APPENDIX G

Beneficial Use of Dredge Material: Old House Channel, Manteo, NC

Sediment Sampling and Analysis: Old House Channel Proposed Dredge Disposal Site

Final Report

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ABSTRACT

The USACE Wilmington District and the State of North Carolina are partnering to develop a Beneficial Use of Dredged Material project to, in part, support oyster reef restoration needs in North Carolina's Pamlico Sound. A potential restoration site was previously identified in 2009 and a further investigation of sediment composition was required in 2012 to verify the sidescan reflectance data in the proposed reef area. Twenty-five samples were collected within the site to characterize the surficial sediment grain size. Overall, the samples were predominantly muddy sand, with varying weight percentages of mud (39.75% to 1.52%). The higher mud percentages were predominantly found in the deeper portion of the site. However, 64% of the samples contained sufficient clay-sized material to be considered weakly cohesive, and the relative weight percent of silt vs. clay-sized material in the mud fraction indicate that the region as a whole may act somewhat cohesively in response to shear stress. Sediment data did not suggest that this site was suitable for winter habitat for mature female blue crabs, but use of the area by juvenile crabs could not be ruled out by this study alone.

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1.0 Overview

The Old House Channel portion of the Manteo-Shallowbag Bay navigation channel requires periodic maintenance dredging by the USACE Wilmington District (USACE-SAW). Recently, USACE-SAW has partnered with the State of North Carolina to develop a project that will use the surplus sandy, dredged material from Old House channel, contained in a submerged rock enclosure, to create new shoals which will be subsequently be topped with clutch to construct a sustainable, high-relief oyster reef habitat. A proposed dredge disposal and oyster restoration site was identified in 2009 but concerns were raised by the NCDMF that the site may contain areas of muddy bottom that provide significant winter habitat for blue crabs. Covering this site with dredge disposal could thus potentially result in a loss of blue crab habitat. Previous research by Schaffner and Diaz (1988) identified blue crab winter habitat in the Chesapeake Bay and found that mature, female blue crabs were more abundant at depths exceeding 9 m where sediment was characterized as silty-fine sand (40-80% sand). Crabs were less common, however, when sediments were finer (<40% sand) or coarser (>80% sand), and the most significant crab populations were found associated with sediments that contained between 41% and 60% sand. Since a review of the previously collected sidescan data could not discern varying percentages of sand vs. mud in the selected area, grab samples were collected in order to characterize surficial bottom sediment.

1.1 Study Site

The proposed dredge disposal site is located to the west of the Manteo-Shallowbag Bay navigation channel (Figure 1). The bathymetry slopes gently from west to east, dropping from 11.6 ft to 14 ft in just over 800 ft (horizontal distance; ~0.3% slope), and then flattens, dropping approximately 1 ft in 1300 ft (horizontal distance; ~0.08% slope; Figure 2). The original sidescan data indicated that the bottom was relatively featureless, supporting the original hypothesis that the region likely had little to no variation in bottom type (Figure 3).

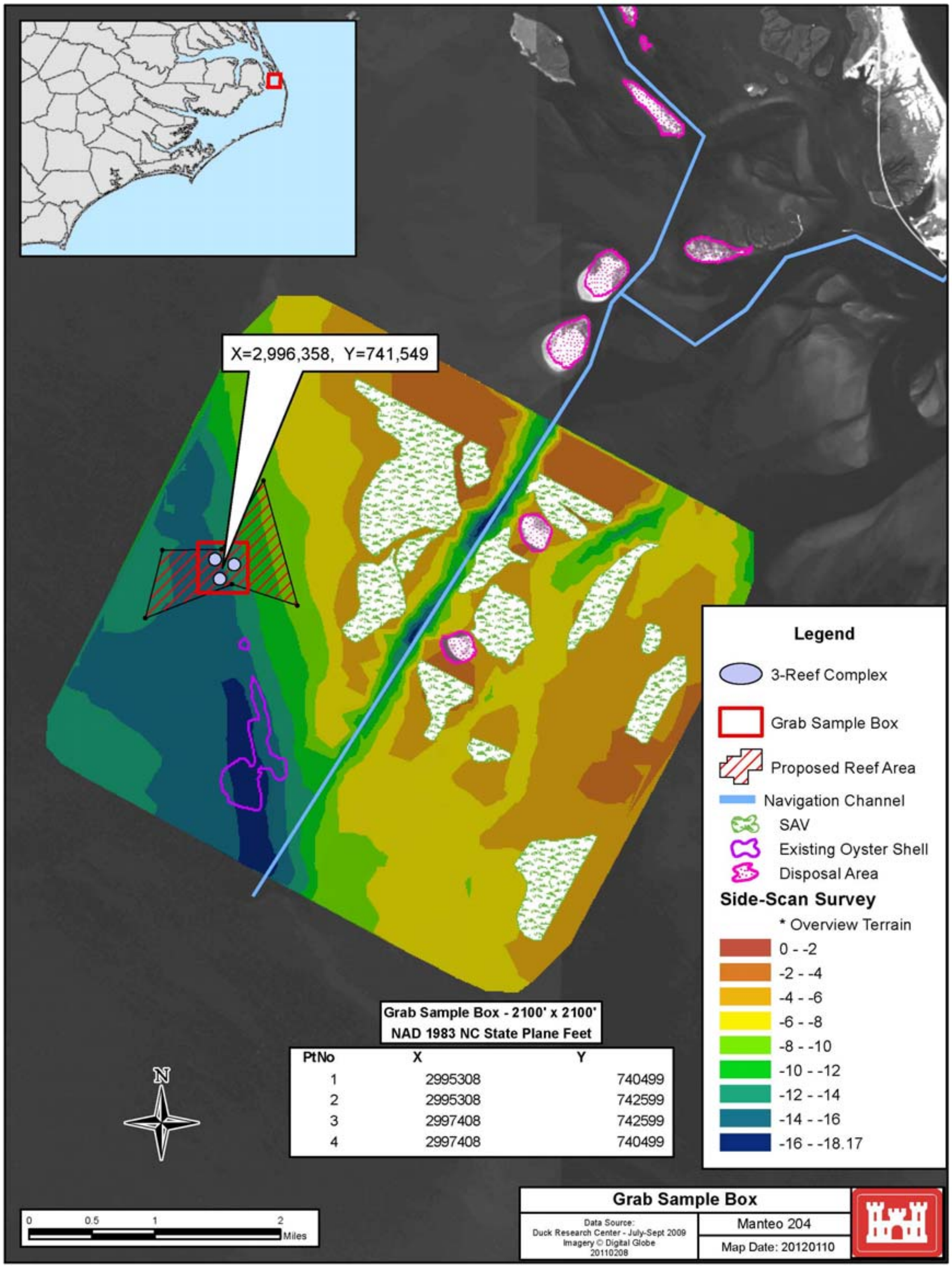

Figure 1: Location of proposed dredge disposal site west of the navigation channel. Inset shows a close-up of the proposed dredge site, with preliminary sample locations shown in red.

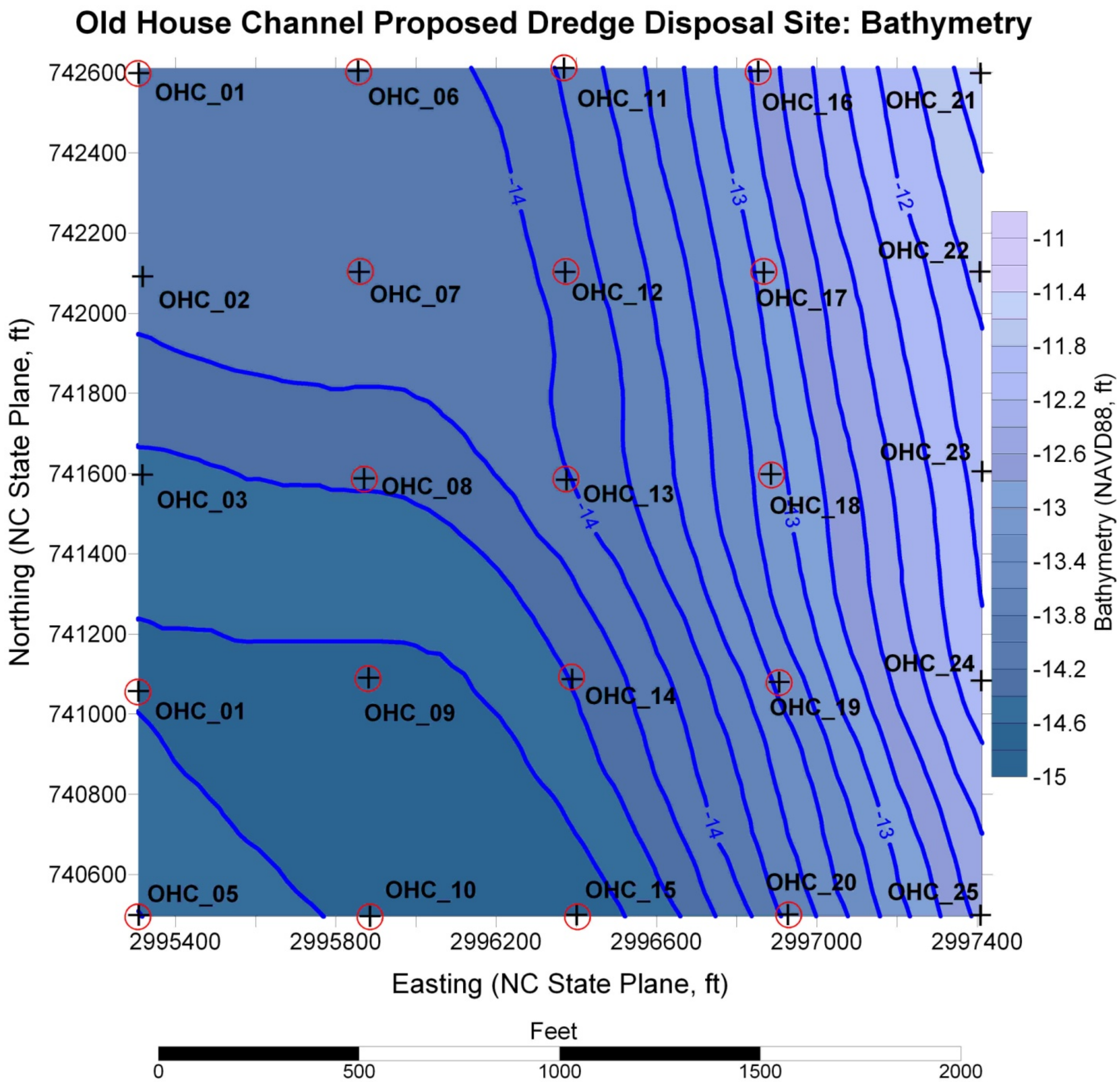

Figure 2: Bathymetry of the proposed dredge site. Grab sample locations are indicated by black crosses. Red circles indicate the presence of various polychaetes in the sediment samples.

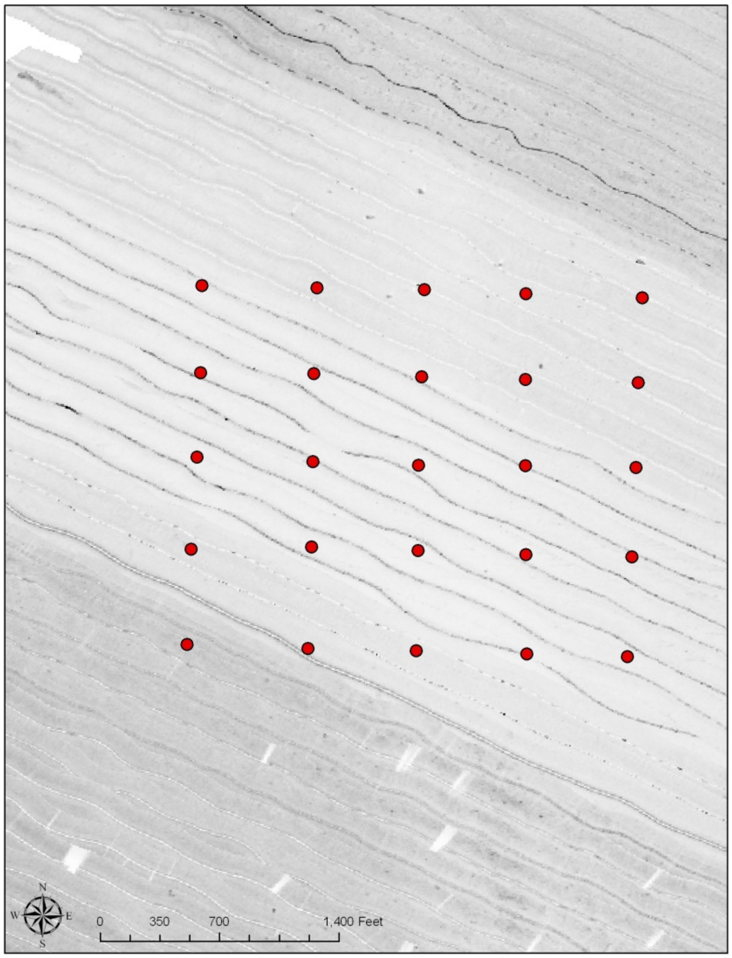

Figure 3: Original sidescan survey of the site, with sample locations plotted in red.

1.2 Methods

In order to assess the surficial sediment bottom type, a grid of 25 equally spaced samples was created for the proposed dredge disposal site. At each site, a ponar grab was deployed to collect a bottom sample (Figure 4), the locations of which are shown on Figures 2 & 3. Up to 5 attempts were made at each site and only 1 site resulted in a rejection (OHC 21). Samples were immediately bagged and stored on ice until returned to the laboratory.

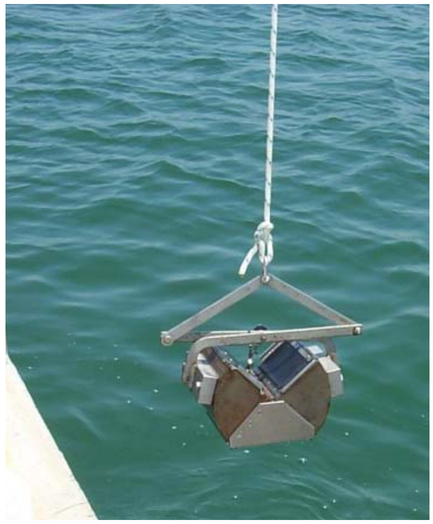

Figure 4: A ponar grab.

Wet-pipette grain size analysis was performed on each sample (e.g. Gee and Bauder, 1986). Briefly, each sample was homogenized and ~10-15 grams were sub-sampled for analysis. Ten ml of dispersant (sodium bicarbonate and sodium metaphosphate) was added to each sample and the samples were allowed to sit overnight. The dispersed sediments were then washed through a 63 µm stainless steel sieve (No. 230) using DI water into 1000ml graduated cylinders. The sand fraction was retained and the silt and clay sized fractions were extracted via pipetting based on standard temperature tables. All samples were dried and weighed to the thousandth of a gram, and weight percentages calculated. Gravel was not observed in any of the samples, so all sediment ≥63 µm was considered to be sand-sized.

2.0 Sediment Characteristics

For the purposes of this report, "sand" indicates sediment equal to or larger than 63 µm and "mud" indicates sediment smaller than 63 µm according to the Wentworth Classification Scale. Mud is further differentiated between "silt" (<63 µm to ≤3.9 µm) and "clay" (<3.9 µm) sized fractions. The data presented below do not include site OHC 21, which is interpreted to be packed sand. The ponar grab was rejected 5 times at this site, typical of hard, sandy bottoms.

Sediment in the dredge disposal site is predominantly muddy sand, with varying amounts of mud (Table 1; Figures 5, 6). Sand weight percentages range from 98.48% to 60.25%, with the most sand found in the shallower region of the site (Figure 5), and ultimately comprises the majority of the surficial sediment size fraction. Mud weight percentages range from 39.75% to 1.52%, and percentages increase with increasing depth (Figure 6). A variety of polychaetes were found in 18 of the 25 samples (72%), including several large tube worms with tube diameters of up to 3 cm (red circles, Figure 2). Although a biological assessment of the site is beyond the scope of this project, the field descriptions suggest that mud is not ephemeral in this region but rather is stable enough to allow the development of an established benthic community. It is worth noting that the mud content at this site was less than that of sediment immediately adjacent to the closest existing oyster reef site (Appendix A).

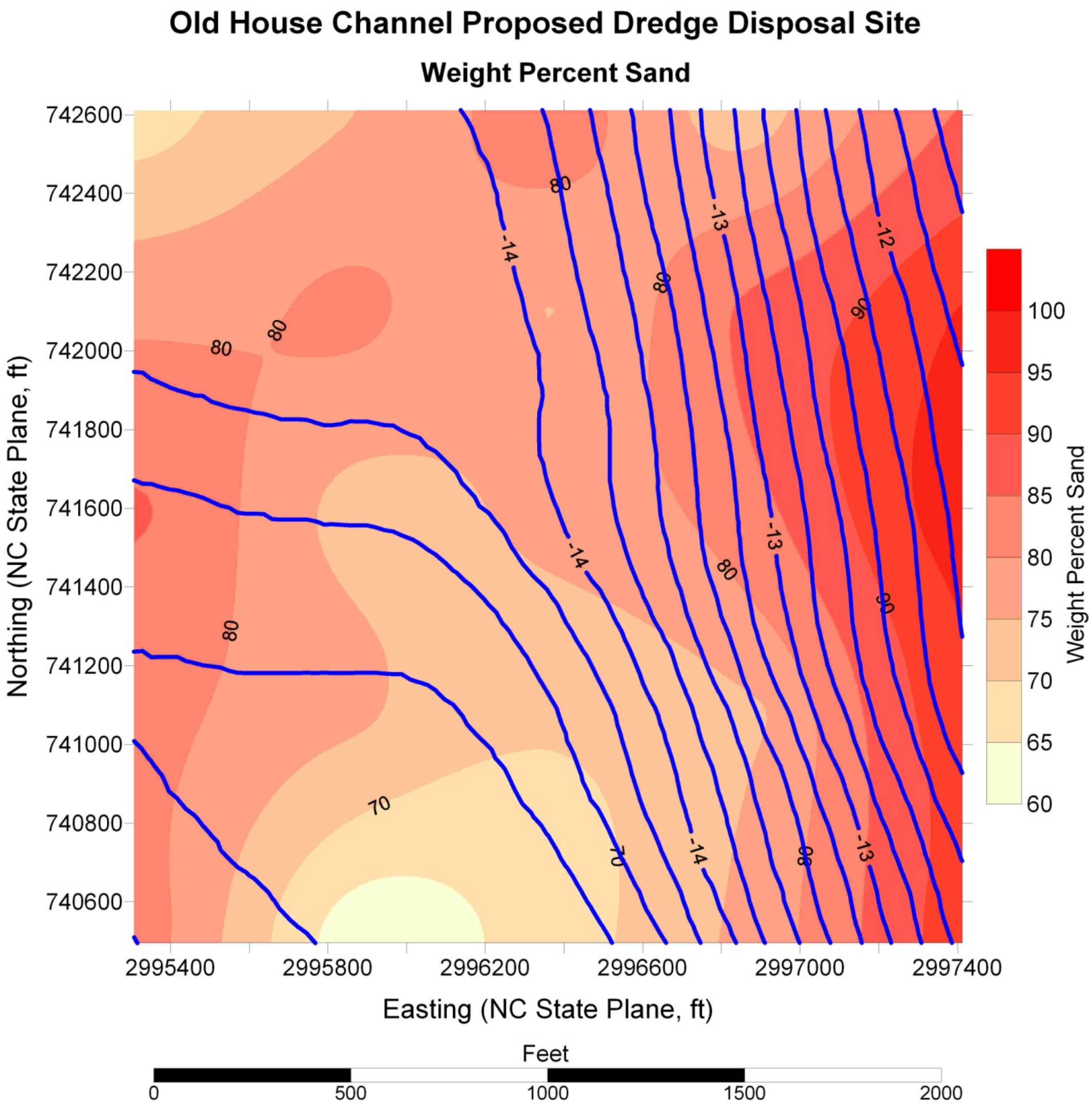

Figure 5: Distribution of weight percent sand. Bathymetric contours are in blue, NAVD88.

2.1 Influence of mud

The influence of mud within sediment impacts, among other factors, the cohesive properties of the sediment. As little as 5-10% clay has been shown to impart cohesive properties to otherwise non-cohesive sandy sediment (e.g. Van Ledden et al., 2004; Hir et al., 2008). Accordingly, the clay vs. silt percentages of the mud in this site were quantified (Figures 7 and 8). Significant (≥5%) weight percents of clay were primarily found in the deepest regions of the site (water depths of ≥13 ft; Figure 7). Silt-sized sediments were more equally distributed throughout the site, with higher weight percentages in the deeper, central region (Figure 8). With respect to the mud fraction alone, silt was the dominant size class, with a weight percent range from 53.33% to 100%. It should be noted, however, that clay averaged ~1/3 of the total mud fraction, even in samples with little weight percent mud (up to 46.67%; Table 2), and was only absent in 1 of the 25 samples. In addition, 64% of the samples (16 of 25) had a clay weight percent of 5% or higher. Accordingly, with the possible exception of the sandier, shallower region (e.g. samples OHC_22 through OHC_25), the sediments in the proposed dredge disposal site should be considered at least weakly cohesive.

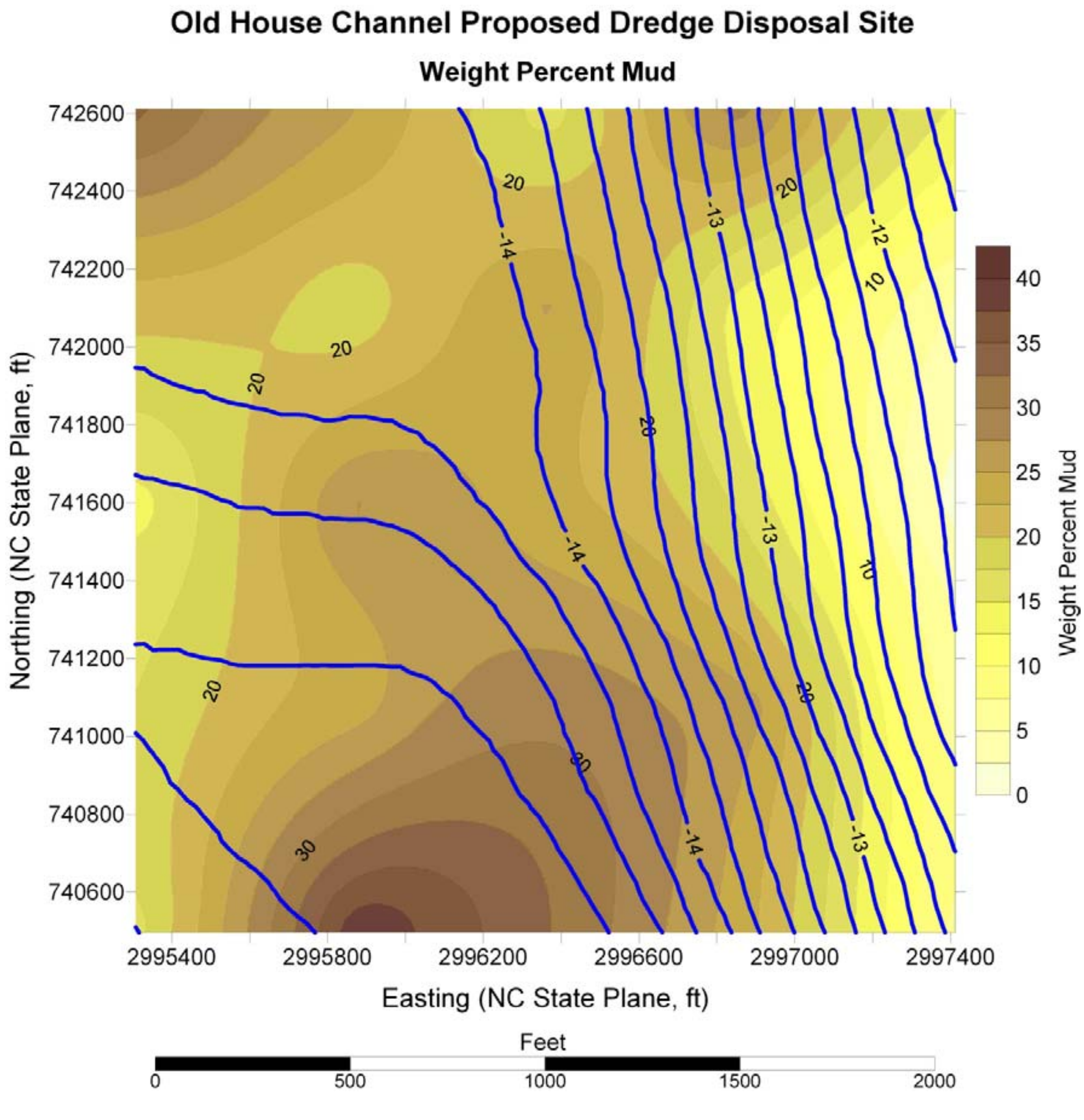

Figure 6: Distribution of weight percent mud. Bathymetric contours are in blue, NAVD88.

High concentrations of suspended sediment have been shown to have a detrimental effect on shellfish both via reduced bivalve pumping rates as well as potential burial of sensitive egg and larval stages (e.g. Clarke and Wilber, 2000 and references therein; Henley et al., 2000;

Wilbur and Clarke, 2001). Specifically, negative impacts to oyster egg development have been observed at suspended silt concentrations of 188 mg/l (Davis, 1960; Davis and Hidu, 1969). When suspended sediment concentrations exceed the threshold of bivalve filtering rates, food dilution, and subsequent oyster decline, can occur (e.g. Widdows et al., 1979). This study did not quantify suspended sediment concentrations in the dredge disposal site. Given that the presence of muddy surface sediments typically results in higher concentrations of suspended fine-grained sediments, the possibility that increases in water column turbidity in this region due to resuspension during sand disposal might reach levels detrimental to shellfish cannot be ruled out from this study alone. However, it is also possible that the natural cohesion found in these sediments will serve to minimize resuspension more so than if the sediments were non-cohesive. Disposal-induced, sediment suspension modeling efforts should be pursued if resuspension during disposal is indeed a potential concern.

	Weight % Sediment			
Sample ID	Sand	Mud	Silt	Clay
OHC 01	66.97	33.03	22.10	10.94
OHC 02	79.14	20.86	15.56	5.30
OHC 03	85.82	14.18	11.11	3.07
OHC 04	82.27	17.73	9.46	8.27
OHC 05	83.44	16.56	13.25	3.31
OHC 06	74.73	25.27	18.29	6.98
OHC 07	81.73	18.27	11.13	7.14
OHC 08	72.26	27.74	20.92	6.82
OHC 09	76.36	23.64	16.82	6.82
OHC 10	60.25	39.75	25.56	14.19
OHC 11	83.73	16.27	12.60	3.67
OHC 12	74.70	25.30	16.38	8.92
OHC 13	76.78	23.22	16.61	6.61
OHC 14	70.81	29.19	23.60	5.59
OHC 15	67.91	32.09	20.12	11.97
OHC 16	71.63	28.37	16.05	12.32
OHC 17	86.19	13.81	11.27	2.54
OHC 18	83.51	16.49	9.88	6.61
OHC 19	74.42	25.58	16.28	9.30
OHC 20	78.06	21.94	13.40	8.54
OHC 22	95.29	4.71	3.96	0.75
OHC 23	98.48	1.52	1.14	0.38
OHC 24	93.87	6.13	4.71	1.42
OHC 25	95.26	4.74	4.74	0.00

Table 1: Sediment grain size distribution. Weight percent mud = silt + clay size fractions.

Sample ID	Weight % Mud % silt	% clay
OHC 01	66.89	33.11
OHC 02	74.58	25.42
OHC 03	78.33	21.67
OHC 04	53.33	46.67
OHC 05	80.00	20.00
OHC 06	72.38	27.62
OHC 07	60.92	39.08
OHC 08	75.41	24.59
OHC 09	71.15	28.85
OHC 10	64.30	35.70
OHC 11	77.42	22.58
OHC 12	64.73	35.27
OHC 13	71.53	28.47
OHC 14	80.85	19.15
OHC 15	62.69	37.31
OHC 16	56.58	43.42
OHC 17	81.60	18.40
OHC 18	59.91	40.09
OHC 19	63.64	36.36
OHC 20	61.07	38.93
OHC 22	84.13	15.87
OHC 23	75.00	25.00
OHC 24	76.83	23.17
OHC 25	100.00	0.00

Table 2: Weight percent silt vs. clay in the mud content of the sediment samples.

A complete assessment of the suitability of this site as potential winter habitat for blue crabs is beyond the scope of this project. However, some basic conclusions can be drawn from the sediment data. Variations in habitat quality can affect the density and survival rates of both juvenile and adult crabs, including unvegetated mud habitats (Pile et al., 1996; Seitz et al., 2005). Schaffner and Diaz (1988) indicated that blue crabs were significantly more abundant in winter habitat characterized by sediment containing 41-60% sand, and in water depths exceeding 9-m (~29.5 feet). This site is both sandier (weight percent sand ranges from 98.48% to 60.25%; averages ~80%), and much shallower (11.6 – 14 ft, or 3.5 – 4.3 m) than the optimal habitat described by Schaffner and Diaz (1988). Their study population was, however, dominated by mature females and thus cannot be used as a standard for all crab life stages, as juvenile crabs frequently stay in shallower waters to avoid cannibalistic predation by older crabs (e.g. Dittel et al., 1995; Hines and Ruiz, 1995; Pile et al., 1996). Whether it is suitable for juvenile blue crabs cannot be discerned from the available data. No blue crabs were noted in the sediment samples but that is likely because a ponar grab is not the proper sampling equipment to assess blue crab population densities (compared to a dredge survey). If the high percentage of sand alone is insufficient to assess the suitability of the site as winter blue crab habitat, further, more detailed biological sampling will need to be performed.

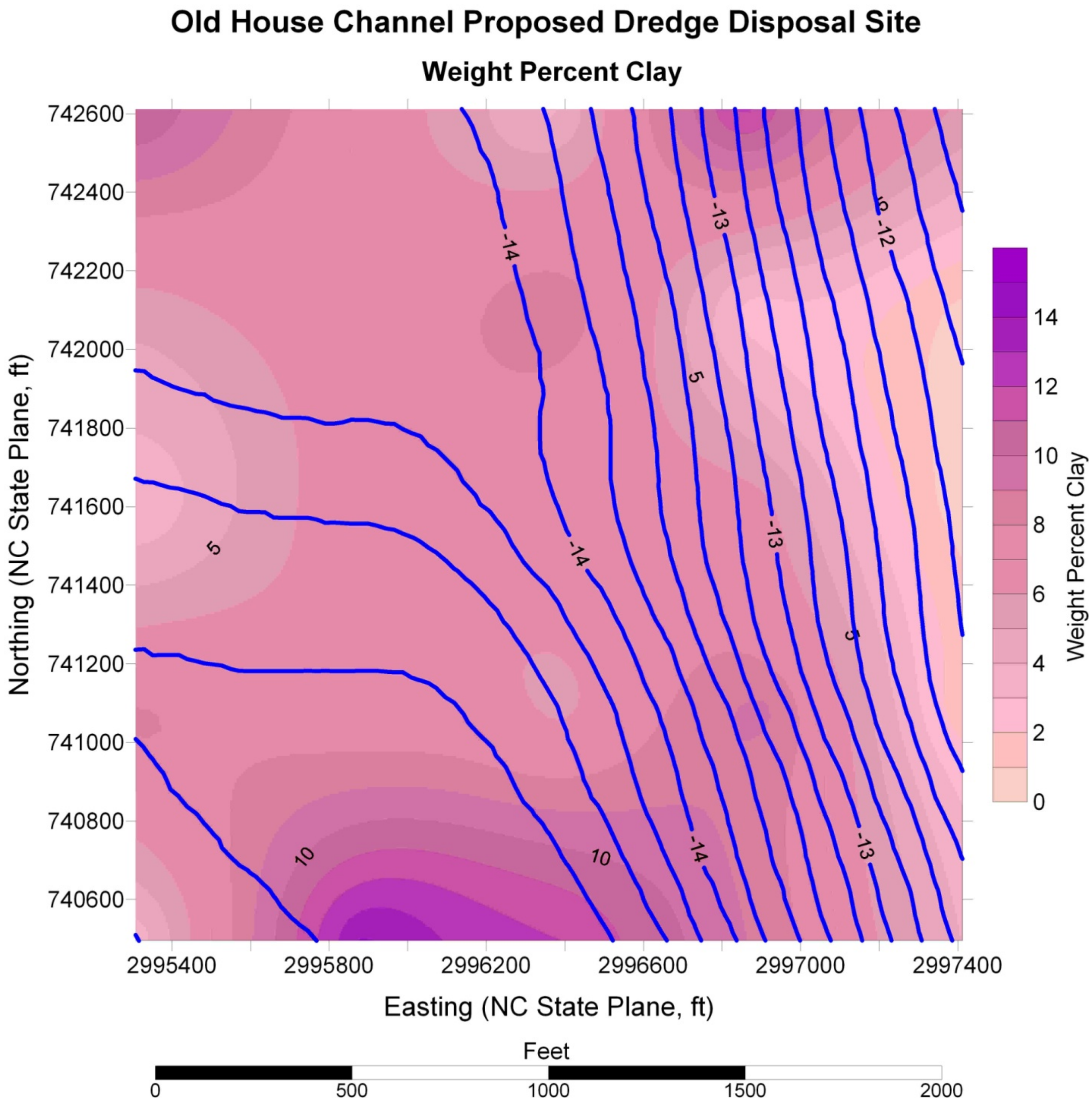

Figure 7: Distribution of weight percent clay. Bathymetric contours are in blue, NAVD88.

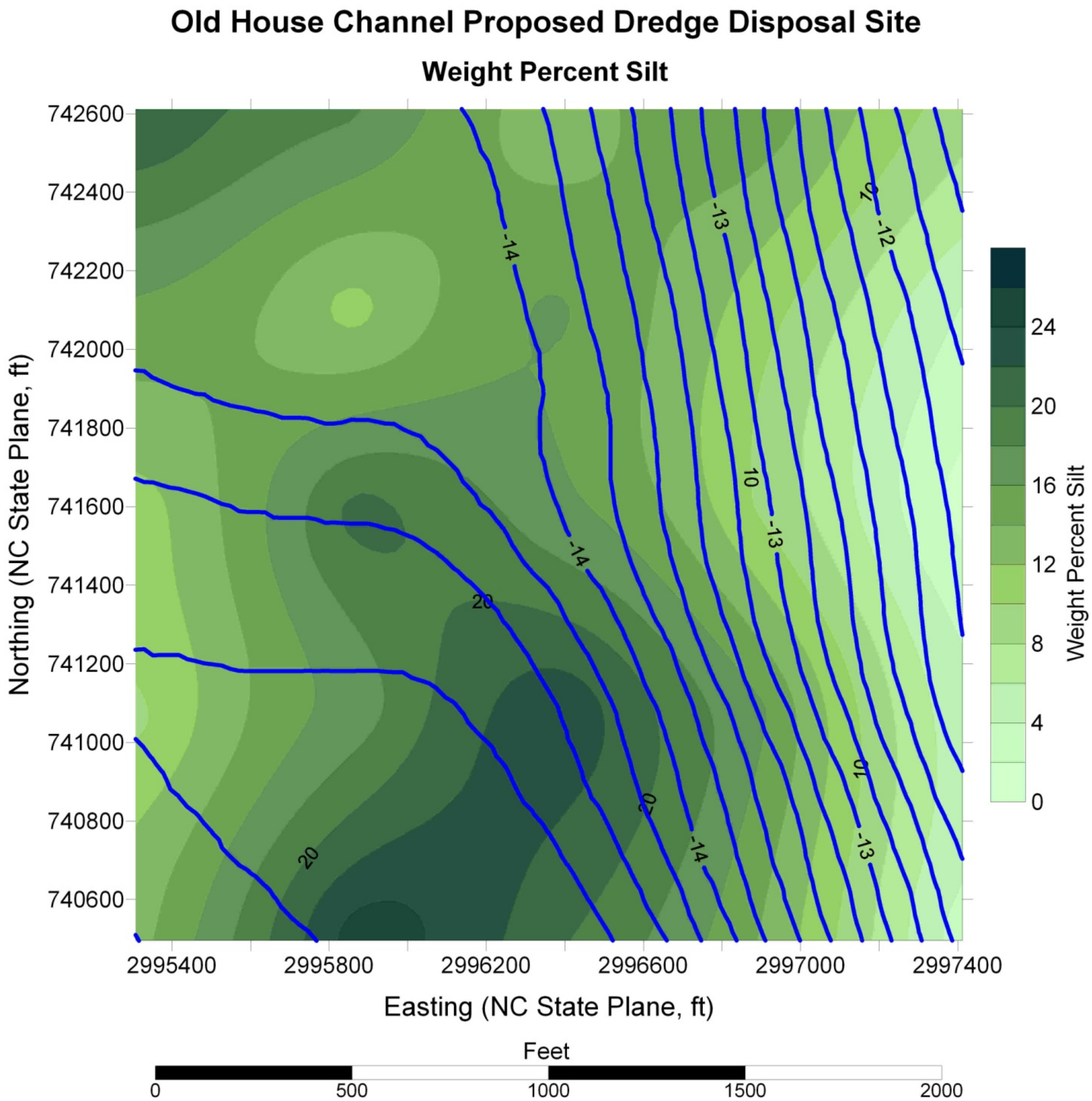

Figure 8: Distribution of weight percent silt. Bathymetric contours are in blue, NAVD88.

2.2 Reexamining the 2009 sidescan data

The sidescan data collected in 2009 did not indicate variations in bottom type in the proposed dredge disposal site (Figure 3) but rather that the region was relatively featureless. In 2010, the USACE-FRF obtained new software for sidescan processing (SonarWiz.MAP; Chesapeake Technology). The original sidescan data from the dredge disposal region were re-processed using this more advanced software suite. From these new images, very little to no differences in amplitude (where brighter colors indicate higher reflection and denser sediment) are found between the sandier vs. muddier regions of the site (see red and green circles for examples; Figure 9). Ultimately, the co-registered sidescan sonar data collected via the 234 kHz swath interferometric system are too low of a frequency to distinguish the observed variations in mud content at this site. While it is possible that variations in moisture content could impact the return amplitudes of the sidescan data, an assessment of the moisture content variability of this site did not suggest that was the case (Appendix B). If the mud concentrations ultimately are high enough to cause a concern for the proposed use for this site, additional sidescan mapping with a higher frequency sonar would likely yield better results in terms of mapping subtle variations in sediment type, than re-processing the existing data alone.

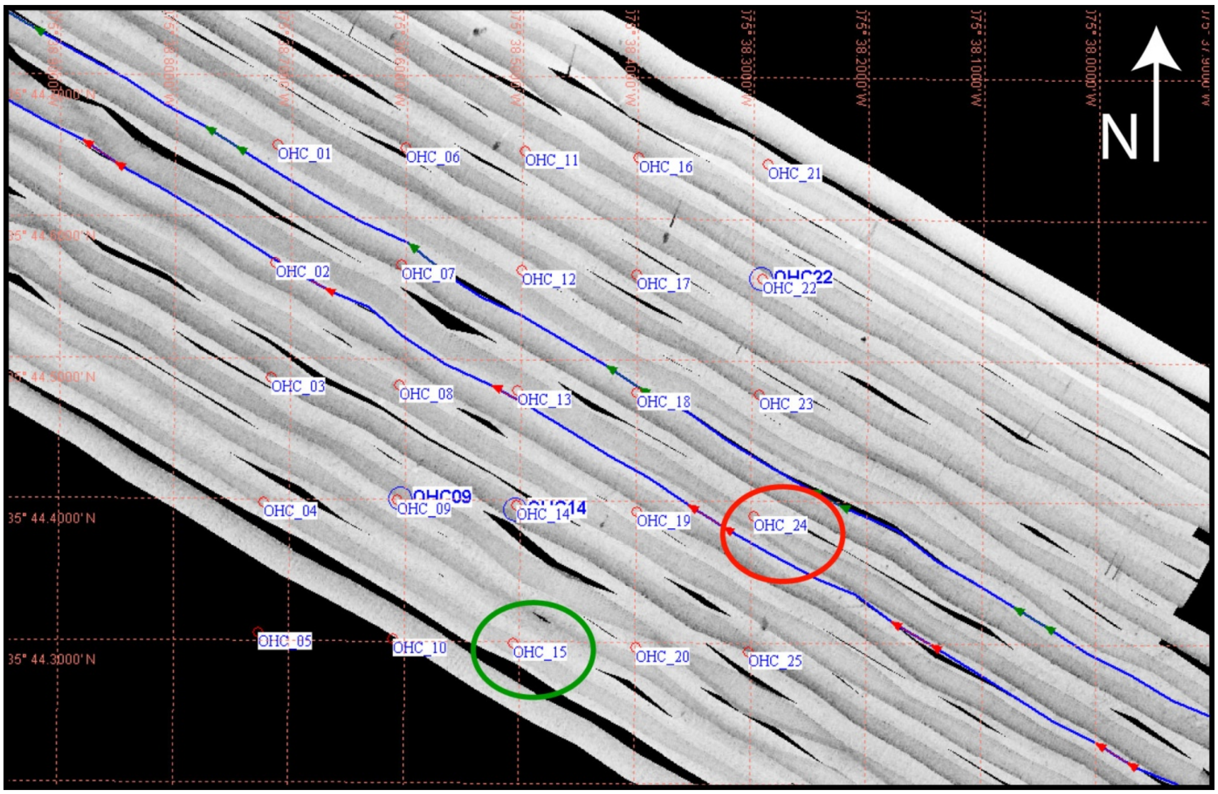

Figure 9: Reprocessed sidescan sonar data. Red circle indicates a sandy sample (OHC 24: 93.87% sand); green circle indicates a muddy sample (OHC 15: 67.91% sand).

3.0 Conclusions

Twenty-five locations were selected to characterize the surficial sedimentary bottom type of the proposed dredge disposal site near Old House Channel, Manteo, NC. The dominant sediment type was muddy sand, and the finer-grained regions were generally found in the deeper region of the site. On average, ~30% of the mud fraction was comprised of clay, and 64% of the samples contained sufficient weight percent clay to be considered to be at least weakly cohesive. The sediment overall was less muddy, and had a higher percentage of sand, than sediment samples taken on either side of the nearest oyster reef complex (~5000 ft to the south; Appendix A). The abundance of various species of polychaetes collected throughout the site suggests that the mud has been stable in this region long enough to allow development of a benthic community. The previously collected sidescan sonar shows little evidence of these grain size variations, even when re-processed with superior software. If a different region needs to be identified in order to better select a disposal site, it is recommended that higher frequency sidescan sonar be used.

A thorough assessment of the suitability of this site as future oyster habitat, or determining if it is currently winter blue crab habitat, is beyond the scope of this report. However, a few general conclusions can be drawn. First, the sediment at this site is weakly cohesive and might potentially resuspend less during the sand disposal process than non-cohesive sediment, thus potentially posing less risk to existing oyster, and other species', nearby habitat. Numerical modeling of potential sediment resuspension should be considered if this is a concern. In addition, the water depths (<9 m) and sand content (60% or greater) suggest that this is not optimal winter habitat for mature female blue crabs, but the possibility of its use by juvenile blue crabs could not be assessed by this study. Determining the nature, extent and thickness of the mud at the site might prove useful in assessing the site's habitat potential. This could be done by: (1) high-frequency (i.e. 800-1000 kHz) sidescan sonar surveys over the site, and adjacent regions, groundtruthed by sediment grabs; (2) chirp sub-bottom profiles to determine the thickness (which will help assess long-term stability) of the muddy sediment; and/or (3) geochemical analyses (e.g. radioisotopes) to determine if the mud is either actively accreting or represents an older, no longer accreting sediment unit. The above suggestions would be greatly complimented by numerical modeling of sediment suspension potential, as well as a proper study of the existing benthic community. These additional tasks would be both costly and time-consuming and should only be considered if the sediment data on its own is insufficient to establish the site's current benthic use and future suitability.

4.0 References

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4.0 Appendix A – Surficial Sediment Associated With Nearby Oyster Reefs

4.1 Description

In an effort to characterize the surficial sediment immediately adjacent to the existing oyster reef near Old House Channel (~5000 ft south of study site), two additional ponar grabs were collected (Figure A-1). Samples were collected from the east and west of the northern edge of the main oyster reef and grain size analyses were performed on both samples. Although linking these sedimentary characteristics of these samples to turbidity conditions on the oyster reef is beyond the scope of this report, the samples do provide a first-order approximation of surficial sediment type associated with the oyster reefs.

Similar to the original study site, both reef samples were composed of muddy sand (48 vs. 61&% sand, OHC_Reef01 and OHC_Reef02, respectively; Table A-1). The remaining mud fraction was split ~60-40 between silt and clay, indicating that these sediments are cohesive (Table A-2). On average, these samples had higher mud and clay contents than all of the samples from the original study site.

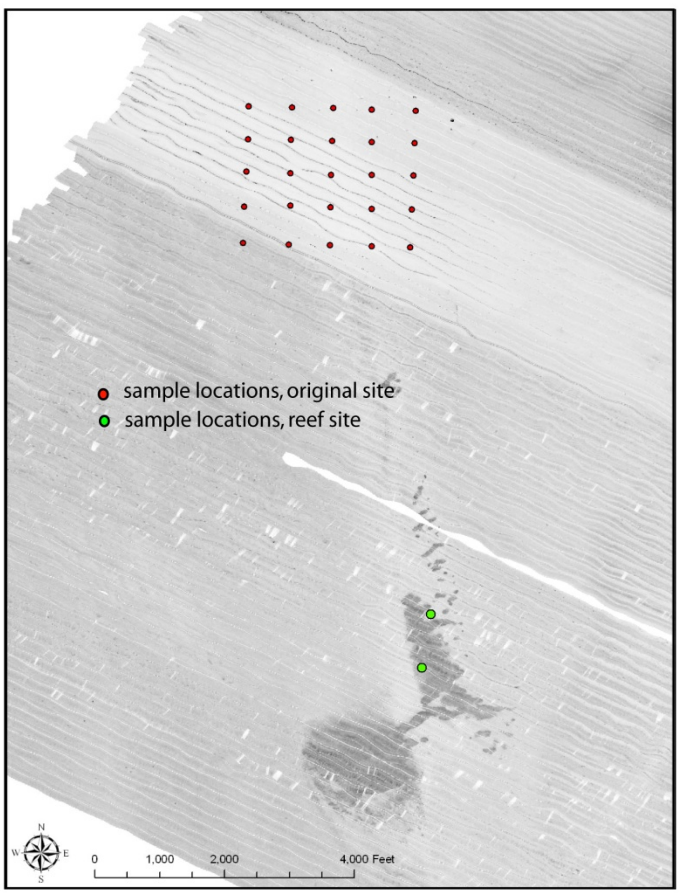

Figure A-1: Location of the reef sediment samples as well as the original sediment samples.

	Weight % Sediment			
Sample ID	Sand	Mud	Silt	Clay
OHC_Reef01	48.41	51.59	32.38	19.21
OHC_Reef02	61.22	38.78	23.15	15.63

Table A-1: Sediment grain size distribution of the reef samples.

	Weight % Mud	
Sample ID	% Silt	% Clay
OHC_Reef01	62.76	37.24
OHC_Reef02	59.69	40.31

Table A-2: Weight percent silt vs. clay in the mud content of the reef samples.

5.0 Appendix B – Percent Moisture of Seabed

5.1 Description

In addition to grain size data, we calculated both the water content, and the percent moisture of the samples to illustrate any patterns in moisture content or porosity. Percent moisture (*P*) was calculated by:

$$P = \frac{wet\ weight - dry\ weight}{wet\ weight * 100}$$

Porosity (ρ) was derived from the water content of the sample as described in Sanford et al. (1990) and Officer et al. (1984) by:

$$\rho = \frac{(sed_g * P)}{((sed_g * P) + (water_g * (1 - P))}$$

where sed_g is the density of the sediment (assumed 2.65 g/cm^3) and $water_g$ is the density of water (assumed 1 g/cm^3). The assumption of sediment density is based on: (1) the high percentage of sand (predominantly quartz in the outer banks) in the samples; and (2) the fact that most common clay minerals are hydrous aluminum layer silicates and thus have a very similar density to quartz. Although the actual mineralogy would have varied in the study site, without a mineralogical study it is not possible to vary sediment density in any meaningful or defendable way.

Overall, percent moisture varied, as would be expected, by the grain size of the sediment sample (Table B-1). The distribution map shown in Figure B-1 clearly shows that the higher percent moisture values correlate to regions of higher mud content (plotted as yellow contour lines). Porosity, however, varied very little over the study site, likely due to the assumption of a single density for all samples. If accurate and detailed porosity data is needed for disposal-related concerns, a mineralogical analysis of the samples is needed in order to more accurately determine variations in sediment density.

Sample ID	Percent Moisture	Porosity
OHC 01	0.48	1.59
OHC 02	0.36	1.58
OHC 03	0.31	1.58
OHC 04	0.36	1.58
OHC 05	0.32	1.58
OHC 06	0.42	1.58
OHC 07	0.32	1.58
OHC 08	0.36	1.58
OHC 09	0.30	1.57
OHC 10	0.46	1.59
OHC 11	0.30	1.57
OHC 12	0.43	1.58
OHC 13	0.40	1.58
OHC 14	0.37	1.58
OHC 15	0.42	1.58
OHC 16	0.46	1.59
OHC 17	0.34	1.58
OHC 18	0.34	1.58
OHC 19	0.39	1.58
OHC 20	0.39	1.58
OHC 22	0.28	1.57
OHC 23	0.28	1.57
OHC 24	0.36	1.58
OHC 25	0.34	1.58

Table B-1: Percent moisture and calculated porosity of the sediment samples.

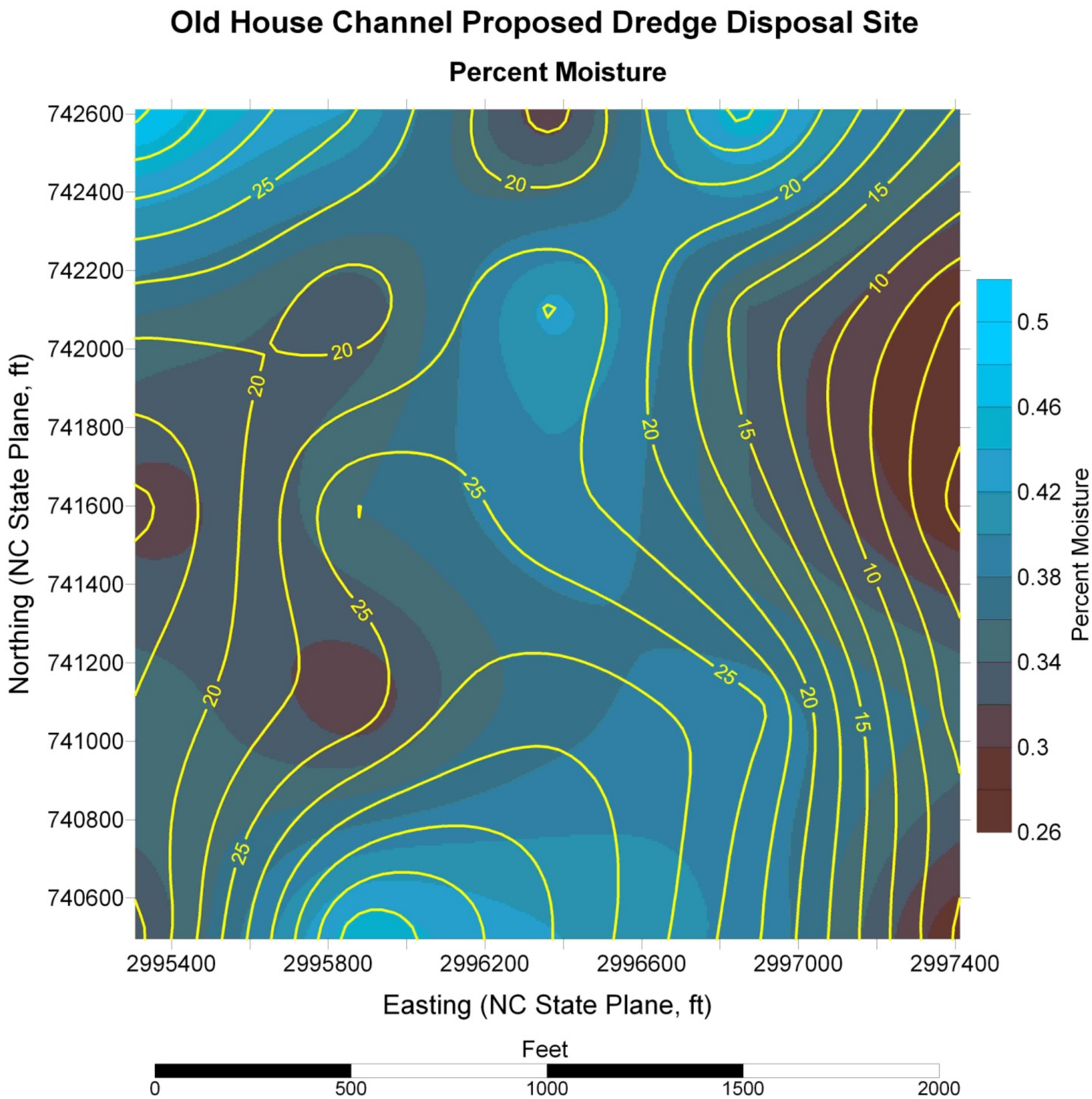

Figure B-1: Distribution of percent moisture. Weight percent mud contours are in yellow.