm**
STD	**0.653 mm**
Skewness	**-0.520**
USCS	**Wentworth**
SP	Medium Sand
Medium Sand	Moderately Well Sorted
Poorly Graded	Coarse Skewed
	Leptokurtic
Total weight (gram)	119.47
% finer than 4.00 phi	0.00
% coarser than -1.00 phi	0.49
% $CaCO_3$	8.1

Class Limits (ϕ)	Mid Point (ϕ)	Weight (gram)	Weight %	Cumm. Wt %
-4	-4.5	0.00	0.00	0.00
-3	-3.5	0.00	0.00	0.00
-2	-2.5	0.00	0.00	0.00
-1.5	-1.75	0.00	0.00	0.00
-1	-1.25	0.58	0.49	0.49
-0.75	-0.875	0.24	0.20	0.69
-0.5	-0.625	0.64	0.54	1.22
-0.25	-0.375	0.88	0.74	1.96
0	-0.125	2.16	1.81	3.77
0.25	0.125	2.75	2.30	6.07
0.5	0.375	7.60	6.36	12.43
0.75	0.625	12.39	10.37	22.80
1	0.875	15.14	12.67	35.47
1.25	1.125	18.17	15.21	50.68
1.5	1.375	22.74	19.03	69.72
1.75	1.625	17.32	14.50	84.21
2	1.875	10.27	8.60	92.81
2.25	2.125	5.29	4.43	97.24
2.5	2.375	2.53	2.12	99.36
2.75	2.625	0.41	0.34	99.70
3	2.875	0.26	0.22	99.92
3.25	3.125	0.07	0.06	99.97
3.5	3.375	0.02	0.02	99.99
3.75	3.625	0.01	0.01	100.00
4	3.875	0.00	0.00	100.00
>4.0	4.25	0.00	0.00	100.00

Percentiles	
1	-0.730
5	0.010
16	0.460
25	0.670
50	1.115
75	1.465
84	1.620
95	2.000
99	2.335

Moment Measures	**(phi)**	**(mm)**
Mean	1.178	0.442
Standard Deviation	0.615	0.653
Skewness	-0.520	
Kurtosis	4.018	
Dispersion		
Standard Deviation		
Deviation from Normal		

Graphic Phi Parameters	**Inman 1952**	**Folk & Ward 1957**
Mean	1.040	1.065
Standard Deviation	0.580	0.592
Skewness (1)	-0.129	-0.120
Skewness (2)	-0.190	
Kurtosis	0.716	1.026

FIGURE 2.4. Representative data sheet for a berm sample along Buxton beach obtained in August 2013 (summer accretional conditions). Note: This station and sample position tested 0.598 mm in October 2014, reflecting erosional conditions following fall storms.

Summary tables of results, including shell and gravel percentages, follow in Section 3.0.

Consistent with North Carolina sediment standards, arithmetic (non-weighted) means of groups of samples were computed from tabulated results using simple statistics (ie, mean, standard deviation, and skewness). Mean is the commonly reported typical grain size; standard deviation is a measure of the degree of sorting; and skewness reflects the degree to which the sample contains higher proportions of coarse sediment or fine sediment. Most beaches tend to have well-sorted and slightly coarse (ie, negative), skewed sediments. Shell material often adds a coarse fraction, as do granules and pebbles which are common on Dare County beaches.

2.2 Borrow Samples

There are no designated offshore borrow areas in the Cape Hatteras vicinity. The USACE (R Keistler, USACE–Wilmington, pers comm, August 2013) and NCDOT delineated borrow areas off Rodanthe for emergency nourishment in the area around the NC Highway 12 S-curve near Mirlo Beach (USACE 2014).

Prior to the recent efforts of NCDOT/USACE and the present project team, the most detailed core data had been developed by the North Carolina Geological Survey (NCGS) with funding by Minerals Management Service and others (eg – Boss & Hoffman 2000, Hoffman et al 2001). A reconnaissance grid of borings obtained in the 1990s between Oregon Inlet and Cape Hatteras is summarized in an excellent report by NCGS (Hanna & Nickerson 2009). The Boss and Hoffman cores located within economical distances to Buxton (ie, <5 nautical miles) tend to contain high proportions of fine-grained material (including fine sand) or, in some cases, too much gravel.

CSE identified one boring off Buxton from the 1990s that contained relatively clean, medium sand (Fig 2.5). Core SNL-199 was identified as having “viable sand sizes” for nourishment (Hanna & Nickerson 2009). Table 2.1 provides a listing of NCGS cores along with CSE’s notes regarding the general suitability of the sediment for beach nourishment. The mean grain sizes of these cores were 0.26 mm to 0.34 mm (Hanna & Nickerson 2009), considerably finer than the existing sand on the Buxton subaerial beach. Fines (silty material) ranged from ~1.4 to 4.8 percent. Core spacing for the Boss and Hoffman borings was relatively large (typically >4,000 ft), which means that sediment quality over broad areas is unknown.

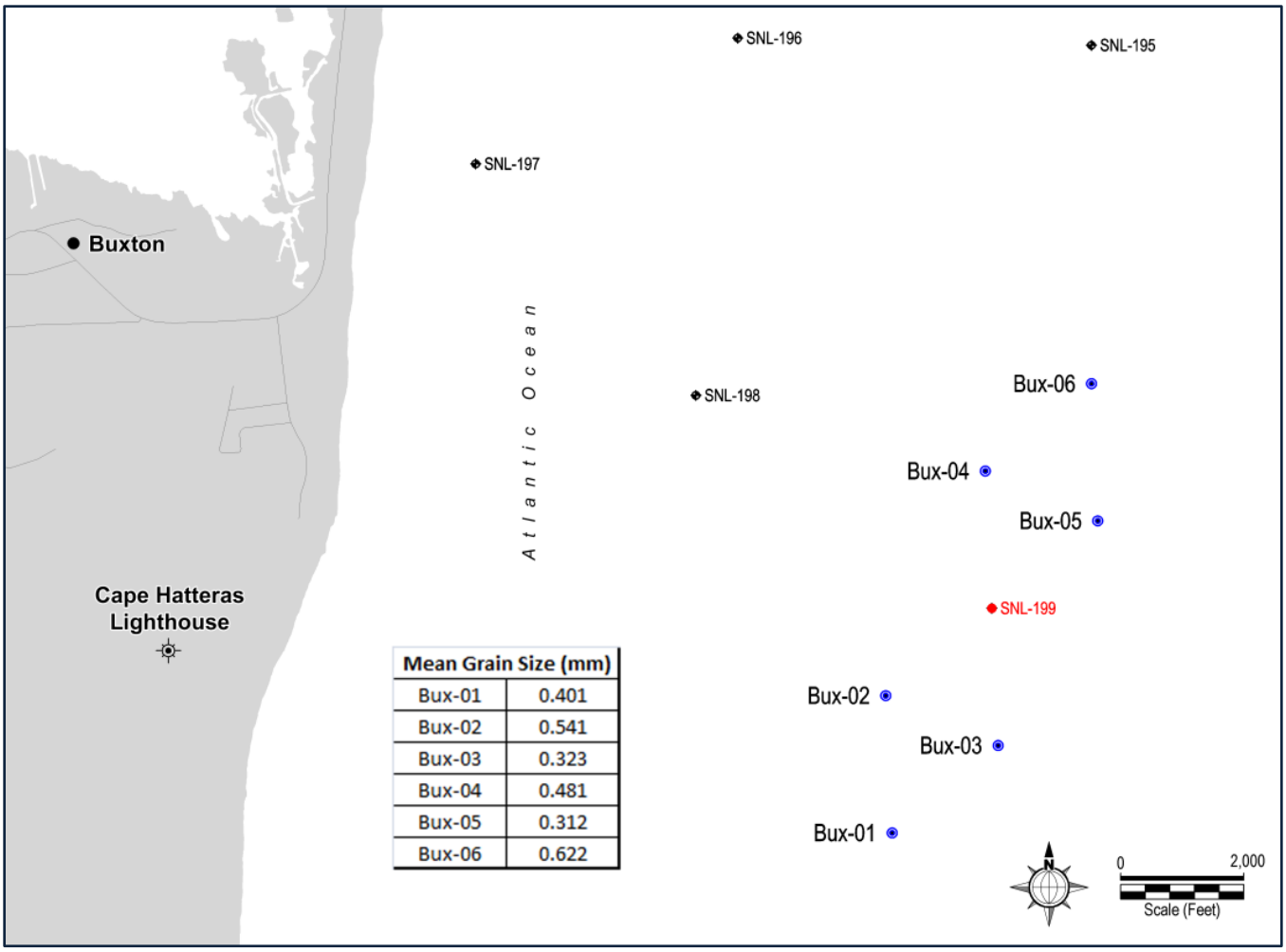


FIGURE 2.5. Locations of CSE borings off **Buxton** obtained in July 2013. Mean grain size (mm) applies to the upper 6 ft of each core, composited (weighted averages) from individual sediment samples. Positions of historical cores from NCGS (Boss & Hoffman 2000) are indicated.

TABLE 2.1. Listing of NCGS cores along with CSE's notes regarding the general suitability of the sediment for beach nourishment along Buxton (from CSE 2013).

CORE	Study Area	Latitude	Longitude	Water Depth (m)	Length (m)	Core TD Subsea (m)	CSE Comments
SNL-001	Diamond Shoals/Buxton	35.21146	-75.48593	7.3	2.82	10.1	Too Fine
SNL-004	Diamond Shoals/Buxton	35.2202	-75.45156	17.4	2.18	19.6	Too Fine
SNL-174	Buxton	35.37957	-75.47082	10.9	3.62	14.6	Fair to Good -
SNL-175	Buxton	35.38321	-75.45197	12.8	4.24	17	Too much Gravel
SNL-176	Buxton	35.37994	-75.42748	16.2	4.81	21	Too Fine
SNL-177	Buxton	35.36663	-75.45529	15.8	3.62	19.5	Too much Gravel
SNL-178	Buxton	35.36828	-75.47264	11	6.1	17.1	Too close to shore
SNL-179	Buxton	35.36968	-75.4864	8.2	3.87	12.1	
SNL-181	Buxton	35.34995	-75.46069	12.5	5.09	17.6	
SNL-182	Buxton	35.36296	-75.43228	15.2	3.78	19	Too Fine
SNL-183	Buxton	35.34019	-75.462	13.7	3.24	17	Too Fine
SNL-184	Buxton	35.34431	-75.47929	11.3	4.8	16.1	Too Fine
SNL-185	Buxton	35.33713	-75.49482	7.6	3.74	11.4	Too Fine
SNL-186	Buxton	35.32693	-75.48364	11.6	5.97	17.6	Too Fine
SNL-187	Buxton	35.31749	-75.46919	14.3	1.96	16.3	Too Fine
SNL-188	Buxton	35.33047	-75.44007	16.8	2.2	19	Too Fine
SNL-189	Buxton	35.3071	-75.47002	15.5	2.35	17.9	Marginal - Admixtures
SNL-190	Buxton	35.30536	-75.49003	12.5	4.24	16.7	Too Fine (top); Gravel (bot)
SNL-191	Buxton	35.3043	-75.50228	8.2	4.8	13	Too Fine; Too close to shore
SNL-192	Buxton	35.29499	-75.49234	12.5	3.04	15.5	Too Fine (top); Gravel (bot)
SNL-193	Buxton	35.28445	-75.47551	15.8	4.2	20	Too much Gravel
SNL-194	Buxton	35.28076	-75.45028	18.6	2.23	20.8	Too Fine
SNL-195	Buxton	35.27604	-75.47679	15.5	2.51	18.1	Too much Gravel
SNL-196	Buxton	35.27692	-75.49604	11.9	3.92	15.8	Too Fine
SNL-197	Buxton	35.27171	-75.51056	5.8	3.91	9.7	Too close to shore
SNL-198	Buxton	35.26101	-75.49901	11.6	6.05	17.6	Too Fine
SNL-199	Buxton	35.25103	-75.48331	10.4	6.11	16.5	***Excellent**
SNL-200	Buxton	35.24655	-75.45816	17.7	2.85	20.5	Too Fine

CSE (2013) used the favorable NCGS core (SNL-199) to lay out a relatively small sand search area off Buxton. The goal was to obtain several cores in a more closely spaced grid (typically <2,000 ft spacing) to determine whether the location with good-quality sand extended for several thousand feet. Six initial borings (Bux-01 to Bux-06) were obtained in August 2013 (see Fig 2.5). Based on the results of the August 2013 borings, CSE conducted a more detailed sampling (October 2014) and obtained 31 additional cores at ~1,000-ft spacing within the sand search area shown in Figure 2.6. The Buxton search grid targeted a shoal ~2 miles offshore of the old Cape Hatteras Lighthouse site. This grid surrounds the location of NCGS core SNL-199 shown in Figure 2.5.

Cores were obtained using CSE's proprietary system which creates a partial vacuum that allows penetration of a 3-inch aluminum core barrel into the substrate. The cores are retrieved by removing the core device, then capping and sealing the ends before they are brought to the coring vessel.

Lengths of CSE cores ranged from 3.4 ft to 9.5 ft. Omitting two short cores of poor-quality material, the average core length was 7.5 ft (n=35) at Buxton. Cores were spilt, logged by an NC-registered professional geologist, and subsampled for sediment analysis. The "saved" core half was photographed and archived in plastic sleeves. Subsamples representing the section lithology were taken from the other half of the core at full-section intervals as given on the core logs. Samples were dried, weighed, disaggregated (if mud was present) and/or washed of salts, dried, weighed, and subsampled (~100 grams) for grain-size analysis via dry sieves at 0.25-phi intervals in the sand size range and several intervals as appropriate up to the "pea" gravel range (−4.0 phi, or 16 mm).

Any pebbles, cobbles, or shells greater than 16-mm diameter were retained on the −4.0 phi sieve and included in the weight percentages. Visual inspections indicated that only trace amounts of mud occurred in most of the borings so mud analysis was only performed on a few samples. A separate subsample (~20 grams) was taken for "shell" analysis ($CaC0_3$ content) which was determined by acid-burning using dilute hydrochloric acid. Percent gravel was determined by sieving as the percent >2-mm diameter retained.

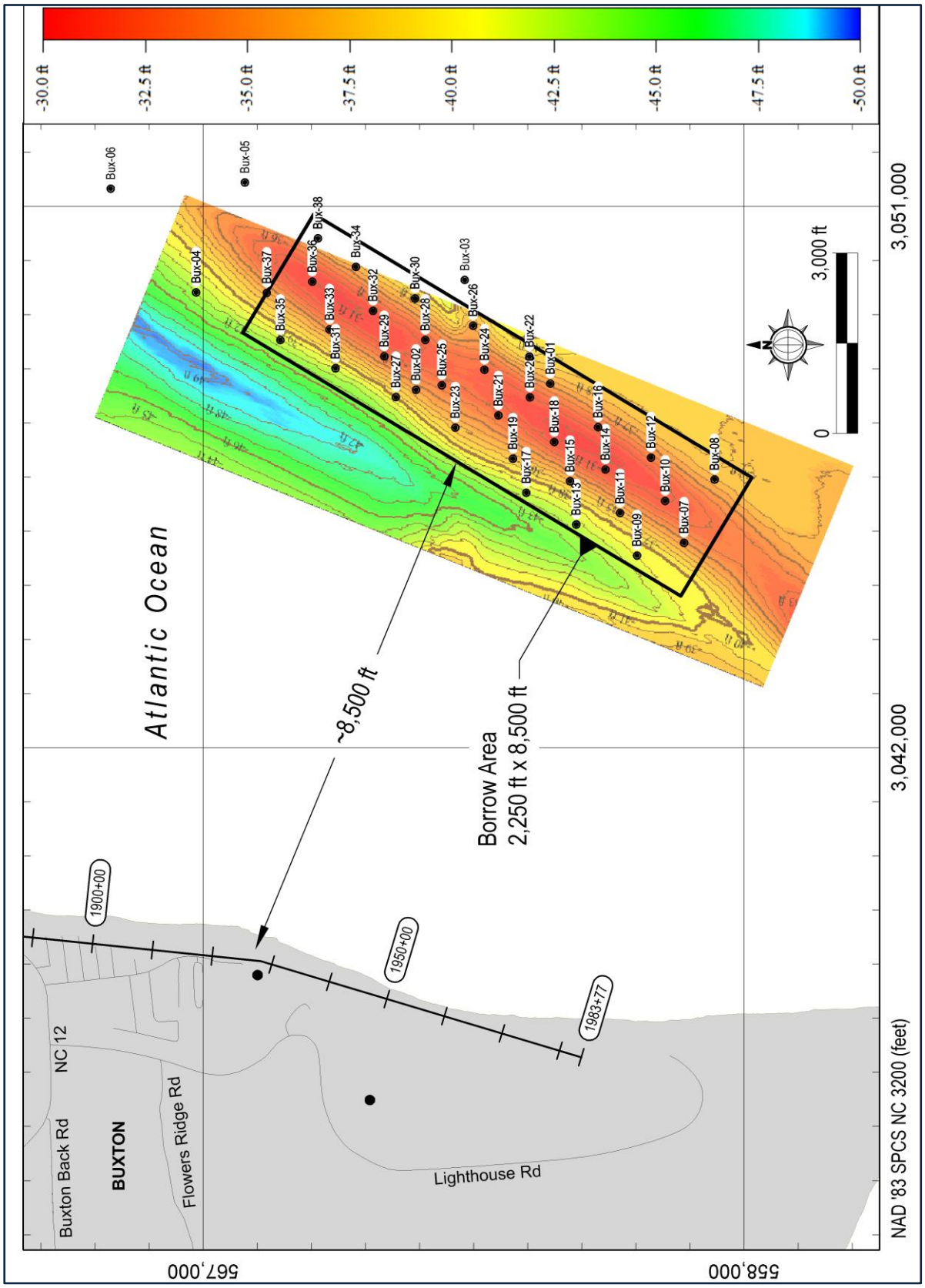


FIGURE 2.6. Location of 37 CSE borings off Buxton obtained in August 2013 and October 2014.

Figures 2.7 and 2.8 contain example photo-mosaic and core logs for CSE core Bux-01. The location of this core is shown in the inset panels of Figure 2.7. Attachment 2 contains the set of photo-mosaic and core logs. Attachment 3 contains the set of grain-size distributions (statistics, frequency, and cumulative frequency curves) for individual samples. Sample results were composited (weighted by section length) for the upper 4 ft, upper 6 ft, and upper 8 ft of substrate (Fig 2.9). This provides a practical operational result for evaluating sediment quality under representative dredge cuts.

Based on the objective of matching the native beach, CSE found that certain cores contained sediments that were too fine for use as beach nourishment in the Buxton setting. Visual inspection of cores provided initial guidance which was later confirmed by sediment testing. Nearly all cores contained grayish-tan sediments similar in color to the native beach with only trace amounts of mud, indicative of high-energy settings with good oxygenation. There was no evidence of anaerobic conditions or an odor of hydrogen sulfide (H_2S) in any of the cores.

Sediment quality for beach nourishment can be evaluated using the analytical model of James (1975), which is a standard method adopted by the USACE (CERC 1984). The James method computes an "overfill factor" (R_A), which uses two simple parameters (mean grain size and standard deviation) to compare a prospective borrow sediment with the native size distributions.

The overfill factor, R_A, compares these parameters (using phi units) with a prospective borrow material and yields a simple ratio between 1 and 10. A value of R_A=1.0 means the prospective borrow material matches or exceeds the native beach in terms of its potential performance (not necessarily a duplicate size distribution). A value of R_A=1.5 means that ~1.5 times more borrow material would have to be placed to provide performance equaling the native beach. Borrow material that is considerably finer than the native sediment may have R_A's >>1 and, consequently, require many times more volume to yield the same performance as native sand. The overfill factor, R_A, is consistent with Dean's equilibrium profile predictions as previously illustrated in Figure 1.2.

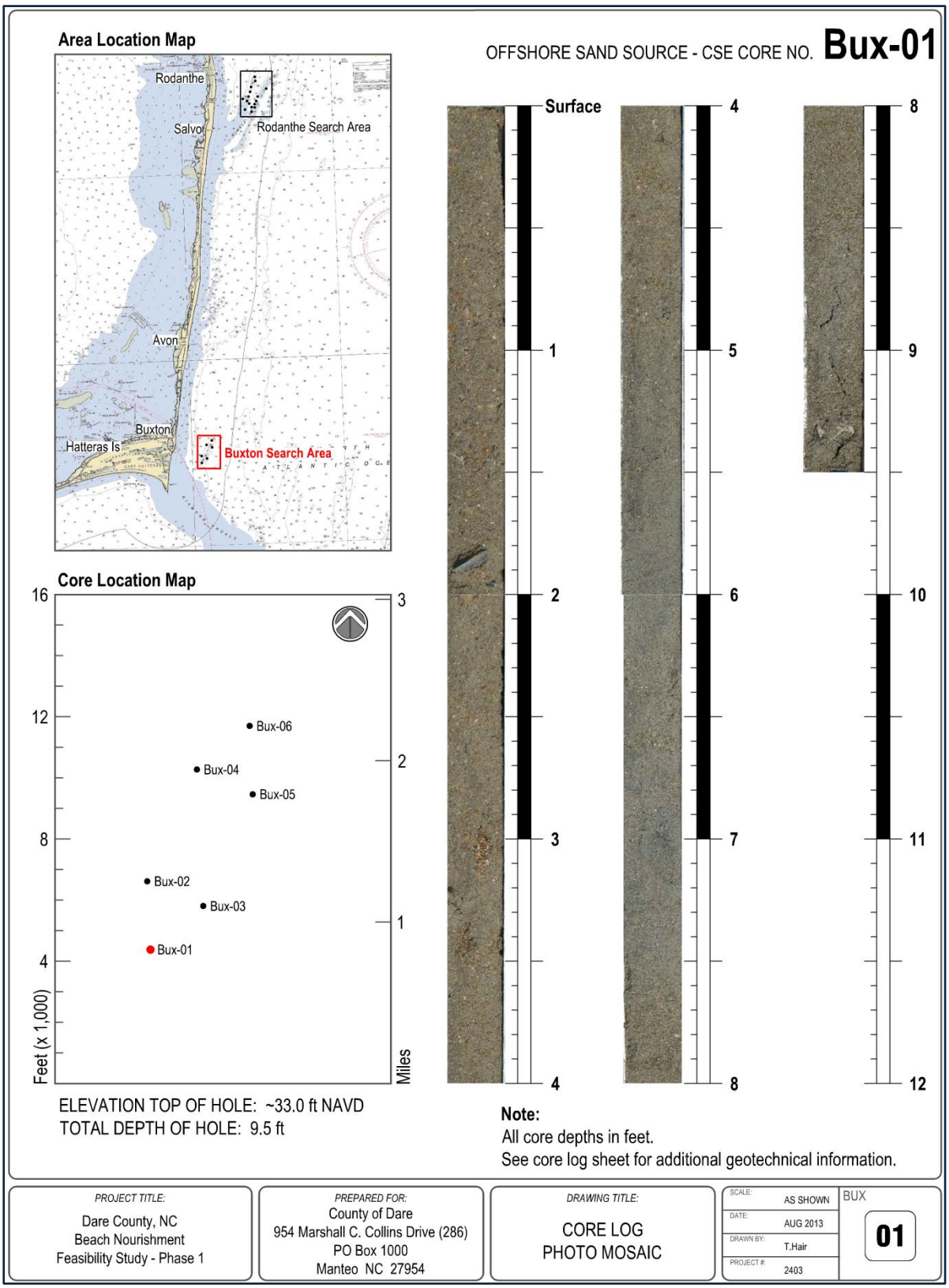
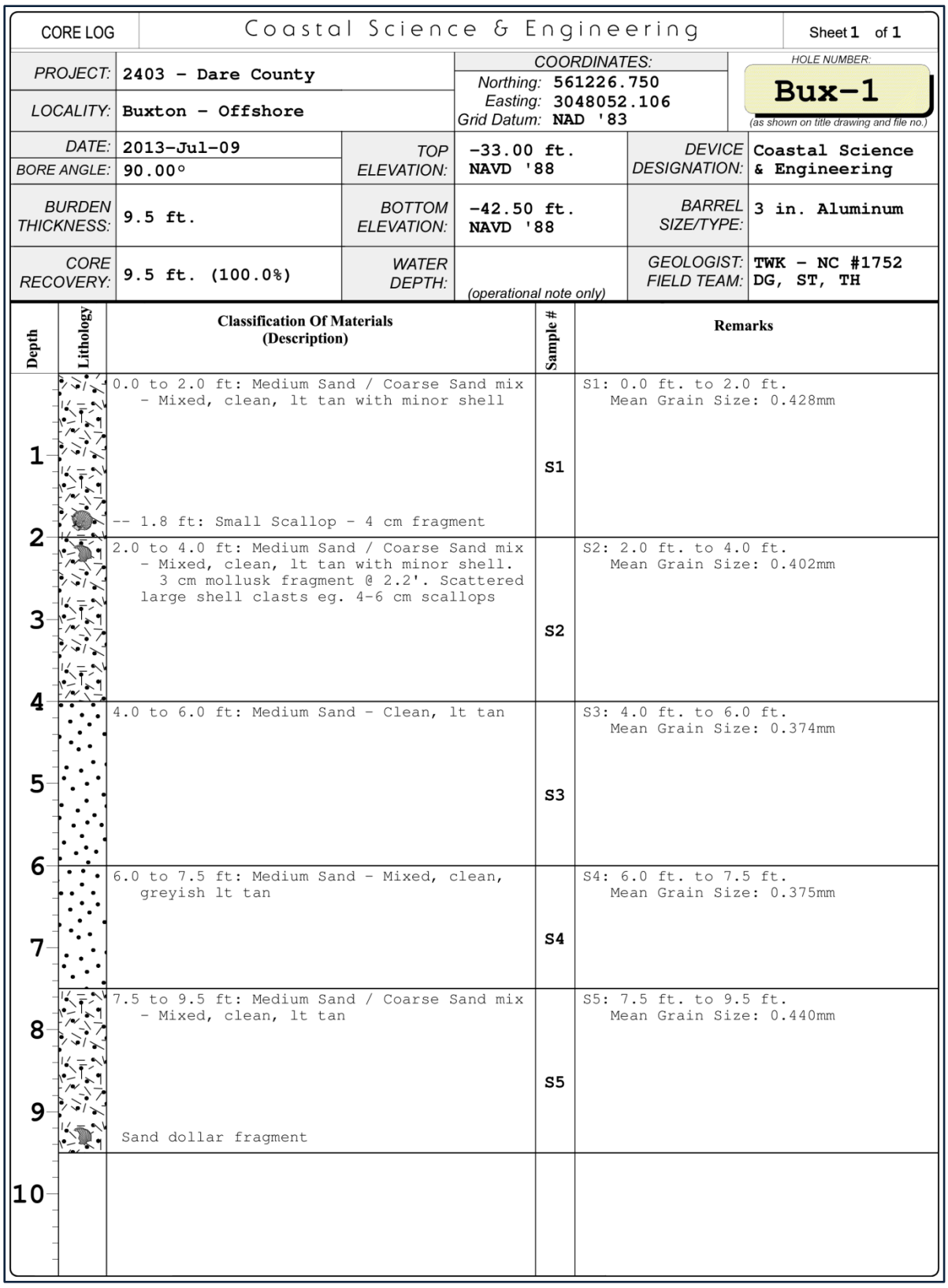


FIGURE 2.7. Example core photo log for BUX-01 obtained by CSE in August 2013 in water depths of ~33 ft.



CORE LOG — Coastal Science & Engineering — Sheet 1 of 1

PROJECT:	2403 – Dare County		COORDINATES: Northing: 561226.750 Easting: 3048052.106 Grid Datum: NAD '83		HOLE NUMBER: Bux–1 (as shown on title drawing and file no.)
LOCALITY:	Buxton – Offshore				
DATE:	2013–Jul–09	TOP ELEVATION:	–33.00 ft. NAVD '88	DEVICE DESIGNATION:	Coastal Science & Engineering
BORE ANGLE:	90.00°				
BURDEN THICKNESS:	9.5 ft.	BOTTOM ELEVATION:	–42.50 ft. NAVD '88	BARREL SIZE/TYPE:	3 in. Aluminum
CORE RECOVERY:	9.5 ft. (100.0%)	WATER DEPTH:	(operational note only)	GEOLOGIST: FIELD TEAM:	TWK – NC #1752 DG, ST, TH

Depth	Lithology	Classification Of Materials (Description)	Sample #	Remarks
1–2		0.0 to 2.0 ft: Medium Sand / Coarse Sand mix – Mixed, clean, lt tan with minor shell -- 1.8 ft: Small Scallop – 4 cm fragment	S1	S1: 0.0 ft. to 2.0 ft. Mean Grain Size: 0.428mm
2–4		2.0 to 4.0 ft: Medium Sand / Coarse Sand mix – Mixed, clean, lt tan with minor shell. 3 cm mollusk fragment @ 2.2'. Scattered large shell clasts eg. 4-6 cm scallops	S2	S2: 2.0 ft. to 4.0 ft. Mean Grain Size: 0.402mm
4–6		4.0 to 6.0 ft: Medium Sand – Clean, lt tan	S3	S3: 4.0 ft. to 6.0 ft. Mean Grain Size: 0.374mm
6–7		6.0 to 7.5 ft: Medium Sand – Mixed, clean, greyish lt tan	S4	S4: 6.0 ft. to 7.5 ft. Mean Grain Size: 0.375mm
8–9		7.5 to 9.5 ft: Medium Sand / Coarse Sand mix – Mixed, clean, lt tan Sand dollar fragment	S5	S5: 7.5 ft. to 9.5 ft. Mean Grain Size: 0.440mm
10				

FIGURE 2.8. Core log for BUX-01 showing the lithology, sample intervals, and mean grain sizes.

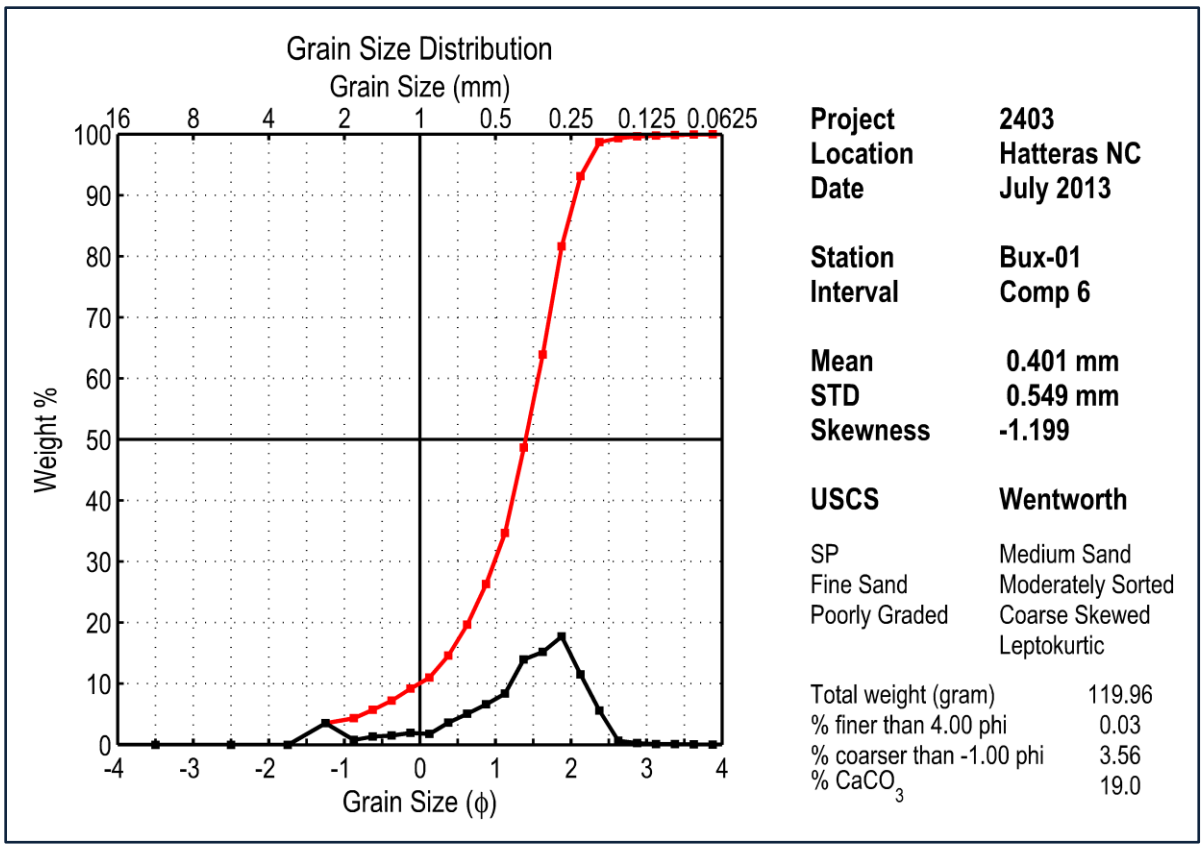


FIGURE 2.9. Example grain-size distribution (GSD) for the upper 6 ft of the Bux-01 core. Results were composited from individual samples (weighted) for the upper 4 ft, 6 ft, and 8 ft of substrate. See Attachment 3 for composite GSDs for each core calculated for the upper 4 ft, 6 ft, and 8 ft. These thicknesses are representative of typical dredging depths (excavation sections) for offshore sediments along the East Coast (USACE 2010).

The similarity between borrow sediments and native beach sediments was also evaluated by means of comparative size-frequency curves for composited samples, which offers a more critical comparison of the beach and borrow sediments. If the two frequency curves are similar, the nourished beach will generally maintain the same aesthetic qualities. In general the broader the size distribution of the native beach, the less likely there will be a perfect match with prospective borrow areas (Kana & Mohan 1998). As Gravens et al (2008) report, sediment grain size is the most important borrow material characteristic. However, it is often not possible to find areas that perfectly match the receiving beach, particularly if there is considerable cross-shore variability in grain sizes (ie, the case along Buxton).

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3.0 RESULTS – BEACH SAMPLES

3.1 Beach Statistics – October 2014

The Buxton project area grain-size distributions (GSDs) for October 2014 samples (140) are given in Attachment 1 and summarized in Tables 3.1 to 3.4. Table 3.2 lists the means by station and cross-shore position. Primary measures based on method of moments and graphical methods show that arithmetic mean grain size for all samples is 0.630 mm (coarse sand) with 6.2 percent shell and 6.6 percent gravel (Table 3.3). However, there is a wide range of sizes in the cross-shore direction. Averaging by sample position (Table 3.3), mean grain size ranges from ~0.20 mm seaward of the bar to >2.35 mm in the trough. The low-tide samples, marking the general area of the inshore surf break ("plunge point"), tested over 1.1 mm on average.

Figure 3.1 plots the results of all samples by station (north to south). Samples in the trough are considered extreme outliers with respect to all other samples. As Table 3.4 indicates, the trough contains a high shell and gravel percentage at 20.8 percent and 54.2 percent (respectively). This result is also quite different compared with samples at Duck and Nags Head (see Figs 1.3 and 1.4). Similarly, samples around the mean low watermark averaged 11.1 percent shell and 16.5 percent gravel, much higher than all other samples.

The mean grain size (unweighted, arithmetic means and standard deviations) by cross-shore sample position is shown in Figure 3.2. The relatively low standard deviation at each point indicates the results were fairly consistent from station to station. Compared with a similar graph for Nags Head (see Fig 1.3), the Buxton results are coarser, particularly in the foredune and trough. Coarsest sediments along Nags Head were observed along the mean low water zone. Nags Head dune samples tested ~0.3 to 0.35 mm (typical), whereas Buxton dune samples averaged ~0.50 to 0.58 mm in October 2014. This difference may reflect the previous manipulations of the Buxton dunes whereby storm deposits of coarse berm sand were scraped off Highway NC 12 and pushed up to form a protective dune (J Jennings, NCDOT, pers comm, August 2014). The underwater samples (seaward of the bar to –24 ft NAVD–North American Vertical Datum) along Buxton generally exhibit mean grain sizes <0.25 mm (fine sand), similar to underwater samples along Nags Head (see Fig 1.4).

Table 3.3 (lower) and Figure 3.3 show the sample averages omitting the trough samples. This has the effect of reducing average mean grain size (130 samples) to 0.504 mm and the shell and gravel content to 5.1 percent and 3.1 percent (respectively). Mean grain size

decreases from north to south along Buxton in the range of ~0.55–0.45 mm (see trend line in Fig 3.3). The percent shell and gravel by station with and without trough stations is shown in Figure 3.4. Shell content is relatively uniform (~5 percent) from north to south, whereas the gravel percent peaks near the center of the project area at ~5 percent (stations 1840+00–1870+00) and drops below 2 percent at the south end (omitting trough samples).

The grain-size distributions (Attachment 1-A) show nearly all gravel (sizes >2 mm, −1.0 phi) falls in the 2–8 mm (−1.0 phi to −3.0 phi) size range with few large shell clasts. No significant concentration of large clasts was observed along the beach at the time of CSE samplings in 2013 and 2014. However, there were fragments of broken asphalt in the dunes and in the vicinity of the shore-protection structures around the former Navy site and the Cape Hatteras Lighthouse site. A large clast survey will be conducted during summer conditions in 2015 per requirements under North Carolina sediment standards for beach nourishment.

Figures 3.5 and 3.6 show the mean grain sizes by station for groups of sample positions across the littoral zone. Dune samples (n=20) increase in size from north to south (range 0.4–0.7 mm) with arithmetic means ranging 0.515 mm to 0.577 mm. The visible beach (berm to mid-tide level) decreases in size from north to south within a range (trend) from ~0.75 mm to ~0.55 mm. As the results show (Fig 3.5, lower), there is a high range of mean grain sizes (0.2–1.4 mm) in the 40 samples analyzed. Samples at station 1840+00 skew the results coarser.

The low-tide "step" (wave plunge point) and trough (Fig 3.6, upper) show the widest range of mean sizes from 0.7 mm to 2.9 mm—material that is much coarser than is typical North Carolina beach sand. The grain sizes occur in the deep trough between the low tide line and outer bar. It is likely this surficial sediment in the trough represents a coarse lag deposit remaining after finer sands have been winnowed from the area under strong littoral currents.

Finally, the group of 60 underwater samples from the bar to a depth of −24 ft shows a predominance of 0.2–0.25 mm sand (Fig 3.6, lower). Bar samples skew the distribution with much coarser sands along northern stations (1760+00–1870+00). Omitting the bar samples, the trend line shows a slight increase from north to south, biased by results at stations 1920+00 and 1940+00.

TABLE 3.1a. Buxton project area beach sediment characteristics (statistical measures) in October 2014. See Attachment 1 for detailed frequency and cumulative frequency results of each sample.

Buxton Beach Sediment Characteristics		Method of Moments						Folk Graphical Method						
		Mean	STD	Mean	STD	Skew	Kurt	Mean	STD	ISTD	Skew	Kurt	Shell	Gravel
		mm	mm	phi				phi					%	%
1760+00	Dune	**0.373**	**0.596**	1.421	0.747	-0.605	3.219	1.288	0.763	0.753	-0.309	1.070	2.2	0.2
1760+00	Dune Toe	**0.568**	**0.576**	0.816	0.795	0.092	2.692	0.678	0.835	0.810	0.087	0.935	6.6	0.8
1760+00	Berm	**0.740**	**0.551**	0.435	0.860	-0.051	2.427	0.320	0.920	0.908	-0.073	0.942	6.5	5.6
1760+00	BC	**0.517**	**0.650**	0.952	0.621	-0.077	3.108	0.833	0.618	0.618	-0.024	0.967	4.3	0.1
1760+00	MHW	**0.358**	**0.682**	1.482	0.552	-0.546	4.243	1.373	0.525	0.535	-0.102	1.077	2.5	0.1
1760+00	MTL	**0.610**	**0.546**	0.713	0.874	-0.182	2.514	0.597	0.913	0.891	-0.035	0.905	6.1	3.3
1760+00	MLW	**0.669**	**0.508**	0.581	0.978	-0.040	2.169	0.452	1.078	1.028	-0.055	0.825	6.9	5.3
1760+00	Trough	**1.550**	**0.492**	-0.632	1.023	0.180	3.081	-0.857	1.093	1.158	-0.160	1.178	13.5	33.8
1760+00	Bar	**0.723**	**0.461**	0.467	1.119	0.071	2.177	0.293	1.290	1.205	-0.087	0.841	2.7	13.8
1760+00	-8 ft NAVD	**0.232**	**0.659**	2.110	0.601	-1.225	6.155	2.028	0.498	0.552	-0.210	1.311	2.6	0.0
1760+00	-12 ft NAVD	**0.208**	**0.693**	2.268	0.530	-0.785	5.286	2.177	0.525	0.512	-0.129	1.133	2.4	0.0
1760+00	-16 ft NAVD	**0.198**	**0.680**	2.337	0.556	-1.238	7.213	2.250	0.485	0.501	-0.092	1.165	2.3	0.0
1760+00	-20 ft NAVD	**0.257**	**0.637**	1.959	0.652	-1.628	8.576	1.877	0.478	0.539	-0.120	1.176	10.5	0.8
1760+00	-24 ft NAVD	**0.336**	**0.522**	1.571	0.939	-1.180	4.450	1.502	0.815	0.902	-0.359	1.387	5.6	3.0
1790+00	Dune	**0.448**	**0.566**	1.157	0.820	-0.218	2.669	1.057	0.848	0.819	-0.094	0.880	3.6	0.6
1790+00	Dune Toe	**0.503**	**0.637**	0.992	0.651	-0.290	3.598	0.885	0.613	0.636	-0.068	1.074	3.5	0.4
1790+00	Berm	**0.701**	**0.586**	0.513	0.772	0.184	2.786	0.402	0.788	0.768	0.119	0.888	6.2	2.4
1790+00	BC	**0.608**	**0.654**	0.718	0.612	0.073	3.385	0.592	0.608	0.605	0.042	1.019	5.2	0.3
1790+00	MHW	**0.736**	**0.575**	0.443	0.798	-0.036	2.847	0.320	0.810	0.827	-0.094	1.052	7.9	4.6
1790+00	MTL	**0.674**	**0.638**	0.569	0.648	-0.170	3.601	0.437	0.633	0.635	-0.106	1.106	6.4	1.6
1790+00	MLW	**0.838**	**0.695**	0.255	0.524	-0.222	4.793	0.142	0.450	0.479	-0.160	1.081	9.2	2.5
1790+00	Trough	**1.655**	**0.552**	-0.727	0.857	-0.360	3.128	-0.890	0.925	0.965	-0.299	1.087	11.4	32.7
1790+00	Bar	**0.943**	**0.425**	0.085	1.234	-0.046	2.393	-0.080	1.390	1.340	-0.054	0.944	2.6	20.0
1790+00	-8 ft NAVD	**0.230**	**0.673**	2.122	0.571	-1.008	5.744	2.023	0.515	0.536	-0.200	1.197	2.2	0.1
1790+00	-12 ft NAVD	**0.204**	**0.698**	2.295	0.519	-0.841	5.614	2.200	0.513	0.500	-0.118	1.073	2.3	0.0
1790+00	-16 ft NAVD	**0.197**	**0.686**	2.343	0.543	-1.186	7.262	2.255	0.473	0.490	-0.068	1.215	2.3	0.0
1790+00	-20 ft NAVD	**0.262**	**0.637**	1.930	0.651	-1.483	7.166	1.850	0.505	0.574	-0.219	1.232	7.8	0.5
1790+00	-24 ft NAVD	**0.398**	**0.484**	1.330	1.048	-0.891	3.236	1.257	1.003	1.069	-0.388	1.156	4.5	5.3
1820+00	Dune	**0.614**	**0.656**	0.704	0.608	0.081	3.427	0.575	0.615	0.606	0.017	1.003	6.6	0.2
1820+00	Dune Toe	**0.598**	**0.673**	0.742	0.570	-0.104	3.797	0.632	0.538	0.552	0.017	1.043	5.7	0.3
1820+00	Berm	**0.469**	**0.605**	1.092	0.724	-0.522	4.039	0.990	0.645	0.684	-0.137	1.092	5.1	1.4
1820+00	BC	**0.600**	**0.656**	0.736	0.608	0.672	3.970	0.597	0.545	0.592	0.205	1.253	6.0	0.1
1820+00	MHW	**0.644**	**0.668**	0.634	0.581	0.608	5.098	0.493	0.480	0.539	0.111	1.372	5.0	0.3
1820+00	MTL	**0.782**	**0.644**	0.355	0.635	0.604	4.532	0.212	0.555	0.593	0.058	1.139	7.5	1.3
1820+00	MLW	**1.780**	**0.569**	-0.832	0.814	-0.377	2.975	-1.018	0.928	0.949	-0.318	1.068	11.9	36.2
1820+00	Trough	**2.458**	**0.515**	-1.297	0.958	-0.026	2.653	-1.605	1.228	1.131	-0.134	0.780	21.5	58.2
1820+00	Bar	**0.676**	**0.454**	0.564	1.140	-0.043	2.000	0.422	1.283	1.209	-0.077	0.815	2.9	12.7
1820+00	-8 ft NAVD	**0.193**	**0.701**	2.373	0.512	-0.975	6.908	2.283	0.458	0.469	0.004	1.039	2.0	0.1
1820+00	-12 ft NAVD	**0.210**	**0.705**	2.251	0.505	-0.705	5.294	2.162	0.490	0.488	-0.118	1.303	2.3	0.0
1820+00	-16 ft NAVD	**0.206**	**0.676**	2.281	0.564	-1.227	6.742	2.200	0.493	0.509	-0.161	1.317	2.3	0.0
1820+00	-20 ft NAVD	**0.281**	**0.635**	1.829	0.654	-1.402	7.292	1.748	0.535	0.576	-0.096	1.119	11.6	0.8
1820+00	-24 ft NAVD	**0.338**	**0.558**	1.565	0.842	-1.092	4.617	1.488	0.748	0.800	-0.280	1.219	5.7	1.6
1840+00	Dune	**0.376**	**0.656**	1.411	0.607	0.046	4.064	1.270	0.573	0.586	-0.033	1.119	1.8	0.1
1840+00	Dune Toe	**0.500**	**0.610**	1.000	0.713	-0.551	3.993	0.902	0.643	0.674	-0.152	1.083	5.3	1.6
1840+00	Berm	**1.430**	**0.634**	-0.516	0.658	-0.268	4.684	-0.688	0.658	0.692	-0.235	1.227	14.6	20.0
1840+00	BC	**0.902**	**0.708**	0.149	0.498	1.146	7.282	-0.002	0.440	0.457	0.124	1.051	9.3	0.3
1840+00	MHW	**0.703**	**0.657**	0.508	0.606	0.324	4.408	0.367	0.558	0.578	0.003	1.148	6.7	0.8
1840+00	MTL	**1.026**	**0.645**	-0.037	0.633	0.027	2.853	-0.165	0.640	0.662	-0.054	1.021	8.3	7.5
1840+00	MLW	**1.414**	**0.529**	-0.500	0.919	-0.535	2.844	-0.642	0.990	1.010	-0.362	0.995	10.9	27.1
1840+00	Trough	**2.331**	**0.503**	-1.221	0.990	0.042	2.963	-1.498	1.225	1.142	-0.281	0.812	23.4	48.7
1840+00	Bar	**0.725**	**0.488**	0.463	1.035	-0.030	2.270	0.323	1.135	1.099	-0.113	0.902	3.3	11.8
1840+00	-8 ft NAVD	**0.210**	**0.686**	2.253	0.544	-0.952	6.009	2.170	0.513	0.513	-0.118	1.252	2.2	0.0
1840+00	-12 ft NAVD	**0.219**	**0.648**	2.190	0.627	-1.362	7.081	2.128	0.563	0.567	-0.192	1.298	2.3	0.2
1840+00	-16 ft NAVD	**0.207**	**0.634**	2.274	0.656	-1.608	7.947	2.212	0.533	0.568	-0.167	1.226	2.1	0.2
1840+00	-20 ft NAVD	**0.259**	**0.631**	1.950	0.663	-1.356	6.480	1.860	0.518	0.591	-0.239	1.238	7.0	0.4
1840+00	-24 ft NAVD	**0.181**	**0.659**	2.462	0.601	-1.998	13.198	2.372	0.413	0.452	0.148	1.179	6.2	0.5
1870+00	Dune	**0.609**	**0.625**	0.715	0.678	-0.500	3.486	0.605	0.658	0.669	-0.126	1.076	6.5	1.9
1870+00	Dune Toe	**0.625**	**0.654**	0.677	0.612	0.060	3.836	0.548	0.593	0.598	-0.012	1.052	5.8	0.5
1870+00	Berm	**0.439**	**0.638**	1.188	0.649	-0.506	3.962	1.083	0.600	0.627	-0.162	1.058	3.1	0.3
1870+00	BC	**0.485**	**0.651**	1.043	0.620	-0.253	3.777	0.928	0.590	0.595	-0.084	0.984	3.1	0.4
1870+00	MHW	**0.482**	**0.651**	1.053	0.619	-0.248	3.893	0.942	0.580	0.592	-0.087	1.003	4.0	0.4
1870+00	MTL	**0.894**	**0.525**	0.161	0.930	-0.171	3.094	0.062	0.920	0.936	-0.112	1.021	9.1	11.1
1870+00	MLW	**1.724**	**0.577**	-0.786	0.793	-0.011	3.186	-0.933	0.788	0.872	-0.090	1.165	16.4	38.0
1870+00	Trough	**2.738**	**0.529**	-1.453	0.919	0.178	3.098	-1.773	1.183	1.081	-0.079	0.731	26.7	64.6
1870+00	Bar	**0.856**	**0.452**	0.225	1.146	-0.201	2.621	0.100	1.243	1.217	-0.128	0.954	2.4	15.2
1870+00	-8 ft NAVD	**0.240**	**0.654**	2.057	0.613	-1.334	6.812	1.945	0.470	0.538	-0.287	1.281	2.1	0.2
1870+00	-12 ft NAVD	**0.211**	**0.668**	2.246	0.582	-1.391	8.387	2.170	0.518	0.517	-0.140	1.248	1.7	0.2
1870+00	-16 ft NAVD	**0.202**	**0.678**	2.304	0.560	-1.406	8.035	2.217	0.460	0.491	-0.140	1.343	1.6	0.1
1870+00	-20 ft NAVD	**0.263**	**0.628**	1.928	0.672	-1.480	7.050	1.842	0.520	0.593	-0.234	1.232	7.3	0.6
1870+00	-24 ft NAVD	**0.150**	**0.614**	2.734	0.704	-2.258	13.659	2.670	0.445	0.513	-0.111	1.431	2.4	0.9

TABLE 3.1a (continued). Buxton project area beach sediment characteristics (statistical measures) in October 2014. See Attachment 1 for detailed frequency and cumulative frequency results of each sample.

Buxton Beach Sediment Characteristics		Method of Moments						Folk Graphical Method						
		Mean	STD	Mean	STD	Skew	Kurt	Mean	STD	ISTD	Skew	Kurt	Shell	Gravel
		mm	mm	phi				phi					%	%
1890+00	Dune	**0.682**	**0.593**	0.552	0.754	-0.205	4.159	0.437	0.708	0.754	-0.181	1.202	6.6	4.5
1890+00	Dune Toe	**0.629**	**0.663**	0.668	0.593	-0.321	3.785	0.553	0.568	0.579	-0.067	1.080	5.5	0.9
1890+00	Berm	**0.575**	**0.639**	0.798	0.647	-0.339	3.561	0.693	0.613	0.624	-0.061	1.022	5.3	0.9
1890+00	BC	**0.523**	**0.672**	0.935	0.573	-0.014	3.852	0.810	0.543	0.554	-0.030	0.993	3.9	0.1
1890+00	MHW	**0.587**	**0.686**	0.768	0.544	0.141	4.270	0.650	0.503	0.522	0.092	1.079	4.2	0.3
1890+00	MTL	**0.696**	**0.741**	0.524	0.432	0.265	5.736	0.395	0.375	0.406	0.051	1.326	6.1	0.4
1890+00	MLW	**0.947**	**0.648**	0.079	0.625	0.221	4.144	-0.058	0.563	0.616	-0.126	1.208	9.9	5.4
1890+00	Trough	**2.215**	**0.547**	-1.147	0.871	0.102	3.022	-1.452	1.100	1.045	-0.157	0.895	18.7	53.4
1890+00	Bar	**0.432**	**0.479**	1.211	1.061	-0.722	2.853	1.113	1.083	1.094	-0.378	1.053	3.5	5.3
1890+00	-8 ft NAVD	**0.184**	**0.664**	2.441	0.590	-1.604	11.468	2.343	0.433	0.465	0.096	1.169	3.0	0.3
1890+00	-12 ft NAVD	**0.188**	**0.664**	2.409	0.590	-1.786	12.720	2.323	0.418	0.458	0.073	1.335	2.9	0.4
1890+00	-16 ft NAVD	**0.194**	**0.622**	2.369	0.684	-2.217	12.453	2.317	0.418	0.493	-0.003	1.568	3.6	0.9
1890+00	-20 ft NAVD	**0.195**	**0.630**	2.360	0.667	-2.316	13.400	2.307	0.408	0.473	0.013	1.520	3.5	1.0
1890+00	-24 ft NAVD	**0.162**	**0.681**	2.628	0.554	-1.412	12.550	2.525	0.390	0.427	0.152	1.110	2.6	0.2
1900+00	Dune	**0.527**	**0.599**	0.924	0.740	-0.029	3.267	0.805	0.703	0.724	-0.016	1.039	4.8	0.7
1900+00	Dune Toe	**0.528**	**0.809**	0.922	0.305	-23.813	-214.462	0.873	0.495	0.507	-0.125	0.980	3.8	0.2
1900+00	Berm	**0.521**	**0.681**	0.940	0.554	-0.472	4.068	0.832	0.518	0.530	-0.102	0.998	4.0	0.3
1900+00	BC	**0.486**	**0.709**	1.041	0.496	-0.278	3.938	0.922	0.480	0.473	-0.075	0.921	3.4	0.1
1900+00	MHW	**0.602**	**0.684**	0.732	0.548	-0.529	4.429	0.635	0.485	0.512	-0.067	1.105	5.5	0.8
1900+00	MTL	**0.549**	**0.714**	0.866	0.487	-0.051	4.025	0.747	0.473	0.477	0.050	1.018	4.6	0.1
1900+00	MLW	**1.251**	**0.492**	-0.323	1.024	-0.732	4.107	-0.463	0.980	1.051	-0.275	1.182	9.6	21.5
1900+00	Trough	**2.797**	**0.486**	-1.484	1.040	0.143	3.650	-1.790	1.265	1.192	-0.179	0.795	25.3	65.5
1900+00	Bar	**0.200**	**0.623**	2.320	0.683	-1.583	8.128	2.247	0.533	0.594	-0.138	1.355	2.6	0.4
1900+00	-8 ft NAVD	**0.202**	**0.625**	2.307	0.678	-1.322	7.023	2.228	0.548	0.608	-0.135	1.349	3.8	0.3
1900+00	-12 ft NAVD	**0.211**	**0.540**	2.246	0.889	-1.754	7.012	2.213	0.598	0.746	-0.297	1.892	3.1	1.6
1900+00	-16 ft NAVD	**0.219**	**0.524**	2.189	0.933	-1.654	6.281	2.145	0.683	0.803	-0.359	1.812	3.7	2.0
1900+00	-20 ft NAVD	**0.344**	**0.516**	1.538	0.956	-0.885	3.808	1.458	0.883	0.929	-0.250	1.082	3.8	3.0
1900+00	-24 ft NAVD	**0.322**	**0.514**	1.633	0.959	-0.921	3.961	1.542	0.873	0.914	-0.272	1.078	5.7	2.8
1920+00	Dune	**0.474**	**0.723**	1.078	0.469	0.206	4.618	0.940	0.445	0.450	0.064	0.992	2.6	0.0
1920+00	Dune Toe	**0.739**	**0.651**	0.436	0.620	-0.213	3.983	0.313	0.563	0.596	-0.111	1.192	8.0	2.6
1920+00	Berm	**0.727**	**0.638**	0.459	0.649	0.038	4.278	0.328	0.593	0.618	-0.099	1.124	11.6	2.2
1920+00	BC	**0.620**	**0.625**	0.690	0.677	-0.037	3.710	0.570	0.643	0.662	0.040	1.131	5.8	1.6
1920+00	MHW	**0.781**	**0.676**	0.357	0.565	-0.195	3.607	0.235	0.540	0.552	-0.109	1.066	7.9	1.6
1920+00	MTL	**0.525**	**0.691**	0.930	0.533	-0.153	4.387	0.812	0.503	0.504	0.050	0.971	4.5	0.4
1920+00	MLW	**1.054**	**0.635**	-0.076	0.656	-5.607	-23.223	-0.133	0.823	0.867	-0.284	1.115	15.7	13.3
1920+00	Trough	**2.905**	**0.501**	-1.539	0.998	-0.020	2.663	-1.838	1.253	1.173	-0.131	0.775	19.9	66.8
1920+00	Bar	**0.302**	**0.564**	1.726	0.827	-0.689	3.269	1.603	0.828	0.801	-0.288	0.880	3.2	0.4
1920+00	-8 ft NAVD	**0.223**	**0.673**	2.163	0.571	-1.240	7.128	2.068	0.470	0.505	-0.220	1.283	2.0	0.1
1920+00	-12 ft NAVD	**0.194**	**0.657**	2.365	0.606	-1.429	8.639	2.285	0.480	0.524	-0.015	1.260	2.3	0.2
1920+00	-16 ft NAVD	**0.204**	**0.653**	2.290	0.614	-1.516	8.429	2.217	0.488	0.530	-0.095	1.347	2.6	0.2
1920+00	-20 ft NAVD	**0.205**	**0.642**	2.286	0.639	-1.698	8.891	2.218	0.495	0.545	-0.131	1.365	2.1	0.3
1920+00	-24 ft NAVD	**0.476**	**0.593**	1.072	0.755	-0.248	3.560	0.973	0.705	0.733	0.013	1.083	5.6	1.2
1940+00	Dune	**0.564**	**0.590**	0.826	0.761	-0.192	3.184	0.707	0.750	0.757	-0.063	1.033	6.9	1.2
1940+00	Dune Toe	**0.495**	**0.649**	1.015	0.624	-0.026	3.436	0.898	0.610	0.611	-0.016	0.963	4.6	0.1
1940+00	Berm	**0.598**	**0.596**	0.742	0.746	0.119	2.846	0.603	0.783	0.753	0.067	0.909	6.8	0.7
1940+00	BC	**0.507**	**0.606**	0.980	0.722	-0.041	3.187	0.860	0.698	0.702	0.008	0.960	4.8	0.8
1940+00	MHW	**0.460**	**0.646**	1.119	0.630	-0.121	3.309	0.998	0.618	0.619	-0.074	0.942	4.4	0.2
1940+00	MTL	**0.475**	**0.604**	1.074	0.728	-0.510	4.212	0.977	0.628	0.677	-0.141	1.118	4.0	1.5
1940+00	MLW	**0.794**	**0.572**	0.333	0.807	-0.055	2.605	0.233	0.843	0.856	-0.064	1.046	10.9	6.8
1940+00	Trough	**2.458**	**0.533**	-1.298	0.908	-0.103	2.627	-1.605	1.178	1.086	-0.161	0.797	26.3	59.2
1940+00	Bar	**0.210**	**0.656**	2.252	0.609	-1.182	6.630	2.167	0.525	0.554	-0.170	1.315	2.0	0.1
1940+00	-8 ft NAVD	**0.224**	**0.639**	2.159	0.646	-0.988	5.233	2.070	0.590	0.611	-0.257	1.204	2.0	0.1
1940+00	-12 ft NAVD	**0.487**	**0.599**	1.039	0.740	-0.272	3.602	0.938	0.685	0.716	0.012	1.098	4.9	1.3
1940+00	-16 ft NAVD	**0.215**	**0.665**	2.216	0.588	-2.368	13.527	2.142	0.348	0.425	-0.199	1.696	3.0	0.6
1940+00	-20 ft NAVD	**0.191**	**0.685**	2.390	0.546	-1.638	12.904	2.302	0.395	0.435	0.081	1.365	2.2	0.3
1940+00	-24 ft NAVD	**0.489**	**0.593**	1.032	0.754	-0.471	3.887	0.943	0.678	0.719	-0.035	1.124	5.2	2.0
1980+00	Dune	**0.483**	**0.633**	1.050	0.661	-0.176	2.833	0.933	0.663	0.666	-0.086	0.969	4.3	0.0
1980+00	Dune Toe	**0.582**	**0.622**	0.780	0.684	-0.287	3.547	0.665	0.663	0.668	-0.064	1.017	6.0	1.4
1980+00	Berm	**0.565**	**0.650**	0.824	0.622	-0.416	3.837	0.725	0.575	0.585	-0.052	0.994	6.2	1.1
1980+00	BC	**0.549**	**0.621**	0.866	0.687	-0.401	3.324	0.755	0.658	0.669	-0.128	1.011	6.0	1.0
1980+00	MHW	**0.439**	**0.636**	1.188	0.653	-0.506	3.926	1.080	0.618	0.631	-0.167	1.013	4.2	0.5
1980+00	MTL	**0.570**	**0.539**	0.811	0.891	-0.164	2.396	0.687	0.948	0.906	0.011	0.853	5.8	2.6
1980+00	MLW	**0.830**	**0.469**	0.269	1.091	-0.276	3.660	0.225	1.050	1.085	0.157	1.126	9.1	9.1
1980+00	Trough	**2.484**	**0.522**	-1.313	0.937	0.017	2.477	-1.623	1.220	1.118	-0.122	0.759	21.3	59.2
1980+00	Bar	**0.220**	**0.694**	2.184	0.528	-1.199	7.882	2.082	0.448	0.472	-0.189	1.222	1.9	0.1
1980+00	-8 ft NAVD	**0.223**	**0.682**	2.163	0.552	-1.559	9.553	2.065	0.448	0.475	-0.201	1.233	2.1	0.3
1980+00	-12 ft NAVD	**0.190**	**0.614**	2.394	0.703	-1.610	9.202	2.308	0.535	0.583	-0.043	1.254	2.2	0.7
1980+00	-16 ft NAVD	**0.190**	**0.640**	2.394	0.643	-1.321	8.472	2.298	0.518	0.558	-0.020	1.226	2.2	0.3
1980+00	-20 ft NAVD	**0.189**	**0.704**	2.405	0.507	-1.002	10.643	2.303	0.388	0.424	0.097	1.369	2.2	0.1
1980+00	-24 ft NAVD	**0.152**	**0.638**	2.719	0.649	-1.290	9.758	2.643	0.508	0.529	-0.028	1.005	3.3	0.3

TABLE 3.1b. Buxton project area beach sediment characteristics (descriptive) in October 2014. See Attachment 1 for detailed frequency and cumulative frequency results of each sample.

Sample	Interval	USCS Description			Wentworth Description			
1760+00	Dune	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Mesokurtic
1760+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1760+00	Berm	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Platykurtic
1760+00	BC	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1760+00	MHW	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1760+00	MTL	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Platykurtic
1760+00	MLW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Platykurtic
1760+00	Trough	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Poorly Sorted	Symmetrical	Mesokurtic
1760+00	Bar	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Symmetrical	Platykurtic
1760+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1760+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1760+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1760+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1760+00	-24 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
1790+00	Dune	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Symmetrical	Mesokurtic
1790+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1790+00	Berm	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1790+00	BC	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1790+00	MHW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1790+00	MTL	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1790+00	MLW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1790+00	Trough	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1790+00	Bar	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Symmetrical	Platykurtic
1790+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1790+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1790+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1790+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
1790+00	-24 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Coarse Skewed	Mesokurtic
1820+00	Dune	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1820+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1820+00	Berm	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
1820+00	BC	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Fine Skewed	Leptokurtic
1820+00	MHW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Fine Skewed	Leptokurtic
1820+00	MTL	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Fine Skewed	Leptokurtic
1820+00	MLW	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1820+00	Trough	SP	Coarse Sand	Poorly Graded	Granule	Moderately Sorted	Symmetrical	Mesokurtic
1820+00	Bar	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Symmetrical	Platykurtic
1820+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1820+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1820+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1820+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
1820+00	-24 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
1840+00	Dune	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1840+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
1840+00	Berm	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1840+00	BC	SP	Medium Sand	Poorly Graded	Coarse Sand	Well Sorted	Fine Skewed	Leptokurtic
1840+00	MHW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1840+00	MTL	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1840+00	MLW	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Moderately Sorted	Coarse Skewed	Mesokurtic
1840+00	Trough	SP	Coarse Sand	Poorly Graded	Granule	Moderately Sorted	Symmetrical	Mesokurtic
1840+00	Bar	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Symmetrical	Platykurtic
1840+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1840+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
1840+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1840+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
1840+00	-24 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1870+00	Dune	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Mesokurtic
1870+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1870+00	Berm	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1870+00	BC	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1870+00	MHW	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1870+00	MTL	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1870+00	MLW	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1870+00	Trough	SP	Coarse Sand	Poorly Graded	Granule	Moderately Sorted	Symmetrical	Mesokurtic
1870+00	Bar	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Symmetrical	Mesokurtic
1870+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
1870+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1870+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1870+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
1870+00	-24 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic

TABLE 3.1b (continued). Buxton project area beach sediment characteristics (descriptive) in October 2014. See Attachment 1 for detailed frequency and cumulative frequency results of each sample.

Sample	Interval	USCS Description			Wentworth Description			
1890+00	Dune	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Leptokurtic
1890+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1890+00	Berm	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1890+00	BC	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1890+00	MHW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1890+00	MTL	SP	Medium Sand	Poorly Graded	Coarse Sand	Well Sorted	Symmetrical	Leptokurtic
1890+00	MLW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1890+00	Trough	SP	Coarse Sand	Poorly Graded	Granule	Moderately Sorted	Symmetrical	Mesokurtic
1890+00	Bar	SP	Medium Sand	Poorly Graded	Medium Sand	Poorly Sorted	Coarse Skewed	Mesokurtic
1890+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1890+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1890+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1890+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1890+00	-24 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1900+00	Dune	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1900+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Very Well Sorted	Strongly Coarse Skewed	Very Platykurtic
1900+00	Berm	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1900+00	BC	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Symmetrical	Leptokurtic
1900+00	MHW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1900+00	MTL	SP	Medium Sand	Poorly Graded	Coarse Sand	Well Sorted	Symmetrical	Leptokurtic
1900+00	MLW	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Poorly Sorted	Coarse Skewed	Leptokurtic
1900+00	Trough	SP	Coarse Sand	Poorly Graded	Granule	Poorly Sorted	Symmetrical	Mesokurtic
1900+00	Bar	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1900+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
1900+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
1900+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
1900+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
1900+00	-24 ft NAVD	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
1920+00	Dune	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Symmetrical	Leptokurtic
1920+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1920+00	Berm	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1920+00	BC	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1920+00	MHW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1920+00	MTL	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1920+00	MLW	SP	Medium Sand	Poorly Graded	Very Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Platykurtic
1920+00	Trough	SP	Coarse Sand	Poorly Graded	Granule	Moderately Sorted	Symmetrical	Mesokurtic
1920+00	Bar	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Mesokurtic
1920+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1920+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1920+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1920+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1920+00	-24 ft NAVD	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Symmetrical	Mesokurtic
1940+00	Dune	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1940+00	Dune Toe	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1940+00	Berm	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1940+00	BC	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1940+00	MHW	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1940+00	MTL	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
1940+00	MLW	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic
1940+00	Trough	SP	Coarse Sand	Poorly Graded	Granule	Moderately Sorted	Symmetrical	Mesokurtic
1940+00	Bar	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1940+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1940+00	-12 ft NAVD	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Symmetrical	Mesokurtic
1940+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1940+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1940+00	-24 ft NAVD	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
1980+00	Dune	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1980+00	Dune Toe	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1980+00	Berm	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
1980+00	BC	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic
1980+00	MHW	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
1980+00	MTL	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Platykurtic
1980+00	MLW	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Symmetrical	Mesokurtic
1980+00	Trough	SP	Coarse Sand	Poorly Graded	Granule	Moderately Sorted	Symmetrical	Platykurtic
1980+00	Bar	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
1980+00	-8 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1980+00	-12 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
1980+00	-16 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
1980+00	-20 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
1980+00	-24 ft NAVD	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic

TABLE 3.2. Mean grain size (mm) for October 2014 beach samples in the Buxton project area.

Position	Dune	Dune Toe	Berm	BC	MHW	MTL	MLW
1760+00	0.373	0.568	0.740	0.517	0.358	0.610	0.669
1790+00	0.448	0.503	0.701	0.608	0.736	0.674	0.838
1820+00	0.614	0.598	0.469	0.600	0.644	0.782	1.780
1840+00	0.376	0.500	1.430	0.902	0.703	1.026	1.414
1870+00	0.609	0.625	0.439	0.485	0.482	0.894	1.724
1890+00	0.682	0.629	0.575	0.523	0.587	0.696	0.947
1900+00	0.527	0.528	0.521	0.486	0.602	0.549	1.251
1920+00	0.474	0.739	0.727	0.620	0.781	0.525	1.054
1940+00	0.564	0.495	0.598	0.507	0.460	0.475	0.794
1980+00	0.483	0.582	0.565	0.549	0.439	0.570	0.830
Average	**0.515**	**0.577**	**0.677**	**0.580**	**0.579**	**0.680**	**1.130**

Position	Trough	Bar	-8 ft NAVD	-12 ft NAVD	-16 ft NAVD	-20 ft NAVD	-24 ft NAVD
1760+00	1.550	0.723	0.232	0.208	0.198	0.257	0.336
1790+00	1.655	0.943	0.230	0.204	0.197	0.262	0.398
1820+00	2.458	0.676	0.193	0.210	0.206	0.281	0.338
1840+00	2.331	0.725	0.210	0.219	0.207	0.259	0.181
1870+00	2.738	0.856	0.240	0.211	0.202	0.263	0.150
1890+00	2.215	0.432	0.184	0.188	0.194	0.195	0.162
1900+00	2.797	0.200	0.202	0.211	0.219	0.344	0.322
1920+00	2.905	0.302	0.223	0.194	0.204	0.205	0.476
1940+00	2.458	0.210	0.224	0.487	0.215	0.191	0.489
1980+00	2.484	0.220	0.223	0.190	0.190	0.189	0.152
Average	**2.359**	**0.529**	**0.216**	**0.232**	**0.203**	**0.245**	**0.300**

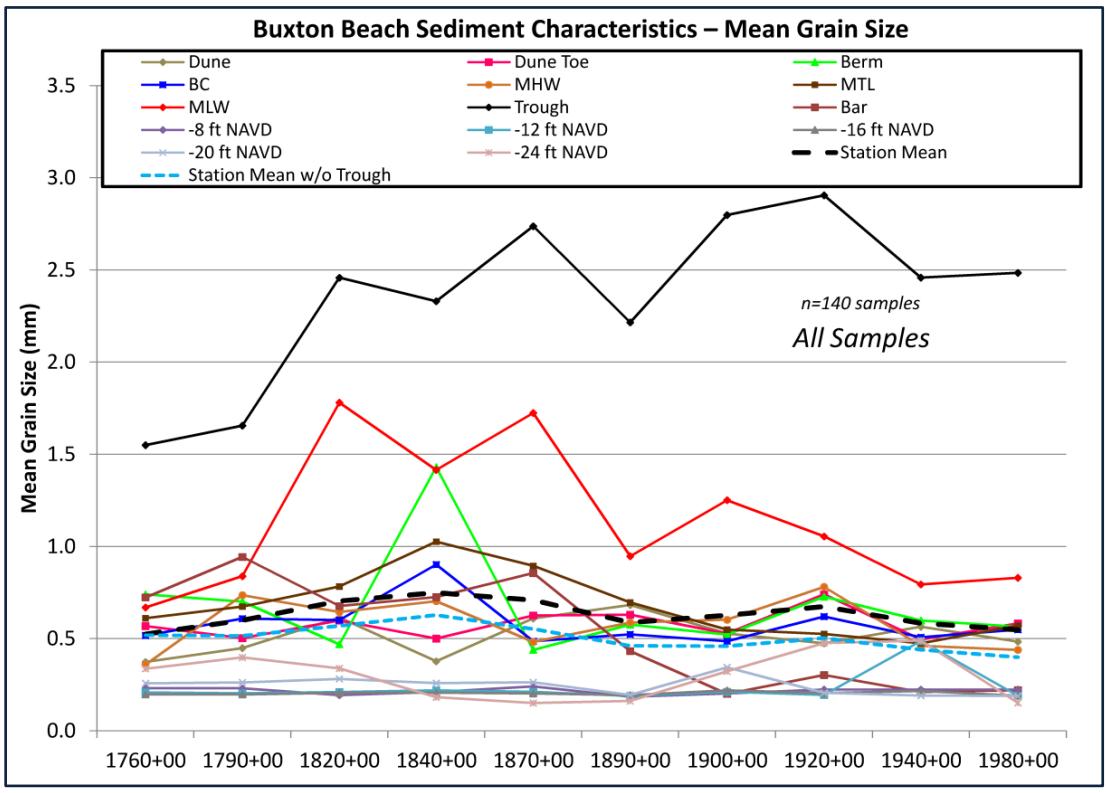
TABLE 3.3. Arithmetic mean grain size and related statistics based on 14 samples per transect (n=140). Lower table gives results omitting the 10 trough samples.

Station Average – All Samples – October 2014				
	Mean	STD	Shell	Gravel
	mm	mm	%	%
1760+00	0.524	0.589	5.3	4.8
1790+00	0.600	0.608	5.4	5.1
1820+00	0.704	0.623	6.9	8.1
1840+00	0.749	0.621	7.4	8.5
1870+00	0.709	0.610	6.6	9.6
1890+00	0.586	0.638	5.7	5.3
1900+00	0.626	0.608	6.0	7.1
1920+00	0.674	0.637	6.7	6.5
1940+00	0.583	0.617	6.3	5.4
1980+00	0.548	0.619	5.5	5.5
Average	**0.630**	**0.617**	**6.2**	**6.6**

Station Average Excluding Trough				
	Mean	STD	Shell (w/o Trough)	Gravel (w/o Trough)
	mm	mm	%	%
1760+00	0.519	0.612	4.9	2.9
1790+00	0.515	0.597	5.6	4.1
1820+00	0.569	0.631	5.7	4.2
1840+00	0.627	0.630	6.2	5.4
1870+00	0.552	0.617	5.1	5.4
1890+00	0.461	0.645	4.7	1.6
1900+00	0.459	0.618	4.5	2.6
1920+00	0.502	0.648	5.7	1.9
1940+00	0.439	0.623	4.7	1.2
1980+00	0.399	0.626	4.3	1.3
Average	**0.504**	**0.625**	**5.1**	**3.1**

TABLE 3.4. Arithmetic mean grain size and related statistics by sample position for 10 transects along the Buxton project area in October 2014.

Cross-Shore Averages – October 2014				
	Mean	STD	Shell	Gravel
	mm	mm	%	%
Dune	0.515	0.624	4.6	1.0
Dune Toe	0.577	0.655	5.5	0.9
Berm	0.677	0.632	6.7	2.9
BC	0.580	0.639	6.6	2.7
MHW	0.579	0.644	6.7	2.6
MTL	0.680	0.629	6.3	3.0
MLW	1.130	0.569	11.1	16.5
Trough	2.359	0.518	20.8	54.2
Bar	0.529	0.529	2.7	8.0
-8 ft NAVD	0.216	0.666	2.4	0.1
-12 ft NAVD	0.232	0.649	2.7	0.5
-16 ft NAVD	0.203	0.646	2.6	0.4
-20 ft NAVD	0.245	0.634	5.8	0.8
-24 ft NAVD	0.300	0.586	4.7	1.8
Average	0.630	0.616	6.4	6.8
Avg w/o Trough	**0.497**	**0.623**	**5.3**	**3.2**



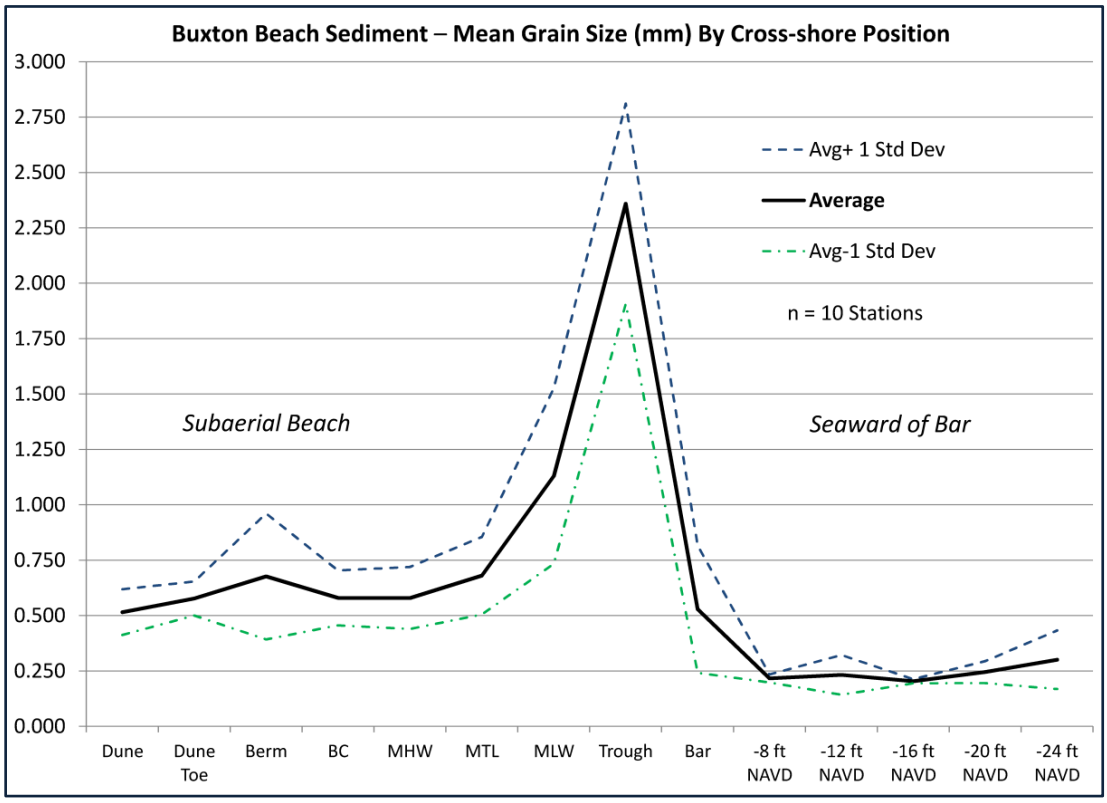
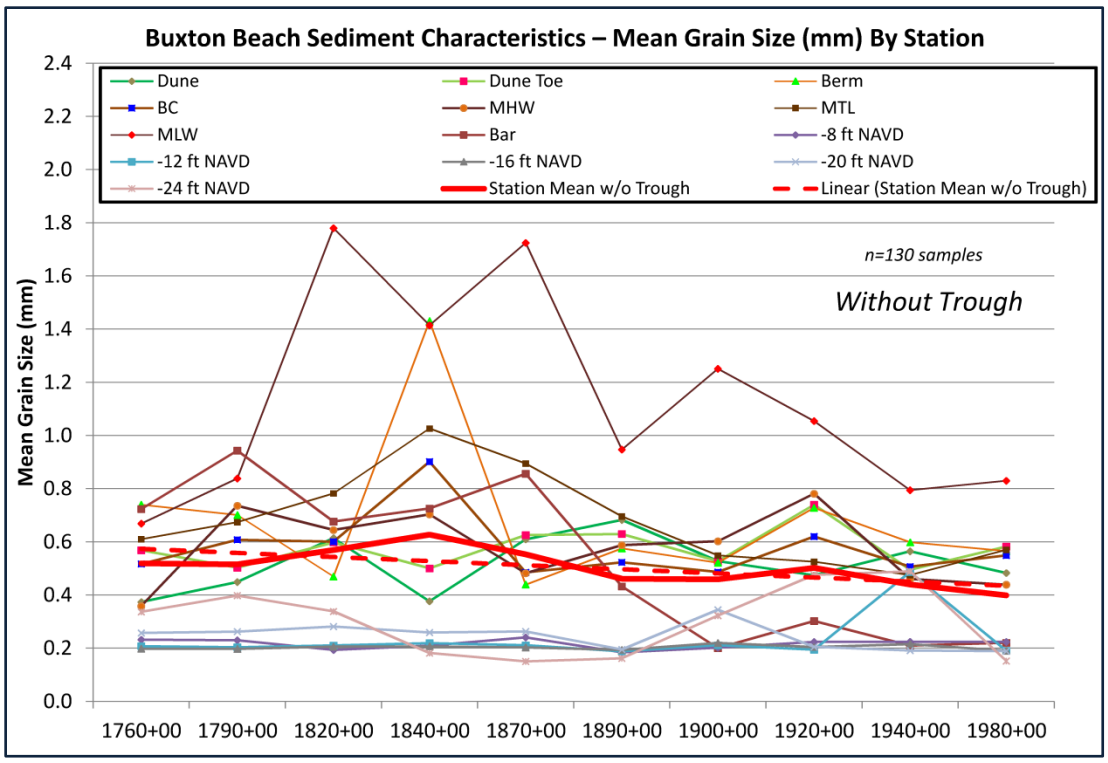


FIGURE 3.1 (upper). Mean grain size by station and sample position in October 2014.

FIGURE 3.2 (lower). Arithmetic mean grain size by sample position based on ten samples per station.



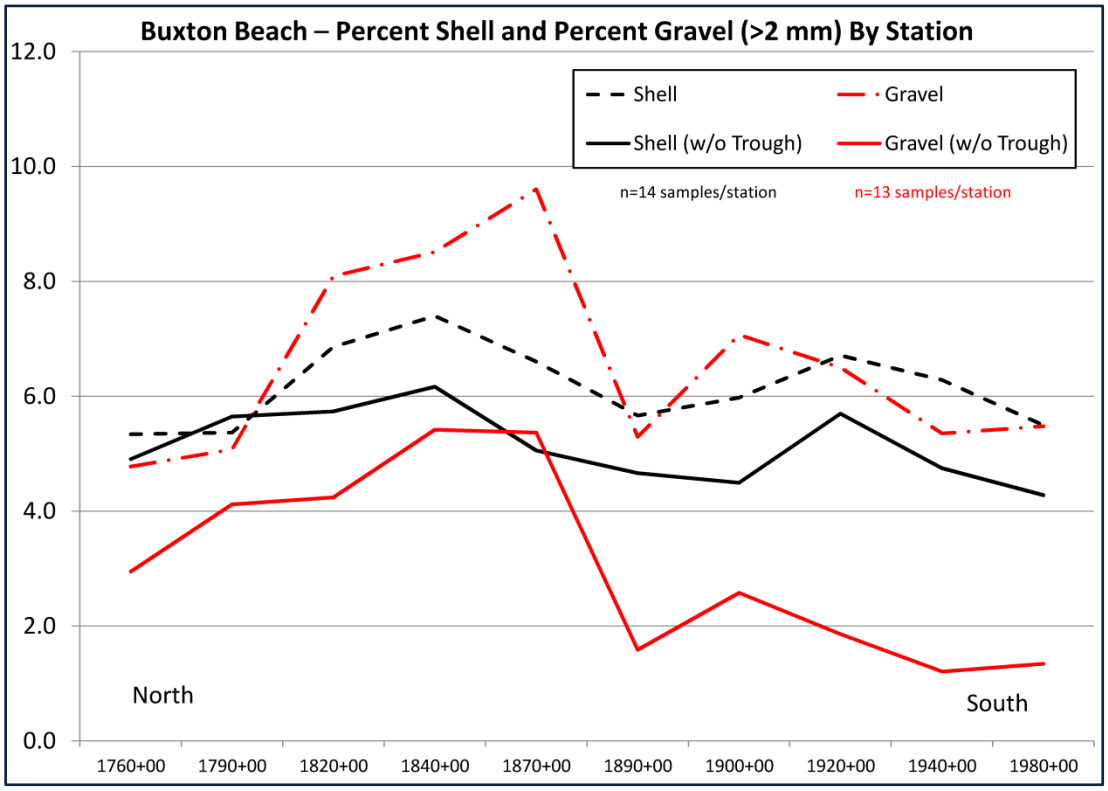


FIGURE 3.3 (upper). Mean grain size by station and sample position omitting the trough samples.

FIGURE 3.4 (lower). Percent shell and percent gravel (>2 mm) by station in October 2014 along the Buxton project area.

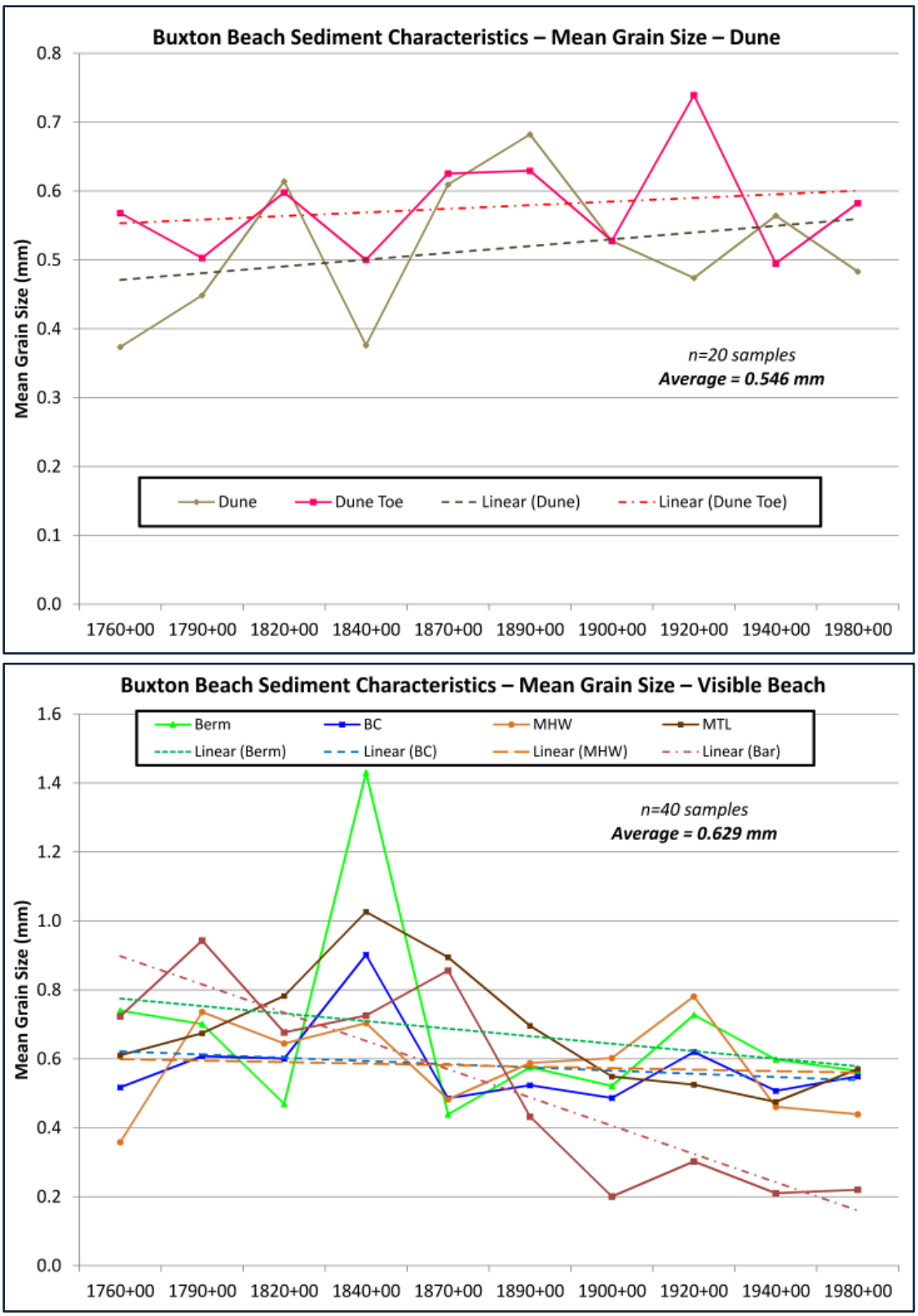


FIGURE 3.5. Alongshore trends in mean grain size for groups of samples along Buxton: (upper) dune area and (lower) subaerial beach to mid-tide level.

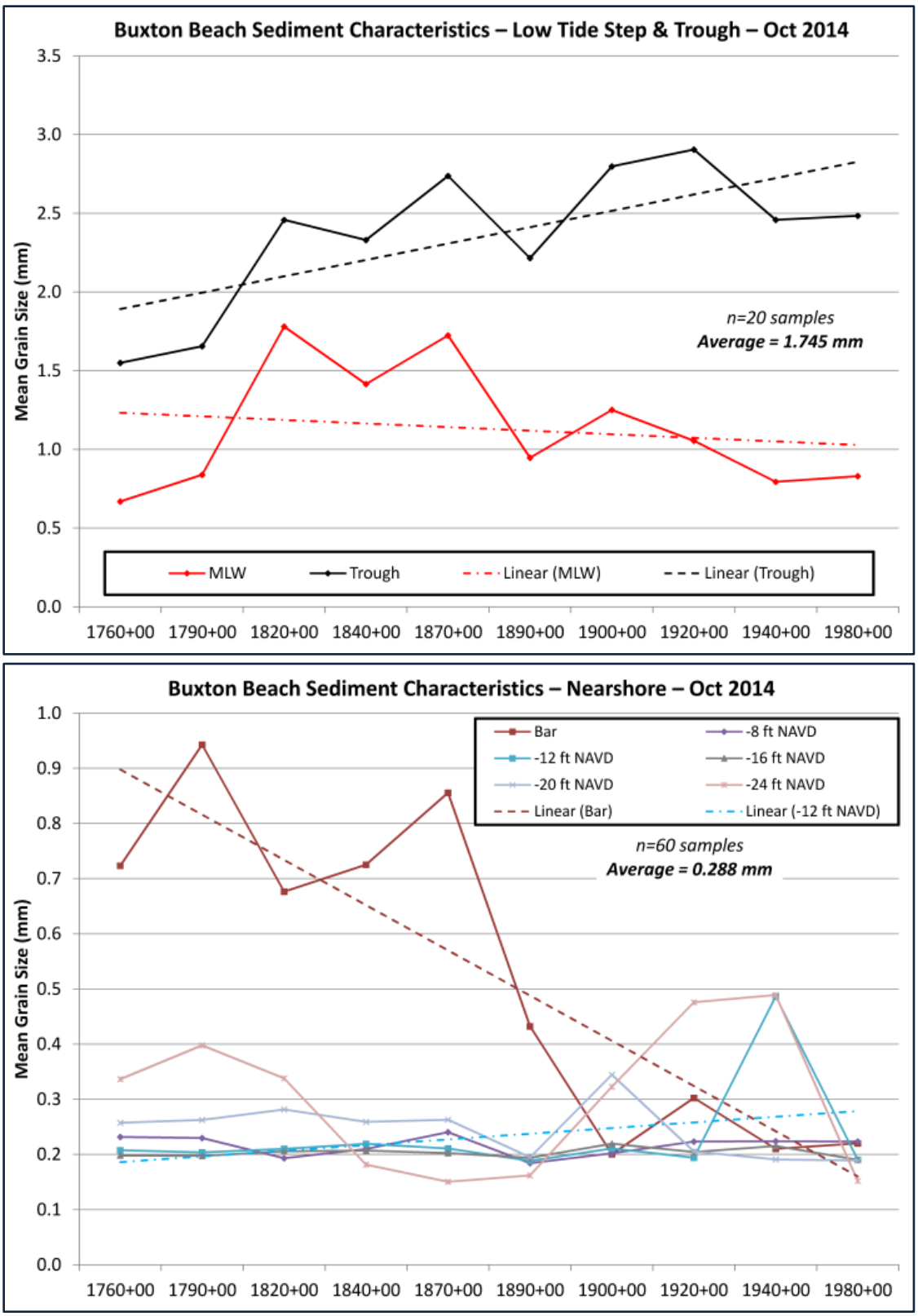


FIGURE 3.6. Alongshore trends in mean grain size for groups of samples along Buxton: (upper) low-tide plunge point and trough, and (lower) nearshore zone seaward of bar.

3.2 Comparative Sample Statistics

CSE performed limited sampling of the project beach in August 2013. Table 3.5 and Figure 3.7 show mean grain size, percent shell, and percent gravel for the subaerial beach at six stations. The August 2013 samples were consistently finer than the October 2014 samples (see Table 3.2) with means in the range 0.37 mm to 0.5 mm. Shell content was higher (~10 percent) while the gravel percentage was ~2.4 percent. This latter result confirms that shell material on the visible beach is predominantly small fragments <2 mm diameter (ie, within sand size ranges). The results in Tables 3.2 and 3.6 suggest surficial sand sizes in the Buxton project area (visible beach) fluctuate between the upper limit of medium sand (0.25–0.5 mm) and the lower limit of coarse sand (0.5–1.0 mm). Swift et al (1971) reported finer sediment in the Buxton area (Transect "11") with berm samples testing around 0.3 mm.

A "typical" mean grain size is likely to fall between 0.4 mm and 0.6 mm, and probably vary with the season—finer during accretional periods and coarser during erosional periods. More sampling would be required to confirm this observation. Southern North Carolina beaches as well as a majority of beaches that have been nourished are dominated by finer sand (~0.25–0.3 mm typical) and are less likely to exhibit as large a difference in "native" sand sizes from season to season. Beaches of New England, where glacial moraines have yielded broad mixtures of gravel and sand, commonly exhibit wide grain-size variability (Colony 1932, Taney 1961).

TABLE 3.5. Native subaerial beach sediment sample mean grain-size, shell percentage, and gravel percentage for samples collected in August 2013. Note results are ~0.05 mm finer than samples from the subaerial beach in October 2014. The differences reflect summer accretional conditions versus fall erosional conditions.

Station	Mean Grain-Size Distribution (mm)						
	Dune	Berm	Beach	Low Tide	Averages	% Shell	% Gravel
	Toe	Middle	Face	Terrace	All	(Average)	(Average)
1790+63	0.469	0.469	0.373	0.461	**0.443**	5.2	1.9
1840+63	0.397	0.345	0.459	0.222	**0.356**	3.4	0.3
1890+63	0.613	0.352	0.464	0.540	**0.492**	11.8	4.4
1900+63	0.666	0.425	0.352	0.643	**0.522**	16.9	5.5
1940+63	0.368	0.442	0.277	0.347	**0.359**	14.0	0.9
1980+63	0.469	0.508	0.278	0.491	**0.437**	9.3	1.1
Averages	**0.497**	**0.424**	**0.367**	**0.451**	**0.435**	**10.1**	**2.4**

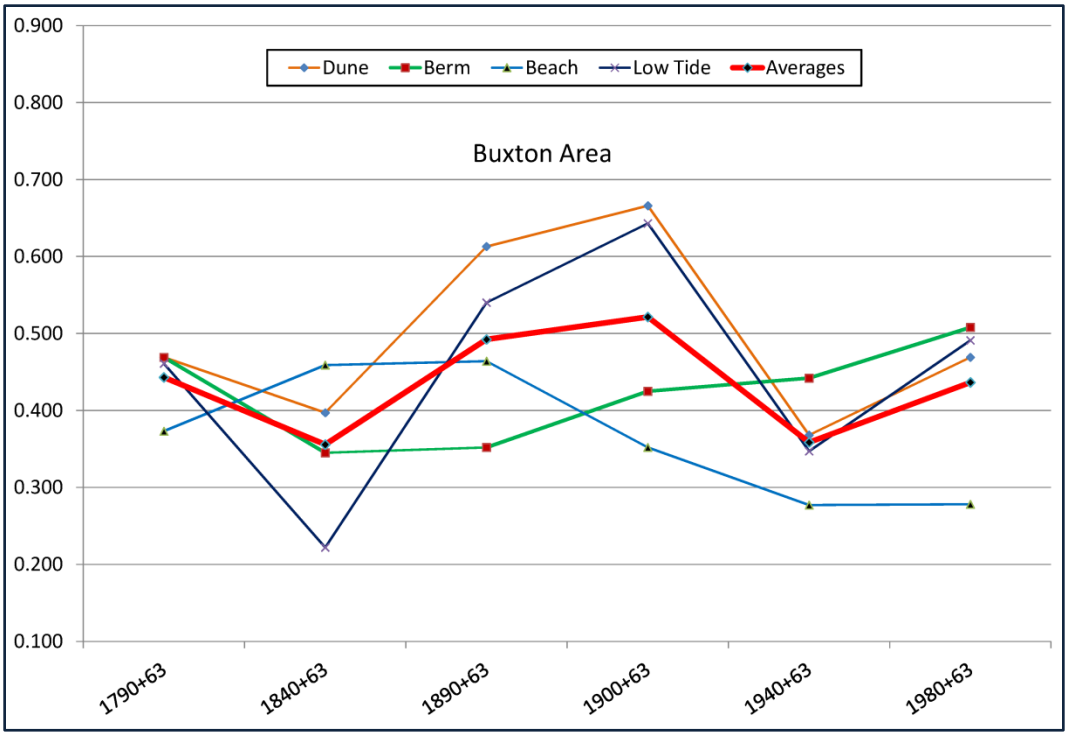


FIGURE 3.7. Sediment mean grain sizes for six transects in the Buxton area in August 2013. The overall trend (bold line) shows relative uniformity in the medium sand range (0.25—0.5 mm). Large variations are common in the low-tide zone due to differing exposures and cover of pea gravel lenses which occur along the Outer Banks. [After CSE 2013]

3.3 Selection of Native Mean Grain Size

According to North Carolina sediment standards for beach nourishment, the native sand should be determined based on an arithmetic average of means for all cross-shore sand samples. This simple calculation yields a mean and standard deviation of 0.630 mm and 0.617 mm (respectively) for the October 2014 samples (see Table 3.3). The principal problem with this result is it is biased in this case by the coarse outlier samples in the trough. Grain-size distributions are non-linear, so an average of mean grain sizes does not equal the mean grain size of the same collection of samples mixed in a bin, then tested for grain-size distribution (and resulting mean).

It can be shown that a more realistic mean for a group of samples (composite mean) can be computed using the results of each sample split. CSE combined results of all subsamples retained on each sieve to compute the total weight by each size class for a designated number of samples, the total weight of all subsamples, and the corresponding proportions of the total. Data were normalized to weight each total sample the same. This yields means and standard deviations via the method of moments, analogous to combining all physical samples into one big sample for sieving by standard lab methods.

Table 3.6 shows the results for selected groups of samples. All 140 samples (10 stations, 14 cross-shore samples each station) yielded a mean and standard deviation of 0.465 mm and 0.413 mm (respectively), considerably lower than the arithmetic mean. Excluding the trough samples, the mean drops to 0.411 mm and standard deviation increases to 0.464 mm. Other means for fewer samples are given in Table 3.6. If only the visible beach/dune samples are included, the resulting mean and standard deviation are 0.582 mm and 0.598 mm (respectively). [Note: This result would be lower for the August 2013 subaerial samples.] Under the Wentworth size classification, the composite means are in the medium sand-size range (0.25–0.5 mm) for calculations involving the majority of samples.

The subaerial samples have a composite mean in the lower coarse sand range (0.5–1.0 mm). Interestingly, the “beach” mixtures are poorly sorted when considered across the entire littoral zone, but better sorted in the visible beach zone. Few nourishment projects along the U.S. East Coast have involved such coarse sand and such wide admixtures across the profile. These ranges slightly exceed results along Nags Head (USACE 2010) and significantly exceed Bogue Banks (CSE 2001) where composite mean grain size was ~0.3–0.35 mm. Beach sediments in the southern part of North Carolina and northern part of South Carolina (the Grand Strand) are typically in the range of 0.2–0.3 mm with less cross-shore variation (eg, USACE 1993).

TABLE 3.6. "Native" mean grain size for Buxton. Results for selected groups of samples. The results in bold are considered most representative of the beach, consistent with size distributions for other Outer Banks localities (Birkemeier et al 1985, USACE 2010). [UW = underwater samples]

Buxton Beach Sediment Characteristics		Method of Moments					
		Mean	STD	Mean	STD	Skew	Kurt
		mm	mm	phi			
All Sta-Comp140	All X-Shore Samples	0.465	0.413	1.104	1.277	-0.612	3.164
All Sta-Comp130	**Exclude Trough**	**0.411**	**0.464**	**1.284**	**1.108**	**-0.391**	**2.807**
All Sta-Comp120	Exclude MLW & Trough	0.380	0.485	1.395	1.043	-0.344	2.672
All Sta-Comp60	Exclude All UW Samples	0.582	0.598	0.780	0.743	-0.256	3.349

Buxton Beach Sediment Characteristics		Folk Graphical Method				
		Mean	STD	ISTD	Skew	Kurt
		phi				
All Sta-Comp140	All X-Shore Samples	1.028	1.273	1.280	-0.146	0.949
All Sta-Comp130	**Exclude Trough**	**1.190**	**1.118**	**1.093**	**-0.076**	**0.842**
All Sta-Comp120	Exclude MLW & Trough	1.288	1.050	1.026	-0.084	0.826
All Sta-Comp60	Exclude All UW Samples	0.655	0.723	0.730	-0.029	1.029

Sample	Interval	USCS Description		
All Sta-Comp140	All X-Shore Samples	SP	Medium Sand	Poorly Graded
All Sta-Comp130	**Exclude Trough**	**SP**	**Fine Sand**	**Poorly Graded**
All Sta-Comp120	Exclude MLW & Trough	SP	Fine Sand	Poorly Graded
All Sta-Comp60	Exclude All UW Samples	SP	Medium Sand	Poorly Graded

Sample	Interval	Wentworth Description			
All Sta-Comp140	All X-Shore Samples	Medium Sand	Poorly Sorted	Coarse Skewed	Mesokurtic
All Sta-Comp130	**Exclude Trough**	**Medium Sand**	**Poorly Sorted**	**Symmetrical**	**Mesokurtic**
All Sta-Comp120	Exclude MLW & Trough	Medium Sand	Poorly Sorted	Symmetrical	Mesokurtic
All Sta-Comp60	Exclude All UW Samples	Coarse Sand	Moderately Sorted	Symmetrical	Mesokurtic

4.0 BORROW AREA INVESTIGATIONS

Two potential borrow areas for nourishment were evaluated for the Buxton project:

1) Offshore area “C" as delineated by CSE (2013) and illustrated in Figure 1.1.
2) Oregon Inlet channels and shoals.

Other potential borrow areas have been previously evaluated by CSE (2005, Post-*Isabel* Emergency Dune Restoration, unpublished report) and others (eg, Dolan & Lins 1986), and were rejected because of transportation distances and costs (eg, upland – off-island – borrow pits), insufficient quantities available (on-island borrow pits), sediments too fine (eg, Pamlico Sound deposits), or other environmental considerations [eg, NPS or USFWS protected areas within CAHA or Pea Island, such as the accreted lands of Cape Point (used for nourishment in the 1971 and 1973 projects–NPS 1980)].

Offshore Area “C" — Area C was delineated because of previous studies by Boss & Hoffman (2000) and CSE (2013). Borrow area C is strategically located ~1.7 miles offshore of Buxton (see Fig 2.6). Preliminary borings (CSE 2013) indicated the area of an offshore shoal (isolated ridge ~2 miles north of Diamond Shoals) contains beach-quality sediment similar to the sand quality of the Buxton beach. Up to 5 million cubic yards of beach-quality sand are potentially contained in the upper 8 ft of the bottom for the search area delineated. Water depths in Area C range from ~30 ft to ~45 ft and are therefore considered well outside the normal limits of the beach zone. Deeper water (~50 ft) exists between the shoal and longshore bar over 1 mile landward of the sand search area. Because the density of prior cores in Area C (~1 per 100 acres) was relatively low (2013), CSE was contracted by Dare County to collect ~30 additional borings and further evaluate the area sediment quality. In anticipation of an ~2.5 million cubic yard project for Buxton, only ~50 percent of Area C would be required.

Oregon Inlet — Oregon Inlet was considered as a potential borrow area for Buxton because of ongoing federal dredging of the channel and the possibility of piggy-backing on the federal project via Section 933, or some other funding means through the US Army Corps of Engineers. Section 933 projects, under federal regulations, allow a local sponsor to obtain dredged material for the difference in cost between what the federal government would pay for nearby disposal and what it costs to place the spoil on the local beach. Oregon Inlet is dredged on a regular basis, and material is usually disposed along Pea Island about one-half mile downcoast of the channel. Because of the comments received

during the public scoping for the Buxton project and the possibility of cost sharing with ongoing federal activities, Oregon Inlet sediments were considered as a potential sand source for Buxton, although transportation distances would be ~45 miles. CSE previously obtained sediment samples and short borings from sites in the inlet and on the Pea Island disposal area for purposes of evaluating sediment quality.

The following sections of the report summarize the results and evaluations of each potential borrow source.

4.1 Offshore Area C

CSE (2013) reviewed the borings obtained by Boss & Hoffman (2000), obtained six additional borings (Bux-01 to Bux-06) in August 2013 then completed a detailed bathymetric survey (200-ft spacing for track lines) of the shoal area off the old Cape Hatteras Lighthouse site. Figure 4.1 shows the location of the bathymetric survey area, and Figure 4.2 presents a contour map and representative cross-sections. The bathymetry confirms the ridge is oblique trending and similar to features described by others (eg, Swift et al 1973).

Ridges tend to contain coarser sediments and have lower concentrations of fines than the swales, although that is not always the case. Riggs et al (1995) discuss the importance of underlying geology on the distribution and thickness of surficial sediments. The northern Outer Banks, including the project area, tends to have a more plentiful supply of Holocene (recent) sediments, whereas southern portions of the North Carolina coast are sediment-starved.

Of the six borings obtained in August 2013, only four (Bux-01, Bux-02, and Bux-04, Bux-05) were considered to represent acceptable quality sediments for consideration as borrow material. The core logs in Attachment 2 and individual grain-size distributions in Attachment 3A show that cores Bux-03 through Bux-06 contained high proportions of dark gray, silty sand or coarse shell. For example, Bux-03 had mean grain sizes of 0.198 mm to 0.285 mm in the upper 4.3 ft of section and immediately below, a coarse shelly layer. Limited recovery at Bux-06 indicated that core consisted of an unacceptable upper layer of coarse shells and a lower layer of muddy fine sand.

The better quality sediments were found to be west of Bux-03 and approximately southwest of Bux-04 to Bux-06 along higher portions of an isolated offshore shoal. CSE obtained detailed bathymetry over the shoal (dashed box in Fig 4.1) to facilitate layout of a Phase 2 core sample grid.

Based on preliminary borings and the bathymetry, CSE delineated a search grid focusing on the higher portions of the ridge. Cores were collected on an ~1,000-ft grid within this subarea (inner box on Fig 4.2); 32 cores were attempted and 31 recovered within the Phase 2 offshore sand search area. Combined with the prior cores (CSE 2013), a total of 33 cores were available for analysis over an area roughly 2,300 ft by 8,500 ft (~450 acres). Four cores (Bux-03, Bux-04, Bux-05, Bux-06) are outside the box. The average core length was ~7.3 ft for all 37 cores recovered. Lengths ranged from 3.4 ft to 9.5 ft.

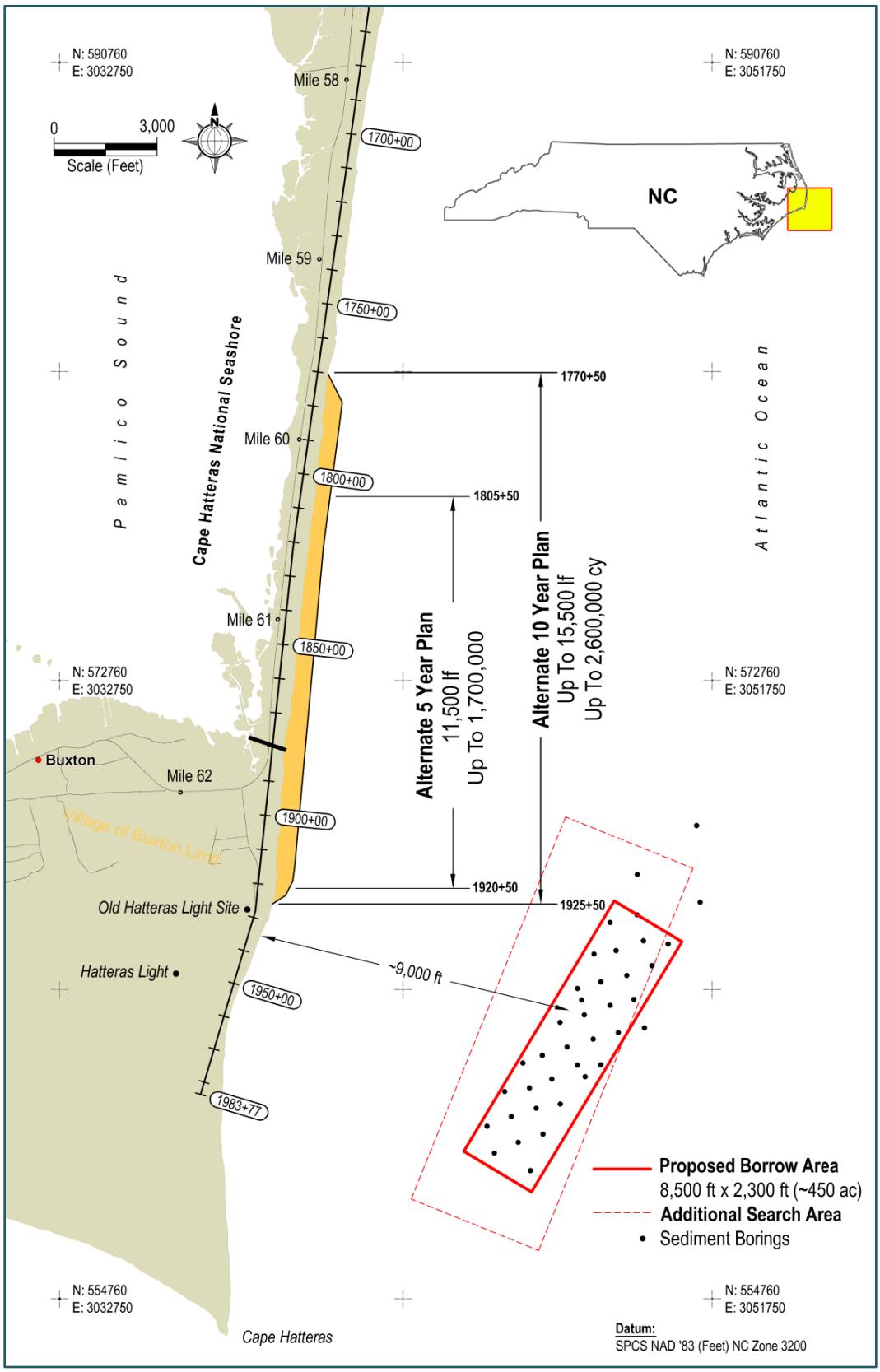


FIGURE 4.1. Location of primary offshore sand search area (solid line box) and limits of bathymetric survey (dashed line box) situated over a shoal area off Buxton and the old Cape Hatteras Lighthouse site.

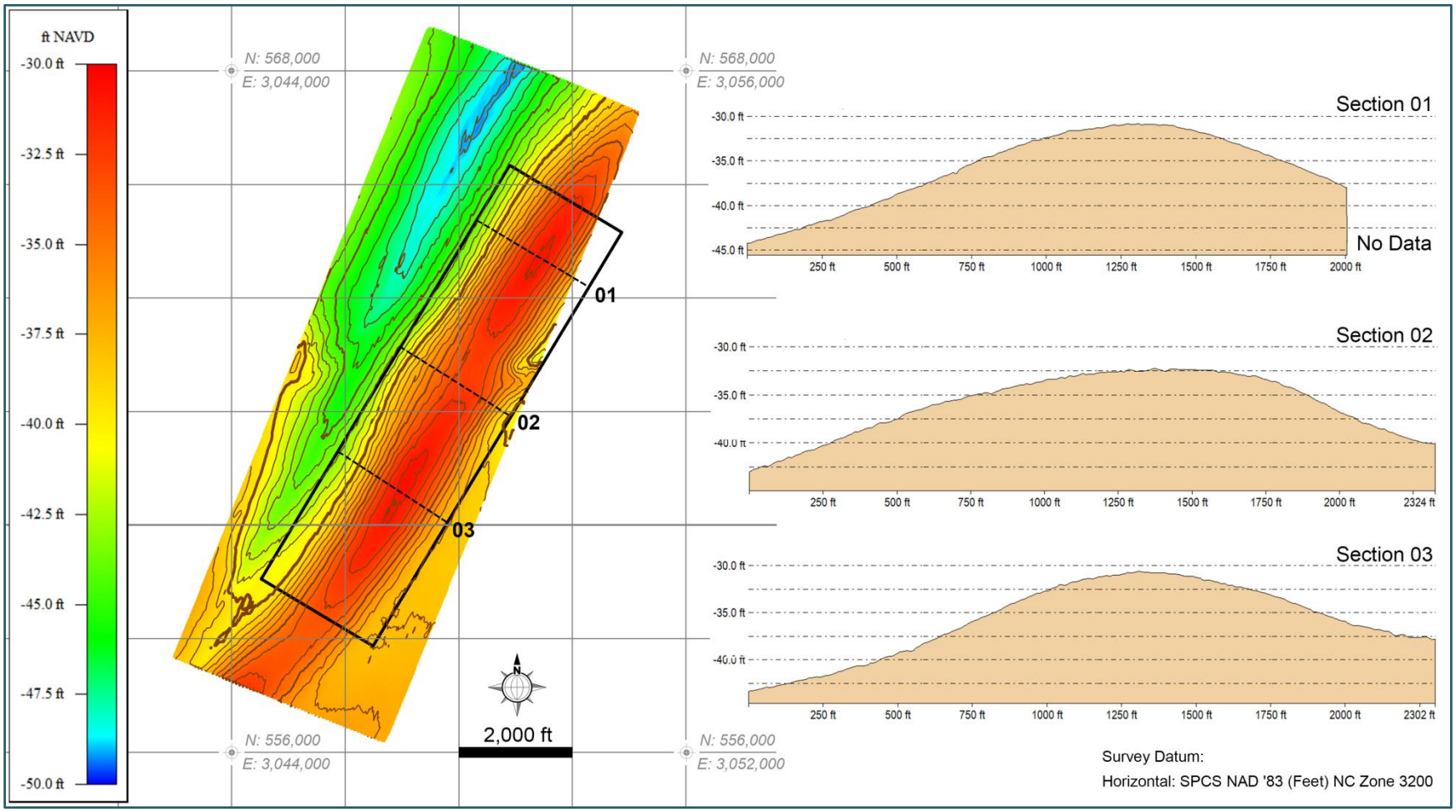


FIGURE 4.2. Bathymetry and sections through the proposed borrow area (black outline) based on field data collection by CSE in October 2014.

Figure 2.7 presented one of the cores (Bux-01) situated near the center east edge of the Phase 2 sand search area. For the most part, sediments in each core were light tan or grayish tan in color and consisted of various mixtures of medium to coarse sand with minor amounts of shell material. Munsell color numbers were interpreted for each sample. Granules and trace amounts of "pea" gravel also occurred in some cores. Core logs and photos of each core are provided in Attachment 2. Sample intervals varied according to lithology but with the intent of establishing size and quality information for the upper several feet. Recent experience indicates that shallow excavations by hopper dredge are likely to be more feasible in this setting than deep cuts by cutterhead dredge (USACE 2010).

The core logs in Attachment 2 document visual breaks in sediment type. In general, the CSE cores tend to have only trace amounts of mud. A couple of cores terminated in muddy layers, particularly sites close to the western side of Area C or in deeper water. Visually, the appearance of a majority of core sediments was similar to the beach. Cores contained similar mixtures of sand, granules, pea gravel, and shell fragments found on the beach along Buxton with only trace fines except an occasional mud lens as noted (see Attachment 2).

Table 4.1a–b lists the key descriptive statistics for each core sample along with the USCS and Wentworth description and the interpreted Munsel color. The unweighted arithmetic mean grain size for all samples is 0.45 mm (medium sand size comparable to the overall average mean grain size for the beach as discussed in Section 3.0). The unweighted arithmetic mean shell and gravel percentages for all 37 cores (135 samples) are 15.1 percent and 2.8 percent (respectively).

Shell percentages for individual samples ranged from 4.8 percent to 49 percent, while gravel (>2 mm) percentages were in the range 0.0–48.4 percent. Approximately 10 percent of the samples (14 out of 135) tested >25 percent shell, whereas 90 percent of the samples ranged between ~5 and 25 percent shell. Figure 4.3 shows the gravel (>2 mm) percentage corresponding to shell percentage in ranked order for each sample. The low gravel percentages confirm that shell material is predominantly small particles under 2 mm diameter. Core photo logs (Attachment 2) further confirm nearly all samples contained negligible concentrations of coarse (>2 mm) shell material. Of the outliers shown in Figure 4.3, two samples are from cores Bux-05 and Bux-06, both of which are outside the Phase 2 sand search grid. Grain-size distributions for each core sample are given in Attachment 3.

TABLE 4.1a. Offshore Area "C" sediment characteristics (statistical measures) for 37 cores (~135 samples obtained in August 2013 and October 2014). See Attachment 3 for detailed frequency and cumulative frequency results of each sample.

Buxton Borrow Area Sediment Characteristics		Method of Moments						Folk Graphical Method						
		Mean	**STD**	Mean	STD	Skew	Kurt	Mean	STD	ISTD	Skew	Kurt	Shell	Gravel
		mm	**mm**	phi				phi					%	%
Bux-01 S1	0.0-2.0	**0.429**	**0.518**	1.220	0.949	-1.157	3.861	1.147	0.825	0.938	-0.466	1.392	21.1	5.7
Bux-01 S2	2.0-4.0	**0.402**	**0.546**	1.315	0.872	-1.163	4.210	1.250	0.763	0.831	-0.380	1.230	19.5	3.3
Bux-01 S3	4.0-6.0	**0.374**	**0.593**	1.420	0.754	-1.111	4.922	1.345	0.670	0.701	-0.250	1.094	16.5	1.7
Bux-01 S4	6.0-7.5	**0.375**	**0.604**	1.413	0.728	-1.098	4.928	1.333	0.650	0.684	-0.247	1.136	17.4	1.3
Bux-01 S5	7.5-9.5	**0.440**	**0.606**	1.184	0.723	-0.242	3.467	1.080	0.718	0.707	-0.065	0.933	26.6	0.7
Bux-02 S1	0.0-2.6	**0.588**	**0.626**	0.767	0.676	-1.024	4.849	0.697	0.563	0.615	-0.347	1.270	28.1	3.4
Bux-02 S2	2.6-5.0	**0.527**	**0.695**	0.925	0.525	-1.069	6.929	0.845	0.430	0.460	-0.321	1.165	17.5	0.8
Bux-02 S3	5.0-6.9	**0.464**	**0.713**	1.109	0.489	-0.762	7.013	0.995	0.408	0.423	-0.289	1.067	18.2	0.3
Bux-03 S1	0.0-3.3	**0.285**	**0.480**	1.813	1.060	-1.010	3.718	1.748	0.975	1.020	-0.392	1.125	10.1	2.7
Bux-03 S2	3.3-4.3	**0.198**	**0.504**	2.336	0.990	-1.565	6.396	2.265	0.638	0.848	-0.265	2.310	15.4	2.0
Bux-03 S3	4.3-5.4	**0.800**	**0.307**	0.322	1.703	-0.632	2.673	0.120	1.913	1.818	-0.326	0.960	26.6	22.0
Bux-03 S4	5.4-6.0	**0.281**	**0.653**	1.829	0.614	-1.399	10.278	1.737	0.413	0.466	-0.128	1.290	7.9	1.0
Bux-04 S1	0.0-2.0	**0.495**	**0.658**	1.016	0.603	-0.177	9.177	0.912	0.385	0.449	-0.268	1.385	13.7	1.4
Bux-04 S2	2.0-4.0	**0.424**	**0.641**	1.236	0.642	1.243	9.000	1.047	0.325	0.517	0.100	2.283	11.7	0.5
Bux-04 S3	4.0-6.3	**0.532**	**0.658**	0.912	0.603	0.167	8.527	0.810	0.425	0.476	-0.106	1.219	17.6	1.3
Bux-04 S4	6.3-7.2	**0.251**	**0.341**	1.996	1.554	-0.379	1.685	2.125	1.545	1.435	-0.614	0.651	29.4	3.3
Bux-04 S5	7.2-7.9	**0.481**	**0.495**	1.057	1.014	1.150	4.742	0.798	0.543	0.835	0.282	2.382	22.4	1.9
Bux-05 S1	0.0-3.0	**0.340**	**0.599**	1.555	0.740	-1.566	6.744	1.502	0.548	0.637	-0.289	1.446	8.2	2.1
Bux-05 S2	3.0-4.3	**0.415**	**0.572**	1.270	0.807	-1.073	4.771	1.198	0.670	0.755	-0.252	1.346	13.9	3.0
Bux-05 S3	4.3-5.2	**0.237**	**0.565**	2.079	0.825	-1.583	6.675	2.027	0.640	0.706	-0.375	1.355	42.9	1.3
Bux-05 S4	5.2-6.3	**0.192**	**0.558**	2.382	0.843	-1.480	6.617	2.305	0.585	0.727	-0.228	1.677	14.4	0.7
Bux-06 S1	0.0-1.9	**1.833**	**0.316**	-0.874	1.661	0.512	2.733	-1.233	1.830	1.844	0.024	0.904	49.0	48.3
Bux-06 S2	1.9-3.4	**0.158**	**0.436**	2.664	1.197	-1.286	4.631	2.562	1.078	1.168	-0.339	1.911	28.3	1.6
Bux-07 S1	0 - 3.0	**0.438**	**0.487**	1.191	1.037	-2.388	8.944	1.260	0.390	0.819	-0.460	3.377	11.3	6.8
Bux-07 S2	3.0 - 6.3	**0.423**	**0.612**	1.241	0.708	-0.650	8.245	1.147	0.368	0.516	-0.204	2.112	11.4	2.8
Bux-08 S1	0 - 1.8	**0.270**	**0.552**	1.890	0.858	-1.312	5.910	1.837	0.620	0.752	-0.247	1.532	9.4	1.6
Bux-08 S2	1.8 - 4.1	**0.217**	**0.503**	2.205	0.990	-1.621	6.487	2.180	0.688	0.873	-0.295	1.563	6.9	2.9
Bux-08 S3	4.1 - 4.6	**0.285**	**0.496**	1.811	1.012	-1.037	4.141	1.735	0.915	0.974	-0.362	1.205	10.7	2.7
Bux-08 S4	4.6 - 7.6	**0.216**	**0.613**	2.208	0.706	-2.636	13.177	2.168	0.385	0.477	-0.233	1.852	4.8	1.6
Bux-09 S1	0 - 2.6	**0.396**	**0.633**	1.335	0.660	0.005	9.258	1.200	0.363	0.467	-0.060	1.661	6.7	1.4
Bux-09 S2	2.6 - 4.5	**0.608**	**0.334**	0.718	1.583	-1.456	5.934	0.722	0.853	1.368	-0.403	2.862	17.0	11.7
Bux-10 S1	0 - 2.6	**0.338**	**0.684**	1.564	0.549	-1.979	11.274	1.495	0.350	0.416	-0.191	1.372	8.2	1.0
Bux-10 S2	2.6 - 5.0	**0.342**	**0.706**	1.546	0.502	-1.222	12.132	1.458	0.318	0.372	-0.084	1.404	7.7	0.5
Bux-10 S3	5.0 - 7.2	**0.361**	**0.694**	1.470	0.527	-1.326	12.213	1.383	0.298	0.365	-0.191	1.503	7.0	0.7
Bux-11 S1	0 - 1.9	**0.389**	**0.619**	1.361	0.693	0.410	7.271	1.190	0.423	0.569	0.044	1.775	8.2	0.9
Bux-11 S2	1.9 - 3.3	**0.210**	**0.453**	2.252	1.141	-0.365	2.549	2.180	1.163	1.106	-0.192	0.774	9.7	0.7
Bux-11 S3	3.3 - 5.7	**0.288**	**0.432**	1.796	1.212	-0.206	2.697	1.705	1.195	1.193	0.195	0.883	10.8	2.7
Bux-12 S1	0 - 3.0	**0.356**	**0.601**	1.488	0.734	-1.709	7.185	1.438	0.478	0.608	-0.344	1.739	10.5	2.3
Bux-12 S2	3.0 - 4.0	**0.246**	**0.553**	2.025	0.855	-1.225	6.219	1.987	0.673	0.743	-0.038	1.177	7.0	1.7
Bux-12 S3	4.0 - 5.6	**0.246**	**0.642**	2.021	0.640	-0.373	5.896	1.920	0.558	0.573	0.189	1.053	6.2	0.2
Bux-12 S4	5.6 - 7.1	**0.286**	**0.643**	1.804	0.637	-0.908	8.450	1.703	0.470	0.524	0.086	1.323	6.9	0.8
Bux-14 S1	0 - 3.3	**0.494**	**0.625**	1.017	0.678	-1.298	4.907	0.937	0.575	0.620	-0.481	1.276	17.7	1.9
Bux-14 S2	3.3 - 4.6	**0.578**	**0.555**	0.791	0.849	-0.865	3.115	0.688	0.845	0.865	-0.472	1.103	21.1	5.6
Bux-14 S3	4.6 - 7.3	**0.393**	**0.712**	1.348	0.491	-1.387	8.584	1.255	0.358	0.403	-0.205	1.264	9.8	0.4
Bux-15 S1	0 - 3.0	**0.410**	**0.739**	1.286	0.437	-0.772	7.558	1.178	0.368	0.380	-0.222	1.106	8.0	0.1
Bux-15 S2	3.0 - 5.9	**0.415**	**0.703**	1.267	0.507	-0.481	9.271	1.155	0.388	0.404	-0.168	1.151	9.6	0.5
Bux-15 S3	5.9 - 6.4	**0.267**	**0.541**	1.904	0.885	0.674	3.072	1.767	0.873	0.855	0.460	0.892	6.0	0.1
Bux-16 S1	0 - 3.0	**0.451**	**0.562**	1.149	0.831	-1.143	4.071	1.072	0.740	0.793	-0.422	1.236	18.4	3.3
Bux-16 S2	3.0 - 6.0	**0.357**	**0.581**	1.487	0.782	-1.643	6.419	1.457	0.545	0.685	-0.316	1.705	11.3	2.8
Bux-16 S3	6.0 - 7.9	**0.377**	**0.557**	1.409	0.843	-1.303	5.132	1.340	0.685	0.783	-0.387	1.479	14.1	3.2
Bux-17 S1	0 - 2.9	**0.445**	**0.721**	1.169	0.471	0.724	12.838	1.030	0.303	0.329	-0.128	1.284	7.3	0.3
Bux-17 S2	2.9 - 3.5	**0.561**	**0.606**	0.833	0.722	0.042	6.943	0.723	0.485	0.573	-0.284	1.441	14.7	2.9
Bux-17 S3	3.5 - 4.2	**0.109**	**0.528**	3.193	0.922	-2.259	8.012	3.258	0.385	0.661	-0.408	3.052	6.0	0.4
Bux-17 S4	4.2 - 4.9	**0.082**	**0.585**	3.603	0.774	-1.799	5.766	3.583	0.428	0.624	-0.392	1.621	14.6	0.0
Bux-18 S1	0 - 3.0	**0.503**	**0.612**	0.993	0.707	-1.338	5.180	0.935	0.573	0.642	-0.382	1.276	17.1	3.4
Bux-18 S2	3.0 - 6.0	**0.586**	**0.594**	0.771	0.752	-1.157	4.305	0.700	0.635	0.743	-0.429	1.567	20.3	5.6
Bux-18 S3	6.0 - 9.3	**0.494**	**0.628**	1.017	0.670	-1.449	5.896	0.957	0.518	0.590	-0.391	1.327	21.7	2.9
Bux-19 S1	0 - 3.0	**0.421**	**0.745**	1.247	0.425	-1.151	11.750	1.147	0.308	0.329	-0.205	1.183	7.5	0.5
Bux-19 S2	3.0 - 6.0	**0.415**	**0.755**	1.269	0.405	0.514	12.516	1.153	0.283	0.308	-0.131	1.171	9.3	0.1
Bux-19 S3	6.0 - 7.6	**0.433**	**0.713**	1.207	0.489	0.573	10.982	1.067	0.338	0.355	-0.110	1.186	8.2	0.3
Bux-19 S4	7.6 - 9.3	**0.534**	**0.655**	0.904	0.611	0.618	10.928	0.792	0.388	0.444	-0.269	1.288	15.5	1.1
Bux-20 S1	0 - 2.5	**0.452**	**0.677**	1.144	0.564	-1.447	7.095	1.067	0.435	0.491	-0.208	1.370	11.9	1.1
Bux-20 S2	2.5 - 3.6	**0.477**	**0.568**	1.067	0.816	-1.045	4.206	0.987	0.693	0.765	-0.379	1.273	19.4	3.7
Bux-20 S3	3.6-4.8	**0.408**	**0.591**	1.295	0.758	-1.542	6.065	1.250	0.535	0.677	-0.317	1.774	20.1	3.2
Bux-20 S4	4.8 - 6.4	**0.476**	**0.541**	1.072	0.886	-1.052	3.717	0.993	0.788	0.870	-0.474	1.262	20.8	4.7
Bux-20 S5	6.4 - 7.3	**0.389**	**0.551**	1.363	0.859	-1.542	5.232	1.325	0.658	0.792	-0.454	1.605	15.4	4.2
Bux-20 S6	7.3 - 9.4	**0.349**	**0.683**	1.519	0.550	-1.235	6.965	1.423	0.465	0.484	-0.227	1.106	9.7	0.4
Bux-21 S1	0 - 3.2	**0.605**	**0.635**	0.725	0.655	-1.018	4.347	0.650	0.573	0.623	-0.234	1.230	20.4	3.2
Bux-21 S2	3.2 - 4.9	**0.503**	**0.648**	0.990	0.627	-1.261	5.150	0.913	0.548	0.571	-0.325	1.081	15.0	1.8
Bux-21 S3	4.9 - 6.9	**0.514**	**0.659**	0.960	0.602	-0.986	5.354	0.872	0.523	0.552	-0.339	1.101	16.6	1.0
Bux-22 S1	0 - 2.2	**0.373**	**0.490**	1.424	1.030	-0.980	3.574	1.360	0.940	1.029	-0.336	1.304	13.2	4.6
Bux-22 S2	2.2 - 5.4	**0.272**	**0.607**	1.877	0.720	-1.505	7.545	1.805	0.548	0.601	-0.253	1.188	8.7	1.2
Bux-22 S3	5.4 - 6.9	**0.287**	**0.684**	1.801	0.547	-0.536	6.380	1.677	0.460	0.481	-0.079	1.094	7.2	0.1
Bux-22 S4	6.9 - 7.9	**0.319**	**0.661**	1.648	0.598	-1.206	7.683	1.557	0.473	0.510	-0.165	1.203	10.7	0.6
Bux-23 S1	0 - 2.2	**0.614**	**0.649**	0.703	0.625	-0.879	5.618	0.630	0.483	0.550	-0.279	1.276	6.0	2.9
Bux-23 S2	2.2 - 3.4	**0.466**	**0.758**	1.102	0.400	-0.464	12.034	0.987	0.300	0.318	-0.092	1.281	8.9	0.3
Bux-23 S3	3.4 - 5.2	**0.503**	**0.739**	0.991	0.435	-0.596	11.348	0.878	0.308	0.334	-0.277	1.235	11.3	0.5
Bux-23 S4	5.2 - 6.5	**0.440**	**0.737**	1.185	0.440	-0.209	10.653	1.065	0.328	0.352	-0.197	1.255	8.5	0.2
Bux-23 S5	6.5 - 8.2	**0.511**	**0.609**	0.969	0.716	1.579	9.201	0.782	0.380	0.513	-0.007	1.663	12.5	0.7

TABLE 4.1a (cont). Offshore Area "C" sediment characteristics (statistical measures) for 37 cores (~135 samples obtained in August 2013 and October 2014). See Attachment 3 for detailed frequency and cumulative frequency results of each sample.

Buxton Borrow Area Sediment Characteristics		Method of Moments						Folk Graphical Method						
		Mean	**STD**	Mean	STD	Skew	Kurt	Mean	STD	ISTD	Skew	Kurt	Shell	Gravel
		mm	**mm**	phi				phi					%	%
Bux-24 S1	0 - 1.4	**0.526**	**0.697**	0.926	0.521	-1.397	6.294	0.848	0.430	0.467	-0.339	1.248	18.8	1.0
Bux-24 S2	1.4 - 2.3	**0.438**	**0.744**	1.192	0.427	-1.007	10.273	1.078	0.318	0.342	-0.066	1.255	22.2	0.4
Bux-24 S3	2.3 - 3.9	**0.566**	**0.627**	0.821	0.674	-1.274	4.729	0.762	0.553	0.623	-0.417	1.370	26.9	3.2
Bux-24 S4	3.9 - 5.6	**0.467**	**0.604**	1.099	0.727	-1.409	5.896	1.038	0.545	0.657	-0.344	1.589	25.3	3.7
Bux-24 S5	5.6 - 7.0	**0.475**	**0.627**	1.075	0.673	-0.996	4.777	0.998	0.588	0.625	-0.211	1.106	16.7	1.6
Bux-25 S1	0 - 2.0	**0.627**	**0.685**	0.673	0.546	-1.358	5.711	0.605	0.435	0.488	-0.292	1.318	18.5	2.3
Bux-25 S2	2.0 - 4.4	**0.876**	**0.446**	0.191	1.165	-1.484	5.364	0.197	0.928	1.125	-0.421	1.437	40.0	12.1
Bux-25 S3	4.4 - 5.6	**0.523**	**0.722**	0.936	0.469	-1.029	6.604	0.845	0.408	0.421	-0.299	1.069	17.0	0.5
Bux-25 S4	5.6 - 7.0	**0.538**	**0.654**	0.895	0.614	-1.011	5.333	0.818	0.525	0.563	-0.333	1.162	18.3	1.6
Bux-26 S1	0 - 3.0	**0.301**	**0.660**	1.733	0.600	-0.887	5.565	1.633	0.540	0.557	-0.082	1.064	5.6	0.3
Bux-26 S2	3.0 - 5.0	**0.302**	**0.633**	1.728	0.659	-0.942	5.937	1.627	0.563	0.599	-0.084	1.148	8.1	0.6
Bux-26 S3	5.0 - 6.8	**0.425**	**0.512**	1.236	0.967	-1.122	3.825	1.183	0.843	0.964	-0.435	1.505	17.3	5.8
Bux-26 S4	6.8 - 8.2	**0.345**	**0.584**	1.535	0.776	-1.541	6.605	1.498	0.568	0.673	-0.238	1.423	12.5	2.7
Bux-27 S1	0 - 3.0	**0.512**	**0.706**	0.967	0.503	-1.196	7.565	0.878	0.405	0.440	-0.271	1.262	13.6	0.9
Bux-27 S2	3.0 - 6.0	**0.540**	**0.673**	0.890	0.572	-0.618	9.126	0.798	0.373	0.432	-0.283	1.289	16.7	2.0
Bux-27 S3	6.0 - 7.4	**0.412**	**0.636**	1.279	0.654	1.472	7.696	1.058	0.338	0.520	0.240	2.402	9.5	0.2
Bux-28 S1	0 - 3.0	**0.455**	**0.696**	1.137	0.522	-1.448	7.508	1.048	0.423	0.448	-0.213	1.266	11.9	0.8
Bux-28 S2	3.0 - 6.0	**0.579**	**0.606**	0.788	0.722	-0.983	4.033	0.710	0.628	0.692	-0.331	1.363	22.7	3.8
Bux-28 S3	6.0 - 8.5	**0.448**	**0.590**	1.159	0.760	-1.358	5.363	1.103	0.598	0.711	-0.283	1.438	18.0	3.7
Bux-29 S1	0 - 3.0	**0.600**	**0.630**	0.737	0.666	-1.124	4.817	0.652	0.533	0.600	-0.445	1.356	23.8	3.5
Bux-29 S2	3.0 - 6.0	**0.470**	**0.746**	1.089	0.423	-1.735	13.179	0.993	0.305	0.335	-0.130	1.543	12.6	0.9
Bux-29 S3	6.0 - 9.0	**0.499**	**0.708**	1.003	0.498	-0.932	8.381	0.903	0.413	0.431	-0.262	1.148	16.0	0.8
Bux-30 S1	0 - 3.0	**0.413**	**0.594**	1.276	0.750	-1.163	5.023	1.205	0.620	0.699	-0.259	1.430	11.0	2.1
Bux-30 S2	3.0 - 5.0	**0.397**	**0.661**	1.332	0.597	-0.945	5.830	1.240	0.508	0.539	-0.095	1.198	10.5	0.6
Bux-30 S3	5.0 - 5.9	**0.904**	**0.326**	0.146	1.617	-0.821	2.466	-0.128	1.990	1.793	-0.585	0.889	31.9	24.5
Bux-30 S4	5.9 - 9.2	**0.338**	**0.645**	1.566	0.632	-2.045	9.926	1.502	0.415	0.476	-0.233	1.382	6.7	1.7
Bux-31 S1	0 - 2.5	**0.624**	**0.698**	0.681	0.520	-0.680	7.572	0.593	0.395	0.439	-0.228	1.362	18.1	1.4
Bux-31 S2	2.5 - 4.7	**0.552**	**0.722**	0.857	0.469	-0.726	8.077	0.757	0.345	0.388	-0.211	1.180	14.0	0.6
Bux-31 S3	4.7 - 6.3	**0.561**	**0.662**	0.834	0.595	0.300	9.207	0.720	0.385	0.441	-0.199	1.256	16.7	1.4
Bux-32 S1	0 - 1.8	**0.414**	**0.700**	1.272	0.515	-1.695	9.371	1.198	0.358	0.405	-0.188	1.238	10.4	0.8
Bux-32 S2	1.8 - 3.8	**0.620**	**0.605**	0.690	0.724	-0.760	4.235	0.583	0.663	0.704	-0.354	1.230	26.4	3.9
Bux-32 S3	3.8 - 4.8	**0.409**	**0.656**	1.288	0.608	-1.371	6.242	1.188	0.505	0.538	-0.353	1.236	12.8	0.9
Bux-32 S4	4.8 - 6.3	**0.447**	**0.572**	1.161	0.807	-1.364	4.784	1.095	0.635	0.750	-0.428	1.560	17.4	3.9
Bux-33 S1	0 - 3.0	**0.546**	**0.635**	0.873	0.655	-1.271	5.336	0.812	0.518	0.597	-0.365	1.409	20.1	2.9
Bux-33 S2	3.0 - 5.2	**0.582**	**0.634**	0.780	0.658	-1.290	5.175	0.717	0.508	0.590	-0.432	1.411	19.4	3.6
Bux-34 S1	0 - 2.4	**0.351**	**0.682**	1.509	0.552	-1.118	8.025	1.415	0.445	0.476	-0.101	1.194	7.8	0.7
Bux-34 S2	2.4 - 3.7	**0.489**	**0.587**	1.033	0.768	-1.305	5.025	0.992	0.575	0.715	-0.335	1.541	14.2	4.4
Bux-34 S3	3.7 - 4.9	**0.499**	**0.693**	1.002	0.529	-0.863	7.463	0.907	0.438	0.460	-0.176	1.133	15.4	1.0
Bux-34 S4	4.9 - 6.3	**0.502**	**0.567**	0.995	0.818	-0.302	4.153	0.902	0.675	0.768	-0.113	1.353	17.1	2.8
Bux-34 S5	6.3 - 7.6	**0.333**	**0.580**	1.585	0.787	-1.315	5.831	1.530	0.618	0.678	-0.229	1.163	11.2	2.2
Bux-35 S1	0 - 1.3	**0.820**	**0.500**	0.287	1.001	-1.695	5.901	0.243	0.793	0.945	-0.559	1.595	30.2	11.0
Bux-35 S2	1.3 - 3.0	**0.524**	**0.736**	0.931	0.442	-0.575	11.079	0.820	0.323	0.342	-0.286	1.108	13.5	0.6
Bux-35 S3	3.0 - 6.0	**0.488**	**0.742**	1.035	0.431	-0.156	14.768	0.913	0.280	0.307	-0.252	1.326	10.4	0.5
Bux-35 S4	6.0 - 8.0	**0.413**	**0.686**	1.275	0.544	1.432	11.827	1.123	0.355	0.377	-0.018	1.211	8.0	0.2
Bux-36 S1	0 - 1.8	**0.656**	**0.498**	0.609	1.006	-1.446	4.838	0.553	0.888	0.964	-0.523	1.341	26.9	8.6
Bux-36 S2	1.8 - 3.7	**0.527**	**0.609**	0.925	0.716	-1.256	4.732	0.860	0.593	0.660	-0.404	1.294	19.4	3.5
Bux-36 S3	3.7 - 4.7	**0.363**	**0.695**	1.461	0.524	-1.714	10.165	1.378	0.378	0.422	-0.252	1.372	8.3	0.8
Bux-36 S4	4.7 - 7.6	**0.453**	**0.651**	1.141	0.620	-1.586	6.763	1.063	0.485	0.548	-0.252	1.412	15.6	1.9
Bux-36 S5	7.6 - 9.4	**0.409**	**0.683**	1.290	0.551	-1.906	9.188	1.230	0.368	0.428	-0.207	1.214	11.5	1.3
Bux-37 S1	0 - 3.0	**0.580**	**0.657**	0.786	0.605	-1.288	6.000	0.708	0.450	0.528	-0.362	1.355	22.1	2.9
Bux-37 S2	3.0 - 5.0	**0.440**	**0.726**	1.185	0.461	-1.149	7.526	1.082	0.415	0.412	-0.058	1.074	16.6	0.4
Bux-37 S3	5.0 - 7.8	**0.397**	**0.747**	1.334	0.421	-0.461	8.298	1.230	0.345	0.367	-0.068	1.003	9.2	0.1
Bux-38 S1	0 - 1.6	**0.307**	**0.677**	1.702	0.562	-0.990	7.158	1.597	0.478	0.501	-0.097	1.125	6.4	0.3
Bux-38 S2	1.6 - 3.3	**0.450**	**0.616**	1.153	0.700	-1.340	6.162	1.075	0.515	0.614	-0.229	1.485	12.7	2.9
Bux-38 S3	3.3 - 5.5	**0.485**	**0.690**	1.043	0.536	-0.988	6.577	0.947	0.453	0.476	-0.188	1.146	11.5	0.8
Bux-38 S4	5.5 - 6.8	**0.339**	**0.564**	1.559	0.827	-1.084	4.416	1.475	0.750	0.782	-0.307	1.106	14.7	1.5

TABLE 4.1b. Offshore Area "C" sediment characteristics (descriptive) for 37 cores (~135 samples obtained in August 2013 and October 2014). See Attachment 3 for detailed frequency and cumulative frequency results of each sample.

Sample	Interval	Munsell Color	USCS Description			Wentworth Description			
Bux-01 S1	0.0-2.0	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-01 S2	2.0-4.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-01 S3	4.0-6.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-01 S4	6.0-7.5	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-01 S5	7.5-9.5	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Symmetrical Skewed	Mesokurtic
Bux-02 S1	0.0-2.6	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-02 S2	2.6-5.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-02 S3	5.0-6.9	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Leptokurtic
Bux-03 S1	0.0-3.3	5Y4/2	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Coarse Skewed	Leptokurtic
Bux-03 S2	3.3-4.3	5Y4/2	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-03 S3	4.3-5.4	5Y4/2	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Coarse Skewed	Mesokurtic
Bux-03 S4	5.4-6.0	5Y3/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-04 S1	0.0-2.0	5Y5/2	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical Skewed	Very Leptokurtic
Bux-04 S2	2.0-4.0	5Y5/2	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Fine Skewed	Very Leptokurtic
Bux-04 S3	4.0-6.3	5Y5/2	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical Skewed	Very Leptokurtic
Bux-04 S4	6.3-7.2	5Y4/2	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Symmetrical Skewed	Very Platykurtic
Bux-04 S5	7.2-7.9	5Y4/2	SP	Medium Sand	Poorly Graded	Medium Sand	Poorly Sorted	Fine Skewed	Leptokurtic
Bux-05 S1	0.0-3.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-05 S2	3.0-4.3	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-05 S3	4.3-5.2	5Y6/2	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-05 S4	5.2-6.3	5Y4/2	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-06 S1	0.0-1.9	5Y5/2	SP	Medium Sand	Poorly Graded	VCoarse Sand	Poorly Sorted	Fine Skewed	Mesokurtic
Bux-06 S2	1.9-3.4	5Y3/2	SM	Fine Sand	Poorly Graded	Fine Sand	Poorly Sorted	Coarse Skewed	Leptokurtic
Bux-07 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Poorly Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-07 S2	3.0 - 6.3	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Very Leptokurtic
Bux-08 S1	0 - 1.8	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-08 S2	1.8 - 4.1	5Y4/2	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-08 S3	4.1 - 4.6	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Coarse Skewed	Leptokurtic
Bux-08 S4	4.6 - 7.6	5Y6/2	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-09 S1	0 - 2.6	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Very Leptokurtic
Bux-09 S2	2.6 - 4.5	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-10 S1	0 - 2.6	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-10 S2	2.6 - 5.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-10 S3	5.0 - 7.2	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-11 S1	0 - 1.9	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
Bux-11 S2	1.9 - 3.3	5Y4/2	SP	Fine Sand	Poorly Graded	Fine Sand	Poorly Sorted	Symmetrical	Platykurtic
Bux-11 S3	3.3 - 5.7	5Y6/2	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Symmetrical	Mesokurtic
Bux-12 S1	0 - 3.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-12 S2	3.0 - 4.0	5Y6/2	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-12 S3	4.0 - 5.6	5Y6/2	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Well Sorted	Symmetrical	Leptokurtic
Bux-12 S4	5.6 - 7.1	5Y6/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-14 S1	0 - 3.3	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-14 S2	3.3 - 4.6	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Mesokurtic
Bux-14 S3	4.6 - 7.3	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-15 S1	0 - 3.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-15 S2	3.0 - 5.9	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-15 S3	5.9 - 6.4	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Fine Skewed	Mesokurtic
Bux-16 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-16 S2	3.0 - 6.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-16 S3	6.0 - 7.9	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-17 S1	0 - 2.9	5Y6/2	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Fine Skewed	Very Leptokurtic
Bux-17 S2	2.9 - 3.5	5Y3/2	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Leptokurtic
Bux-17 S3	3.5 - 4.2	5Y3/2	SP-SM	Fine Sand	Poorly Graded	Very Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-17 S4	4.2 - 4.9	10Y1/2	SM	Fine Sand	Poorly Graded	Very Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-18 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-18 S2	3.0 - 6.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-18 S3	6.0 - 9.3	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-19 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-19 S2	3.0 - 6.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Well Sorted	Fine Skewed	Very Leptokurtic
Bux-19 S3	6.0 - 7.6	5Y5/2	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Fine Skewed	Very Leptokurtic
Bux-19 S4	7.6 - 9.3	5Y5/2	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Fine Skewed	Very Leptokurtic
Bux-20 S1	0 - 2.5	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-20 S2	2.5 - 3.6	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-20 S3	3.6-4.8	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-20 S4	4.8 - 6.4	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-20 S5	6.4 - 7.3	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-20 S6	7.3 - 9.4	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic

TABLE 4.1b (cont). Offshore Area "C" sediment characteristics (descriptive) for 37 cores (~135 samples obtained in August 2013 and October 2014). See Attachment 3 for detailed frequency and cumulative frequency results of each sample.

Sample	Interval	Munsell Color	USCS Description			Wentworth Description			
Bux-21 S1	0 - 3.2	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-21 S2	3.2 - 4.9	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-21 S3	4.9 - 6.9	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-22 S1	0 - 2.2	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Coarse Skewed	Mesokurtic
Bux-22 S2	2.2 - 5.4	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-22 S3	5.4 - 6.9	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-22 S4	6.9 - 7.9	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-23 S1	0 - 2.2	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-23 S2	2.2 - 3.4	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-23 S3	3.4 - 5.2	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-23 S4	5.2 - 6.5	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Symmetrical	Very Leptokurtic
Bux-23 S5	6.5 - 8.2	5Y5/2	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Strongly Fine Skewed	Very Leptokurtic
Bux-24 S1	0 - 1.4	5Y6/2	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-24 S2	1.4 - 2.3	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-24 S3	2.3 - 3.9	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-24 S4	3.9 - 5.6	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-24 S5	5.6 - 7.0	5Y6/2	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-25 S1	0 - 2.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-25 S2	2.0 - 4.4	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-25 S3	4.4 - 5.6	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Well Sorted	Coarse Skewed	Leptokurtic
Bux-25 S4	5.6 - 7.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-26 S1	0 - 3.0	5Y6/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-26 S2	3.0 - 5.0	5Y6/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-26 S3	5.0 - 6.8	5Y6/2	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-26 S4	6.8 - 8.2	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-27 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-27 S2	3.0 - 6.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-27 S3	6.0 - 7.4	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Fine Skewed	Very Leptokurtic
Bux-28 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-28 S2	3.0 - 6.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-28 S3	6.0 - 8.5	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-29 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-29 S2	3.0 - 6.0	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-29 S3	6.0 - 9.0	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-30 S1	0 - 3.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-30 S2	3.0 - 5.0	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-30 S3	5.0 - 5.9	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Coarse Skewed	Platykurtic
Bux-30 S4	5.9 - 9.2	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-31 S1	0 - 2.5	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-31 S2	2.5 - 4.7	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-31 S3	4.7 - 6.3	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Very Leptokurtic
Bux-32 S1	0 - 1.8	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-32 S2	1.8 - 3.8	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-32 S3	3.8 - 4.8	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-32 S4	4.8 - 6.3	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-33 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-33 S2	3.0 - 5.2	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-34 S1	0 - 2.4	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-34 S2	2.4 - 3.7	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-34 S3	3.7 - 4.9	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-34 S4	4.9 - 6.3	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Symmetrical	Leptokurtic
Bux-34 S5	6.3 - 7.6	5Y6/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-35 S1	0 - 1.3	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-35 S2	1.3 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-35 S3	3.0 - 6.0	5Y5/2	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Symmetrical	Very Leptokurtic
Bux-35 S4	6.0 - 8.0	5Y5/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Fine Skewed	Very Leptokurtic
Bux-36 S1	0 - 1.8	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Poorly Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-36 S2	1.8 - 3.7	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux-36 S3	3.7 - 4.7	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-36 S4	4.7 - 7.6	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-36 S5	7.6 - 9.4	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux-37 S1	0 - 3.0	5Y6/4	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-37 S2	3.0 - 5.0	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-37 S3	5.0 - 7.8	5Y6/2	SP	Fine Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux-38 S1	0 - 1.6	5Y6/4	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-38 S2	1.6 - 3.3	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux-38 S3	3.3 - 5.5	5Y6/4	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux-38 S4	5.5 - 6.8	5Y6/2	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic

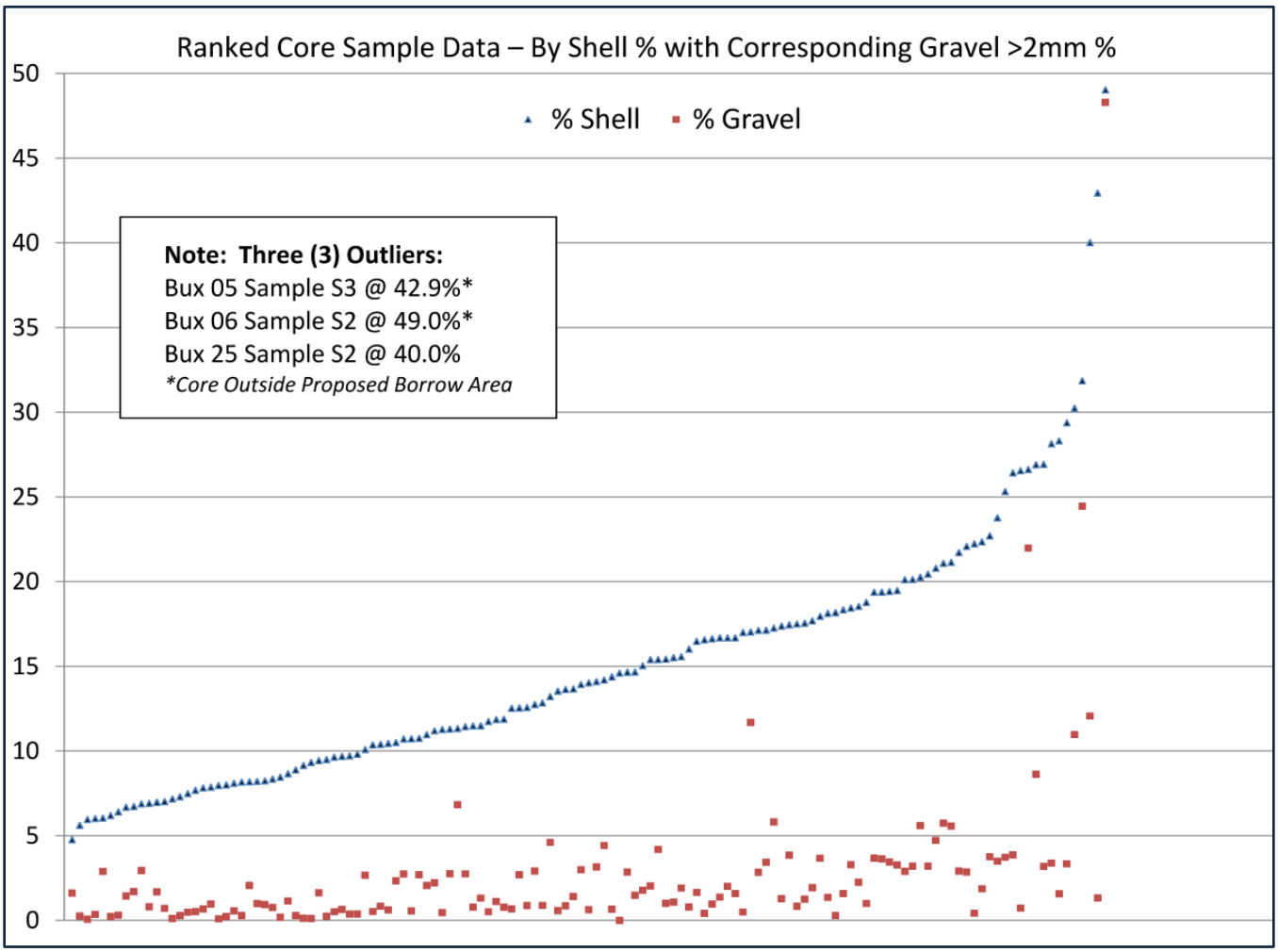


FIGURE 4.3. Shell percentage for 135 individual samples from 37 offshore cores with the corresponding gravel (>2 mm mean diameter) percentage.

For purposes of visualizing sediment quality within the sand search area, CSE computed weighted composite statistics to 4 ft, 6 ft, and 8 ft of section. Under operational conditions, dredges excavate to a particular depth, mixing sediments before discharge along the beach. The results of random length core samples were weighted proportionally over the applicable section. This yields a "composite" mean grain size, shell content, and gravel content for each designated interval.

Similarities between the results for each composite are a measure of the down-core consistency of the sediments. It is anticipated excavations will be restricted by design to the upper ~6–8 ft of substrate and possibly shallower if construction is via hopper dredge. A goal of the design is to leave sediments at the base of the excavation which are similar in size and character as the removed sediments. This improves the chance for rapid recovery

of benthic organisms (Van Dolah et al 1998, NPS 2012). Table 4.2, Table 4.3, and Table 4.4 provide key statistics for each core to the composited lengths of 4 ft, 6 ft, and 8 ft. The composite grain-size distributions for each set of data are given in Attachment 3-B. Table 4.4 provides average arithmetic mean sizes, standard deviations, shell percentages, and gravel percentages for individual samples and weighted composite samples.

Figure 4.4 shows selected composite statistics for each core within the sand search area. To more easily visualize the results, Figures 4.5–4.7 provide color isopach maps of mean grain size, shell percentages, and gravel percentages for Comp 4 and Comp 8 results. Given the close similarity between results for Comp 4 and Comp 8, and the fact the Comp 6 falls between the two sets of data, isopach maps for Comp 6 are not shown.

Coarsest sediments are found over a broad area encompassing the northern 75 percent of the search area. Mean grain size is slightly lower along the eastern edge and south end of the area. The size minima are at the southernmost corner of the grid (core Bux-08 ~0.25 mm). The coarsest samples are in the center of the search area (core Bux-25 ~0.7 mm). Figure 4.6 (percent shell) shows similar isopachs and a correlation of shell percentage with mean grain size. Gravel percentages (Fig 4.7) are generally low throughout the sand search area, peaking at ~7.1 percent (core Bux-25).

TABLE 4.2a. Composited offshore core sediment statistics to 4 ft based on weighted averages of individual samples. See Attachment 3-B for size frequency curves.

Buxton Borrow Area Sediment Characteristics		Method of Moments						Folk Graphical Method						
		Mean	**STD**	Mean	STD	Skew	Kurt	Mean	STD	ISTD	Skew	Kurt	Shell	Gravel
		mm	**mm**	phi				phi					%	%
Bux 1	0-4 ft Comp	**0.415**	**0.531**	1.268	0.913	-1.171	4.059	1.200	0.790	0.887	-0.423	1.332	20.3	4.5
Bux 2	0-4 ft Comp	**0.566**	**0.645**	0.822	0.632	-1.106	5.504	0.750	0.515	0.562	-0.348	1.239	24.4	2.5
Bux 3	0-4 ft Comp	**0.267**	**0.477**	1.904	1.067	-1.053	3.936	1.855	0.958	1.023	-0.446	1.187	11.0	2.6
Bux 4	0-4 ft Comp	**0.458**	**0.645**	1.126	0.633	0.605	9.253	0.988	0.348	0.406	-0.176	1.306	12.7	1.0
Bux 5	0-4 ft Comp	**0.358**	**0.587**	1.483	0.768	-1.406	5.955	1.423	0.603	0.685	-0.294	1.414	9.6	2.3
Bux 6	0-4 ft Comp	**0.622**	**0.204**	0.685	2.293	-0.152	1.712	0.293	2.775	2.487	-0.084	0.705	39.9	27.7
Bux 7	0-4 ft Comp	**0.434**	**0.513**	1.204	0.964	-2.297	9.646	1.230	0.395	0.710	-0.397	2.716	11.4	5.8
Bux 8	0-4 ft Comp	**0.239**	**0.519**	2.063	0.946	-1.396	5.946	2.047	0.700	0.846	-0.227	1.491	8.0	2.4
Bux 9	0-4 ft Comp	**0.468**	**0.450**	1.096	1.153	-2.065	11.241	1.072	0.508	0.837	-0.312	2.587	10.3	5.4
Bux 10	0-4 ft Comp	**0.340**	**0.692**	1.557	0.532	-1.737	11.572	1.480	0.340	0.402	-0.143	1.378	8.0	0.8
Bux 11	0-4 ft Comp	**0.298**	**0.483**	1.746	1.049	0.246	3.114	1.677	1.050	1.008	0.369	0.880	9.2	1.2
Bux 12	0-4 ft Comp	**0.327**	**0.576**	1.613	0.797	-1.237	6.342	1.552	0.533	0.692	-0.145	1.857	9.6	2.2
Bux 14	0-4 ft Comp	**0.509**	**0.608**	0.974	0.719	-1.229	4.478	0.895	0.623	0.664	-0.479	1.224	18.3	2.6
Bux 15	0-4 ft Comp	**0.412**	**0.729**	1.281	0.456	-0.681	8.381	1.173	0.373	0.385	-0.211	1.111	8.4	0.2
Bux 16	0-4 ft Comp	**0.426**	**0.562**	1.231	0.832	-1.212	4.381	1.160	0.718	0.788	-0.423	1.365	16.7	3.2
Bux 17	0-4 ft Comp	**0.394**	**0.542**	1.345	0.884	1.248	5.411	1.063	0.403	0.679	0.229	2.718	8.2	0.7
Bux 18	0-4 ft Comp	**0.522**	**0.605**	0.938	0.725	-1.279	4.886	0.878	0.585	0.665	-0.381	1.309	17.9	4.0
Bux 19	0-4 ft Comp	**0.420**	**0.748**	1.253	0.420	-0.760	12.002	1.148	0.303	0.325	-0.178	1.188	7.9	0.4
Bux 20	0-4 ft Comp	**0.456**	**0.627**	1.133	0.674	-1.318	5.853	1.060	0.523	0.605	-0.281	1.431	14.8	2.1
Bux 21	0-4 ft Comp	**0.584**	**0.634**	0.777	0.658	-1.030	4.383	0.712	0.570	0.620	-0.215	1.208	19.4	2.9
Bux 22	0-4 ft Comp	**0.322**	**0.526**	1.635	0.926	-1.276	4.826	1.592	0.738	0.859	-0.334	1.381	11.2	3.0
Bux 23	0-4 ft Comp	**0.547**	**0.675**	0.871	0.567	-1.044	7.122	0.792	0.418	0.469	-0.356	1.259	7.7	1.7
Bux 24	0-4 ft Comp	**0.519**	**0.662**	0.945	0.594	-1.405	6.161	0.877	0.458	0.523	-0.335	1.374	23.0	1.8
Bux 25	0-4 ft Comp	**0.741**	**0.521**	0.433	0.940	-2.001	8.316	0.400	0.693	0.783	-0.411	1.383	29.3	7.1
Bux 26	0-4 ft Comp	**0.301**	**0.653**	1.731	0.616	-0.908	5.737	1.630	0.545	0.569	-0.082	1.090	6.2	0.3
Bux 27	0-4 ft Comp	**0.520**	**0.695**	0.945	0.525	-1.004	8.244	0.858	0.400	0.441	-0.276	1.278	14.4	1.2
Bux 28	0-4 ft Comp	**0.482**	**0.662**	1.053	0.596	-1.405	6.291	0.973	0.480	0.529	-0.282	1.294	14.6	1.5
Bux 29	0-4 ft Comp	**0.565**	**0.645**	0.823	0.634	-1.297	5.614	0.753	0.478	0.554	-0.471	1.409	21.0	2.9
Bux 30	0-4 ft Comp	**0.409**	**0.609**	1.289	0.716	-1.161	5.310	1.217	0.590	0.661	-0.226	1.394	10.8	1.7
Bux 31	0-4 ft Comp	**0.598**	**0.702**	0.742	0.510	-0.709	7.556	0.648	0.390	0.435	-0.198	1.274	16.6	1.1
Bux 32	0-4 ft Comp	**0.509**	**0.616**	0.975	0.699	-1.091	4.895	0.903	0.585	0.638	-0.350	1.221	18.5	2.4
Bux 33	0-4 ft Comp	**0.557**	**0.634**	0.846	0.657	-1.269	5.272	0.785	0.518	0.600	-0.381	1.430	19.9	3.1
Bux 34	0-4 ft Comp	**0.401**	**0.628**	1.319	0.671	-1.309	6.653	1.242	0.518	0.578	-0.197	1.348	10.5	1.9
Bux 35	0-4 ft Comp	**0.591**	**0.597**	0.758	0.743	-2.313	12.014	0.725	0.415	0.531	-0.431	1.591	18.2	3.9
Bux 36	0-4 ft Comp	**0.566**	**0.543**	0.821	0.881	-1.556	5.834	0.767	0.728	0.811	-0.474	1.390	22.0	5.6
Bux 37	0-4 ft Comp	**0.543**	**0.660**	0.882	0.599	-1.265	6.144	0.818	0.460	0.530	-0.285	1.387	20.7	2.3
Bux 38	0-4 ft Comp	**0.398**	**0.621**	1.330	0.688	-1.043	5.898	1.250	0.565	0.611	-0.119	1.289	10.0	1.7

TABLE 4.2b (cont). Composited offshore core sediment characteristics to 4 ft based on weighted averages of individual samples. See Attachment 3-B for size frequency curves.

Sample	Interval	USCS Description			Wentworth Description			
Bux 1	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 2	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 3	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Coarse Skewed	Leptokurtic
Bux 4	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Fine Skewed	Very Leptokurtic
Bux 5	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 6	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Very Poorly Sorted	Symmetrical	Platykurtic
Bux 7	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 8	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 9	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Poorly Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 10	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 11	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Symmetrical	Mesokurtic
Bux 12	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 14	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 15	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux 16	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 17	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Fine Skewed	Leptokurtic
Bux 18	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 19	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Well Sorted	Coarse Skewed	Very Leptokurtic
Bux 20	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 21	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 22	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 23	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 24	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 25	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 26	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 27	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux 28	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 29	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 30	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 31	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux 32	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 33	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 34	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 35	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 36	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 37	0-4 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 38	0-4 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic

TABLE 4.3a. Composited offshore core sediment statistics to 6 ft based on weighted averages of individual samples. See Attachment 3-B for size frequency curves.

Buxton Borrow Area Sediment Characteristics		Method of Moments						Folk Graphical Method						
		Mean	**STD**	Mean	STD	Skew	Kurt	Mean	STD	ISTD	Skew	Kurt	Shell	Gravel
		mm	**mm**	phi				phi					%	%
Bux 1	0-6 ft Comp	**0.401**	**0.549**	1.319	0.866	-1.199	4.416	1.255	0.740	0.820	-0.367	1.275	19.0	3.6
Bux 2	0-6 ft Comp	**0.541**	**0.659**	0.887	0.603	-1.120	5.990	0.812	0.488	0.535	-0.331	1.220	22.2	1.9
Bux 3	0-6 ft Comp	**0.323**	**0.398**	1.629	1.330	-1.376	5.201	1.585	1.140	1.237	-0.414	1.307	13.8	5.9
Bux 4	0-6 ft Comp	**0.481**	**0.646**	1.055	0.631	0.474	8.887	0.920	0.400	0.450	-0.196	1.264	14.3	1.1
Bux 5	0-6 ft Comp	**0.312**	**0.550**	1.682	0.864	-0.948	4.976	1.613	0.705	0.791	-0.154	1.297	15.5	2.0
Bux 6	0-6 ft Comp	**0.622**	**0.204**	0.685	2.293	-0.152	1.712	0.293	2.775	2.487	-0.084	0.705	39.9	27.7
Bux 7	0-6 ft Comp	**0.430**	**0.541**	1.216	0.885	-2.084	10.187	1.203	0.395	0.643	-0.347	2.434	11.4	4.8
Bux 8	0-6 ft Comp	**0.237**	**0.532**	2.076	0.911	-1.543	6.520	2.062	0.648	0.788	-0.271	1.590	7.5	2.2
Bux 9	0-6 ft Comp	**0.483**	**0.429**	1.050	1.220	-2.000	10.221	1.043	0.535	0.899	-0.322	2.650	11.1	6.2
Bux 10	0-6 ft Comp	**0.344**	**0.694**	1.540	0.527	-1.578	11.684	1.465	0.333	0.394	-0.123	1.402	7.8	0.7
Bux 11	0-6 ft Comp	**0.295**	**0.466**	1.761	1.102	0.072	2.969	1.687	1.100	1.064	0.323	0.843	9.7	1.6
Bux 12	0-6 ft Comp	**0.301**	**0.586**	1.731	0.770	-1.122	6.630	1.670	0.533	0.653	-0.008	1.608	8.5	1.6
Bux 14	0-6 ft Comp	**0.483**	**0.612**	1.049	0.708	-1.307	4.913	0.977	0.595	0.651	-0.466	1.329	16.6	2.4
Bux 15	0-6 ft Comp	**0.410**	**0.713**	1.286	0.489	-0.318	9.072	1.170	0.380	0.396	-0.186	1.138	8.7	0.3
Bux 16	0-6 ft Comp	**0.402**	**0.564**	1.314	0.825	-1.317	4.823	1.243	0.683	0.769	-0.425	1.475	14.9	3.0
Bux 17	0-6 ft Comp	**0.337**	**0.465**	1.568	1.106	1.038	3.496	1.650	1.230	1.149	0.588	2.833	9.1	0.6
Bux 18	0-6 ft Comp	**0.542**	**0.599**	0.882	0.738	-1.227	4.646	0.825	0.590	0.699	-0.392	1.418	18.7	4.5
Bux 19	0-6 ft Comp	**0.418**	**0.750**	1.259	0.415	-0.353	12.215	1.150	0.295	0.319	-0.170	1.187	8.4	0.3
Bux 20	0-6 ft Comp	**0.454**	**0.599**	1.138	0.739	-1.278	5.219	1.068	0.575	0.672	-0.340	1.443	16.7	2.8
Bux 21	0-6 ft Comp	**0.558**	**0.637**	0.841	0.650	-1.049	4.595	0.770	0.568	0.607	-0.256	1.144	18.2	2.4
Bux 22	0-6 ft Comp	**0.306**	**0.553**	1.710	0.855	-1.387	5.680	1.665	0.653	0.764	-0.305	1.369	10.2	2.3
Bux 23	0-6 ft Comp	**0.520**	**0.689**	0.942	0.537	-0.982	8.040	0.855	0.403	0.446	-0.315	1.311	8.5	1.2
Bux 24	0-6 ft Comp	**0.501**	**0.641**	0.996	0.642	-1.301	5.909	0.920	0.488	0.563	-0.316	1.369	23.2	2.3
Bux 25	0-6 ft Comp	**0.684**	**0.537**	0.549	0.896	-2.103	9.236	0.503	0.655	0.743	-0.406	1.404	26.8	5.8
Bux 26	0-6 ft Comp	**0.321**	**0.605**	1.641	0.725	-1.309	6.337	1.567	0.580	0.629	-0.143	1.182	8.4	1.4
Bux 27	0-6 ft Comp	**0.527**	**0.686**	0.925	0.543	-0.851	8.658	0.837	0.395	0.441	-0.271	1.290	15.2	1.5
Bux 28	0-6 ft Comp	**0.512**	**0.637**	0.967	0.652	-1.270	5.281	0.898	0.525	0.590	-0.316	1.302	17.3	2.2
Bux 29	0-6 ft Comp	**0.532**	**0.666**	0.911	0.587	-1.499	6.905	0.845	0.415	0.497	-0.398	1.566	18.2	2.2
Bux 30	0-6 ft Comp	**0.457**	**0.504**	1.129	0.987	-2.015	8.371	1.125	0.660	0.830	-0.343	1.701	13.9	5.0
Bux 31	0-6 ft Comp	**0.584**	**0.693**	0.776	0.529	-0.347	8.452	0.677	0.388	0.437	-0.197	1.265	16.3	1.1
Bux 32	0-6 ft Comp	**0.482**	**0.607**	1.052	0.721	-1.153	4.874	0.980	0.598	0.668	-0.324	1.271	17.6	2.5
Bux 33	0-6 ft Comp	**0.563**	**0.634**	0.828	0.658	-1.271	5.240	0.768	0.518	0.600	-0.396	1.422	19.8	3.3
Bux 34	0-6 ft Comp	**0.431**	**0.617**	1.214	0.698	-0.960	5.580	1.112	0.555	0.623	-0.166	1.280	12.4	1.9
Bux 35	0-6 ft Comp	**0.551**	**0.633**	0.860	0.660	-2.347	14.678	0.805	0.355	0.448	-0.444	1.524	15.6	2.6
Bux 36	0-6 ft Comp	**0.513**	**0.564**	0.964	0.826	-1.667	6.615	0.922	0.635	0.730	-0.396	1.387	19.0	4.2
Bux 37	0-6 ft Comp	**0.496**	**0.669**	1.010	0.581	-1.236	6.568	0.937	0.480	0.517	-0.204	1.236	18.1	1.6
Bux 38	0-6 ft Comp	**0.411**	**0.622**	1.281	0.684	-0.857	5.425	1.188	0.578	0.621	-0.067	1.276	10.8	1.4

TABLE 4.3b (cont). Composited offshore core sediment characteristics to 6 ft based on weighted averages of individual samples. See Attachment 3-B for size frequency curves.

Sample	Interval	USCS Description			Wentworth Description			
Bux 1	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 2	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 3	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 4	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Fine Skewed	Very Leptokurtic
Bux 5	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 6	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Very Poorly Sorted	Symmetrical	Platykurtic
Bux 7	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 8	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 9	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Poorly Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 10	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 11	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Symmetrical	Mesokurtic
Bux 12	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 14	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 15	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Well Sorted	Symmetrical	Very Leptokurtic
Bux 16	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 17	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Fine Skewed	Mesokurtic
Bux 18	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 19	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Well Sorted	Symmetrical	Very Leptokurtic
Bux 20	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 21	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 22	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 23	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux 24	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 25	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 26	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 27	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic
Bux 28	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 29	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 30	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 31	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Very Leptokurtic
Bux 32	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 33	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 34	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 35	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 36	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 37	0-6 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 38	0-6 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic

TABLE 4.4a. Composited offshore core sediment statistics to **8 ft** based on weighted averages of individual samples. See Attachment 3-C for size frequency curves.

Buxton Borrow Area Sediment Characteristics		Method of Moments						Folk Graphical Method						
		Mean	**STD**	Mean	STD	Skew	Kurt	Mean	STD	ISTD	Skew	Kurt	Shell	Gravel
		mm	**mm**	phi				phi					%	%
Bux 1	0-8 ft Comp	**0.398**	**0.561**	1.328	0.835	-1.157	4.501	1.258	0.728	0.790	-0.330	1.212	19.2	3.0
Bux 2	0-8 ft Comp	**0.530**	**0.663**	0.916	0.594	-1.115	6.145	0.838	0.478	0.524	-0.309	1.204	21.7	1.6
Bux 3	0-8 ft Comp	**0.323**	**0.398**	1.629	1.330	-1.376	5.201	1.585	1.140	1.237	-0.414	1.307	13.8	5.9
Bux 4	0-8 ft Comp	**0.449**	**0.544**	1.156	0.879	0.976	5.521	0.920	0.455	0.743	0.114	2.288	16.9	1.4
Bux 5	0-8 ft Comp	**0.305**	**0.545**	1.715	0.875	-0.914	4.877	1.640	0.718	0.799	-0.148	1.260	15.4	1.9
Bux 6	0-8 ft Comp	**0.622**	**0.204**	0.685	2.293	-0.152	1.712	0.293	2.775	2.487	-0.084	0.705	39.9	27.7
Bux 7	0-8 ft Comp	**0.430**	**0.544**	1.218	0.878	-2.054	10.218	1.200	0.393	0.630	-0.334	2.368	11.4	4.7
Bux 8	0-8 ft Comp	**0.233**	**0.545**	2.103	0.875	-1.700	7.287	2.080	0.603	0.736	-0.287	1.657	6.9	2.1
Bux 9	0-8 ft Comp	**0.483**	**0.429**	1.050	1.220	-2.000	10.221	1.043	0.535	0.899	-0.322	2.650	11.1	6.2
Bux 10	0-8 ft Comp	**0.347**	**0.694**	1.528	0.527	-1.530	11.712	1.455	0.328	0.391	-0.125	1.430	7.7	0.7
Bux 11	0-8 ft Comp	**0.295**	**0.466**	1.761	1.102	0.072	2.969	1.687	1.100	1.064	0.323	0.843	9.7	1.6
Bux 12	0-8 ft Comp	**0.299**	**0.594**	1.742	0.752	-1.119	6.887	1.675	0.523	0.633	0.004	1.584	8.3	1.5
Bux 14	0-8 ft Comp	**0.465**	**0.623**	1.106	0.683	-1.386	5.417	1.033	0.555	0.621	-0.433	1.396	15.4	2.0
Bux 15	0-8 ft Comp	**0.400**	**0.688**	1.321	0.539	0.368	9.030	1.187	0.380	0.410	-0.136	1.193	8.6	0.3
Bux 16	0-8 ft Comp	**0.396**	**0.562**	1.336	0.830	-1.307	4.886	1.263	0.680	0.773	-0.414	1.472	14.7	3.1
Bux 17	0-8 ft Comp	**0.337**	**0.465**	1.568	1.106	1.038	3.496	1.650	1.230	1.149	0.588	2.833	9.1	0.6
Bux 18	0-8 ft Comp	**0.530**	**0.606**	0.917	0.724	-1.282	4.908	0.857	0.573	0.663	-0.388	1.349	19.5	4.1
Bux 19	0-8 ft Comp	**0.426**	**0.732**	1.230	0.450	-0.118	11.644	1.110	0.325	0.342	-0.181	1.185	8.7	0.3
Bux 20	0-8 ft Comp	**0.439**	**0.591**	1.188	0.758	-1.289	5.167	1.123	0.600	0.699	-0.329	1.459	16.1	2.9
Bux 21	0-8 ft Comp	**0.552**	**0.639**	0.856	0.646	-1.046	4.687	0.785	0.565	0.602	-0.268	1.130	18.0	2.2
Bux 22	0-8 ft Comp	**0.305**	**0.576**	1.713	0.797	-1.390	6.208	1.658	0.610	0.697	-0.241	1.327	9.9	1.8
Bux 23	0-8 ft Comp	**0.513**	**0.672**	0.964	0.573	-0.034	9.269	0.858	0.405	0.449	-0.263	1.319	9.3	1.1
Bux 24	0-8 ft Comp	**0.497**	**0.638**	1.009	0.648	-1.239	5.706	0.933	0.510	0.580	-0.279	1.352	22.3	2.2
Bux 25	0-8 ft Comp	**0.661**	**0.547**	0.597	0.871	-2.098	9.540	0.545	0.635	0.718	-0.398	1.372	25.6	5.2
Bux 26	0-8 ft Comp	**0.334**	**0.585**	1.581	0.773	-1.385	6.128	1.528	0.593	0.674	-0.207	1.303	9.9	2.0
Bux 27	0-8 ft Comp	**0.504**	**0.668**	0.990	0.581	-0.056	9.063	0.877	0.398	0.442	-0.220	1.342	14.1	1.3
Bux 28	0-8 ft Comp	**0.496**	**0.623**	1.010	0.683	-1.229	5.209	0.947	0.548	0.627	-0.260	1.345	17.5	2.6
Bux 29	0-8 ft Comp	**0.524**	**0.675**	0.934	0.567	-1.430	7.317	0.862	0.418	0.482	-0.355	1.480	17.6	1.9
Bux 30	0-8 ft Comp	**0.424**	**0.524**	1.237	0.931	-2.127	9.240	1.227	0.623	0.755	-0.357	1.645	12.1	4.2
Bux 31	0-8 ft Comp	**0.583**	**0.691**	0.779	0.533	-0.296	8.552	0.678	0.390	0.437	-0.192	1.249	16.3	1.1
Bux 32	0-8 ft Comp	**0.481**	**0.605**	1.057	0.725	-1.161	4.859	0.987	0.598	0.671	-0.330	1.274	17.6	2.6
Bux 33	0-8 ft Comp	**0.563**	**0.634**	0.828	0.658	-1.271	5.240	0.768	0.518	0.600	-0.396	1.422	19.8	3.3
Bux 34	0-8 ft Comp	**0.415**	**0.601**	1.270	0.734	-0.894	5.191	1.182	0.613	0.672	-0.135	1.302	12.4	2.0
Bux 35	0-8 ft Comp	**0.515**	**0.634**	0.957	0.658	-1.700	14.388	0.880	0.385	0.458	-0.294	1.542	13.7	2.1
Bux 36	0-8 ft Comp	**0.494**	**0.582**	1.018	0.782	-1.739	7.114	0.975	0.583	0.677	-0.359	1.391	17.9	3.6
Bux 37	0-8 ft Comp	**0.470**	**0.677**	1.088	0.564	-1.213	6.978	1.002	0.478	0.497	-0.156	1.127	16.0	1.2
Bux 38	0-8 ft Comp	**0.402**	**0.612**	1.313	0.707	-0.828	5.118	1.225	0.613	0.654	-0.075	1.280	11.2	1.5

TABLE 4.4b. Composited offshore core sediment statistics to **8 ft** based on weighted averages of individual samples. See Attachment 3-C for size frequency curves.

Sample	Interval	USCS Description			Wentworth Description			
Bux 1	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 2	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 3	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 4	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Fine Skewed	Leptokurtic
Bux 5	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 6	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Very Poorly Sorted	Symmetrical	Platykurtic
Bux 7	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 8	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Fine Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 9	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Poorly Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 10	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 11	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Symmetrical	Mesokurtic
Bux 12	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 14	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 15	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Symmetrical	Very Leptokurtic
Bux 16	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 17	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Poorly Sorted	Fine Skewed	Mesokurtic
Bux 18	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 19	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Well Sorted	Symmetrical	Very Leptokurtic
Bux 20	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 21	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 22	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 23	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Very Leptokurtic
Bux 24	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 25	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 26	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 27	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Very Leptokurtic
Bux 28	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 29	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 30	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 31	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Symmetrical	Very Leptokurtic
Bux 32	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 33	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 34	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
Bux 35	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Coarse Sand	Moderately Well Sorted	Strongly Coarse Skewed	Very Leptokurtic
Bux 36	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Sorted	Strongly Coarse Skewed	Leptokurtic
Bux 37	0-8 ft Comp	SP	Medium Sand	Poorly Graded	Medium Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic
Bux 38	0-8 ft Comp	SP	Fine Sand	Poorly Graded	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic

TABLE 4.5. Average arithmetic mean grain size, standard deviation, shell percentage, and gravel percentage for 37 borings (135 samples) off Buxton ("All Samples"). Composites are weighted by applicable length of individual samples for the upper 4 ft of core (Comp 4), the upper 6 ft of core (Comp 6), and the upper 8 ft of core (Comp 8). Composite statics are based on 33 cores within the box shown in Figure 4.4. Standard deviation for shell and gravel percentages is given in parentheses.

Core Samples	Mean Size (mm)	Std Deviation (mm)	Shell (%)	Gravel (%)
All Samples	0.446	0.615	15.1 (7.5)	2.8 (5.2)
Comp 4 ft	0.466	0.609	14.8 (5.9)	2.5 (1.7)
Comp 6 ft	0.455	0.604	14.2 (4.8)	2.3 (1.4)
Comp 8 ft	0.447	0.605	14.5 (5.1)	2.5 (1.5)

FIGURE 4.4. Mean grain size, percent shell, and percent gravel for core composite samples to 4 ft and 8 ft in the Buxton offshore sand search area based on borings obtained in October 2014. Bux-13 was attempted but not recovered. Composite results to 6 ft (not shown) fall between the results for 4 ft and 8 ft.

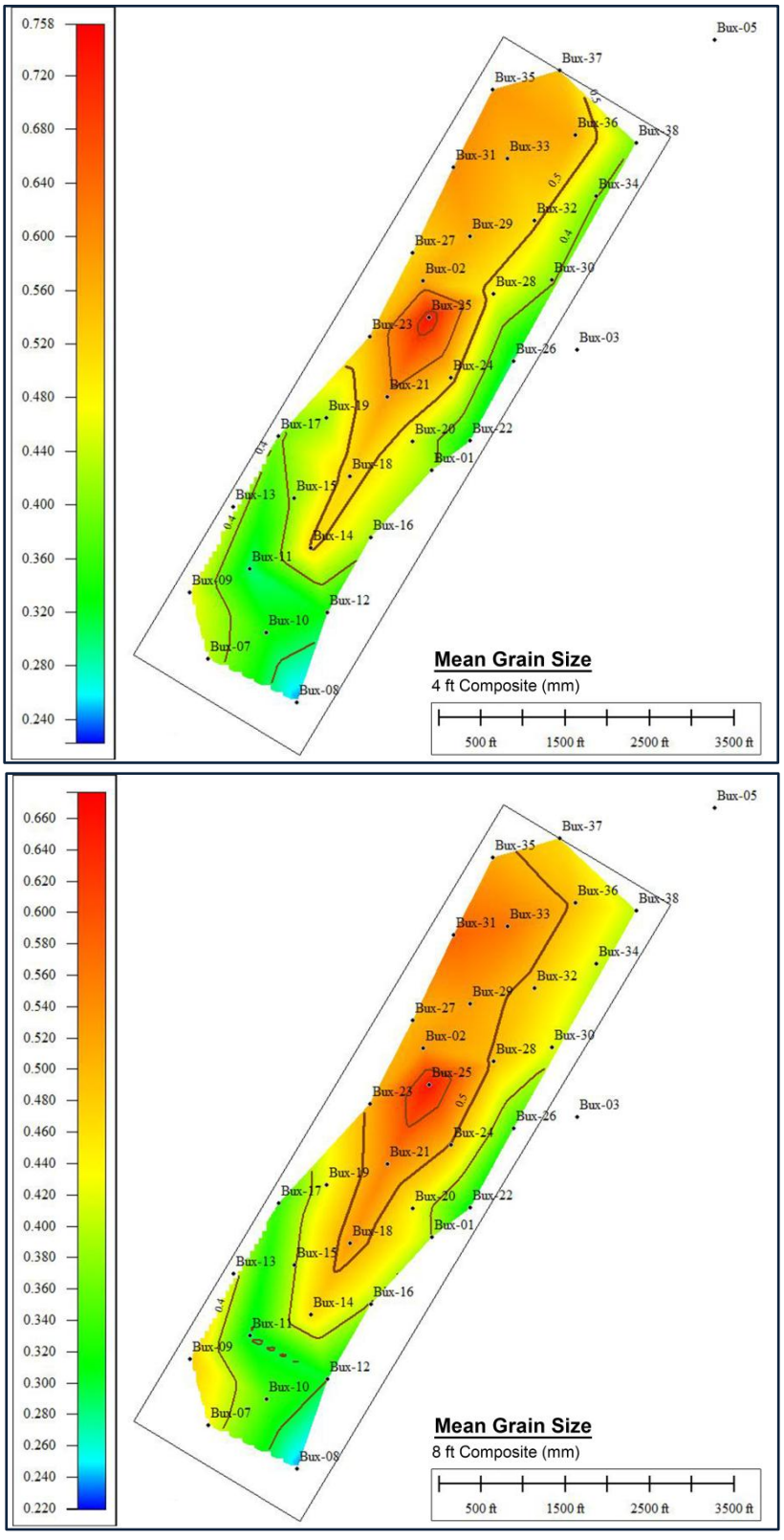


FIGURE 4.5. Isopach map of mean grain size to 4 ft (upper) and 8 ft (lower) based on 30+ cores within the indicated sand search grid off Buxton. Composite results to 6 ft are similar and fall between 4 ft and 8 ft results.

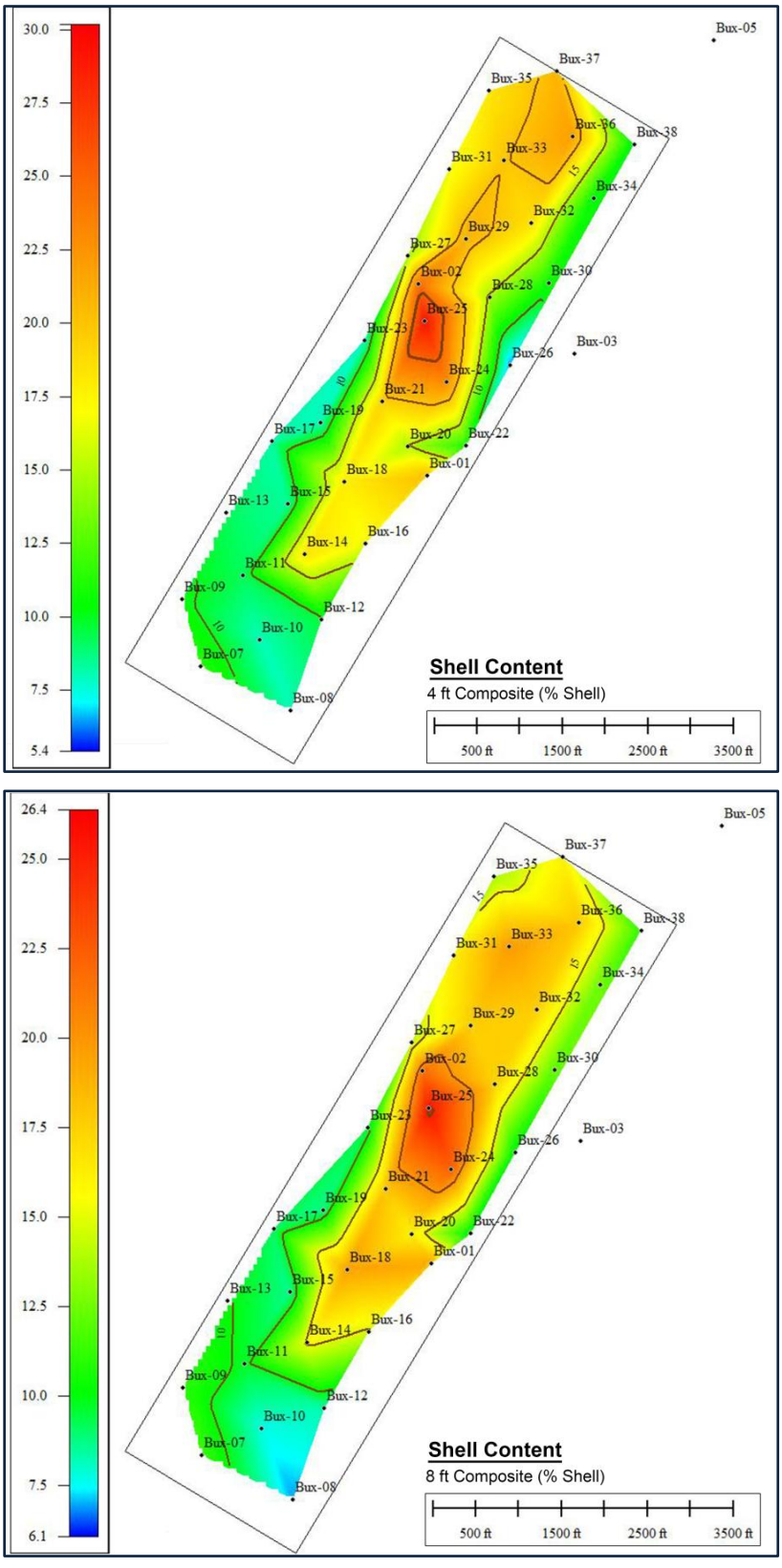


FIGURE 4.6. Isopach map of percent shell to 4 ft (upper) and 8 ft (lower) based on 30+ cores within the indicated sand search grid off Buxton. Composite results to 6 ft are similar and fall between 4 ft and 8 ft results.

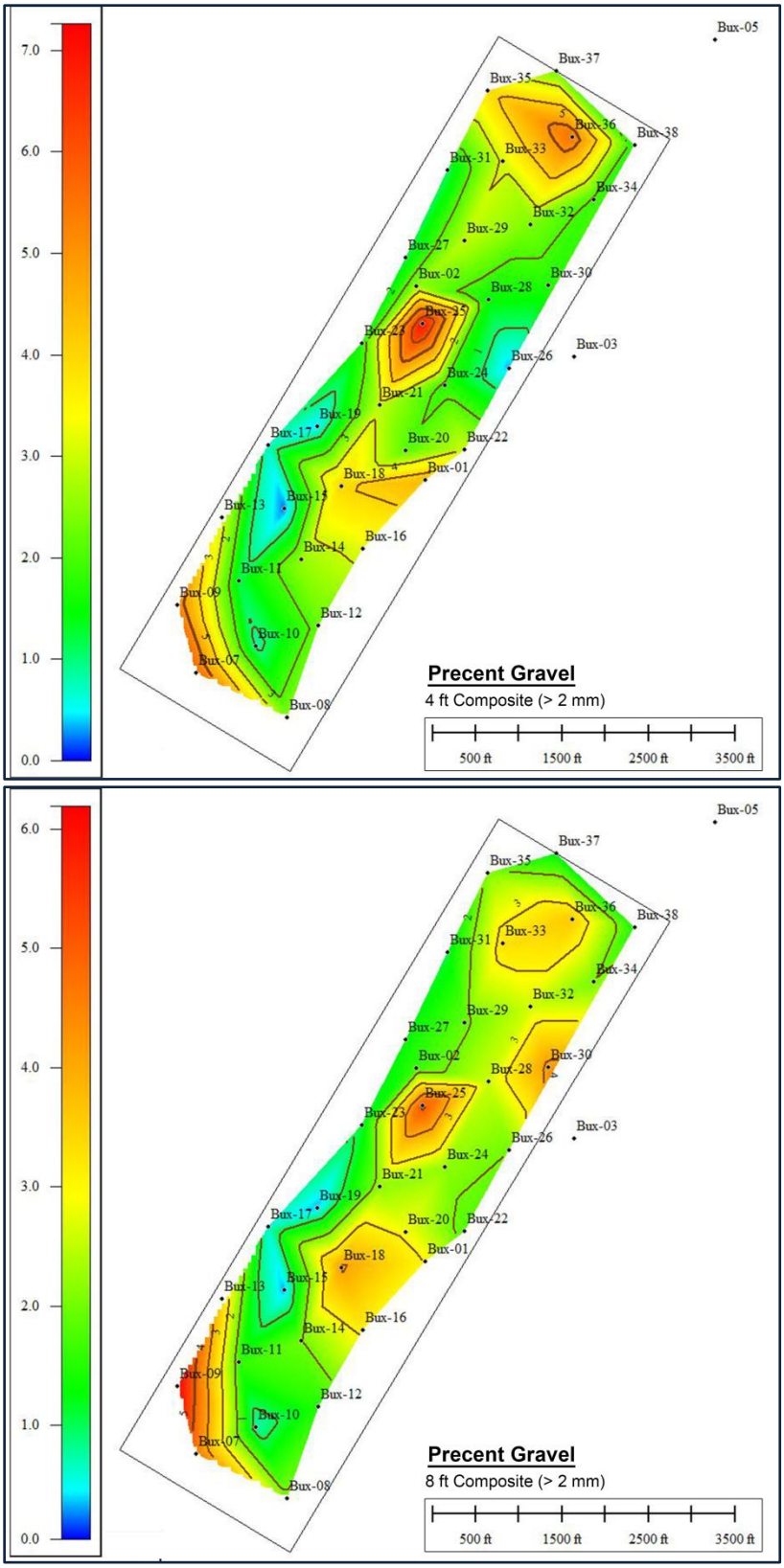


FIGURE 4.7. Isopach map of percent gravel to 4 ft (upper) and 8 ft (lower) based on 30+ cores within the indicated sand search grid off Buxton. Composite results to 6 ft are similar and fall between 4 ft and 8 ft results.

4.2 Oregon Inlet Channel Maintenance for Possible Borrow Source

As part of the review of alternative borrow sources, this section provides results of prior analyses of Oregon Inlet sediments. CSE (2005) obtained a limited number of samples and cores from the Oregon Inlet channel, adjacent spit, and Pea Island disposal area in consideration of possible use of Oregon Inlet dredge spoils for Dare County nourishment projects.

Under USACE Section 933, it is possible for communities to cost-share navigation projects, such as inlet maintenance, and place the spoil directly on the beach. This practice is encouraged to make "best use" of dredged material. If the cost of disposal onshore exceeds the least-cost disposal option (such as offshore disposal), a community has the option of paying the difference to the federal government and receiving the spoil. Such 933 projects have been implemented at Indian Beach and Pine Knoll Shores (NC) (cf, CSE 2004 and www.carteretcountyncgov/295/shore-protection).

A 933 project for Buxton would require transfer of material to an ocean-going hopper dredge, steaming ~45 miles to Buxton, and pumpout of the material via a submerged line to shore. At Bogue Banks (NC), similar projects involved steaming distances of ~20–25 miles. Presently, USACE disposes spoil from the inlet about 0.5 mile south along Pea Island. It is not considered feasible to perform maintenance in the inlet via hopper dredge because of depth limitations. Consequently, spoil would have to be pumped from cutterhead dredges offshore to a hopper dredge with pumpout capability.

For a 933 project to be cost effective, the difference in costs between Pea Island disposal and Buxton disposal would have to be less than the cost of using offshore Area C. Furthermore, the quality of sediment in the inlet would have to be comparable to Area C and the native beach. Otherwise, a larger volume of Oregon Inlet spoil would be required to achieve the same performance as Area C sediment (NRC 1995, Dean 2002).

Figure 4.8 shows localities in the inlet (via custom clam-shell grab sampler), on Bodie Island spit, and on the Pea Island disposal area previously sampled by CSE. Short cores were obtained on Bodie Island spit (OR-10 and OR-11) and on Pea Island (OR-12 and OR-13) to sample through a section of spoil material (ie, surface, 0–1 ft, and 1–2 ft below substrate) from recent inlet maintenance projects. The sediment test results are given in Table 4.6. (For additional information, see USACE 2010.) A glance at Table 4.6 shows that the typical grain size in Oregon Inlet, on Bodie Island spit, and on Pea Island (disposal area) averages ~0.3 mm (medium sand) with low percentages of gravel. This is considerably finer than the

native beach or the majority of samples tested from Buxton beach and offshore Area C. While the CSE sampling was by no means exhaustive, the general lack of coarse sand is not surprising and likely represents conditions for much of the inlet. Pre-project sediment sampling along the National Seashore on Bodie Island and along Nags Head prior to the 2011 nourishment project confirmed Nags Head sand sizes generally fine from north to south. The results for Oregon Inlet sediments reinforced this observed trend.

Based on the significantly finer grain size of Oregon Inlet sands and the long transportation distance, its use as a borrow area for the Buxton project is rejected.

FIGURE 4.8. Oregon Inlet, Bodie Island spit (Cape Hatteras National Seashore), and Pea Island showing general location of sediment samples obtained by CSE (2005) prior to the 2011 nourishment project along Nags Head (USACE 2010). Sample positions in red consisted of triplicate samples from the surface, 0–1 ft, and 1–2 ft below the substrate.

TABLE 4.6. Oregon Inlet sediment characteristics (June-July 2005 survey). Station OR-10 and station OR-11 are on Bodie Island spit; station OR-12 and station OR-13 are on Pea Island. [*P–pebble, G–granule, VCS–very coarse sand, CS–coarse sand, MS–medium sand, FS–fine sand, ms–moderately sorted, mws–moderately well sorted, ws–well sorted, ps–poorly sorted, c-s–coarse skewed, sc-s–strongly coarse skewed, f-s–fine skewed, sym–symmetrical size distribution, ns–nearly symmetrical.] (After CSE 2005, USACE 2010)

Locality	Core	Sample	Interval	Grain Size Distributions			%Coarser	%	%	Sediment
(Borrow Area)	ID	ID	(ft)	Mean (mm)	*Std Dev (mm)*	*Skewness*	*Than 2 mm*	*<0.0625 mm*	*Carbonate*	Description*
Oregon Inlet	**OR-1**	Grab	N/A	**0.420**	0.570	-0.276	11.9	0.00	2.8	MS,ps,sc-s
Shoals & Channel	**OR-2**	Grab	N/A	**0.314**	0.747	-0.237	0.3	0.00	0.4	MS,ws,ns
	OR-3	Grab	N/A	**0.231**	0.710	-0.548	0.0	0.01	0.6	FS,ws,c-s
	OR-4	Grab	N/A	**0.311**	0.461	-0.397	20.5	0.00	18.0	CS,vps,sc-s
	OR-5	Grab	N/A	**0.688**	0.579	0.199	19.0	0.00	2.6	CS,ps,c-s
	OR-6	Grab	N/A	**0.192**	0.793	-0.393	0.1	0.01	0.4	FS,vws,ns
	OR-7	Grab	N/A	**0.233**	0.699	-0.506	0.5	0.01	0.5	FS,ws,c-s
	OR-8	Grab	N/A	**0.359**	0.602	-0.206	1.0	0.00	2.9	MS,ms,ns
	OR-9	Grab	N/A	**0.255**	0.671	-0.784	1.7	0.00	0.7	FS,mws,c-s
	Averages			**0.334**	0.648	-0.350	6.1	0.00	3.2	MS,ms,c-s
Oregon Inlet	**OR-10**	OR-10-A	Surface	**0.247**	0.775	0.086	0.0	0.00	0.3	FS,vws,f-s
Pea Island		OR-10-B	0-1'	**0.244**	0.785	-0.139	0.0	0.00	0.3	FS,vws,f-s
Disposal Area		OR-10-C	1-2'	**0.227**	0.737	0.171	0.0	0.00	0.4	FS,ws,f-s
	OR-11	OR-11-A	Surface	**0.177**	0.732	-0.218	0.0	0.01	0.3	FS,ws,ns
		OR-11-B	0-1'	**0.223**	0.776	0.008	0.0	0.02	2.7	FS,vws,ns
		OR-11-C	1-2'	**0.242**	0.773	-0.336	0.4	0.01	0.4	FS,vws,f-s
	OR-12	OR-12-A	Surface	**0.375**	0.545	-0.425	2.6	0.00	2.6	MS,ms,sc-s
		OR-12-B	0-1'	**0.324**	0.691	-0.346	0.5	0.00	0.7	MS,mws,ns
		OR-12-C	1-2'	**0.397**	0.654	-0.189	0.5	0.01	1.2	MS,mws,ns
	OR-13	OR-13-A	Surface	**0.310**	0.709	0.031	0.2	0.01	0.4	MS,ws,ns
		OR-13-B	0-1'	**0.282**	0.734	-0.050	0.0	0.00	0.2	MS,ws,ns
		OR-13-C	1-2'	**0.278**	0.686	-0.236	0.0	0.00	0.2	MS,mws,c-s
	Averages			**0.290**	0.700	-0.196	0.5	0.00	1.0	MS,ws,ns

5.0 SEDIMENT COMPATIBILITY

CSE evaluated sediment compatibility by comparison of grain-size distribution (GSD) of all "native" beach and offshore borrow areas sampled. Select groups of beach and offshore samples were also compared. The GSDs of each group of samples are weighted composites using the results of individual sample splits to derive numeric results for each size interval. Four groups of native beach samples were considered:

Comp 140 – All samples (n=140)

Comp 130 – Excludes trough samples (n=130)

Comp 120 – Excludes trough and low-tide step samples (n=120)

Comp 60 – Subaerial samples from dune to mid tide (n=60)

Figure 5.1 contains the set of composited beach sample GSDs. A striking result is the poor sorting for the three groups which represent the majority of the October 2014 samples. Only Comp 60 (visible beach) showed moderate sorting. Poor sorting is reflected in the broad size-frequency distributions with no dominant size class. Large proportions of coarse sediment (<1.0 phi) are present in all composites. The size distribution narrows considerably for Comp 60 with a better defined peak in the 0.5–1.5 phi size range (~0.7–0.4 mm). Elimination of the trough and low-tide step samples drops the mean grain size from 0.456 mm (all samples) to 0.380 mm (Comp 120). Comp 60 mean is 0.582 mm versus a mean of ~0.435 mm for August 2013 (summer) subaerial samples.

Similar composite GSDs were computed for cores in the offshore sand search area. All cores in the box and selected cores within a smaller area of the box were evaluated. Table 5.1 lists the available cores and applicable cores for the analysis (ie, "All cores"– n=33 and "Select cores"– n=24). Weighted GSDs were computed for the upper 4 ft, upper 6 ft, and upper 8 ft composited length (Attachment 3).

Figure 5.2 contains the set of composited borrow area GSDs. The results show relative uniformity of size distribution with means ranging from 0.438 mm (all cores to "8 ft") to 0.494 mm (select cores to "4 ft"). Composite borrow sediments were classed as moderately sorted and coarse skewed typical of most beaches (Komar 1998).

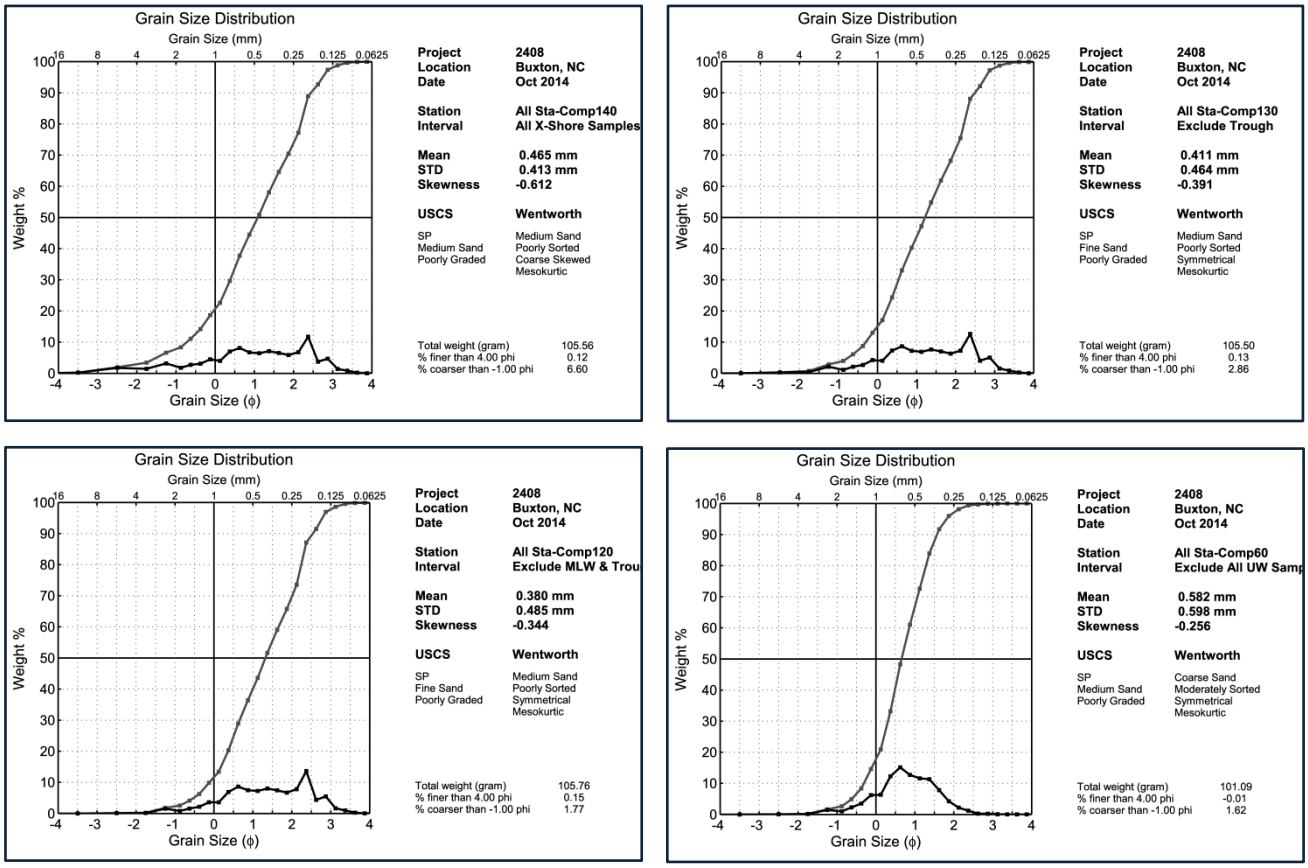
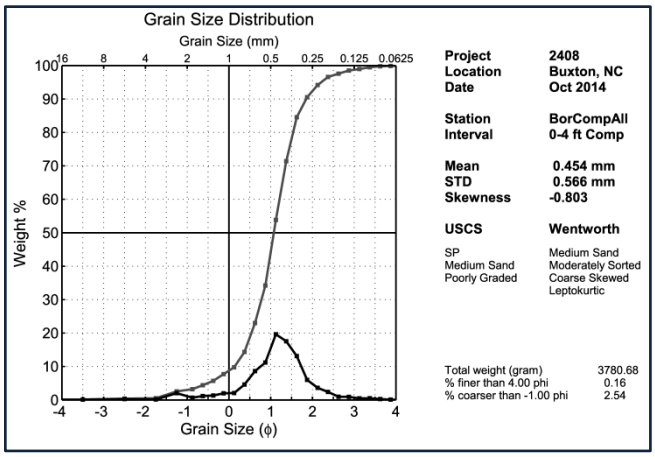
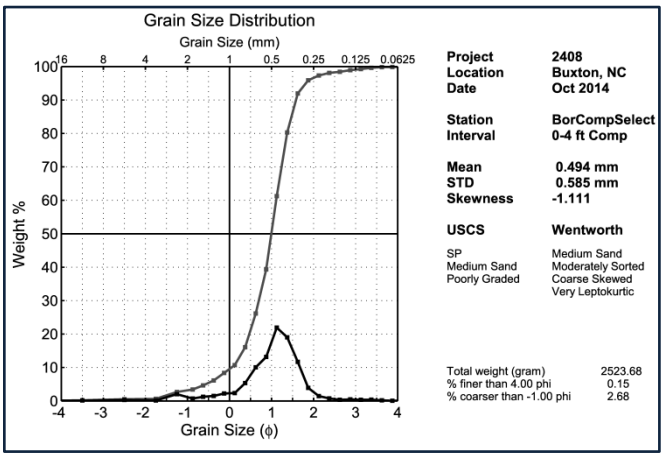


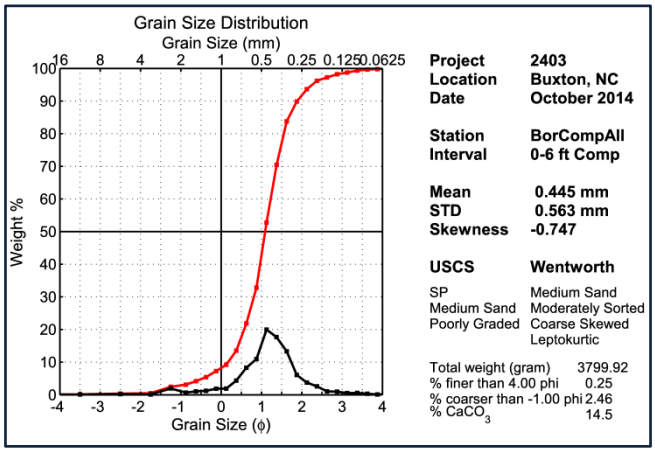
FIGURE 5.1. Grain-size distribution (frequency and cumulative frequency) for composited groups of October 2014 beach samples showing the poor sorting across the littoral zone from the dune to the −24-ft depth contour (Comp 140 n=140). The other graphs show results for select groups of beach samples.

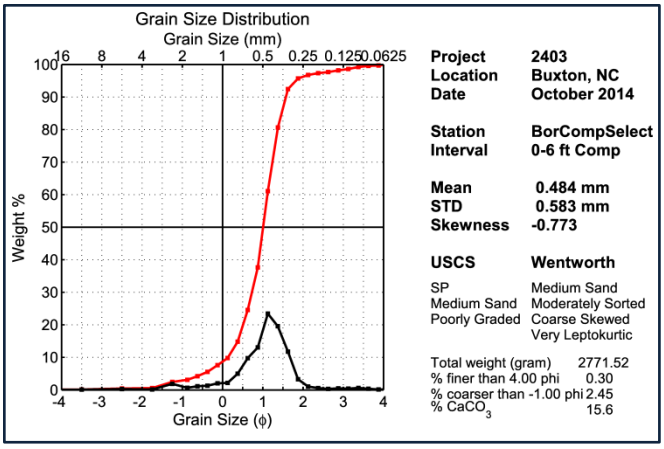
TABLE 5.1. CSE cores obtained off the Buxton project area. Initial cores (August 2013) include four borings (shaded cells) outside the October 2014 sand search area, represented by "All Cores." "Select" cores are a subset of cores within the central ~75 percent of the sand search area.

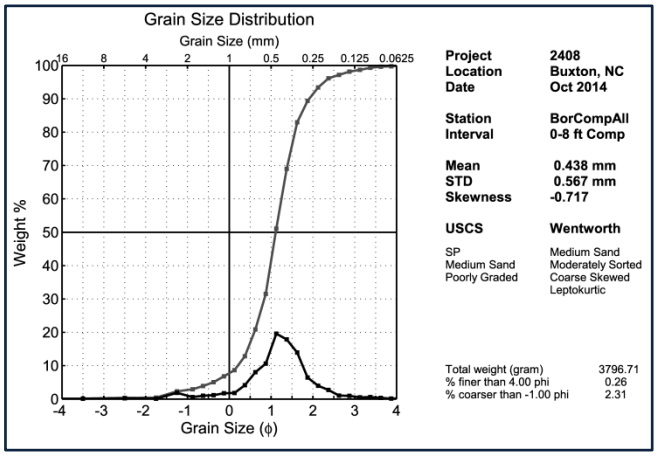
Core #	Length (ft)	Easting	Northing	"All Cores"	Core #	"Select Cores" – 8 ft Composite			Meets NC Criteria
						Mean Size	Shell %	Gravel %	
Bux-01	9.5	3,048,052.11	561,226.75	Bux-01	Bux-02	0.530	21.7	1.6	No*
Bux-02	6.9	3,047,948.70	563,460.43	Bux-02	Bux-07	0.430	11.4	4.7	Yes
Bux-03*	6.6	3,049,777.00	562,649.68	Bux-07	Bux-09	0.483	11.1	6.2	Yes
Bux-04*	7.9	3,049,570.18	567,117.04	Bux-08	Bux-10	0.347	7.7	0.7	Yes
Bux-05*	6.3	3,051,398.48	566,306.29	Bux-09	Bux-11	0.295	9.7	1.6	Yes
Bux-06*	3.4	3,051,295.07	568,539.97	Bux-10	Bux-14	0.465	15.4	2.0	Yes
Bux-07	6.3	3,045,405.53	559,002.16	Bux-11	Bux-15	0.400	8.6	0.3	Yes
Bux-08	7.6	3,046,459.04	558,493.04	Bux-12	Bux-17	0.337	9.1	0.6	Yes
Bux-09	4.5	3,045,193.69	559,784.32	Bux-14	Bux-18	0.530	19.5	4.1	Yes
Bux-10	7.2	3,046,101.67	559,315.65	Bux-15	Bux-19	0.426	8.7	0.3	Yes
Bux-11	5.7	3,045,901.72	560,065.71	Bux-16	Bux-20	0.439	16.1	2.9	Yes
Bux-12	7.1	3,046,822.51	559,552.00	Bux-17	Bux-21	0.552	18.0	2.2	Yes
Bux-13	ND	3,045,708.57	560,794.90	Bux-18	Bux-23	0.513	9.3	1.1	Yes
Bux-14	7.3	3,046,623.90	560,309.27	Bux-19	Bux-24	0.497	22.3	2.2	No*
Bux-15	6.4	3,046,430.41	560,898.02	Bux-20	Bux-25	0.661	25.6	5.2	No*
Bux-16	7.9	3,047,327.59	560,431.72	Bux-21	Bux-27	0.504	14.1	1.3	Yes
Bux-17	4.9	3,046,238.24	561,625.71	Bux-22	Bux-28	0.496	17.5	2.6	Yes
Bux-18	9.3	3,047,081.22	561,159.82	Bux-23	Bux-29	0.524	17.6	1.9	Yes
Bux-19	9.3	3,046,803.59	561,847.64	Bux-24	Bux-31	0.583	16.3	1.1	Yes
Bux-20	9.4	3,047,824.83	561,565.93	Bux-25	Bux-32	0.481	17.6	2.6	Yes
Bux-21	6.9	3,047,525.05	562,090.97	Bux-26	Bux-33	0.563	19.8	3.3	Yes
Bux-22	7.9	3,048,503.65	561,573.20	Bux-27	Bux-35	0.515	13.7	2.1	Yes
Bux-23	8.2	3,047,320.20	562,807.20	Bux-28	Bux-36	0.494	17.9	3.6	Yes
Bux-24	7.0	3,048,283.05	562,321.28	Bux-29	Bux-37	0.470	16.0	1.2	Yes
Bux-25	7.0	3,048,025.59	563,028.85	Bux-30					
Bux-26	8.2	3,049,016.62	562,509.56	Bux-31	**Averages**	0.481	15.2	2.3	Yes
Bux-27	7.4	3,047,827.72	563,794.81	Bux-32					
Bux-28	8.5	3,048,779.51	563,305.25	Bux-33			*>15% shell over ambient		
Bux-29	9.0	3,048,506.09	563,988.74	Bux-34					
Bux-30	9.2	3,049,468.77	563,476.00	Bux-35					
Bux-31	6.3	3,048,308.39	564,799.63	Bux-36					
Bux-32	6.3	3,049,263.50	564,174.98	Bux-37					
Bux-33	5.2	3,048,951.92	564,897.99	Bux-38					
Bux-34	7.6	3,049,994.27	564,459.98						
Bux-35	8.0	3,048,776.92	565,716.91						
Bux-36	9.4	3,049,747.80	565,185.56	**Search Area**	**"Select" Area**				
Bux-37	7.8	3,049,561.71	565,942.48	2250 x 8500 ft	Irregular				
Bux-38	7.2	3,050,467.85	565,091.73	**439.05 Acres**	**~273.7 Acres**				
Average	**7.3**		*Applicable:*	*33 cores*	*24 cores*				
			~Core Density:	**1 per 13.3 Ac**	**1 per 11.4 Ac**				











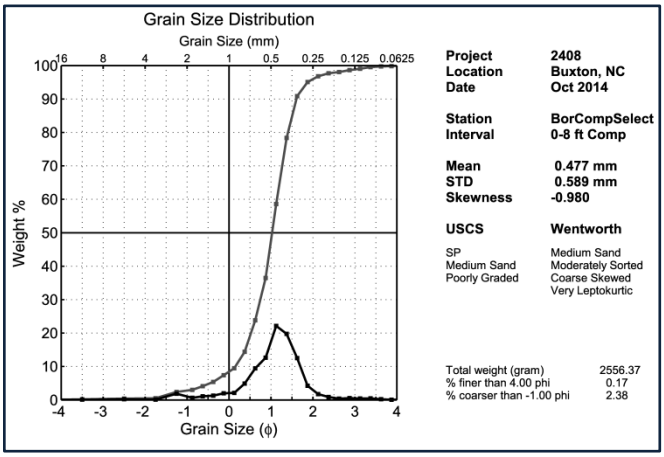


FIGURE 5.2. Grain-size distribution (frequency and cumulative frequency) for composited groups of offshore borings showing better sorting than the "beach" composites (Fig 5.1). The graphs include composite results for "all" (n=33) borings within the offshore sand search area and "select" (n=24) borings encompassing about 75 percent of the sand search area.

Figures 5.3–5.5 provide comparative frequency and cumulative frequency size distributions for native and borrow sediments. The first set of comparisons utilizes all beach samples (n=140) and four different borrow composites within the primary search box. Comparisons of beach sediments are made with the composite 4 ft, 6 ft, and 8 ft borrow sediments for all cores (n=33) and select cores (n=24). Note the close match in D_{50} for each comparison (ie, where the two cumulative curves intersect).

Figure 5.4 offers the same comparisons but utilizes Beach Comp 130 (excluding coarse trough samples). Figure 5.5 shows the comparisons utilizing Beach Comp 60, which omits all underwater samples from the native size distribution. The shapes of the frequency curves match more closely although the subaerial beach means are roughly 0.1–0.15 mm coarser under Comp 60. As previously discussed, sampling of the subaerial beach in August 2013 yielded a mean grain size of 0.435 mm, a result that is within 0.01–0.06 of the various combinations of borrow means in Figures 5.3–5.5.

CSE also computed overfill factors, R_A, for various combinations of native GSDs and each core. The overfill factor, R_A (CERC 1984) provides a measure of how a particular sediment will perform as beach nourishment. Low R_A's are generally preferred, with ideal being equal to 1.0. To apply the method, a native sediment size must be assumed. In this case, three possible native size distributions were applied:

1) Comp 140 representing all sediments sampled on the beach to deep water in October 2014.
2) Comp 130 representing all but the trough sediments.
3) Comp 60 representing all subaerial beach samples.

In the first case, the mean grain size (Mz) is 0.465 mm. In the second case, Mz=0.411 mm, and in the third case, Mz=0.582 mm.

Table 5.2a provides the R_A's for each core composite to 4 ft; Table 5.2b provides R_A's for each core composite to 6 ft; and Table 5.2c provides R_A's for each core composite to 8 ft. [Because mud was only found in trace amounts (order of 0.1 percent), it is not factored into the calculation here.] Each table lists the applicable mean and standard deviation in phi units which are required in the James (1975) formulation (CERC 1984). Inspection of Table 5.2 shows that R_A's range from ~1.0 to >10. Approximately 60 percent of the samples have R_A's less than 2.0 for the various combinations of native samples and composite core depths.

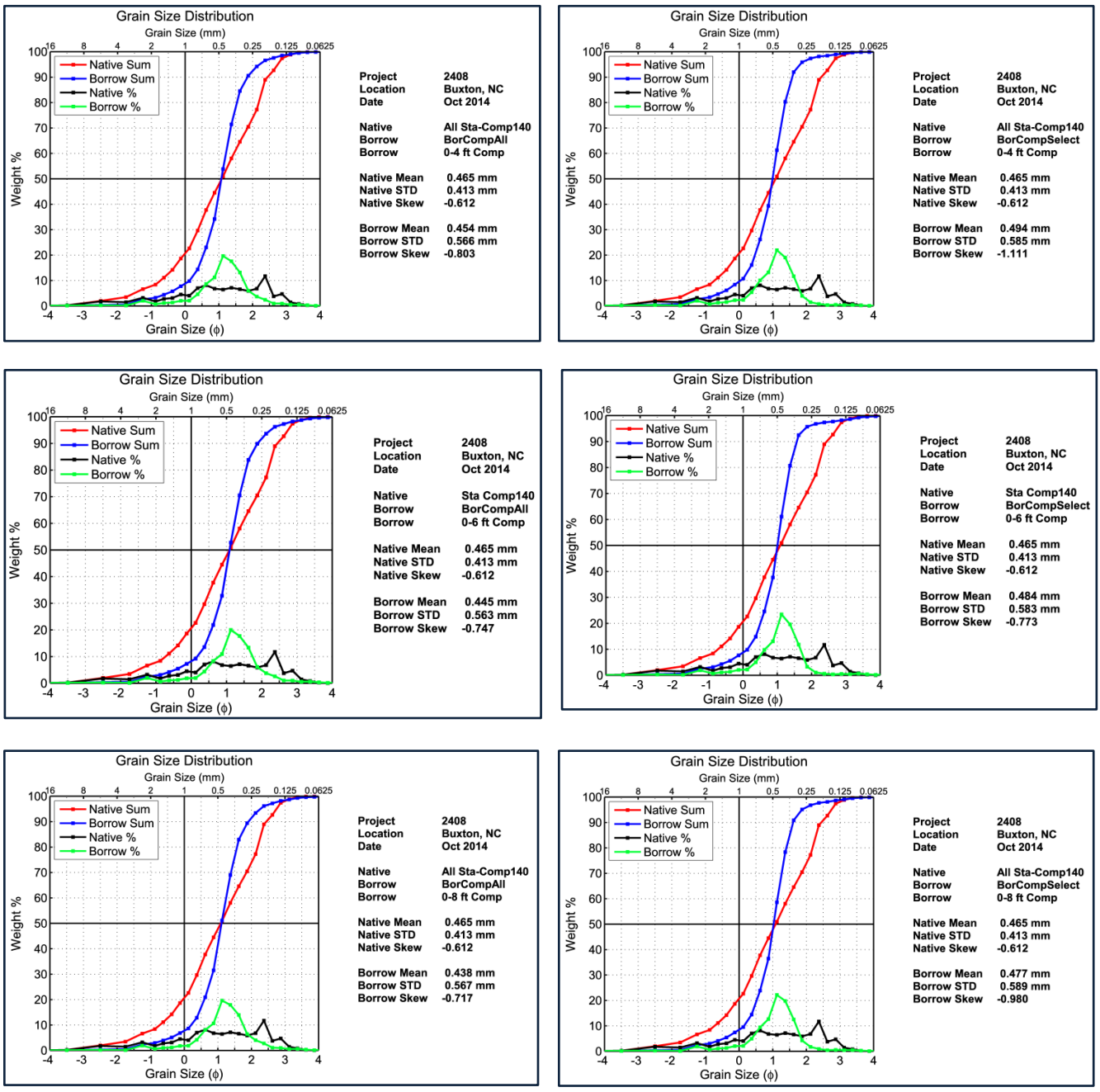


FIGURE 5.3. GSDs for Buxton native beach samples (n=140) compared with offshore samples to (upper) 4 ft (composite), to (middle) 6 ft composite, and to (lower) 8 ft (composite). "BorComp All" applies all 33 cores within the primary sand search area. "BorComp Select" applies to 24 cores from within the central ~75 percent of the sand search area.

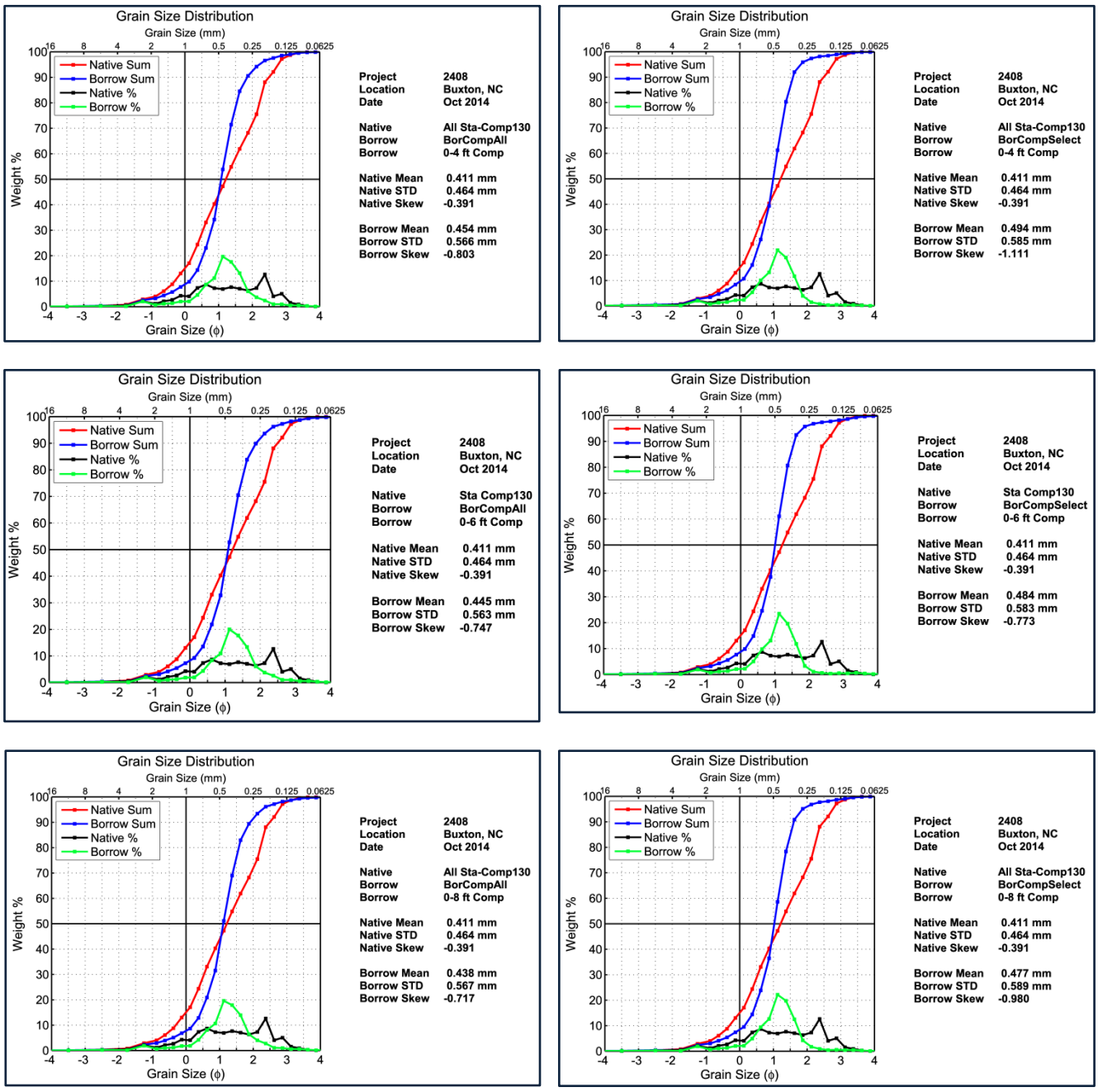


FIGURE 5.4. GSDs for Buxton native beach samples (n=130, omitting trough) compared with offshore samples to (upper) 4 ft (composite), to (middle) 6 ft (composite), and to (lower) 8 ft (composite). "BorComp All" applies to all 33 cores within the primary sand search area. "BorComp Select" applies to 24 cores from within the central ~75 percent of the sand search area.

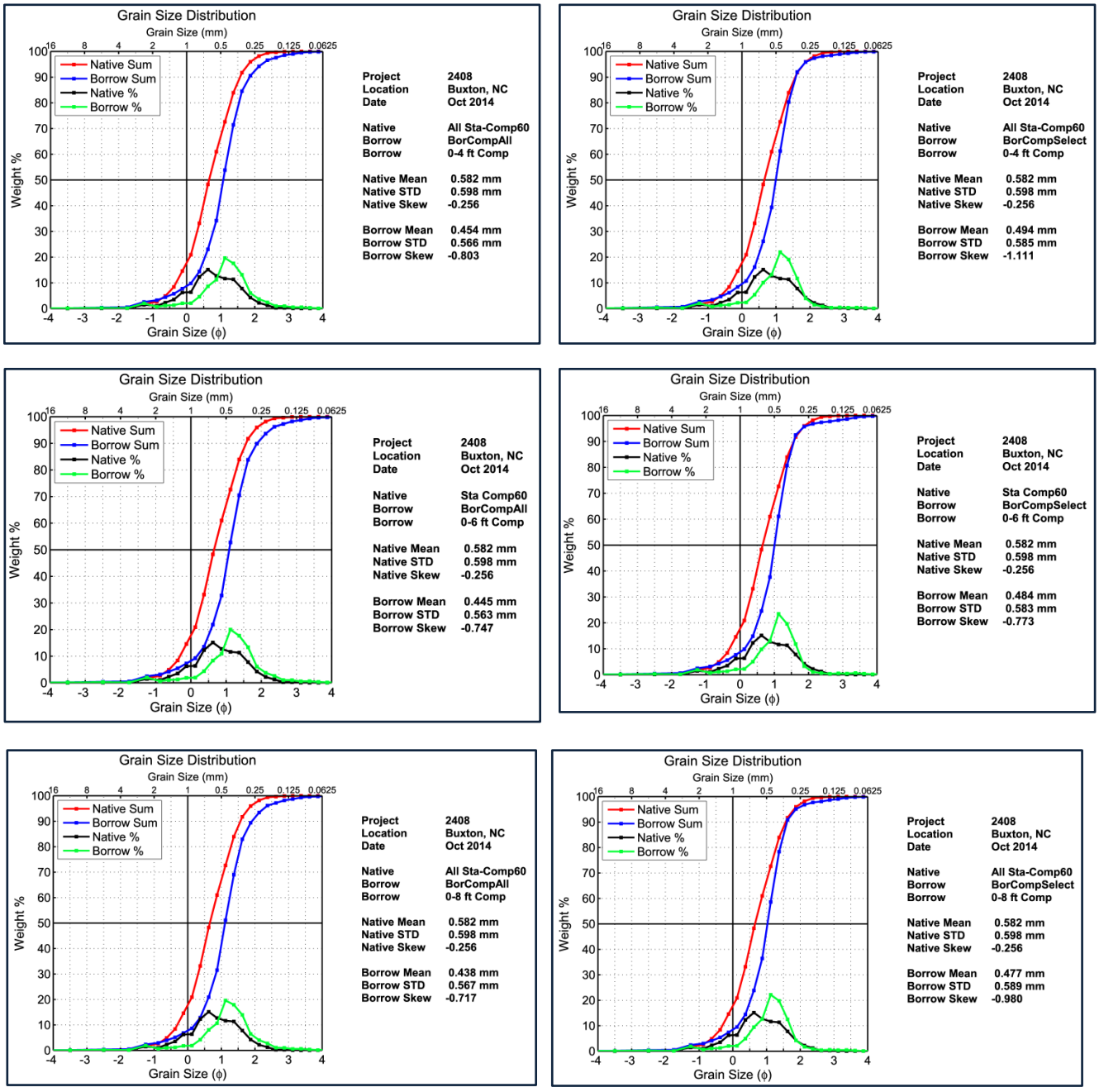


FIGURE 5.5. GSDs for Buxton native beach samples (n=60, only subaerial samples) compared with offshore samples to (upper) 4 ft (composite), to (middle) 6 ft (composite), and to (lower) 8 ft (composite). "BorComp All" applies to all 33 cores within the primary sand search area. "BorComp Select" applies to 24 cores from within the central ~75 percent of the sand search area.

TABLE 5.2a. Computed R_As (overfill factor) for each composite core sample (4 ft composite) compared with three composite native beach results (Comp 140 – all beach samples; Comp 130 – exclude trough samples; Comp 60 – subaerial beach samples).

Buxton Borrow Area Sediment Characteristics		Method of Moments				RA Comp140 Mn=1.104 Sn=1.277	RA Comp60 Mn=.780 Sn=.743	RA Comp130 Mn=1.284 Sn=1.108
		Mean	**STD**	Shell	Gravel			
		phi	**phi**	%	%			
Bux 1	0-4 ft Comp	**1.268**	**0.913**	20.3	4.5	1.7	1.9	1.1
Bux 2	0-4 ft Comp	**0.822**	**0.632**	24.4	2.5	1.6	1.2	1.0
Bux 3	0-4 ft Comp	**1.904**	**1.067**	11.0	2.6	4.1	4.3	2.3
Bux 4	0-4 ft Comp	**1.126**	**0.633**	12.7	1.0	3.6	2.5	1.5
Bux 5	0-4 ft Comp	**1.483**	**0.768**	9.6	2.3	5.6	4.3	2.0
Bux 6	0-4 ft Comp	**0.685**	**2.293**	39.9	27.7	1.2	1.5	1.2
Bux 7	0-4 ft Comp	**1.204**	**0.964**	11.4	5.8	1.4	1.6	1.0
Bux 8	0-4 ft Comp	**2.063**	**0.946**	8.0	2.4	10.0	10.0	4.8
Bux 9	0-4 ft Comp	**1.096**	**1.153**	10.3	5.4	1.1	1.4	1.0
Bux 10	0-4 ft Comp	**1.557**	**0.532**	8.0	0.8	10.0	10.0	10.0
Bux 11	0-4 ft Comp	**1.746**	**1.049**	9.2	1.2	3.0	3.3	1.9
Bux 12	0-4 ft Comp	**1.613**	**0.797**	9.6	2.2	8.6	5.8	2.5
Bux 14	0-4 ft Comp	**0.974**	**0.719**	18.3	2.6	1.6	1.4	1.1
Bux 15	0-4 ft Comp	**1.281**	**0.456**	8.4	0.2	10.0	10.0	10.0
Bux 16	0-4 ft Comp	**1.231**	**0.832**	16.7	3.2	1.9	2.0	1.2
Bux 17	0-4 ft Comp	**1.345**	**0.884**	8.2	0.7	2.1	2.2	1.3
Bux 18	0-4 ft Comp	**0.938**	**0.725**	17.9	4.0	1.5	1.3	1.0
Bux 19	0-4 ft Comp	**1.253**	**0.420**	7.9	0.4	10.0	10.0	10.0
Bux 20	0-4 ft Comp	**1.133**	**0.674**	14.8	2.1	2.8	2.2	1.3
Bux 21	0-4 ft Comp	**0.777**	**0.658**	19.4	2.9	1.4	1.1	1.0
Bux 22	0-4 ft Comp	**1.635**	**0.926**	11.2	3.0	3.6	3.6	1.9
Bux 23	0-4 ft Comp	**0.871**	**0.567**	7.7	1.7	2.3	1.5	1.2
Bux 24	0-4 ft Comp	**0.945**	**0.594**	23.0	1.8	2.5	1.7	1.2
Bux 25	0-4 ft Comp	**0.433**	**0.940**	29.3	7.1	1.0	1.0	1.0
Bux 26	0-4 ft Comp	**1.731**	**0.616**	6.2	0.3	10.0	10.0	10.0
Bux 27	0-4 ft Comp	**0.945**	**0.525**	14.4	1.2	4.3	2.2	1.4
Bux 28	0-4 ft Comp	**1.053**	**0.596**	14.6	1.5	3.6	2.3	1.4
Bux 29	0-4 ft Comp	**0.823**	**0.634**	21.0	2.9	1.6	1.2	1.0
Bux 30	0-4 ft Comp	**1.289**	**0.716**	10.8	1.7	3.7	3.0	1.6
Bux 31	0-4 ft Comp	**0.742**	**0.510**	16.6	1.1	2.1	1.3	1.1
Bux 32	0-4 ft Comp	**0.975**	**0.699**	18.5	2.4	1.7	1.5	1.1
Bux 33	0-4 ft Comp	**0.846**	**0.657**	19.9	3.1	1.5	1.2	1.0
Bux 34	0-4 ft Comp	**1.319**	**0.671**	10.5	1.9	6.6	4.0	1.9
Bux 35	0-4 ft Comp	**0.758**	**0.743**	18.2	3.9	1.2	1.1	1.0
Bux 36	0-4 ft Comp	**0.821**	**0.881**	22.0	5.6	1.1	1.1	1.0
Bux 37	0-4 ft Comp	**0.882**	**0.599**	20.7	2.3	2.0	1.4	1.1
Bux 38	0-4 ft Comp	**1.330**	**0.688**	10.0	1.7	5.7	3.8	1.9

TABLE 5.2b. Computed R_As (overfill factor) for each composite core sample (6 ft composite) compared with three composite native beach results (Comp 140 – all beach samples; Comp 130 – exclude trough samples; Comp 60 – subaerial beach samples).

Buxton Borrow Area Sediment Characteristics		Method of Moments				RA Comp140 Mn=1.104 Sn=1.277	RA Comp60 Mn=.780 Sn=.743	RA Comp130 Mn=1.284 Sn=1.108
		Mean	**STD**	Shell	Gravel			
		phi	**phi**	%	%			
Bux 1	0-6 ft Comp	**1.319**	**0.866**	19.2	3.0	2.1	2.2	1.3
Bux 2	0-6 ft Comp	**0.887**	**0.603**	21.7	1.6	2.0	1.4	1.1
Bux 3	0-6 ft Comp	**1.629**	**1.330**	13.8	5.9	1.6	2.1	1.3
Bux 4	0-6 ft Comp	**1.055**	**0.631**	16.9	1.4	2.8	2.1	1.3
Bux 5	0-6 ft Comp	**1.682**	**0.864**	15.4	1.9	6.2	5.1	2.4
Bux 6	0-6 ft Comp	**0.685**	**2.293**	39.9	27.7	1.6	1.5	1.2
Bux 7	0-6 ft Comp	**1.216**	**0.885**	11.4	4.7	1.6	1.8	1.1
Bux 8	0-6 ft Comp	**2.076**	**0.911**	6.9	2.1	10.0	10.0	6.2
Bux 9	0-6 ft Comp	**1.050**	**1.220**	11.1	6.2	1.0	1.4	1.0
Bux 10	0-6 ft Comp	**1.540**	**0.527**	7.7	0.7	10.0	10.0	10.0
Bux 11	0-6 ft Comp	**1.761**	**1.102**	9.7	1.6	2.7	3.1	1.8
Bux 12	0-6 ft Comp	**1.731**	**0.770**	8.3	1.5	10.0	10.0	4.1
Bux 14	0-6 ft Comp	**1.049**	**0.708**	15.4	2.0	2.0	1.7	1.1
Bux 15	0-6 ft Comp	**1.286**	**0.489**	8.6	0.3	10.0	10.0	7.3
Bux 16	0-6 ft Comp	**1.314**	**0.825**	14.7	3.1	2.4	2.3	1.3
Bux 17	0-6 ft Comp	**1.568**	**1.106**	9.1	0.6	2.0	2.3	1.4
Bux 18	0-6 ft Comp	**0.882**	**0.738**	19.5	4.1	1.4	1.2	1.0
Bux 19	0-6 ft Comp	**1.259**	**0.415**	8.7	0.3	10.0	10.0	10.0
Bux 20	0-6 ft Comp	**1.138**	**0.739**	16.1	2.9	2.1	1.9	1.2
Bux 21	0-6 ft Comp	**0.841**	**0.650**	18.0	2.2	1.6	1.2	1.0
Bux 22	0-6 ft Comp	**1.710**	**0.855**	9.9	1.8	7.7	5.9	2.7
Bux 23	0-6 ft Comp	**0.942**	**0.537**	9.3	1.1	3.7	2.0	1.4
Bux 24	0-6 ft Comp	**0.996**	**0.642**	22.3	2.2	2.2	1.7	1.2
Bux 25	0-6 ft Comp	**0.549**	**0.896**	25.6	5.2	1.0	1.0	1.0
Bux 26	0-6 ft Comp	**1.641**	**0.725**	9.9	2.0	10.0	10.0	3.9
Bux 27	0-6 ft Comp	**0.925**	**0.543**	14.1	1.3	3.3	1.9	1.3
Bux 28	0-6 ft Comp	**0.967**	**0.652**	17.5	2.6	2.0	1.6	1.1
Bux 29	0-6 ft Comp	**0.911**	**0.587**	17.6	1.9	2.3	1.6	1.2
Bux 30	0-6 ft Comp	**1.129**	**0.987**	12.1	4.2	1.2	1.5	1.0
Bux 31	0-6 ft Comp	**0.776**	**0.529**	16.3	1.1	2.1	1.3	1.1
Bux 32	0-6 ft Comp	**1.052**	**0.721**	17.6	2.6	1.9	1.7	1.1
Bux 33	0-6 ft Comp	**0.828**	**0.658**	19.8	3.3	1.5	1.2	1.0
Bux 34	0-6 ft Comp	**1.214**	**0.698**	12.4	2.0	3.2	2.6	1.4
Bux 35	0-6 ft Comp	**0.860**	**0.660**	13.7	2.1	3.2	1.2	1.0
Bux 36	0-6 ft Comp	**0.964**	**0.826**	17.9	3.6	3.2	1.3	1.0
Bux 37	0-6 ft Comp	**1.010**	**0.581**	16.0	1.2	1.6	2.1	1.4
Bux 38	0-6 ft Comp	**1.281**	**0.684**	11.2	1.5	4.6	1.5	1.7

TABLE 5.2c. Computed R_As (overfill factor) for each composite core sample (8 ft composite) compared with three composite native beach results (Comp 140 – all beach samples; Comp 130 – exclude trough samples; Comp 60 – subaerial beach samples).

Buxton Borrow Area Sediment Characteristics		Method of Moments				RA Comp140 Mn=1.104 Sn=1.277	RA Comp60 Mn=.780 Sn=.743	RA Comp130 Mn=1.284 Sn=1.108
		Mean	**STD**	Shell	Gravel			
		phi	**phi**	%	%			
Bux 1	0-8 ft Comp	**1.328**	**0.835**	19.2	3.0	2.4	2.3	1.3
Bux 2	0-8 ft Comp	**0.916**	**0.594**	21.7	1.6	2.3	1.6	1.2
Bux 3	0-8 ft Comp	**1.629**	**1.330**	13.8	5.9	1.6	2.1	1.3
Bux 4	0-8 ft Comp	**1.156**	**0.879**	16.9	1.4	1.5	1.6	1.1
Bux 5	0-8 ft Comp	**1.715**	**0.875**	15.4	1.9	6.5	5.4	2.5
Bux 6	0-8 ft Comp	**0.685**	**2.293**	39.9	27.7	1.2	1.5	1.2
Bux 7	0-8 ft Comp	**1.218**	**0.878**	11.4	4.7	1.7	1.8	1.1
Bux 8	0-8 ft Comp	**2.103**	**0.875**	6.9	2.1	10.0	10.0	9.8
Bux 9	0-8 ft Comp	**1.050**	**1.220**	11.1	6.2	1.0	1.4	1.0
Bux 10	0-8 ft Comp	**1.528**	**0.527**	7.7	0.7	10.0	10.0	10.0
Bux 11	0-8 ft Comp	**1.761**	**1.102**	9.7	1.6	2.7	3.1	1.8
Bux 12	0-8 ft Comp	**1.742**	**0.752**	8.3	1.5	10.0	27.9	4.9
Bux 14	0-8 ft Comp	**1.106**	**0.683**	15.4	2.0	2.5	2.0	1.3
Bux 15	0-8 ft Comp	**1.321**	**0.539**	8.6	0.3	10.0	10.0	4.4
Bux 16	0-8 ft Comp	**1.336**	**0.830**	14.7	3.1	2.4	2.4	1.4
Bux 17	0-8 ft Comp	**1.568**	**1.106**	9.1	0.6	2.0	2.3	1.4
Bux 18	0-8 ft Comp	**0.917**	**0.724**	19.5	4.1	1.5	1.3	1.0
Bux 19	0-8 ft Comp	**1.230**	**0.450**	8.7	0.3	10.0	10.0	10.0
Bux 20	0-8 ft Comp	**1.188**	**0.758**	16.1	2.9	2.2	2.1	1.2
Bux 21	0-8 ft Comp	**0.856**	**0.646**	18.0	2.2	1.6	1.2	1.1
Bux 22	0-8 ft Comp	**1.713**	**0.797**	9.9	1.8	10.0	9.2	3.4
Bux 23	0-8 ft Comp	**0.964**	**0.573**	9.3	1.1	3.0	1.9	1.3
Bux 24	0-8 ft Comp	**1.009**	**0.648**	22.3	2.2	2.3	1.7	1.2
Bux 25	0-8 ft Comp	**0.597**	**0.871**	25.6	5.2	1.0	1.0	1.0
Bux 26	0-8 ft Comp	**1.581**	**0.773**	9.9	2.0	9.7	6.0	2.6
Bux 27	0-8 ft Comp	**0.990**	**0.581**	14.1	1.3	3.1	2.0	1.3
Bux 28	0-8 ft Comp	**1.010**	**0.683**	17.5	2.6	2.0	1.6	1.1
Bux 29	0-8 ft Comp	**0.934**	**0.567**	17.6	1.9	2.8	1.8	1.3
Bux 30	0-8 ft Comp	**1.237**	**0.931**	12.1	4.2	1.6	1.7	1.1
Bux 31	0-8 ft Comp	**0.779**	**0.533**	16.3	1.1	2.1	1.3	1.1
Bux 32	0-8 ft Comp	**1.057**	**0.725**	17.6	2.6	1.9	1.7	1.1
Bux 33	0-8 ft Comp	**0.828**	**0.658**	19.8	3.3	1.5	1.2	1.0
Bux 34	0-8 ft Comp	**1.270**	**0.734**	12.4	2.0	3.1	2.7	1.5
Bux 35	0-8 ft Comp	**0.957**	**0.658**	13.7	2.1	1.9	1.5	1.1
Bux 36	0-8 ft Comp	**1.018**	**0.782**	17.9	3.6	1.5	1.4	1.0
Bux 37	0-8 ft Comp	**1.088**	**0.564**	16.0	1.2	6.3	3.0	1.7
Bux 38	0-8 ft Comp	**1.313**	**0.707**	11.2	1.5	4.4	3.3	1.7

Nearly 80 percent of the core composites to 4 ft, 6 ft, or 8 ft have low R_A's when compared with the Comp 130 native size distribution (omits the outlier trough samples). While R_A's are not considered to be definitive in matching sediment texture for nourishment (Dean 2002), the results herein suggest the majority of cores will provide good nourishment performance. The overlap of the GSDs (Figs 5.3–5.5) further supports this finding.

Oregon Inlet sediment was compared with Nags Head sediment by CSE (CSE 2005, USACE 2010) and was found to be significantly finer than the Nags Head native beach. Table 4.6 (USACE 2010) previously showed that 14 of 21 samples had a mean grain size of <0.31 mm. Table 5.3 provides the phi measures used in the calculation of R_A's. When compared against the Nags Head native mean grain size of 0.36 or 0.47, the Oregon Inlet sediments were found to have high R_A's (>7.0). This means that at least seven times more sediment would be required to yield the same performance as sediments with R_A's=1.0 along Nags Head. Based on the fact that Buxton native sediments test coarser than Nags Head sediments, CSE concludes that R_A's for Buxton would be even higher, making Oregon Inlet sands even less stable for nourishment.

TABLE 5.3. Nags Head sediment compatibility comparing Oregon Inlet sediment with the Nags Head native beach sand. (Comp 110 is a composite of 110 beach samples from the foredune to the outer littoral zone.) [From USACE 2010]

Overfill Ratios Based On Native Beach Equals Composite of All Samples (Comp 110)						**MzNative=**	**1.465** phi *(0.362 mm)*	
						StdDevNat=	**1.091** phi *(0.469 mm)*	
Borrow	**Core**	**Sample**	**Sediment**	**Moment Measures**		X	Y	**Overfill Ratio (R_A)**
Area	**ID**	**Number**	**Description****	**M-phi-b**	**Sigma-b**	**(Mb-Mn)/SDn**	**(SDb/SDn)**	(R_A) on Comp 110
Oregon Inlet	**OR-1**	N/A	MS,ps,sc-s	1.252	0.812	-0.20	0.74	**1.24**
Channel	**OR-2**	N/A	MS,ws,ns	1.672	0.421	0.19	0.39	**>10**
Spit	**OR-3**	N/A	FS,ws,c-s	2.113	0.493	0.59	0.45	**>10**
& Pea Island	**OR-4**	N/A	CS,vps,sc-s	1.687	1.118	0.20	1.02	**1.2**
	OR-5	N/A	CS,ps,c-s	0.540	0.788	-0.85	0.72	**1.02**
	OR-6	N/A	FS,vws,ns	2.377	0.334	0.84	0.31	**>10**
	OR-7	N/A	FS,ws,c-s	2.103	0.516	0.58	0.47	**>10**
	OR-8	N/A	MS,ms,ns	1.479	0.733	0.01	0.67	**1.7**
	OR-9	N/A	FS,mws,c-s	1.974	0.576	0.47	0.53	**>10**
	OR-10	OR-10-A	FS,vws.f-s	2.015	0.367	0.50	0.34	**>10**
		OR-10-B	FS,vws,f-s	2.037	0.348	0.52	0.32	**>10**
		OR-10-C	FS,ws,f-s	2.139	0.441	0.62	0.40	**>10**
	OR-11	OR-11-A	FS,ws,ns	2.495	0.451	0.94	0.41	**>10**
		OR-11-B	FS,vws.ns	2.163	0.366	0.64	0.34	**>10**
		OR-11-C	FS,vws,f-s	2.047	0.371	0.53	0.34	**>10**
	OR-12	OR-12-A	MS,ms.sc-s	1.413	0.875	-0.05	0.80	**1.24**
		OR-12-B	MS,mws,ns	1.626	0.534	0.15	0.49	**5.0**
		OR-12-C	MS,mws,ns	1.333	0.613	-0.12	0.56	**2.0**
	OR-13	OR-13-A	MS,ws,ns	1.691	0.495	0.21	0.45	**>10**
		OR-13-B	MS,ws,ns	1.824	0.446	0.33	0.41	**>10**
		OR-13-C	MS,mws,c-s	1.848	0.543	0.35	0.50	**>10**
							Average	**>7.0**

Table 5.1 provided a measure of the core density within the offshore sand search area (2,250 ft by 8,500 ft) and a central corridor representing ~75 percent of the sand search area ("Select Cores"). These areas total ~439 acres and 238 acres (respectively) and are represented by 33 cores and 24 cores. The corresponding range in core density is one core per 11.4–13.3 acres. This density exceeds North Carolina standards for offshore borrow areas under Code 15A NCAC 07H.0312.

The final borrow area for the Buxton project will be determined after results of cultural resource surveys (in progress). Nevertheless, the following areas potentially provide sufficient volume to accomplish an ~2.6 million cubic yard project (Table 5.4). The minimum excavation area to provide the design volume would be ~200 acres, assuming a dredge cut averaging ~8 ft deep. More realistically, to avoid deep dredge cuts, an area 250–300 acres (ie, ~60-70 percent of the offshore search area) could provide the design volume with excavations averaging 6–7 ft.

TABLE 5.4. Sediment volumes contained in the indicated areas and depths (section thickness).

Area Acres	Volume (cy)				
	To 4 ft	To 5 ft	To 6 ft	To 7 ft	To 8 ft
200					**2,581,333**
250				**2,823,333**	3,226,667
300			**2,904,000**	3,388,000	3,872,000
350		**2,823,333**	3,388,000	3,952,667	4,517,333
400	**2,581,333**	3,226,667	3,872,000	4,517,333	5,162,667

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