Table 5.1
Grain Size Analysis for Jet Probe Samples
Jet Probes Located on or Near the Centerline of the Proposed Channel

Sample	Approx. Depth ft NGVD	Mean (mm) M_{mm}	Mean (phi) M_{phi}	Sorting S_{phi}	Variance S^2_{phi}	% Silt <230 sieve	% > 2 mm	%> 1 mm	Type of Analysis
			BIJP-02-01						
Top	-4.9	0.20	2.30	0.58	0.34	1.52	0.15	0.43	Sieve
Middle	-11.9	.18 to .25	--	--		--			Visual
Bottom	-18.9	.20 to .25	--	--		--			Visual
			BIJP-02-03						
Top	-11.7	.25 to .35	--	--		--			Visual
Middle	-18.4	.23 to .30	--	--		--			Visual
Bottom	-25.2	0.25	2.00	0.74	0.55	1.71	0.19	0.94	Sieve
			BIJP-02-05						
Top	-4.3	.23 to .27	--	--		--			Visual
Middle	-13.8	0.25	1.99	0.89	0.79	1.27	0.35	1.94	Sieve
Bottom	-23.3	.23 to .27	--	--		--			Visual
			BIJP-02-07						
Top	-3.4	0.20	2.32	0.45	0.20	1.52	0.20	0.50	Sieve
Middle	-13.4	.18 to .23	--	--		--			Visual
Bottom	-23.4	.20 to .25	--	--		--			Visual
			BIJP-02-08						
Top	-12.3	0.29	1.77	0.95	0.90	1.38	1.55	4.10	Sieve
Middle	-19.0	.30 to .40	--	--		--			Visual
Bottom	-25.8	.30 to .40	--	--		--			Visual
			BIJP-02-09						
Top	-4.5	.18 to .23	--	--		--			Visual
Middle	-12.5	0.26	1.92	0.72	0.52	1.34	0.46	1.51	Sieve
Bottom	-20.5	.20 to .25	--	--		--			Visual
			BIJP-02-11						
Top	-2.8	0.30	1.74	0.66	0.44	1.03	0.32	1.33	Sieve
Middle	-8.8	.25 to .30	--	--		--			Visual
Bottom	-14.8	.33 to .35	--	--		--			Visual
			BIJP-02-13						
Top	-3.4	.38 to .42	--	--		--			Visual
Middle	-10.4	0.35	1.52	1.10	1.21	1.53	2.64	6.97	Sieve
Bottom	-17.4	.38 to .42	--	--		--			Visual
			BIJP-02-14						
Top	-4.4	.25 to .30	--	--		--			Visual
Middle	-11.4	.20 to .25	--	--		--			Visual
Bottom	-18.4	0.30	1.75	0.78	0.61	1.39	0.93	2.75	Sieve
			BIJP-02-15						
Top	-5.4	0.36	1.49	0.65	0.42	1.14	0.06	1.01	Sieve
Middle	-13.9	.30 to .35	--	--		--			Visual
Bottom	-22.4	.33 to .38	--	--		--			Visual
			BIJP-02-16						
Top	-6.5	0.20	2.35	0.49	0.24	1.78	0.01	0.17	Sieve
Middle	-14.2	.17 to .23	--	--		--			Visual
Bottom	-22.0	.17 to .23	--	--		--			Visual
			BIJP-02-17						
Top	-5.5	.20 to .25	--	--		--			Visual
Middle	-13.5	.25 to .30	--	--		--			Visual
Bottom	-21.5	0.33	1.59	0.68	0.46	1.52	0.31	0.31	Sieve
			BIJP-02-18						
Top	-14.7	0.16	2.63	0.49		1.77	0.00	0.08	Sieve
Middle	-24.2	.17 to .23	--	--		--			Visual
Bottom	-33.7	.17 to .23	--	--		--			Visual
			BIJP-02-19						
Top	-11.4	0.36	1.48	0.90	0.81	1.93	0.65	4.27	Sieve
Middle	-19.9	.40 to .45	--	--		--			Visual
Bottom	-28.4	.30 to .35	--	--		--			Visual
Avg all Sieve Samples		**0.27**	**1.92**	**0.76**	**0.58**	**1.49**	**0.56**	**1.88**	

Table 5.2
Computed Composite Distributions 2002 Bogue Inlet Vibracores
For Channel Depths of -13.5-ft, -15.5-ft, and 17.5-ft NGVD

Depth of Cut Feet below NGVD	Phi (M_{Φ})	Mean (mm) (M_{mm})	Phi Sorting (s_{Φ})	Percent Silt d≤ 0.0625mm	Percent d≥ 2 mm	Percent d≥ 1 mm
-13.5	1.72	.30	1.05	1.25	4.97	8.58
-15.5	1.76	.30	0.98	1.25	4.65	8.09
-17.5	1.67	.31	1.14	1.24	4.40	7.97

5.2. Characteristics of the Native Beach Material. When beach fill material is placed on the upper portion of the beach profile, it undergoes a certain degree of sorting by wave action that tends to move discrete grain sizes to quasi-equilibrium positions on the active beach profile. In general, the coarser fraction of the material will remain on the upper or higher energy portion of the profile while the finer grained material will be transported to deeper depths. Accordingly, compatibility analyses between beach fill material and native beach material is normally carried out using composite characteristics that include samples of the native beach out to the depth of closure of the fill with the pre-project profile. Based on the wave climate in the Bogue Banks area and the configuration of the existing beach profile, the depth of closure is approximately 20 feet below MLW (-21.5 feet NGVD). The COE, as part of an island-wide Federal Storm Damage Reduction Feasibility Study, has collected samples of the native material for the entire length of the island from the base of the dune seaward to the 30-foot depth contour at 2-foot depth intervals across the profile. At the present time, the grain size analysis for these samples has not been completed. When completed, the COE samples will be used as a basis to compare the compatibility of the inlet material with the native material and determining the final overfill factor. In the interim, samples of the native beach material obtained by Coastal Science and Engineering (CSE, 2002) from the upper portion of the active profile were combined with COE samples taken in deeper depths off Atlantic Beach in 1972 to obtain an estimate of the composite grain size characteristics of the native material on the active profile. Note that the 1972 COE samples from Atlantic Beach predated the disposal of navigation maintenance material from Morehead City Harbor along this beach.

CSE collected samples from the native beaches of Bogue Banks in 1999 and 2001. A summary of the composite grain size analysis for these samples is given in Table 5.3. The samples collected by CSE were obtained from the dune, seaward to the low tide terrace (LTT). Since some of the dune material was deposited via mechanical means (bulldozing of the foreshore), the dune samples were excluded from the composite analysis of the native beach material. Also, samples collected from Station 90 on Atlantic Beach and Station 110 near the U.S. Coast Guard Station at Fort Macon, were from areas previously nourished by navigation maintenance material obtained from the Morehead City Harbor navigation project and were also excluded from the composite analysis. The composite characteristics of the foreshore material collected by CSE

Table 5.3
Analysis of Composite Characteristics for
Bogue Banks Native Sediment Samples Collected by Coastal Science & Engineering in 1999 and 2001
(Note: All Samples collected from the foreshore)

				Grain Size Distributions				
Profile # - Locality	Sample	Sample	Sample	Mean	Mean	Max M_{phi} = **A**	Std. Dev.	Variance
	Year	Location	ID	M_{mm}	M_{phi}	Min M_{phi} = **B**	s_{phi}	$(s_{phi})^2$
				(mm)	phi units		phi units	$(\text{phi units})^2$
10 - Emerald Isle	1999	Berm	BB10B	0.365	1.454		0.667	0.444
10 - Emerald Isle	1999	MBF	BB10C	0.290	1.786		0.685	0.469
10 - Emerald Isle	1999	LTT	BB10D	0.380	1.396		0.930	0.864
30 - Emerald Isle	1999	Dune	BB30A	0.246	2.023		0.434	0.189
30 - Emerald Isle	1999	Berm	BB30B	0.384	1.381		0.692	0.479
30 - Emerald Isle	1999	MBF	BB30C	0.312	1.680		0.486	0.236
30 - Emerald Isle	1999	LTT	BB30D	0.270	1.889		0.496	0.246
Sta 48-50 - Indian Beach	2001	Dune	B4850a	0.262	1.932		0.431	0.186
Sta 48-50 - Indian Beach	2001	Berm	B4850b	0.266	1.911		0.400	0.160
Sta 48-50 - Indian Beach	2001	Beach Face	B4850c	0.278	1.847		0.377	0.142
Sta 48-50 - Indian Beach	2001	LTT	B4850d	0.460	1.120		0.844	0.712
50 - Indian Beach	1999	Berm	BB50B	0.418	1.258		0.878	0.771
50 - Indian Beach	1999	MBF	BB50C	0.302	1.727		0.396	0.157
50 - Indian Beach	1999	LTT	BB50D	0.215	2.218	**A**	0.529	0.280
Sta 52-54 - Indian Beach	2001	Dune	B5254a	0.250	2.000		0.450	0.203
Sta 52-54 - Indian Beach	2001	Berm	B5254b	0.224	2.158		0.385	0.148
Sta 52-54 - Indian Beach	2001	Beach Face	B5254c	0.314	1.671		0.567	0.321
Sta 52-54 - Indian Beach	2001	LTT	B5254d	0.329	1.604		0.692	0.479
Sta 56-58 - Indian Beach	2001	Dune	B5658a	0.321	1.639		0.653	0.426
Sta 56-58 - Indian Beach	2001	Berm	B5658b	0.227	2.139		0.480	0.230
Sta 56-58 - Indian Beach	2001	Beach Face	B5658c	0.348	1.523		0.404	0.163
Sta 56-58 - Indian Beach	2001	LTT	B5658d	0.374	1.419		0.798	0.637
Sta 60-62 - Pine Knoll Shores	2001	Dune	B6062a	0.500	1.000		0.839	0.704
Sta 60-62 - Pine Knoll Shores	2001	Berm	B6062b	0.274	1.868		0.377	0.142
Sta 60-62 - Pine Knoll Shores	2001	Beach Face	B6062c	0.347	1.527		0.713	0.508
Sta 60-62 - Pine Knoll Shores	2001	LTT	B6062d	0.346	1.531		0.773	0.598
Sta 64-66 - Pine Knoll Shores	2001	Dune	B6466a	0.310	1.690		0.444	0.197
Sta 64-66 - Pine Knoll Shores	2001	Berm	B6466b	0.231	2.114		0.460	0.212
Sta 64-66 - Pine Knoll Shores	2001	Beach Face	B6466c	0.293	1.771		0.360	0.130
Sta 64-66 - Pine Knoll Shores	2001	LTT	B6466d	0.382	1.388		0.924	0.854
Sta 68-70 - Pine Knoll Shores	2001	Dune	B6870a	0.245	2.029		0.492	0.242
Sta 68-70 - Pine Knoll Shores	2001	Berm	B6870b	0.222	2.171		0.370	0.137
Sta 68-70 - Pine Knoll Shores	2001	Beach Face	B6870c	0.422	1.245		0.886	0.785
Sta 68-70 - Pine Knoll Shores	2001	LTT	B6870d	0.348	1.523		0.723	0.523
70 - Pine Knoll Shores	1999	Berm	BB70B	0.338	1.565		0.821	0.674
70 - Pine Knoll Shores	1999	MBF	BB70C	0.475	1.074		0.952	0.906
70 - Pine Knoll Shores	1999	LTT	BB70D	0.288	1.796		0.580	0.336
Sta 72-74 - Pine Knoll Shores	2001	Dune	B7274a	0.279	1.842		0.624	0.389
Sta 72-74 - Pine Knoll Shores	2001	Berm	B7274b	0.258	1.955		0.421	0.177
Sta 72-74 - Pine Knoll Shores	2001	Beach Face	B7274c	0.326	1.617		0.897	0.805
Sta 72-74 - Pine Knoll Shores	2001	LTT	B7274d	0.268	1.900		0.697	0.486
Sta 76-78 - Pine Knoll Shores	2001	Dune	B7678a	0.233	2.102		0.462	0.213
Sta 76-78 - Pine Knoll Shores	2001	Berm	B7678b	0.236	2.083		0.346	0.120
Sta 76-78 - Pine Knoll Shores	2001	Beach Face	B7678c	0.492	1.023	**B**	0.938	0.880
Sta 76-78 - Pine Knoll Shores	2001	LTT	B7678d	0.293	1.771		0.744	0.554
90 - Atlantic Beach	1999	Dune	BB90A	0.234	2.095		0.415	0.172
90 - Atlantic Beach	1999	Berm	BB90B	0.228	2.133		0.498	0.248
90 - Atlantic Beach	1999	UBF	BB90C	0.244	2.035		0.667	0.444
90 - Atlantic Beach	1999	LTT	BB90D	0.243	2.041		0.653	0.426
110 - Coast Guard Station	1999	Dune	BB110A	0.801	0.320		1.211	1.466
110 - Coast Guard Station	1999	Berm	BB110B	0.541	0.886		0.960	0.922
110 - Coast Guard Station	1999	MBF	BB110C	0.457	1.130		1.083	1.173
110 - Coast Guard Station	1999	LTT	BB110D	0.200	2.322		0.739	0.547
Averages [(a)]				$(M_{phi})_{ave}$ =	1.670		$((s_{phi})^2)_{ave}$ =	0.438

Stations 90 & 110 in beach nourishment area and were excluded from composite analysis

[(a)] **Samples in gray excluded from composite analysis**

Composite Variance = $s_c^2 = (s_{phi})^2_{ave} + ((B-A)^2)/12 = 0.438 + (1.023 - 2.218)^2/12$ 0.557

Summary Composite of CSE Native Sediment Samples

Composite Variance	s_c^2 =	0.557	$(\text{phi})^2$
Composite Standard Deviation	s_c =	0.746	(phi)
Composite Mean (phi units)	M_{phi}	1.670	(phi)
Composite Mean (mm)	M_{mm}	0.314	(mm)

(composite of three samples collected at each sampling station) has a mean grain size of 1.67Φ (phi) or .31 mm and a sorting coefficient (standard deviation) of 0.746Φ. The resulting composite characteristics of the native sand (Table 5.4) from the foreshore seaward to -20 feet MLW has a mean grain size of 2.4Φ (.19 mm) and a standard deviation of 0.73Φ.

The characteristics of all three channel depth alternatives indicate that the Bogue Inlet material is highly compatible with the native beach material. This is expected considering that the ebb tide delta is composed primarily of material derived from the adjacent beaches. Apart from the compatibility of the grain sizes, when material is removed from a borrow area and deposited on a beach, there are inherent differences in the volume of material removed from the borrow area compared to the volume that can be measured on the beach. Much of this difference is due to measurement error and a factor commonly referred to as shrinkage. Based on past experience, the difference between borrow area volume and the volume of sediment retained on the beach generally ranges from ten to twenty percent. Since the material in Bogue Inlet is highly compatible with the native beach material, the total overfill factor used for beach fill quantity estimates is 1.15. For an overfill factor of 1.15, the total or gross volume of material that would be required to satisfy the beach nourishment requirements for Phase 3 of the Emerald Isle Beach Nourishment Project would be 830,300 cubic yards.

6. **DESIGN OF THE RELOCATED CHANNEL**: The proposed centerline of the new channel would be located approximately 3,400 feet west of Inlet Drive. If the new channel undergoes similar changes as exhibited by the existing channel between 1981 and 2001, the channel could return to its existing location in about sixteen years. If the new channel does not make an initial dramatic move to the east after relocation and migrates at the rate documented between February 1984 and September 2001, the channel would not return to its 2003 position for nearly thirty-seven years.

As discussed earlier, the primary purpose of the channel relocation project is to create a stable channel that will capture the majority of the flow through the inlet and divert flow away from The Pointe area of Emerald Isle. If the relocated channel is too small, frictional forces could prevent velocities in the channel from attaining magnitudes necessary to flush littoral sediment out of the channel resulting in the eventual closure of the new channel. Although the channel may be large enough to capture the flow, initial adjustments in the channel cross-sectional area immediately following construction could lead to excessive scour with possible deposition of the scoured material in the ebb tidal delta, connecting channels, adjacent marshes, and wetland areas.

If the channel is excessively large, it will gradually shoal to a more stable cross-section. However, during the period of adjustment, the tidal prism of the inlet (i.e., the total volume of water that flows through the inlet during an ebb of flood cycle) could be increased. Furthermore, the material required to shoal the channel could adversely impact the sediment balance on the adjacent beaches. Therefore, the design focus was on developing the proper size channel that would be large enough to remain open without an excessive amount of shoaling yet small enough to not cause excessive scour. The design