APPENDIX C

DESIGN & ENGINEERING

Study Authority. This study is authorized under Section 204 of the Water Resources Development Act of 1992, as amended.

Study Description. This appendix presents the results of the engineering evaluations supporting studies aimed at creating a man-made submerged oyster reef habitat. The study involved evaluation of the feasibility of creating submerged oyster reef habitat using dredged material and alternatives to contain the dredged material.

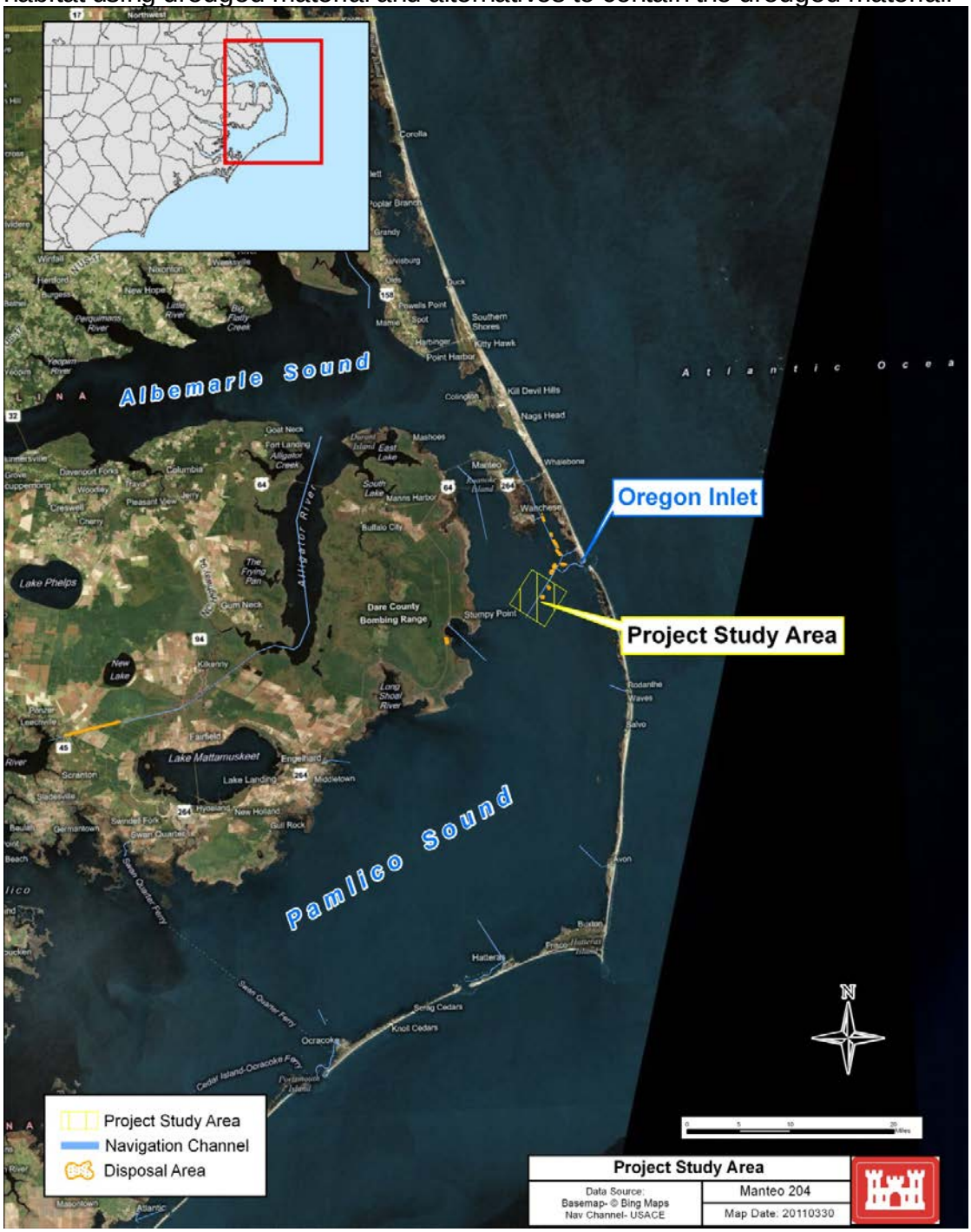

Figure 1. Map of Project Location

Project Description

Location. The proposed project site is located in Pamlico Sound approximately 5 miles southwest of Oregon Inlet in Dare County, North Carolina, as shown in figure 1. The site is also approximately 1.7 miles west of the Manteo Old House Range 2 federal navigation channel.

Description. The proposed project involves the construction of a submerged oyster reef habitat using dredged material from maintenance of the Manteo (Shallowbag) Bay project. This action is considered a beneficial use of dredged material. A containment structure will be constructed to contain the dredged material. The dredged material will be capped with Class A stone (2"-6") and oyster shell to provide habitat for establishment of oysters.

Tide Data. The closest tide gage to the project site is at the Old House Channel gauge (8652648). Provided below is pertinent tide data for the area.

Mean Higher-High Water (MHHW): 1.18 feet MLLW
Mean High Water (MHW): 1.04 feet MLLW
North American Vertical Datum (NAVD88): 0.71 feet MLLW
Mean Low Water (MLW): 0.13 feet MLLW

Being approximately 5 miles inside the inlet, the regular astronomical tide is sufficiently dampened.

Due to the width and long fetch lengths and relatively shallow water in Pamlico Sound, the wind has a greater impact on tide levels than normal tide cycles. Depending on the wind direction, the tides can be considerably higher than normal or considerably lower.

Project Design

Alternatives. Several containment structure alternatives were evaluated to determine the best project design. The containment structure would be constructed in an area located approximately 1.7 miles from Old House Channel where the bottom elevation is at about -14' MLLW.

Construction Type 1: Sheetpile Wall and stone sill structure. This alternative would involve creation of oyster habit by using a composite sheetpile wall to contain the dredged material. For this alternative various containment area sizes for single and multiple sites were evaluated as discussed in section 5.3.3 of the main report. The outside perimeter of the sheetpile wall would be protected with NCDOT Class 2 armor stone (9"-23"). Bedding stone for the armor stone would be NCDOT Class B stone (5"-12"). Dredged material from maintenance dredging of the federal navigation channel would be pumped by hydraulic pipeline dredge into the containment area. The dredged material would be covered with NCDOT Class A

stone (2”-6”) and oyster shell to provide habitat for establishment of oysters. A typical cross section is shown in Figure 2.

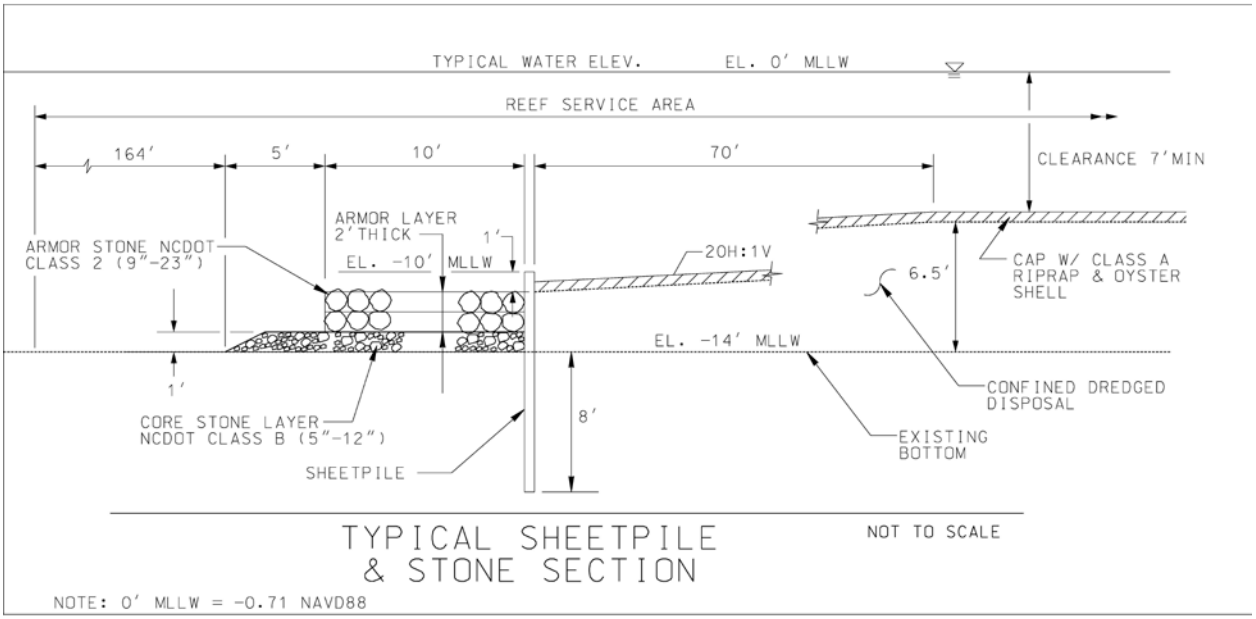

Figure 2. Typical cross section of sheetpile wall & stone sill containment structure

Construction Type 2: Stone sill containment structure. This alternative would involve creation of oyster habitat by using NCDOT Class 2 armor stone (9”-23”) to contain the dredged material. For this alternative various containment area sizes for single and multiple sites were evaluated as discussed in section 5.3.3 of the main report. The core portion of the containment structure would be constructed of NCDOT Class B Stone (5”-12”). Dredged material from maintenance dredging of the federal navigation channel would be pumped by hydraulic pipeline dredge into the containment area. The dredged material would be covered with NCDOT Class A stone and oyster shell to provide habitat for establishment of oysters. A typical cross section is shown in Figure 3.

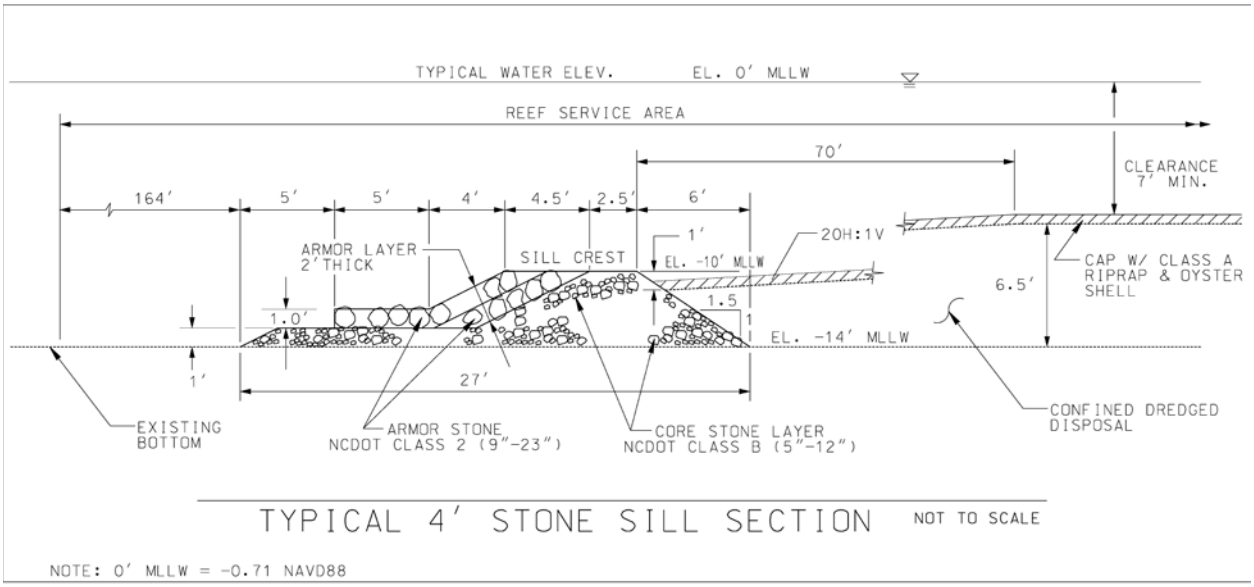

Figure 3. Typical cross section of stone sill containment structure

For Construction Types 1 and 2 various containment area sizes for single and multiple sites were evaluated as discussed in section 5.3.3 of the main report. The largest containment structure plan was sized to contain one maintenance dredging cycle from Old House Channel Range 2. The maintenance dredging cycle volume is based on the average pay quantity (209,000 cubic yards) removed from Old House Channel Range 2 for the three most recent dredging contracts. It was assumed that during dredging of Old House Channel Range 2 there would be 15% losses with only 177,650 cubic yards of the 209,000 cubic yards removed from the channel ending up in the containment area. The 15% losses are based on average losses observed on previous dredging projects for channel dredging with beach disposal. Therefore the largest containment area of 18.6 acres was sized to contain approximately 178,000 cubic yards of dredged material. In addition to the 18.6 acre site, the array of alternatives evaluated in the main report included one 15.06 acre site, one 9.7 acre site, two 9.7 acre sites, one 5.07 acre sites, two 5.07 acre sites, three 5.07 acre sites, and four 5.07 acre sites. If the quantity of the maintenance dredging material exceeds the capacity of the containment area(s) the additional dredged material would be pumped to nearby existing disposal islands.

Alternative Evaluations.

Construction Type 1. This alternative uses composite sheetpile driven into the bottom. There are some constructability concerns with this alternative. Constructability concerns include working from a barge in an open water location subject to wind and waves which may impact alignment and driving of sheetpile. Safety would also be a concern as it may be necessary to use divers during installation of sheetpile, the final top elevations of which would be submerged.

Construction Type 2. Stone placement is expected to be by barge mounted crane. There are no constructability issues of concern for this alternative.

Selected Alternative. Based on evaluation of costs, benefits, effectiveness and constructability of the alternatives, the Construction Type 2 stone sill containment structure plan with three 5.07 acre sites is the selected plan.

Armor Stone. Armor stone will be granite. The size of the armor stone for the containment structure was based on a design wave generated at the site using a predicted wind speed for a 50-yr recurrence storm event. The design wave was calculated using the "Wind Adjustment and Wave Growth Option" available in the CEDAS-ACES computer program suite. The design wave conditions were governed by the wind acting over the long-axis of the Pamlico Sound extending generally southwest of the project site. The result of the analysis was a design wave with a height and period of 6.0 ft and 6.0 sec, respectively. The stone size was subsequently calculated using the Van der Meer Stability formula for a 2-layer submerged breakwater, as contained in the Coastal Engineering Manual (CEM). The stone size was evaluated assuming a minimum clearance of 7-ft over the mound, and water depths of 12-14 ft. This resulted in a design stone weight, W_{50}, equal to 154 lbs. A standard NCDOT Class 2 stone gradation slightly exceeds this median weight and was selected for the submerged stone sill design. The NCDOT Class 2 stone gradation (9"-23") has a median size of 14" and a median weight of 172 lbs (assuming a granite stone having a unit weight of 165 lbs/cf). Table X lists the pertinent design information for the submerged stone sill.

Table X. Armor Stone Design Results for Submerged Stone Sill

Design Wave Height (ft)	6.0
Design Wave Period (s)	6.0
Stone Unit Weight (lb/cf)	165
Design Stone Weight, W50 (lb)	154
Recommended Stone W50 (lb)	172 (NCDOT Class 2)
Armor Layer Thickness (ft)	2.0

Core Stone. The core stone for the stone sill will be NCDOT Class B stone. Core stone will be limestone. The NCDOT Class B gradation (5'-12") has a median size of 8" and a median weight of 22 lbs (assuming a limestone stone having a unit weight of 115 lbs/cf).

Oyster Reef Habitat construction.

The oyster reef habitat will be created within the containment structure using material from maintenance dredging of Manteo Old House Channel Range 2. The interior of the containment areas will be filled with dredged material to a maximum top elevation at -7.5' MLLW with the perimeter sloped toward the containment

structure. It is assumed the material will lay out at a 20H:1V slope. This assumption is based on slopes observed following beach disposal of similar type dredged material. The dredged material will be capped with NCDOT Class A stone (2”-6”) and oyster shell to provide habitat for establishment of oysters. The Class A stone will be granite. Two 90’ wide strips which extend from side to side and bisect the containment structure will be left bare of NCDOT Class A stone and oyster shell.

Construction Sequence. The containment structure will be constructed before the dredged material is placed. The core stone will be placed first followed by the protective armor layer. The dredged material will be placed on the inside of the containment structure. It is anticipated that the dredged material will be excavated and pumped into the containment area using a hydraulic pipeline dredge. The dredging contractor will be required to submerge the end of the discharge pipe to minimize turbidity. The Class A riprap and oyster shell will be placed on top of the dredged material.

Maintenance. Once the project is constructed, there will be a cost associated with maintenance of the project. The expected life of the project will be 50 years.