Final General Reevaluation Report
and
Final Environmental Impact Statement

on

Hurricane Protection and Beach Erosion Control

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

Appendix C

Geotechnical Analysis

Appendix C: Geotechnical Analyses

Table of Contents

Appendix C: Geotechnical Analyses

Table of Contents (cont.)

List of Tables

Attachments

Appendix C: Geotechnical Analyses

1. Regional Geology

A. Physiography and Geomorphology. The study area encompasses Topsail Island and nearshore Onslow Bay. Topsail Island is a 40 km long barrier island, which lies within the Atlantic Coastal Plain Physiographic Province. It is bounded by New River Inlet to the northeast, New Topsail Inlet to the southwest, Onslow Bay to the southeast, and the Atlantic Intracoastal Waterway (AIWW) to the northwest. Onslow Bay is a modern embayment of the Atlantic Ocean. It is bounded by Cape Lookout to the north and Cape Fear to the south. Present on Topsail Island are beaches, dunes, and marshes, landforms typical of barrier island complexes. On the nearshore floor of Onslow Bay are submarine scarps, shoals, and bars.

B. Stratigraphy. The Atlantic Coastal Plain and the inner continental shelf of Onslow Bay are both underlain by relatively flat-lying sedimentary units which gently dip and thicken to the southeast. This large sedimentary wedge includes both sediments, which have not been indurated or cemented and rock units. The oldest (lowest units) were deposited during the Cretaceous Period, from 144 to 65 million years ago. The youngest part of the wedge dates to the Quaternary Period, from 1.8 million years ago to 10,000 years ago. This sediment and sedimentary rock wedge overlies pre-Mesozoic (older than 248 million years ago) crystalline basement rock (Horton and Zullo, 1991). A patchy veneer of Holocene (10,000 years ago to present) sand and gravel overlies the Quaternary strata in the project area.

C. Coastal Processes. Dynamic coastal processes continually shape the barrier islands of southeastern North Carolina. Rivers and streams entering Onslow Bay are generally small with low gradients. Their continentally derived sediment loads are therefore not very large. In addition, much of this fluvial sediment becomes trapped within the river estuaries. This lack of significant sediment discharge into Onslow Bay limits the build-up of nearshore continental shelf sand deposits. In other areas along the Atlantic coast these nearshore deposits are an important source of sand. When deprived of this source of sand as at Topsail Island, seasonal storms and longshore currents can cause episodic severe shoreface erosion and migration (Cleary, 1968; Sarle, 1977; Riggs and others, 1996; Cleary 2002).

2. Site Geology

A. Topsail Island. Several Oligocene formations outcrop on the nearshore floor of Onslow Bay. These strata extend westward under Topsail Island, vertically removed from the island surface. The stratigraphy and lithology of these strata are described below in paragraph "Onslow Bay." The geologic materials of concern to the project on Topsail Island are the surficial sand soils.

Sand soils encountered on the Topsail Island beaches are classified as fine- to medium-grained poorly-graded sands according to the Unified Soils Classification System. These sands are the result of a complex combination of factors. Part of the sand is accumulated from storm overwash and longshore drift. Another part results from the biological, chemical, and physical erosion of nearshore sedimentary rocks. Winnowing by wind and wave action results in the predominantly fine- to medium-grained poorly-graded sands on the beach today.

B. Onslow Bay. The continental shelf in Onslow Bay is composed of a complex sequence of seaward dipping Tertiary age (65 million to 1.8 million years ago) strata, which was deposited during an age of periodic sea-level fluctuations (Hine and Riggs, 1986; Snyder and others, 1985, 1986; Snyder and others, 1991).

The oldest rocks outcropping within the study area are Oligocene age (33.7 million to 23.8 million years ago) limestones submerged offshore of Topsail Island. Riggs and others (1985) describe these limestones as the Belgrade and Trent formations, which consist of "moldic biomicrudite (Folk, 1974) limestones with interbedded calcarenite sands and grayish-green calcareous quartz sands." A stratigraphically similar unit named the River Bend Formation, which consists of olive green quartz sand and silt, is reported to also underlie areas offshore of Topsail Island (OSI, 2004). Northeast and east of the survey area lies a major unconformity separating the Oligocene rock and sediments from the younger Miocene (23.8 million to 5.3 million years ago) Pungo River Formation.

Quaternary paleofluvial channels, which generally trend normal to shore, crosscut the older strata offshore of Topsail Island. These channels were down cut during a period of lower sea level elevation. The paleofluvial channels are remnant streambeds, which were infilled with sediments during Pliocene to Pleistocene times (1.8 million years ago to 10,000 years ago) (Hoffman, C. W. and others, 1994), and were drowned during the Holocene sea-level rise (Belknap, 1982; Hine and Snyder, 1985, Snyder and Snyder, 1992).

Surficial Holocene sedimentary deposits are scarce offshore of Topsail Island in Onslow Bay. Much of the native beach sand is derived from the physical and biological erosion of Oligocene rock and strata submerged in Onslow Bay. These sediments are then reworked, redistributed and deposited within submarine valleys and ridges, or along the shoreface of Topsail Island (Cleary, 1968; HDR, 2002; HDR, 2003; Meisburger, 1979; McQuarrie, 1998; Riggs and others, 1996; Snyder and Snyder, 1992).

3. Subsurface Investigation

A. Geophysical Investigation (refer OSI Report dated 29 Sep 04).

1. General. A search for suitable beach fill materials for this project was begun offshore in Onslow Bay. A marine geophysical investigation was conducted by Ocean Surveys March 27 to April 17, 2004 in order to locate and evaluate potential sand resource areas. Approximately 315 miles of bathymetric and subbottom data were collected along 60 tracklines. Twenty-two (22) tracklines were shore-parallel and twenty-eight (28) tracklines were run perpendicular to shore along with 10 diagonal tie lines to insure thorough coverage.

2. Sand Borrow Search Area. Geophysical data was collected in the area between 0.5 nautical miles (30 foot isobath) to 5.0 nautical miles offshore of Topsail Island. The site stretches nearly 23 nautical miles from Rich Inlet to northeast of New River Inlet. Survey limits were established to further resolve sand resource areas identified by earlier surveys.

3. Geophysical Methods. Two types of sub-bottom methods were used: a “CHIRP Sonar” seismic reflection profiler, which generates a high frequency, short duration acoustic pulse providing high resolution of shallow sub-bottom strata; and a “Boomer” seismic reflection profiler which uses a low frequency pulse to achieve deeper penetration of the

sub-bottom strata. These were run simultaneously to achieve the best possible resolution and penetration. Augmenting the seismic equipment was survey equipment that allowed real-time depth sounding, positioning, and motion (heave) corrections.

4. Positioning System. A differential global positioning system was used to determine position along the seismic lines. Equipment included a Trimble 4000 Global positioning System (GPS) and a Leica MX52R U.S. Coast Guard (USCG) Differential Beacon Receiver interfaced with HYPACK software. Navigation fixes were recorded on an onboard PC every second.

5. Depth Sounder. Bathymetric data was collected at a near continuous rate using an Innerspace Model 448 Digital Depth sounder, which operated at a frequency of 200 kHz. Tidal data from the NOAA station in Beaufort, North Carolina were used for tidal corrections.

6. CHIRP Sonar System. The Contractor accomplished the high-resolution subbottom profiling utilizing an EdgeTech Xstar Full Spectrum "CHIRP" Subbottom Profiler system operating with frequencies of 0.5-12 kHz. The system has three components: a deck unit that is comprised of a PC system and amplifier, an underwater cable, and a Model 512 towed vehicle that houses the transducers. The tow fish vehicle emits a high frequency FM pulse over the full spectrum range of 0.5-12 kHz for a 20 millisecond period, and the acoustic return is received by a hydrophone array, which allows high resolution of the shallow subsurface. The higher frequency yields higher resolution with a tradeoff in lesser depth penetration.

7. Seismic Reflection Profiling System. Deeper sub-bottom penetration was accomplished using an Applied Acoustics 100-300 joule "boomer" system comprised of a boomer plate, power supply, hydrophone array, TSS-model 360 filter and time-varied-gain system, and an EPC 1086 thermal paper recorder. The "boomer" employs a sound source that utilizes electrical energy discharged from a capacitor bank to rapidly move a metal plate in the transducer bed. The short duration motion of the metal plate creates a broad-band (500-8000 Hz) pressure wave capable of penetrating hundreds of feet of marine sediments under favorable site conditions.

8. Summary of Geophysical Results

a. Stratigraphy. The geophysical and bathymetric surveys showed that shallow rock scarps and outcrops dominate and control the submarine topography offshore of Topsail Island. A surficial sand horizon was resolved. However, it is very discontinuous and broken by Oligocene rock outcrops. Erosion and reworking of this rock contributes coarse and fine-grained materials to the surficial sand. This decreases its aesthetic value as beach fill. The thickest sequence of unconsolidated sediment occurs in or adjacent to the paleochannels. These sediments tend to be dominated by estuarine muds and fine sands and thus unsuitable as beach fill. Borrow areas must generally be configured to avoid these channels.

b. Vibracore Targets. The subsurface investigation was performed between May and November 2003. The boring locations were based on the seismic data available from the geophysical investigation conducted by OSI.

c. Borrow Areas. The results of the 2004 geophysical survey in combination with vibracore data were used to identify potential borrow areas within the study area.

B. Vibracore Investigation

1. Field Investigation. The subsurface investigation was performed between May and November 2003. The criteria for the boring locations was between 1 and 6.5 miles from the beach, water depth greater than 30 feet, and change in seismic profile, which could represent differing soil types. A total of 369 borings were performed in the Topsail Island area, 167 of which were for the Topsail Beach project. Borings performed for the Topsail Beach project are designated TI-V-1 through TI-V-12A, TI-V-105 through TI-V-153A, TI-V-170 through TI-V-192, TI-V-194 through TI-V-246, TI-V-263, and TI-V-363 through TI-V-365 (See Appendix A, Figure A-2). Other borings from TI-V-1 through TI-V-369 not mentioned here were performed for the Surf City/North Topsail Beach project. Borings were performed offshore of Topsail Beach, in the Banks Channel behind Topsail Beach, in the connecting channel between the Atlantic Intracoastal Water Way (AIWW) and New Topsail Inlet, and in New Topsail Inlet.

Borings were performed from the USACE Snagboat *SNELL* using a 3 7/8 inch diameter, 20-foot long, Alpine vibracore drill machine. The sampler consists of a metal barrel in which a plastic cylinder or tube is inserted. After the plastic tube was inserted, a metal shoe was screwed onto the plastic tube and then the metal barrel. The shoe provided a cutting edge for the sampler and retained the plastic tube. An air-powered vibrator was mounted at the upper-most end of the vibracore barrel, and the vibrator and the vibracore barrel was mounted to a stand. This stand was lowered to the ocean floor by the Snell's crane, the vibrator was activated and vibrated the vibracore barrel into the ocean sediment. The sediment sample is retained in the plastic tube. All borings were drilled to a depth of 20 feet below the ocean floor, unless vibracore refusal was encountered. Vibracore refusal was defined as a penetration rate of less than 0.1 feet in 10 seconds.

2. Laboratory Analysis. The recovered vibracore tubes were visually classified by Wilmington District personnel in accordance with the Unified Soils Classification System (USCS). Samples were taken at a minimum of every two feet or at each change of material. A total of 1327 samples were collected in the Topsail Island area, of which 595 samples were tested for this project. Grain size tests were performed in accordance with ASTM D-422 using a fourteen-sieve test and visual classifications were

performed in accordance with ASTM D-2488, by Wolf Technologies, Inc. The sieves used in these tests were the 3/4, 3/8, Number 4, Number 7, Number 10, Number 14, Number 18, Number 25, Number 35, Number 45, Number 60, Number 80, Number 120, and Number 230. Boring logs and grain size test results are in Attachment 2 and Attachment 3 respectively.

C. Compatibility Analysis. The compatibility analysis compares the grain size of the "native beach" or the "reference beach" with the material in the proposed borrow material. The procedure for calculating the overfill ratio for borrow areas in relation to the reference beach was performed in accordance with the U.S. Army Corps of Engineers Coastal and Hydraulics Laboratory Automated Coastal Engineering System (ACES) software version 4.01. This procedure is discussed in section V-4-1.e.(2)i. of the U.S. Army Corps of Engineers Engineer Manual (EM) 1110-2-1100, part V, titled Coastal Engineering Manual. As stated in this manual, the overfill ratio is the primary indicator of the compatibility of the borrow material to the beach material, with a value of 1.00 to 1.05 considered optimum for sediment compatibility. However, obtaining this level of compatibility is not always possible due to limitations in available borrow sites. Six borrow areas were identified as compatible for the Topsail Beach project and the overfill ratios for these potential borrow areas ranged from 1.04 to 1.45. See Appendix E for more information regarding the compatibility analysis.

D. Sand Borrow Areas. Six offshore borrow areas were identified for the Topsail Beach project and are labeled as A, B, C, D, E, and F (See Appendix A, Figure A-2). The material classification ranged from clean sand (SP), slightly silty sand (SP-SM), with minor amounts of very silty sand (SM), silt (MH and ML), and clay (CH). Banks Channel was initially identified as a potential borrow area for material bounded by the authorized channel from the Coastal Barrier Resource Act (CBRA) zone to the AIWW. However, Banks Channel has been eliminated as a borrow area due to a negligible amount of material available to the project.

The characteristics of each borrow area is shown in Table C-1. As shown in this table, the borrow areas are typically between 1 and 6.5 miles offshore and contain material with approximately 10% or less passing the #200 sieve. The borrow areas have bottom depths of less than 66 feet. The total estimated volume in all potential borrow areas is 21,100,000 cubic yards.

4. Conclusion

Based on the total estimated volume in the borrow areas, there is an adequate quantity of suitable beach quality material to complete the full 50-year life of the project. For a complete description of the borrow area materials and the sand compatibility see Appendix E, Sand Compatibility Analysis.

Areas to be used for borrow will be further defined during the plans and specifications phase of this project. Additional borings and/or geophysical surveys will be performed to better delineate the borrow area boundaries and material types. Vibracore borings will be performed in a grid pattern, on a 500 foot to 1000 foot spacing, in any area prior to its use as a borrow source.

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Table C-1
Topsail Beach Borrow Area Characteristics

Borrow Area	Composite Grain Size	Silt Content (#200 Sieve)	Estimated Volume (cy)	Distance offshore (miles)	Surface Elevation (ft. MLLW)
A	2.35 phi (0.20 mm)	7.6%	13,200,000	1 to 3	-38.5 to –48.2
B	2.17 phi (0.22 mm)	5%	820,000	1.5 to 2.5	-42.2 to –43.2
C	2.32 phi (0.20 mm)	4.4%	2,570,000	4 to 5.5	-45.5 to -47.7
D	2.13 phi (0.23 mm)	6%	1,860,000	3.5 to 4.5	-43.5 to –46.9
E	2.15 phi (0.23 mm)	3.4%	1,390,000	4.5 to 5.5	-49 to –50
F	0.80 phi (0.57 mm)	4.9%	1,290,000	4.5 to 5.5	-47.2 to -48
Total Estimated Volume is 21,100,000 cubic yards					

cy - cubic yards
mm - millimeter
MLLW – Mean Low Low Water
NA – Not applicable