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FINAL SITE INSPECTION REPORT MUNITIONS RESPONSE PROGRAM OTHER THAN OPERATIONAL WATER RANGES NAS OCEANA VA

12/01/2010

CH2M HILL

Final

Site Inspection Report
Munitions Response Program
Other-than-Operational Water Ranges, North Carolina

Naval Air Station Oceana

Virginia Beach, Virginia

Prepared for

Department of the Navy

Naval Facilities Engineering Command
Mid-Atlantic Division

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Prepared by

CH2MHILL

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Site Inspection Report
Munitions Response Program Other-than-Operational Water Ranges, North Carolina

Naval Air Station Oceana
Virginia Beach, Virginia

Contract Task Order 0028

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Prepared for

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Under the

NAVFAC CLEAN 1000 Program
Contract N62470-08-D-1000

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Virginia Beach, Virginia

Executive Summary

This report summarizes the results of the Site Inspection (SI) conducted at three other-than-operational (OTO) water ranges located in North Carolina that are associated with Naval Air Station (NAS) Oceana, Virginia Beach, Virginia. The Navy, Naval Facilities Engineering Command (NAVFAC), Mid-Atlantic Division, is conducting this SI in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The sites have been identified under the Navy Munitions Response Program.

The primary objective of this investigation was to evaluate the potential presence or suggested absence of munitions and explosives of concern (MEC) and munitions constituents (MC) associated with the use of the ranges. This SI Report was prepared under the NAVFAC Mid-Atlantic, Comprehensive Long-term Environmental Action—Navy (CLEAN) 1000, Contract Task Order 0028 for submittal to the North Carolina Department of Environment and Natural Resources, the lead regulatory agency.

The three OTO water ranges addressed in this SI are off-installation, former target sites that were used by the Navy for air-to-ground training exercises in the Currituck and Albemarle Sounds. The three sites include: the Northern Currituck Sound Target (NCST) Site, North Landing River Target (NLRT) Site, and the Palmetto Point Bombing Range (PPBR) Site. Evidence presented in the Preliminary Assessment (PA) (Malcolm Pirnie, 2009) indicated that there is potential for MEC to be present at each of the ranges based on their historical use. According to the PA, the NCST Site and NLRT Site were used from approximately 1950 until the mid-1960s, and the PPBR Site was used from 1957 until 1998 for aerial bombardment and rocketry training. Records indicate only practice munitions were used at the NCST and NLRT Sites. Although live munitions were authorized for use during times of war at Palmetto Point, no evidence or documentation was identified to suggest live munitions were used at the site. Possible munitions used at the PPBR Site include practice bombs, air-to-surface rockets, and associated spotting and witness charges.

To assess whether MEC are present, a digital geophysical mapping (DGM) survey was conducted for the areas adjacent to potential hard target locations at each of the ranges. An approximately 1,000-yard radius around each potential target was investigated. The survey was performed by traversing the investigation area with an underwater DGM system on evenly spaced transects. Total DGM coverage of each of the investigation areas was approximately 5 percent. Based on the results of the DGM survey, a total of 197 anomalies were detected from 27.4 miles of transects at the NLRT Site, which equates to an average of approximately nine anomalies per acre with no discernible target area or primary anomaly concentration. At NCST Site, 829 anomalies were detected from 41.5 miles of transects, which equates to an average of approximately 25 anomalies per acre. However, the majority of these anomalies are focused around the presumed target location. At PPBR, 3,429 anomalies from 137 miles of transects, which equates to an average of approximately 34 anomalies per acre. The majority of these detections are concentrated around four of six presumed target locations.

Based on the results of the DGM performed, additional investigation may be necessary for each of the OTO water ranges included in this SI to determine if anomalies detected are MEC. Because this investigation was intended to be an initial data gathering and the data is not intended to be used for risk based decisions, additional data collection may be necessary to identify anomalies during future activities. The following actions should be considered for the North Carolina OTO ranges associated with NAS Oceana to further evaluate the potential presence of MEC at the sites.

- **NLRT Site—**Inspection and identification of anomalies from high density areas located at the NLRT Site to determine if MEC is present. If determined to be MEC, MC sampling may be necessary. Additionally, if MEC is found, access to Troublesome Point may need to be gained for further investigation of MEC and MC on the land portion of the site.
- **NCST Site—**Inspection and identification of anomalies from high density areas located at NCST Site to determine if MEC is present. If determined to be MEC, then MC sampling may be necessary.
- **PPBR Site—**Inspection and identification of anomalies from high density areas located at four of the six target locations (Target NAB 42, Primary Target, area northwest of Target D, and Lewis Point) to determine if MEC is present. If determined to be MEC, then MC sampling may be necessary.

Future investigations and data collected should be performed and documented as a Remedial Investigation (RI) and will be used to determine the path forward for the site.

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Acronyms and Abbreviations

AES	Albemarle Estuarine System
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-term Environmental Action—Navy
CSM	conceptual site model
DGM	digital geophysical mapping
FACSFAC	Fleet Area Control and Surveillance Facility
GPS	global positioning system
in./yr	inches per year
IVS	Initial Verification Study
MC	munitions constituents
MEC	munitions and explosives of concern
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
NCDENR	North Carolina Department of Environment and Natural Resources
NCST	Northern Currituck Sound Target
NLRT	North Landing River Target
NOAA	National Oceanographic and Atmospheric Administration
OTO	other-than-operational
PA	Preliminary Assessment
PPBR	Palmetto Point Bombing Range
QA	quality assurance
QC	quality control
SAV	submerged aquatic vegetation
SI	Site Inspection
SOP	standard operating procedure
USACE	United States Army Corps of Engineers
UXO	unexploded ordnance
VACAPES	Virginia Capes

SECTION 1

Introduction

This report summarizes the Site Inspection (SI) activities conducted at three other-than-operational (OTO) water ranges located in North Carolina that are associated with Naval Air Station (NAS) Oceana, Virginia Beach, Virginia under the Navy's Munitions Response Program. This report also includes relevant historical data from previous investigations such as the Preliminary Assessment (PA), as applicable, for the purposes of completing data evaluation and making site-specific determinations (Malcolm Pirnie, 2009). The investigation was conducted in accordance with the *Final Munitions and Explosives of Concern Uniform Federal Policy - Quality Assurance Project Plan for Phase I Site Inspection of the Other-than-Operational Water Ranges, North Carolina (*CH2M HILL, 2010), herein referred to as the Work Plan. Field activities were initiated at the Northern Currituck Sound Target (NCST) Site on August 10, 2010. Activities at NCST Site and North Landing River Target (NLRT) Site were performed from August 10, 2010 through August 18, 2010. Upon completion of data collection at these two sites, field activities were performed at the Palmetto Point Bombing Range (PPBR) from August 20, 2010 through September 1, 2010.

This SI Report was prepared under Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic, Comprehensive Long-term Environmental Action—Navy (CLEAN) 1000, Contract Task Order 0028, for submittal to the North Carolina Department of Environment and Natural Resources (NCDENR), the lead regulatory agency.

1.1 Problem Definition and Objectives of the Site Investigation

Three OTO water ranges (NLRT Site, NCST Site, and PPBR Site) have been identified as OTO ranges associated with NAS Oceana. These sites potentially contain munitions and explosives of concern (MEC) (including unexploded ordnance [UXO]) and munitions constituents (MC). No access restrictions are in place at the sites, and no reported future changes in site use are currently foreseen. All three of the sites are frequently used by recreational users. Hazards associated with unmarked "hard targets" (navigational hazard), potential MEC (explosive hazard), or MC (environmental hazard) may be present as a result of the range usage.

The primary objective of this investigation was to determine the potential presence or suggested absence of MEC at these OTO water ranges. To accomplish this, a digital geophysical mapping (DGM) survey was performed using a towed array of electromagnetic sensors to identify geophysical anomalies on or just below the seafloor sediment in the vicinity of potential hard target locations. Although the DGM survey does not directly determine if the anomaly is MEC or other metallic debris, the data can be used to evaluate the anomaly concentrations in the vicinity of the targets. This investigation was performed to serve as an initial gathering of information that will be used to plan and evaluate any additional activities at the sites. Although the data from this initial SI may provide a preliminary assessment of the extent of each site, it will not be used to make any quantitative risk-based decisions.

1.2 Organization of the Site Inspection Report

This SI Report is organized as follows:

- **Section 1, Introduction:** Provides the objectives of the SI and overall format of the report.
- **Section 2, Site Background:** Provides a brief description and history of the NAS Oceana facility, site descriptions, and history of each of the OTO water ranges. This section also summarizes previous investigations relevant to the SI conducted in association with one or all of the ranges.
- **Section 3, Physical Characteristics:** Describes the physical characteristics, such as physiography, climate, and surface water hydrology of each of the OTO water ranges.
- **Section 4, Investigation Methodology:** Provides a detailed description of the SI and data collection activities.
- **Section 5, Conclusions and Recommendations:** Summarizes the conclusions and recommendations made for each of the OTO water ranges.
- **Section 6, References:** Lists the documents used in preparation of this SI Report.

Tables and figures are presented at the end of each section, as applicable. Appendixes are provided at the end of the report.

SECTION 2

Site Background

2.1 Facility Description and History

NAS Oceana is approximately 5,331 acres in size and is located within the southeastern portion of the city of Virginia Beach, Virginia (**Figure 2-1**). The facility has been in existence since 1940 when it was established as a small auxiliary airfield. Since 1940, NAS Oceana has grown to more than 16 times its original size and is now a Master Jet Base supporting a community of more than 9,700 Navy personnel and 12,300 dependents. The primary mission of NAS Oceana is to provide personnel, operations, maintenance, and training facilities to ensure that fighter and attack squadrons on aircraft carriers of the U.S. Atlantic Fleet are ready for deployment.

Principal operations at NAS Oceana include training and deployment of the Navy's fighter/attack squadrons of F/A-18 Hornet and Super Hornet aircraft. NAS Oceana is the only East Coast Master Jet Base and is home to all East Coast strike-fighter (VFA) squadrons (with the exception of VFA-86, Marine Corps Air Station Beaufort, South Carolina). Currently, pilots fly approximately 219,000 training sorties per year at NAS Oceana. In addition to the fighter squadrons, NAS Oceana is host to several other tenant commands, including the Strike Fighter Weapons and Tactics School, Atlantic; Navy Landing Signal Officer School; Naval Atlantic Meteorology and Oceanography Detachment; Fleet Area Control and Surveillance Facility (FACSFAC), Virginia Capes (VACAPES) Operating Area; Fleet Aviation Specialized Operational Training Group, Atlantic; and Marine Aviation Training Support Group 33 (Malcolm Pirnie, 2009).

2.2 North Landing River Target Description and History

The NLRT Site consists of the waters of the North Landing River within a 1,000-yard radius from a target as described in Title 33, Section 334.410 of the Code of Federal Regulations (CFR) although no visual signs of the target still remain. The range is approximately 20 miles south of NAS Oceana (**Figure 2-1**), near the mouth of the North Landing River in the Currituck Sound (**Figure 2-2**). The range is 649 acres in size and is defined as a danger zone in 33 CFR 334.410. The site is identified as a restricted area on the National Oceanic and Atmospheric Association (NOAA) nautical charts.

Approximately 60 percent of the site is located in open water while the remaining 40 percent of the site is located on coastal salt marshes on a peninsula known locally as Troublesome Point (**Photograph 2-1** and **Photograph 2-2**). The portion of the site that is in open water is located in the northern portion of the Currituck Sound in shallow waters, ranging from approximately 3 to 10 feet deep (a bathymetric map is presented on **Figure 2-3**). This area of the Currituck Sound is part of the Atlantic Coastal Plain.

PHOTOGRAPH 2-1
North Landing River Target Site (Looking Northeast) Troublesome Point Land Area

PHOTOGRAPH 2-2
North Landing River Target Site (Looking Northwest) Troublesome Point Land Area

The site was used for day and night dive bombing by naval aircraft from the mid-1950s until the mid-1960s. The PA indicates that only practice bombs with "small explosive charges for producing smoke puffs to mark point of impact" were dropped on the target; however, the specific qualities and types of munitions usage at the site could not be identified. No munitions have been used at the NLRT Site since the mid-1960s (Malcolm Pirnie, 2009).

Due to the shallow water depth of the Northern Currituck Sound, it is expected that there is limited submerged aquatic vegetation (SAV) within the vicinity of the target. The land portion of the site is made up of coastal marshes associated with the North Landing River and is vegetated with various salt marsh grasses.

No cultural resources are known to exist at the NLRT Site. However, Troublesome Point is identified as a Significant Natural Heritage Area (an area which is important for the conservation of the state's biodiversity) by the state of North Carolina. The PA Report (Malcolm Pirnie, 2009) notes a possible occurrence of some rare species of vegetation located in the Troublesome Point Marsh. Additional, ecological receptors within the site may include benthic invertebrates and several fish species, such as white perch, spot, and striped mullet. The area is a popular hunting and fishing spot for local residents.

2.3 Northern Currituck Sound Target Description and History

The NCST Site consists of one "hard target," according to nautical charts and 33 CFR 334.410, although no visual signs of the target still remain. The range is approximately 25 miles south of NAS Oceana (**Figure 2-1**).The total site area is approximately 3,831 acres with a hard target located in the approximate center of the site and is located in the northern portion of the Currituck Sound, with the Atlantic Intracoastal Waterway immediately to the west (**Figure 2-2**). The range is defined as a danger zone in 33 CFR 334.410 and a prohibited area on the NOAA nautical charts.

Similar to the NLRT Site, this site was used for day and night dive bombing by naval aircraft from approximately 1950 until the mid-1960s. The PA Report (Malcolm Pirnie, 2009) indicates that only practice bombs with "small explosive charges for producing smoke puffs to mark point of impact" were dropped on the target; however, the specific quantities and types of munitions usage at the site could not be identified. No munitions have been used at the NCST Site since the mid-1960s.

The site is located in shallow waters, ranging from 5 to 11 feet deep (a bathymetric map of the site is presented on **Figure 2-4**). Because of the shallow nature of the Northern Currituck Sound, limited SAV is expected within the vicinity of the target. No federally listed threatened, endangered, or special concern species are specifically known to inhabit the NCST Site. However, listed species that may use the area in and around the targets for foraging or during migration may be found in the vicinity (Malcolm Pirnie, 2009). Ecological receptors within the site may include benthic invertebrates and several fish species such as white perch, spot, and striped mullet (Malcolm Pirnie, 2009). The area is a popular fishing spot for local sport fishing.

2.4 Palmetto Point Bombing Range Description and History

According to the PA Report, the PPBR Site consisted of three target subareas labeled as A, B, and C. The site is located off the south shore of Albemarle Sound in North Carolina and is approximately 55 miles south of NAS Oceana (**Figure 2-**1). The PPBR Site is believed to have contained approximately six hard targets. The total site area is approximately 18,440 acres (**Figure 2-5**). The range is defined in 33 CFR 334.410 and is identified as a danger zone on the NOAA nautical charts.

The site was used for basic loft bombing and high-altitude dive bombing from approximately 1957 until 1998. The targets were also used by pilots as initial skill testing until they developed accuracy. According to ordnance reports available from the range (1975 through 1998), as well as the CFR, only non-explosive munitions (practice munitions, water filled, or smoke bombs) were used at the site. Although the range was authorized for live munitions use during times of war, no records were identified that document the use of live munitions at the range. As a result of a lack of use and lack of benefit to training operations, a range closure document was signed on October 30, 2000, officially closing the PPBR (Malcolm Pirnie, 2009). Remnants of two of the potential hard targets were identified during a 2009 boat tour of the site, one target being a series of pilings (**Photograph 2-3**) and the other a portion of a submerged vessel (**Photograph 2-4**). Two additional potential targets, Bull Bay and Scuppernong, were also identified in the vicinity of the PPBR Site. These target areas are to be addressed by the United States Army Corps of Engineers (USACE) as part of the Formerly Used Defense Sites Program.

PHOTOGRAPH 2-3
Pilings (Possibly Target 42)

PHOTOGRAPH 2-4
Submerged Vessel (Possibly Target NAB 42)

The site is located in the southern shore of the Albemarle Sound in relatively shallow waters, ranging from approximately 2 to 21 feet deep (bathymetric maps are presented on **Figures 2-6** and **2-7**). The range may have aquatic vegetation, such as Eurasian water milfoil and various aquatic grass species. Several species of fish and shellfish live within the Albemarle Sound including striped bass, blue back herring, spot, Atlantic croaker, anchovies, and blue crabs. No access restrictions are currently imposed for the site boundaries or targets, except for a sequential series of signs posted on pilings that identify the "Bombing Area" (**Photograph 2-5**). The area is a popular spot for local sport fishing.

2.5 Previous Studies and Investigations

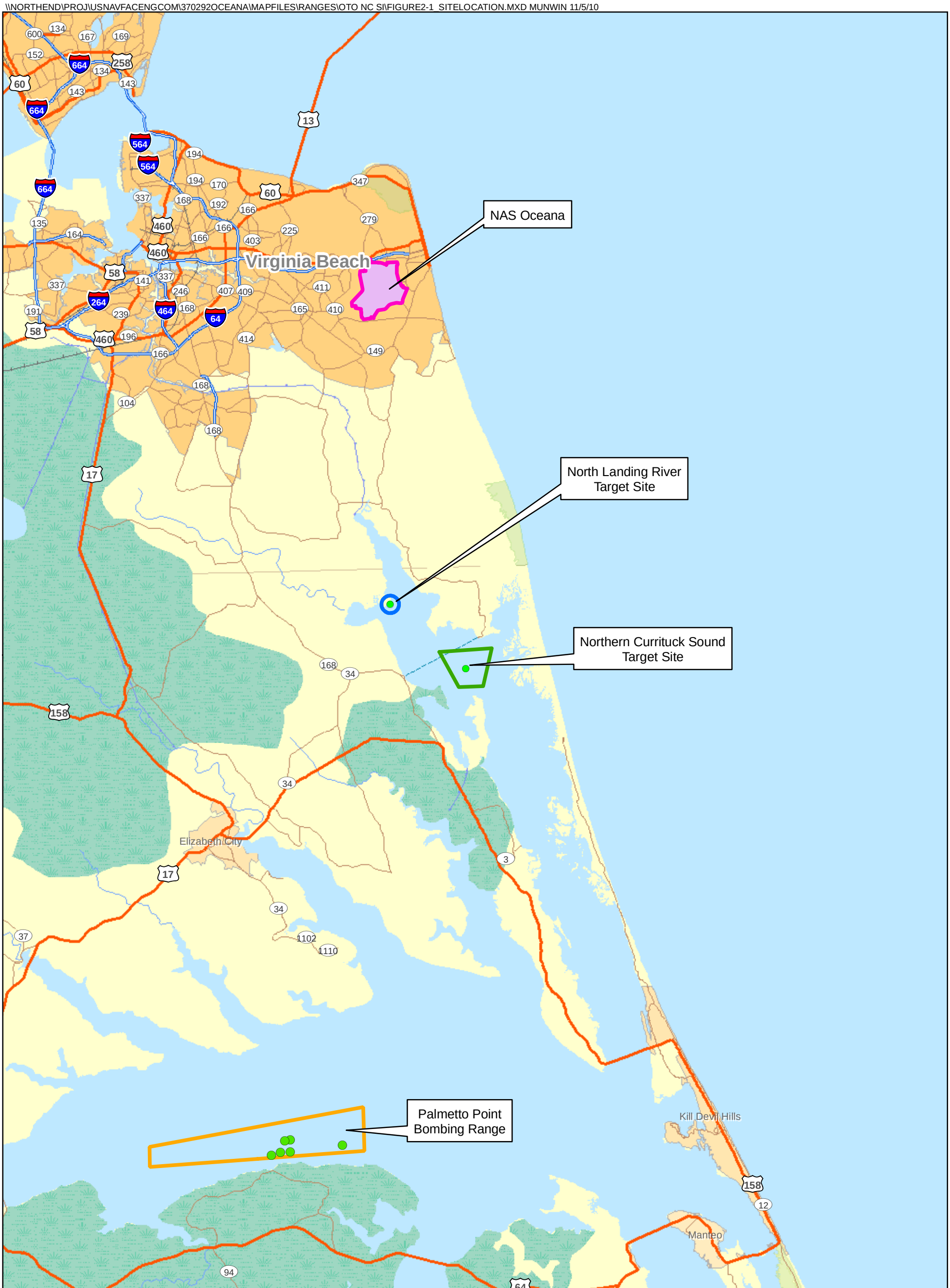
2.5.1 Final Preliminary Assessment Report

The PA Report (Malcolm Pirnie, 2009) addressed the history of munitions use at the three other-than-operational ranges. Several sources were researched during the PA to determine the potential for munitions at the OTO water ranges. Data were collected from historical archives, personal interviews, installation data repositories, and off-site data sources and repositories; however, due to the nature of the sites (being underwater), no visual surveys were conducted for the PA.

Based upon information obtained during the PA, it was determined that the three OTO water ranges located in North Carolina were suspected to contain MEC and, therefore, required further investigation.

PHOTOGRAPH 2-5
Palmetto Point Bombing Range Marker

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE2-1_SITELOCATION.MXD MUNWIN 11/5/10



Legend

- NAS Oceana
- Northern Currituck Sound Target Site (3,831 acres)
- North Landing River Target Site (649 acres)
- Palmetto Point Bombing Range (18,440 acres)
- Target Location

N W E S

0 6 12 Miles

Figure 2-1
Base and Site Map
NAS Oceana
Virginia Beach, Virginia

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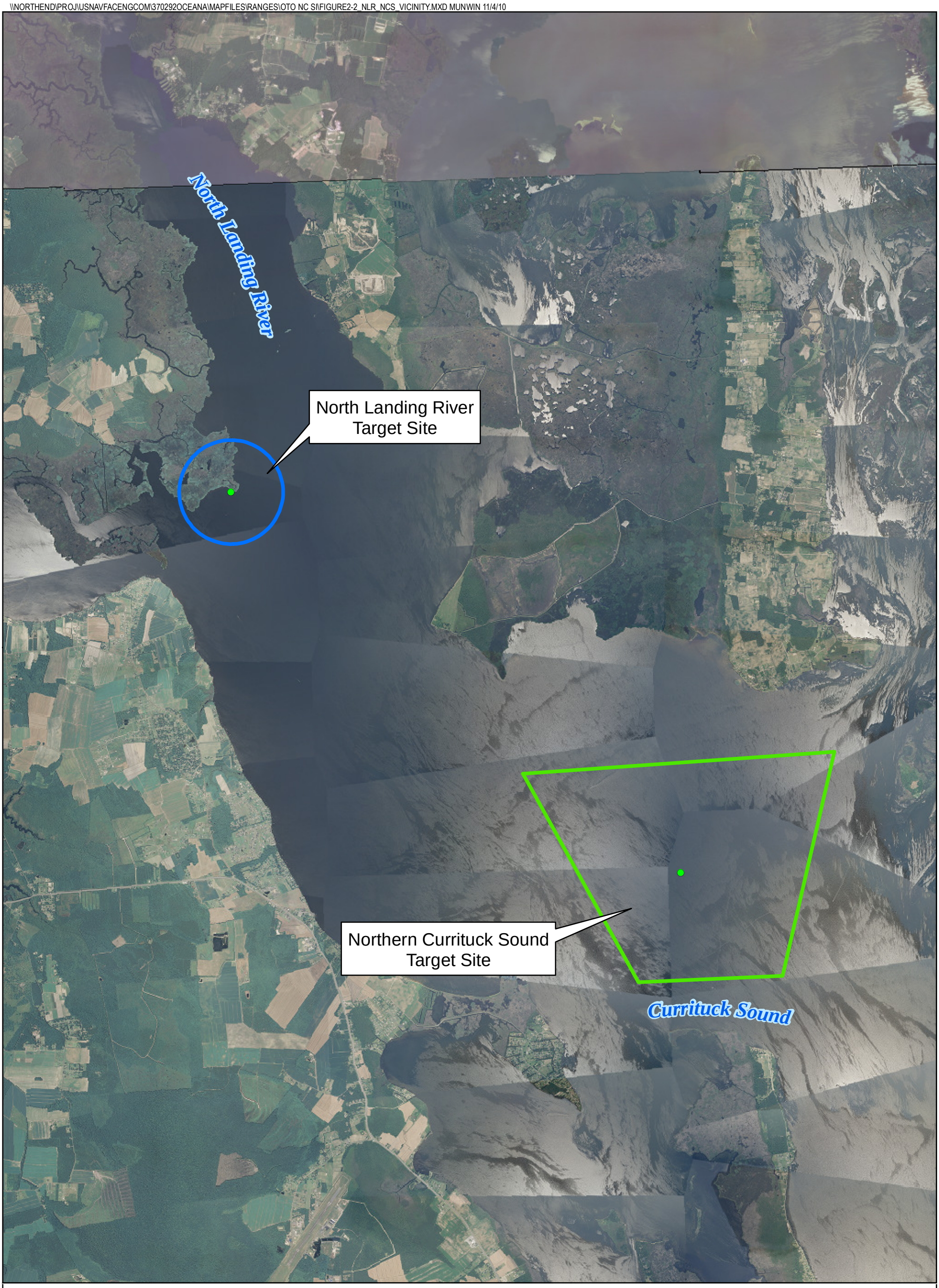
\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE2-2_NLR_NCS_VICINITY.MXD MUNWIN 11/4/10



Legend

- Northern Currituck Sound Target Site (3,831 acres)
- North Landing River Target Site (649 acres)
- Target Location

N
W E
S

0 1 2 Miles

Figure 2-2
North Landing River Target and Northern Currituck Sound Target Vicinity Map
NAS Oceana
Virginia Beach, Virginia

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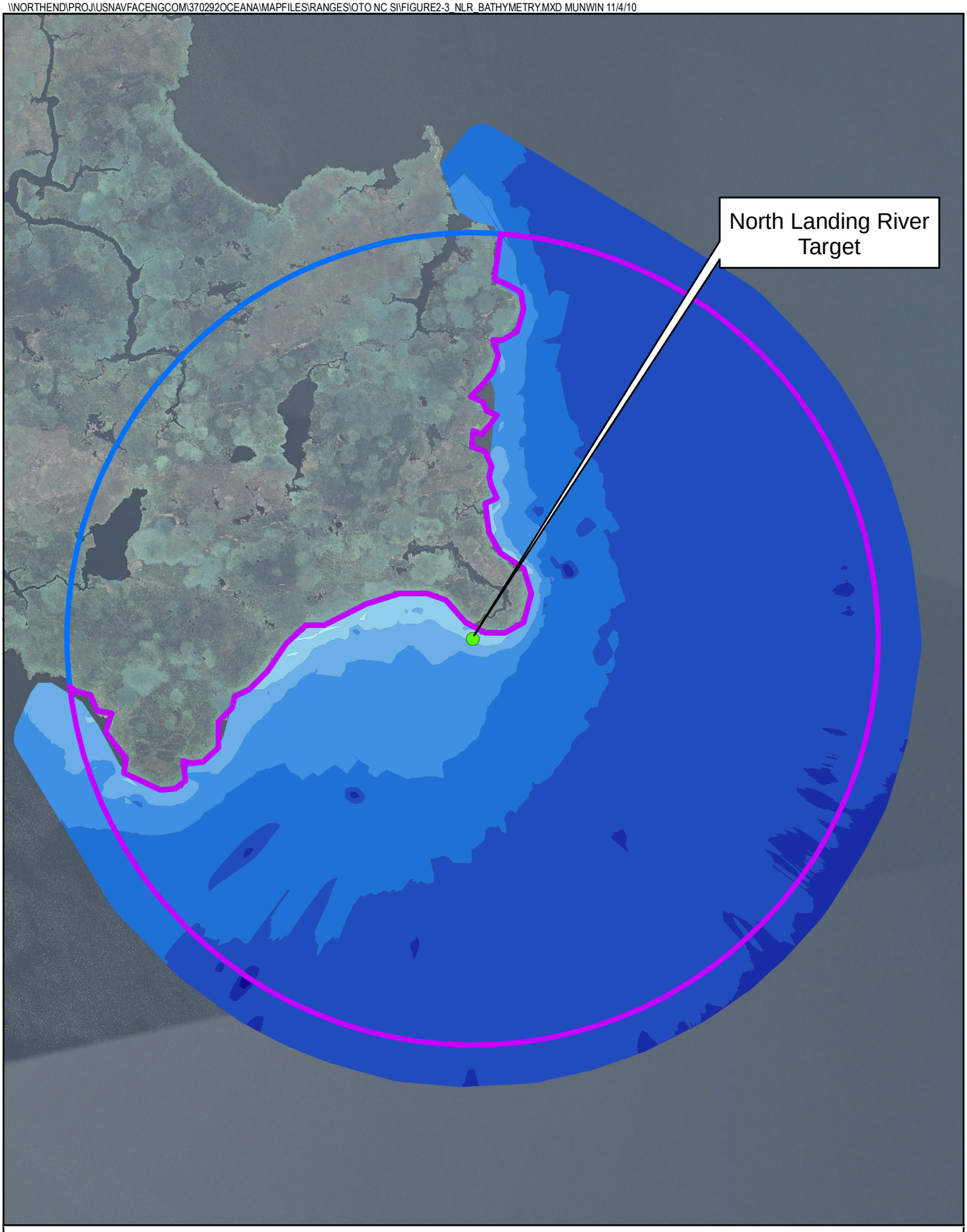
\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE2-3_NLR_BATHYMETRY.MXD MUNWIN 11/4/10



Legend

- Investigation Area
- Site Boundary
- Target Location

Depth (ft)

- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

N
W E
S

0 500 1,000
Feet

Figure 2-3
North Landing River
Bathymetric Map
NAS Oceana
Virginia Beach, Virginia

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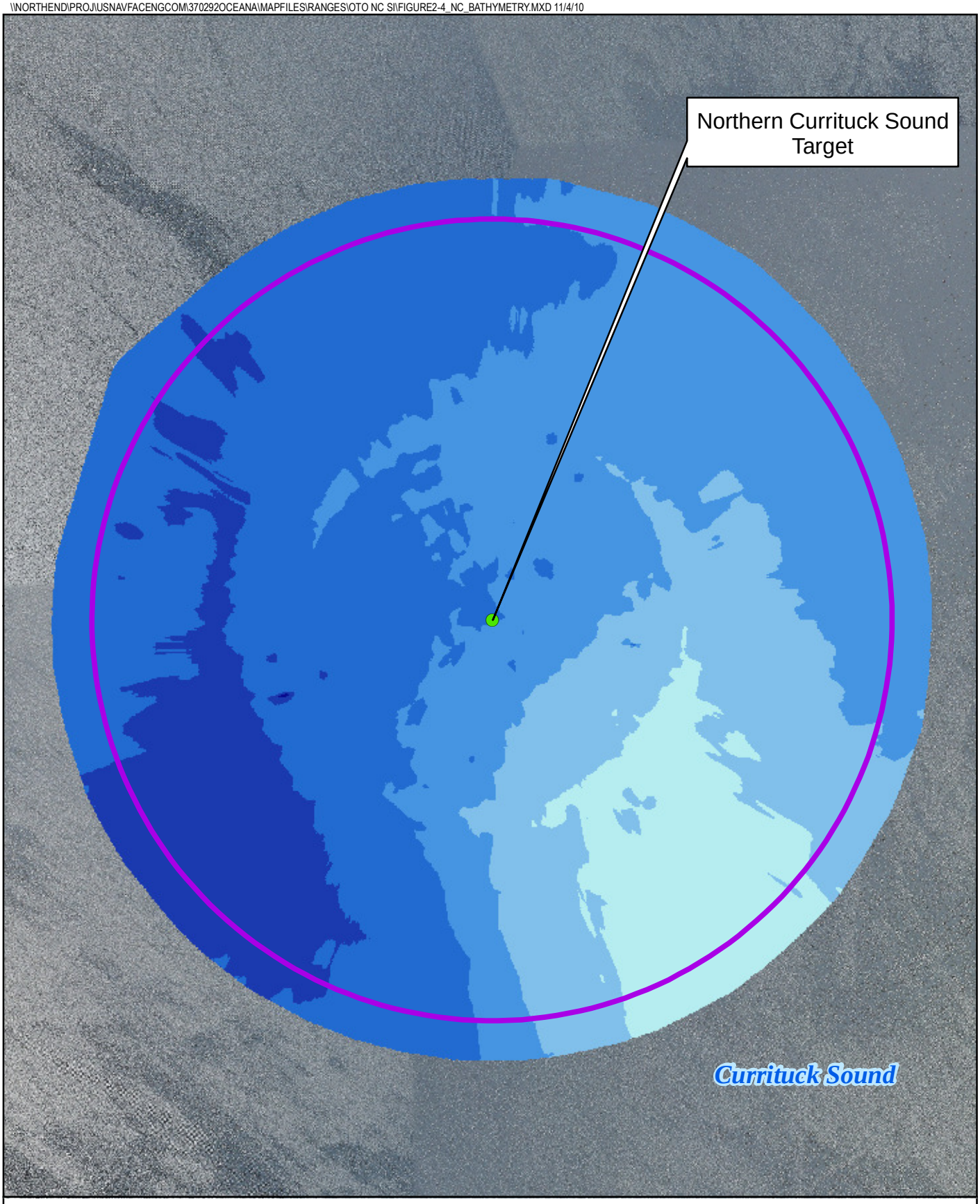
\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE2-4_NC_BATHYMETRY.MXD 11/4/10



Legend

Investigation Area

Target Location

Depth (ft)

5

6

7

8

9

10

N

W E

S

0 500 1,000

Feet

Figure 2-4
Northern Currituck Sound Target
Bathymetric Map
NAS Oceana
Virginia Beach, Virginia

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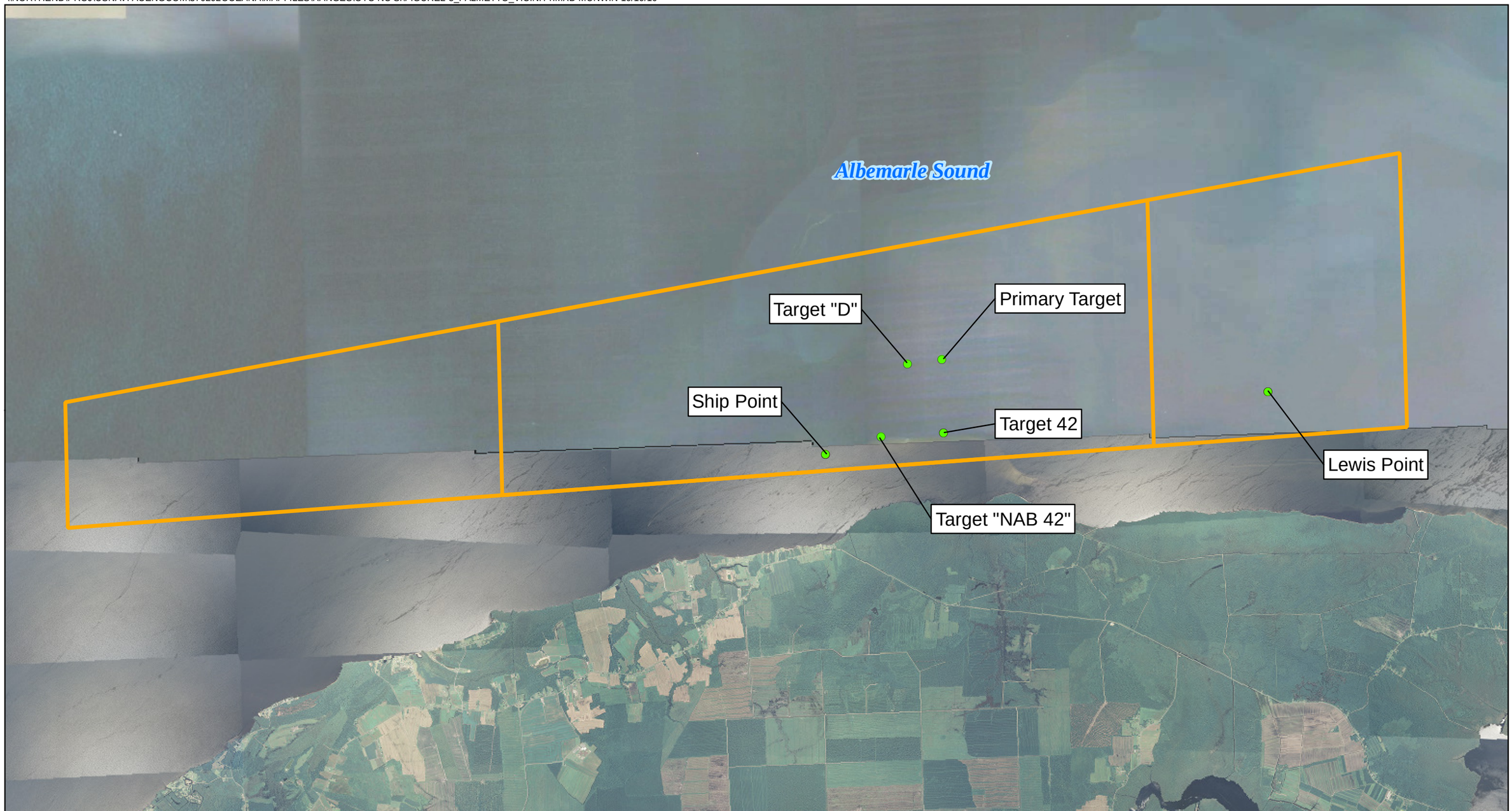
\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE2-5_PALMETTO_VICINITY.MXD MUNWIN 10/19/10



Legend

Palmetto Point Range Area (18,440 acres)

Target Location

N
W E
S

0 1 2
Miles

Figure 2-5
Palmetto Point Bombing Range
Vicinity Map
NAS Oceana
Virginia Beach, Virginia

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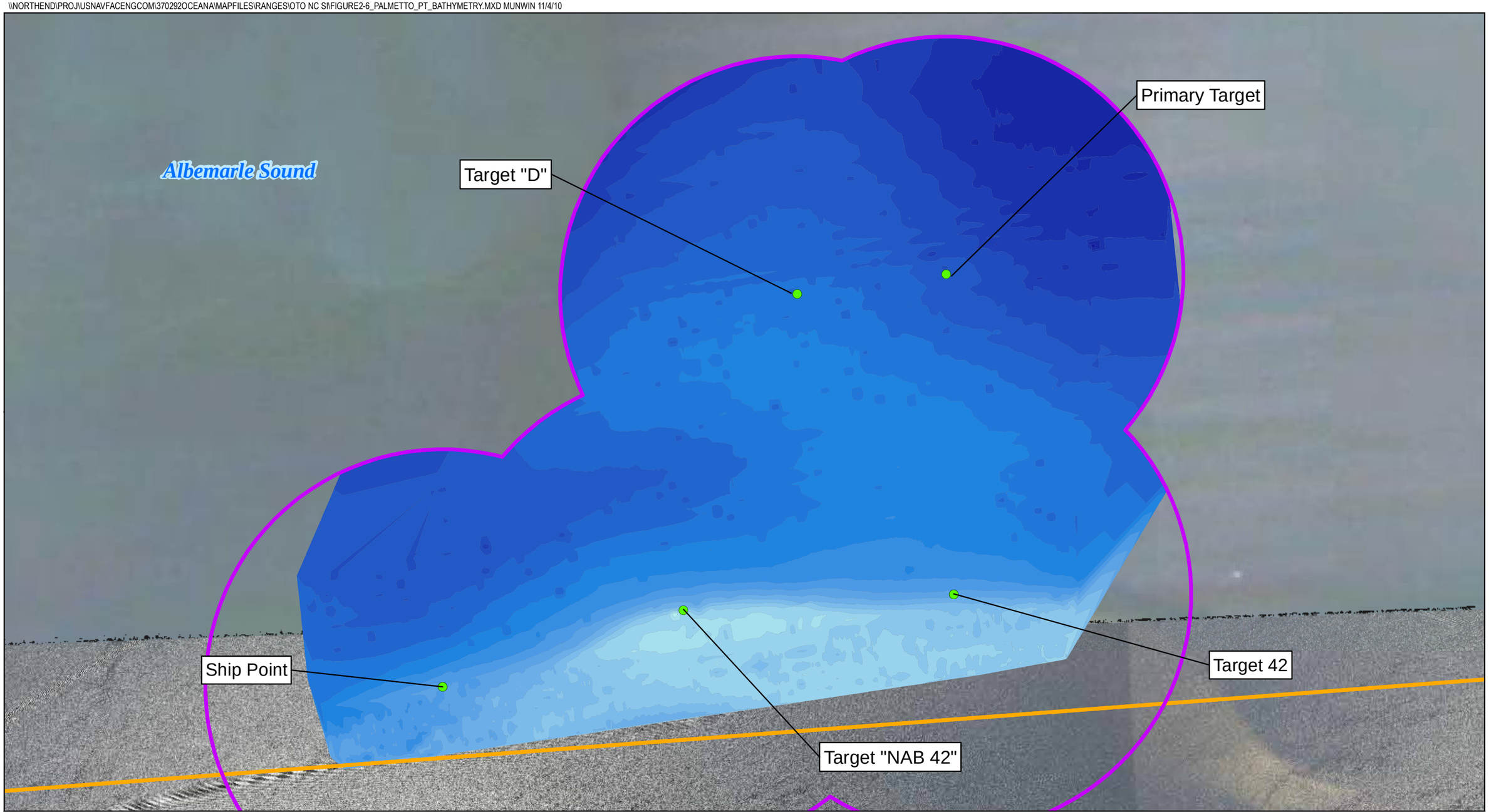
\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE2-6_PALMETTO_PT_BATHYMETRY.MXD MUNWIN 11/4/10



Legend

- Palmetto Point Range Area Boundary
- Investigation Area
- Target Location

Depth (ft)

2	8	15
3	9	16
4	10	17
5	11	18
6	12	19
7	13	20
	14	

N
W E
S

0 1,200 2,400
Feet

Figure 2-6
Palmetto Point Bombing Range
Bathymetric Map
NAS Oceana
Virginia Beach, Virginia

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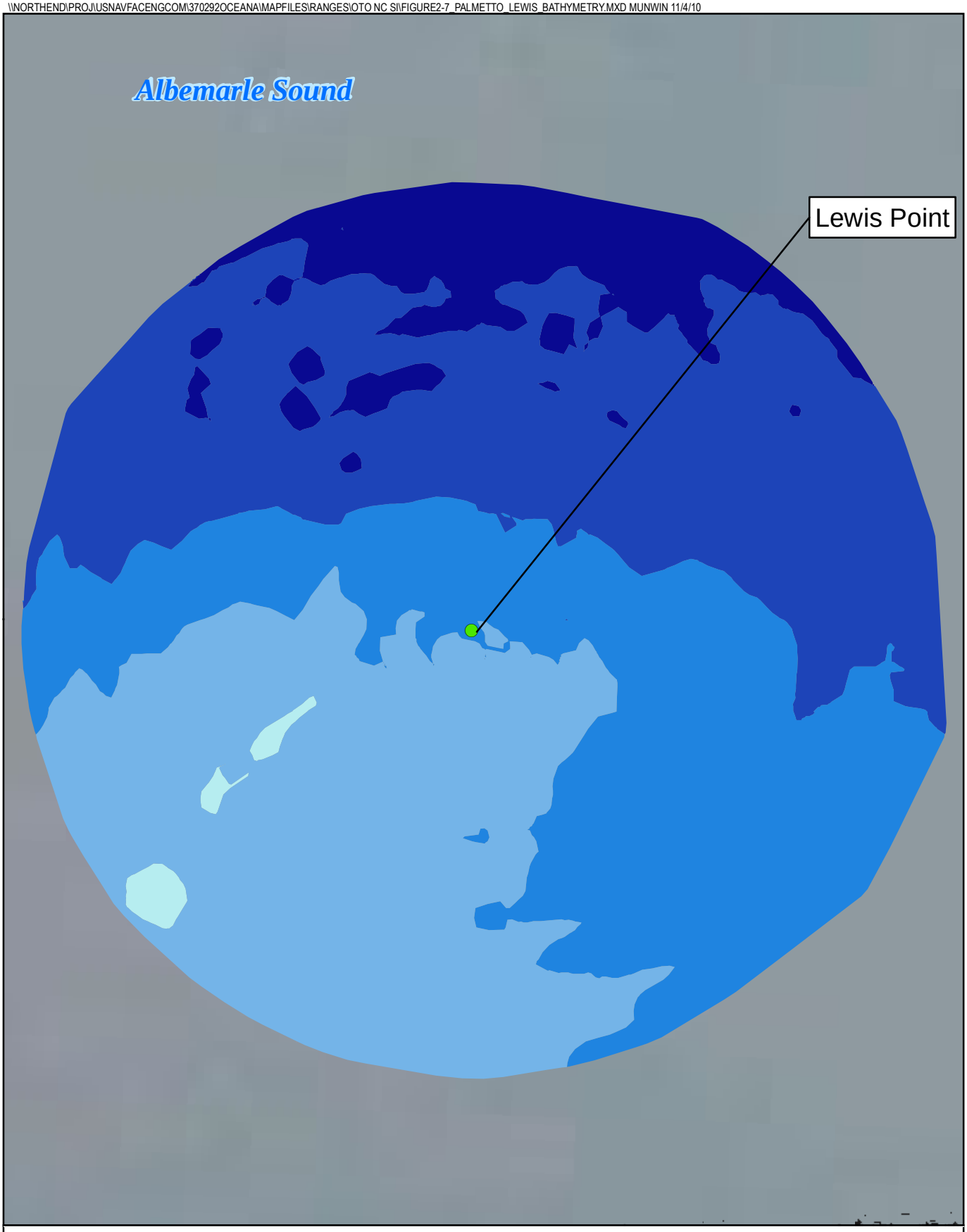
\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE2-7_PALMETTO_LEWIS_BATHYMETRY.MXD MUNWIN 11/4/10



Legend

Target Location

Depth (ft)

- 14
- 15
- 16
- 17
- 18

N
W E
S

0 250 500
Feet

Figure 2-7
Palmetto Point - Lewis Point
Bathymetric Map
NAS Oceana
Virginia Beach, Virginia

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SECTION 3

Physical Characteristics

3.1 NAS Oceana Regional Land Use

NAS Oceana is located in the southeastern portion of Virginia Beach, Virginia. The installation encompasses 5,331 acres of land, plus many outlying annex properties including the three OTO ranges—NCST Site, NLRT Site, and PPBR Site. NAS Oceana's land area includes runways, personnel, operations, maintenance, and training facilities. Since the three OTO sites are located within water bodies, the main uses are commercial and recreational fishing, and boating (hunting also likely occurs in the marsh areas).

3.2 Physiography, Climate, Surface Water Hydrology, and Sediment Characteristics

NAS Oceana is located in the Tidewater Region of Virginia's coastal plain. The NCST Site, NLRT Site, and PPBR Site lie to the south of NAS Oceana in the Currituck and Albemarle Sounds located in North Carolina.

The climate near NAS Oceana and the OTO water ranges is moderated from extremes by the Atlantic Ocean and is relatively mild, though humid. Winters are generally milder than inland locations. The area receives an average of 48 inches per year (in./yr) of rain, which is evenly distributed throughout the year, with July and August receiving slightly greater amounts. Winter and early spring months are considered the wet season because of increased evidence of standing water due to low rates of evapotranspiration (GMI, 2006).

Coastal weather events in the form of severe thunderstorms, Nor'easters, and occasional hurricanes can have significant but temporary effects on the climate of the area. Winds typically blow from a northerly direction from January through March and again in September and October. During the remaining months, winds generally blow from a southerly direction (GMI, 2006).

The NLRT Site, NCST Site, and PPBR Site are all located in a large, shallow estuary to the west of the North Carolina Outer Banks. The NLRT and NCST Sites are located in Currituck Sound, and the PPBR Site is located in Albemarle Sound. Both of these water bodies are part of the Albemarle Estuarine System (AES) (Corbett et al., 2007).

The AES is comprised of drowned river valleys formed in response to the post-glacial rise in sea level that flooded the stream valleys of the coastal plain drainage system (Corbett et al., 2007; Riggs and Ames, 2003). The AES includes Albemarle Sound and its tributaries, Currituck Sound, Croatan Sound, and Roanoke Sound. These water bodies are dominated by fresh water due to protection from the Atlantic Ocean by the Outer Banks, which form a continuous barrier island. The nearest inflow of saline water into the estuary is through Oregon Inlet, approximately 25 miles southeast of the mouth of Albemarle Sound. There are virtually no astronomical tides in the AES because of the lack of free exchange with the

ocean. Therefore, circulation is driven predominately by freshwater inflow and winds (Corbett et al., 2007).

The Currituck Sound is shallow, with an average depth of 5 feet and a maximum depth of 13 feet. The Sound trends in a north-south direction for 36 miles from the Virginia/North Carolina state line to the confluence with Albemarle Sound. The Atlantic Intracoastal Waterway passes through Currituck Sound to the east of the NLRT Site and to the west of the NCST Site. The waterway has been dredged only infrequently since 1947, with the last major dredging event occurring in 1965 (Currituck Sound Restoration Project, 2006). However, the USACE Wilmington District anticipates that dredging will be needed in the future. The navigational charts show that dredged material was placed on the east sides of the dredged channel. No dredged material appears to have been removed or placed within the boundaries of the sites.

The Albemarle Sound trends in an east-west direction and is approximately 55 miles long. The Sound is 8 miles wide in the vicinity of the PPBR Site. It has a shallow perimeter platform that slopes gradually from the shoreline to a depth of 3 to 7 feet below mean sea level, and then slopes more abruptly to the floor of the basin at 11.5 to 25 feet deep (Riggs and Ames, 2003). No dredging is performed for navigational purposes in Albemarle Sound.

Wells (1989) created a sediment distribution map of the AES based on the grain size distribution of sediment samples from a number of different studies. Both the NLRT and NCST Sites are shown as being composed of silt, although few samples were collected in Northern Currituck Sound. The land portion of the NLRT Site is a coastal marsh, and the sediments in the adjacent water portion are most likely organic-rich sandy muds primarily derived from eroding marsh peat, similar to sediments further north in the North Landing River (Riggs et al., 1993). Fine-grained sediments near the NCST Site also are likely to be derived primarily from the erosion of marsh shoreline although no specific information about sediment characteristics in vicinity of the site were found. However, the sediment type in the Currituck Sound changes to sand immediately south of the NCST Site.

The composition and distribution patterns of sediments in Albemarle Sound were defined based on the analysis of 248 sediment samples (Riggs, 1996). Within the boundaries of the PPBR Site, fine to medium sands are present along the shoreline perimeter platform to a depth of about 5 to 6.5 feet. The sands grade into organic-rich mud on the slope down to the central basin. The major source of sediment is the erosion of the shoreline by wave activity (Wells, 1989). Shoreline recession provides sand to the perimeter platform, and mud and organic detritus to the central basin. Fine-grained suspended sediment from rivers also accumulates in central basin, although the river inflows have a low sediment load (USGS, 1992).

The sediment type in Albemarle Sound is controlled by the wave base, which is a function of fetch (i.e., distance over which the wind blows) and water depth. Sediments within the range of the wave base have the potential for being resuspended during high-energy storm events (Riggs and Ames, 2003). Following resuspension, the winnowing action of waves and wind currents sort the fine and coarse sediment. The finer-grained sediments are eventually transported to and deposited in the deeper central basin, or flushed from the system by river discharge and wind tides, probably to Pamlico Sound (Corbett et al., 2007).

The net sediment accumulation rate measured in a sediment core from the middle of Albemarle Sound directly north of the PPBR Site was estimated at 0.04 to 0.06 in./yr based on radioisotope profiling (lead-210 and Cesium-137) (Corbett et al., 2007). Estimates of sediment accumulation rates at the NLRT and NCST Sites were not available, but are estimated to be low based on the need for only infrequent dredging of the Intracoastal Waterway. A detailed description of the sediment transport and hydrodynamic effects within the vicinity of the OTO water ranges in included in the *Tier I Sediment Transport Evaluation Technical Memorandum* (**Appendix A**).

3.3 Ecological Settings and Natural Resources

The Northern Currituck Sound, North Landing River, and Albemarle Sound are beneficial resources and habitat to many aquatic species. The North Carolina Natural Heritage Program also recognizes Troublesome Point, which is located at the NLRT Site, as a significant natural heritage area (North Carolina Natural Heritage Program, 2006).

The Virginia Department of Conservation and Recreation Division of Natural Heritage identified four reptiles present in the City of Virginia Beach that are threatened and endangered species and may be present in the Northern Currituck Sound, North Landing River, or Albemarle Sound. The loggerhead sea turtle (*Caretta caretta*) is a federally and state listed threatened species. The Canebrake rattlesnake (*Crotalus horridus atricaudatus*) and the chicken turtle (*Deirochelys reticularia*) are both state-listed endangered species. The eastern glass lizard (*Ophisaurus ventralis*) is a state-listed threatened species. Additionally, the North Carolina Natural Heritage Program cited the following specific rare plant species at Troublesome Point, located at the NLRT Site: long-awned sprangletop (*Leptochloa fascicularis var. maritime*), Carolina lilaeopsis (*Lilaeopsis carolinensis*), and beaked spikerush (*Eleocharis rostellata*).

The Northern Currituck Sound and North Landing River have increased turbidity due to dredging and the problems with fluctuations of salinity levels. This results in a decreased amount of SAV. The Albemarle Sound is part of the Albemarle estuarine system, with seasonal variations in salinity; high salinity is seen from September through November, and lower salinity is present from February through May. This contributes to fluctuating levels of SAV in the Albemarle Sound (GMI, 2006).

3.4 Cultural Resources

There are no cultural resources located on the former ranges (Malcolm Pirnie, 2009). However, the sites are popular locations for recreational sport fishing, hunting, boating, and crabbing.

SECTION 4

Investigation Methodology

This section summarizes the field investigation procedures of the SI at NAS Oceana OTO ranges: NCST Site, NLRT Site, and PPBR Site. The investigation activities and data presented below summarize the field activities conducted from August 10 through September 1, 2010, in accordance with the Work Plan. The investigation activities consisted of a DGM survey of the three OTO water ranges.

4.1 Mobilization and Site Preparation

Initial mobilization for the field activities was conducted on August 10, 2010 at the NCST Target. The investigation approach is defined in the Work Plan. Upon mobilization, a kickoff meeting was conducted with representatives from CH2M HILL and the subcontractor (NAEVA Geophysics and second tier subcontractor 3D Geophysics). During the kickoff meeting, all onsite personnel reviewed the Work Plan, as well as the standard operating procedures and health and safety documentation. In addition, the field team reviewed nautical charts to identify the location of the targets as well as any navigational hazards that could potentially be encountered during the survey. An inspection of the boat and safety equipment was also performed.

All site specific training was verified by CH2M HILL prior to field activities. Prior to the start of field activities, equipment was inspected and tested to ensure it was functioning properly prior to data collection. Communication requirements for all team members were established before field work began. Additionally, local agencies and emergency services (including nearby hospitals and the United States Coast Guard Rescue Coordination Center) were notified in advanced of site activities by CH2M HILL, so that they would be prepared and equipped to respond to any emergencies. During field activities at the PPBR Site, daily communication was also required with FACSFAC VACAPES to notify them of planned activities for scheduling purposes of the Harvey Point Range (located north of PPBR Site).

4.2 Sequence of Data Collection

The first mobilization was to the NCST and NLRT Sites. Due to their proximity, both of these sites were surveyed during a single mobilization. Data were initially collected at the NCST Site and then the NLRT Site. Upon completion of field activities at NLRT and NCST Sites on August 18, 2010, the crew mobilized to the PPBR Site for data collection beginning on August 20, 2010. Data collection activities at PPBR Site could not be performed on August 19, 2010 due to previously scheduled activities identified by the FACSFAC VACAPES range scheduling authority at the Harvey Point Bombing Range adjacent to the Palmetto Point. No other delays occurred as a result of scheduling conflicts.

4.3 DGM Survey

The DGM survey was conducted using an EM61-Flex3, which is a high-resolution time-domain electromagnetic instrument designed to detect shallow ferrous and non-ferrous metallic items on or just beneath the sediment within the investigation area. The instrument was assembled in a 6.56-foot wide array and towed from a boat, with the detection coils maintained just above the seafloor. Detailed descriptions of the DGM survey equipment, field methodology, and functionality are included in the NAEVA Geophysical Investigation Report provided as **Appendix B**.

The data collection approach was outlined in the Work Plan, and included a focused investigation of each of the known target locations. The investigation areas for NLRT Site, NCST Site, and PPBR Site are shown in **Figures 4-1**, **4-2**, and **4-3**, respectively. The DGM survey focused on the target locations (an approximate radius of 1,000 yards around each target) as they are the most likely area where evidence of range activities may be observed. At all the sites, transects were spaced 100 feet apart for the first 500 yards from the presumed target location. The spacing of the transects was increased to 250 feet for the remaining 500 yards, up to a total distance of 1,000 yards from the presumed target location. The interior lines (first 500 yards) were collected first at each target location, so that the data could be assessed to determine whether or not it was necessary to collect the remaining data (from 500 to 1,000 yards). During the survey, the sensors were towed just above the seafloor surface (no higher than 5 feet); to prevent inadvertent contact with MEC and to prevent damage to aquatic habitats while obtaining quality DGM data. The average depth maintained above the seafloor was estimated to be approximately 2.5 feet.

Prior to mobilization to the sites, a variety of transect designs were reviewed and considered. Initially, linear transects were proposed (as detailed in the Work Plan; however, it was determined that concentric circles at sites containing a single target, such as the NCST Site, would be more efficient while providing the same coverage. Since the NLRT Site is adjacent to land, concentric circles were not possible. Therefore, the transect design was modified to concentric semi-circles to accommodate data collection near the land. At the PPBR Site (excluding Lewis Point Target), the most efficient transect design was parallel lines since five of the six target radii overlapped. However, concentric circles were again implemented during data collection at the individual Lewis Point target of Palmetto Point. Modification of the transect designs was discussed and agreed to by the Navy and NCDENR prior to mobilization to the sites.

4.4 Deviations from the Work Plan

Efforts were taken to conduct all aspects of the investigation within the specifications established in the Work Plan. Instances where the investigation approach deviated from the Work Plan are detailed below:

- The terrestrial DGM survey at the Troublesome Point portion of North Landing River could not be conducted as originally detailed in the Work Plan. As documented in the *North Landing River Land Investigation Technical Memorandum* (Appendix C of the Work Plan [CH2M HILL, 2010]), the land portion of North Landing River known as

Troublesome Point is privately owned. During the work planning, permission to perform the survey of the land was denied by the current landowners.

- At sites where there were single targets (such as Northern Currituck Sound, North Landing River, and the Lewis Point Target of Palmetto Point) that did not have overlapping transects, the DGM survey transects were altered from the Work Plan to improve efficiency while maintaining the same target area coverage. In these instances, concentric circles (or semi-circles in the case of North Landing River) were implemented rather than the "parallel" transects as proposed in the Work Plan.
- Survey activities were initially performed for the 100 feet spaced transects from 0 to 500 yards away from the target. Based upon the results of this survey, the determination was made as to whether the remaining transects (250 feet spaced transects from 500 to 1,000 yards away from the target) would be beneficial. In some instances (such as at North Landing River, Lewis Point Target, and some portions of the main target area of Palmetto Point) it was determined that adequate data had been collected and significant detections were no longer observed after the 1,500-foot radius. In these areas, additional surveying of the 500 to 1,000 yards transect area was not performed.
- At the Target D location of the PPBR Site, it was determined that significant anomalies were not detected at the identified target location but a large amount of anomalies were located to the northeast of the target location. Therefore, additional transects were added in the area of the high response area northwest of the Target D location.
- At the PPBR Site, data collection along the southern most portion of the range could not be performed because of cypress tree stumps that were present in the shallow waters near the shoreline, which posed a safety hazard for navigation.

Although these changes to the Work Plan were made during field implementation, the overall objectives of the field investigation and the quality assurance (QA)/quality control (QC) data quality objectives were maintained. Significant amounts of data were still collected and all of the modifications were field determined to increase the efficiency and safety of the project. Additionally, changes to the work plan were reviewed with the project team and Regulators, as necessary.

4.5 Quality Assurance/Quality Control

To establish data reliability, equipment used and data collected went through QC tests throughout the entire project. Tests were performed prior to and after all data collection sessions. If equipment response failed QC criteria, equipment was recalibrated or repaired and then retested until results were satisfactory. All QC criteria were achieved during the DGM investigation. A complete summary of the QC testing is included in **Appendix B**.

Prior to beginning the main survey and every collection day from that point forward, a series of QC tests were performed. The purpose of the QC tests was to demonstrate the proper functionality of all instruments, methods, and personnel prior to the fieldwork and to document site-specific noise and capability of the DGM system.

The following is a list of QC procedures that were performed during the data collection process. All QC test results were reviewed by a qualified geophysicist on a daily basis.

- **Global Positioning System (GPS) Check Point:** At the beginning of the day, after setting up the equipment but before data collection, the bow and stern GPS antennas were mounted on a survey pole and placed at a known point to check the accuracy. The measured positions were compared to the reported location. This QC procedure confirmed proper operation of the GPS. Results of this test showed that all recorded points were within tolerance.
- **Static Background and Static Spike:** Prior to deployment of the system in the water, static tests were performed on land by positioning the survey equipment in an area free of metallic response and collecting data for a 3-minute period. A static test is the primary measurement of instrument functionality, and the purpose of the test is to determine whether unusual levels of ambient noise exist and to check for consistent response. All static and spike tests were within acceptance criteria.
- **Pressure Test:** Prior to data collection, the pressure sensor was tested for accuracy. The test was conducted on land prior to deployment of the system, with two data points recorded to verify the functionality of the sensor. Functionality was confirmed with all tests being within acceptance criteria.
- **Repeat Data:** The Instrument Verification Strip (IVS) was used to verify the repeatability of the data, due to the difficulty of accurately recollecting a line of data in the water. Because of the complexity of towing the system along the same line and height twice in the marine environment this test was evaluated on a qualitative basis. To confirm repeatable data, the IVS item was surveyed on the way out to the site as well as upon returning. If the location of the IVS item was repeatable, the survey data collected that day was considered acceptable. Repeat lines generally showed acceptable repeatability, discrepancies in the response on some repeat lines were likely a result of line path or coil height deviation. One IVS was established for the NCST and NLRT Site, and a separate IVS for PPBR Site. A more in-depth description of the IVS process is included in NAEVA's Geophysical Investigation Report (**Appendix B**).

4.6 Data Processing and Analysis

Initial data processing was performed by the field team, which included reviewing the data for integrity and completeness. For preprocessing, the raw data was imported into Geosoft's Oasis Montaj where the following was performed:

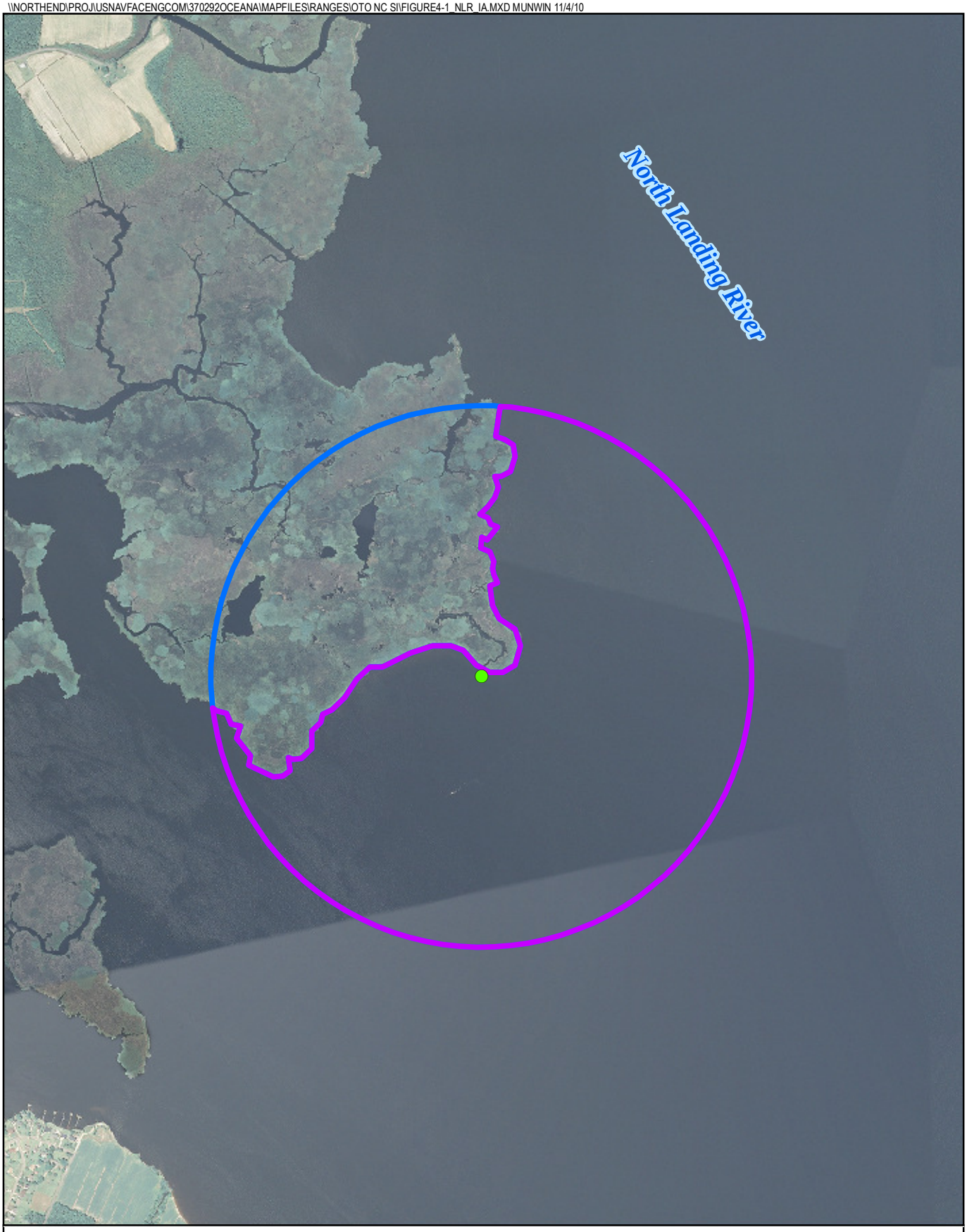
- Review and finalization of QC tests
- Evaluation of GPS accuracy and positioning
- Evaluation of data density and coil height
- Application of auto leveling and instrument drift corrections
- Application of default lag correction
- Creation of preliminary contour maps.

Once the preprocessing was complete, the data went through final processing, which included:

- Evaluation and refinement of drift and lag corrections
- Additional digital filtering and enhancement
- Targeting of data
- Generation of ASCII and final maps showing contoured gridded data, target locations and culture (man-made features affecting geophysical data).

For anomaly selection, a Geosoft algorithm was used to identify peak amplitude responses associated with, but not limited to, MEC items. Initial target selections were made based on the minimum curvature gridded data. Noise levels across all the sites were generally low, with a few areas containing slightly elevated levels due to an increased sea state. Background geophysical "noise" was determined to be below 5 millivolts. All data profiles corresponding to the anomalies selected were then analyzed by trained geophysicists. Invalid or incorrect targets were removed and any anomalies missed by the algorithm but deemed to represent a potential MEC target were manually selected by the geophysicist.

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE4-1_NLR_IA.MXD MUNWIN 11/4/10



Legend

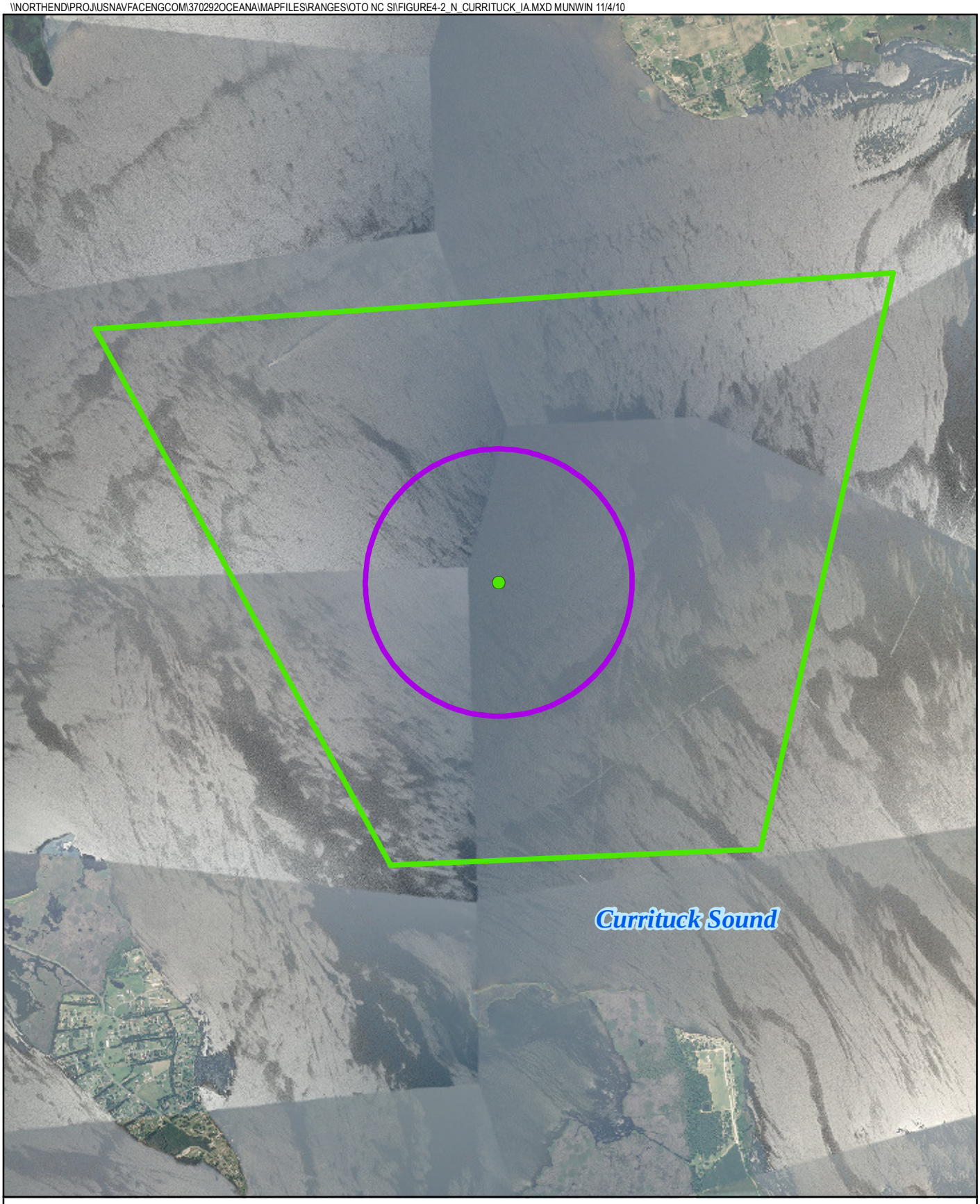
- Investigation Area (454 acres)
- Site Boundary (649 acres)
- Target Location

N
W E
S

0 750 1,500
Feet

Figure 4-1
North Landing River Target
Investigation Area
NAS Oceana
Virginia Beach, Virginia

CH2MHILL



Legend

- Northern Currituck Sound Target Site (3,831 acres)
- Investigation Area (649 acres)
- Target Location

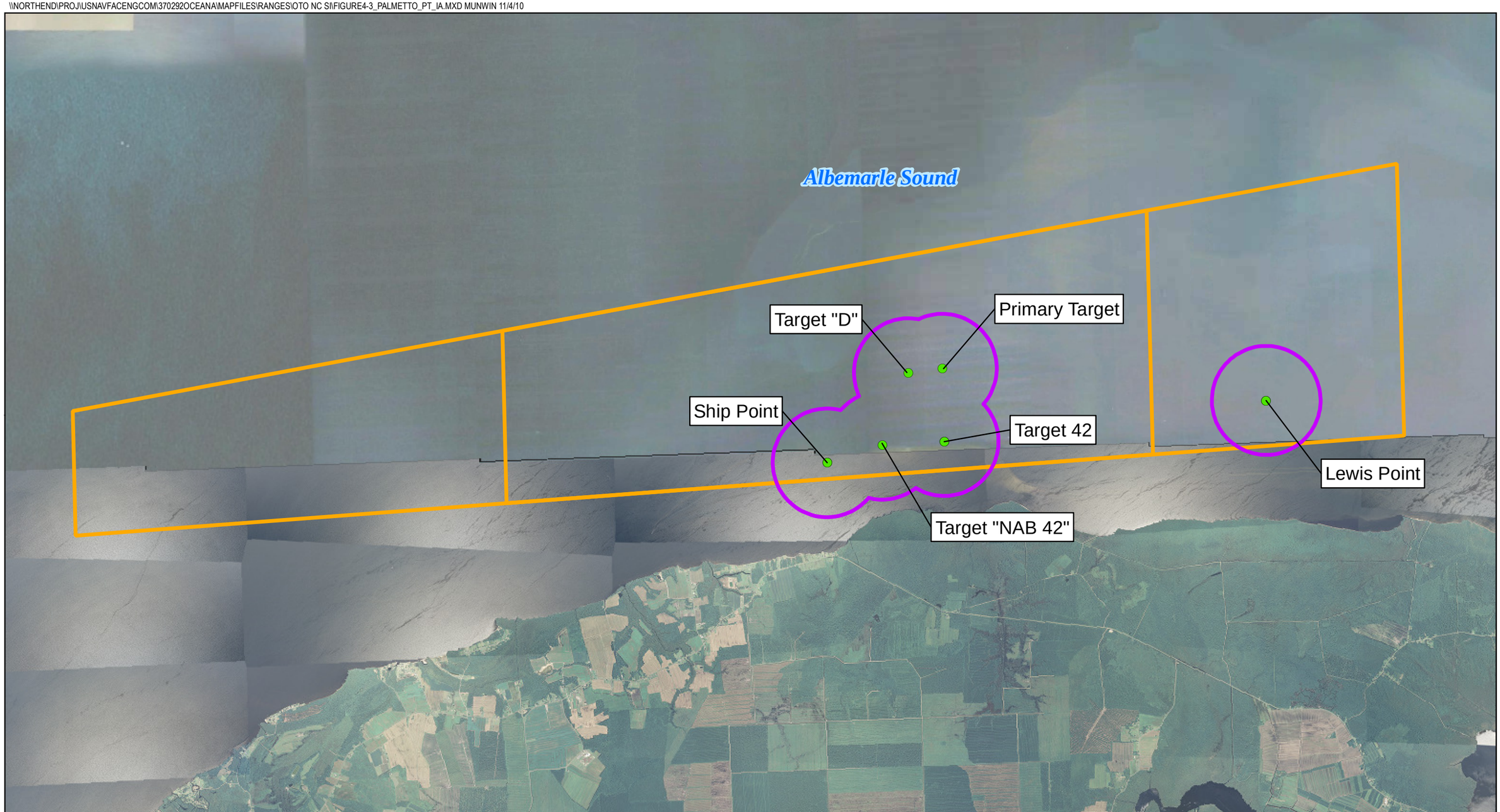
N
W E
S

0 1,500 3,000
Feet

Figure 4-2
Northern Currituck Sound Target
Investigation Area
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE4-3_PALMETTO_PT_IA.MXD MUNWIN 11/4/10



Legend

- Palmetto Point Range Area (18,440 acres)
- Investigation Area (2,830 acres)
- Target Location

N
W E
S

0 0.5 1 1.5 2
Miles

Figure 4-3
Palmetto Point Bombing Range
Investigation Area
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

SECTION 5

Investigation Results

5.1 SI Activities and Data Result Summary

At the three OTO ranges in NC, 206 miles of transects (with an instrument detection footprint of 6.56 feet) were surveyed with 4507 anomalies detected. This corresponds to 163.8 acres (approximately 5 percent of the total investigation area acreage) with an average of 27.5 anomalies per acre. **Table 5-1** outlines the mileage, acreage, and number of anomalies found at each target site area.

TABLE 5-1
Digital Geophysical Mapping Survey Results

Target Site	Total Site Area (Acres)	Investigation Area (Acres)	Miles/ Acres Surveyed	Number of Anomalies Detected	Estimated Anomalies Per Acre (of Surveyed Area)
Northern Currituck Sound Target	3,831	649	42/33.1	829	25
North Landing River Target	649	454	27/21.8	197	9
Palmetto Point Bombing Range	18,440 [a]	2181 [b]	117/93.5	3152	34
Palmetto Point: Lewis Point Target		649[b]	20/15.8	329	21

[a] Includes Lewis Point Target area
[b] Initial Investigation area; however, this area was reduced during field activities

Based on the findings from the DGM survey, NAEVA (DGM subcontractor), generated density maps displaying the anomaly densities within each target area. To create the density maps a software program called Visual Sample Plan (Battelle Memorial Institute, Version 6.0) was used, as it has a module designed specifically to analyze transect surveys with applications toward unexploded ordnance. Actual transect paths and anomaly locations were imported into the program along with a selected search window diameter. The program produces an output file that is then overlain on the map of the target area (**Appendix B**).

5.1.1 North Landing River Target Site

At the NLRT Site, approximately 27 miles of transects were surveyed, detecting 197 anomalies which equates to 21.8 acres of data collection with an average of nine anomalies per acre. The field data and DGM response is presented in **Figure 5-1**. This figure shows a relatively even distribution of anomalies across the site. As is displayed on the NLRT Site density map (**Figure 5-2**), there is no definitive concentration near the proposed target location or anomaly distribution that indicates range related usage. There are some sparse low concentrations of anomalies throughout the Site.

Water depth had originally been reported to be less than 5 feet. The results of the bathymetric survey show that the depths range from 3 to 10 feet (**Figure 2-4**).

5.1.2 Northern Currituck Sound Target Site

At the NCST Site, approximately 42 miles of transects were surveyed, detecting 828 anomalies which equates to 33.1 acres of data collection with an average of 25 anomalies per acre. The field data and DGM response is presented in **Figure 5-3**. A higher number of anomalies are skewed toward the target location out to about 110 yards from the target. As depicted in the NCST Site density map (**Figure 5-4**), the number of detected anomalies significantly diminished away from the target center, with the highest concentration of anomalies in the area immediately around the proposed target. Based upon the DGM results, it is estimated that 80 percent of the anomalies detected are located within the first 235 yards of the target and 95 percent of the anomalies are within 500 yards. This concentration of anomalies around the target location is suggestive of the range related activities at this location.

Water depth had originally been reported to range from 3 to 6 feet. The results of the bathymetric survey show that the depths range from 5 to 11 feet (**Figure 2-6**).

5.1.3 Palmetto Point Bombing Range

At the main target area of PPBR Site (in the area of Target NAB 42, Target #42, Ship Point, Target D, and the Primary Target), approximately 117 miles of transects were surveyed, detecting 3,152 anomalies which equates to 93.5 acres of data collection with an average of 34 anomalies per acre. The field data and DGM response is presented in **Figure 5-5.** Of all the anomalies detected, the majority of the detections are located within three main areas: the area around Target NAB 42 (approximately 125.8 acres), Primary Target (approximately 55.8 acres), and approximately 630 yards northwest of Target D (approximately 17.1 acres). As seen on the density map (**Figure 5-6**), the highest concentrations are around the Primary Target and Target NAB 42. These concentrations significantly decrease moving away from the target locations. The concentration northwest of Target D is slightly lower than the other two main targets. In these three high response areas, 1,899 anomalies were detected, constituting 60 percent of all anomalies with an average anomaly density of 67 anomalies per acre. Anomaly density within the high response area for each of these three targets is as follows: Target NAB 42 is 74, Primary Target is 74, and area northwest of Target D is 54. These concentrations are suggestive of range related usage of the targets at these locations. Target #42 and Ship Point do not show significant evidence of range related usage.

The Lewis Point target of the PPBR Site is a single target located 2.8 miles east of the main target area. For Lewis Point, approximately 20 miles of transects were surveyed, detecting 329 anomalies which equates to 15.8 acres with an average of 21 anomalies per acre. The field data and DGM response is presented in **Figure 5-7.** As seen on the density map (**Figure 5-8**), the majority of the anomalies were found south of the identified target location with a linear trend of anomalies trailing off to the east. Based upon the results of the density map, it is estimated that approximately 70 percent of the anomalies are located within 170 yards of the high response area center and 90 percent are located within 365 yards of the high response area center. The concentrations around this target location are suggestive of range related usage.

Water depths at the PPBR Site, including Lewis Point, were originally reported to range from 3 to 15 feet. The results of the bathymetric survey show that the depths of the Bombing

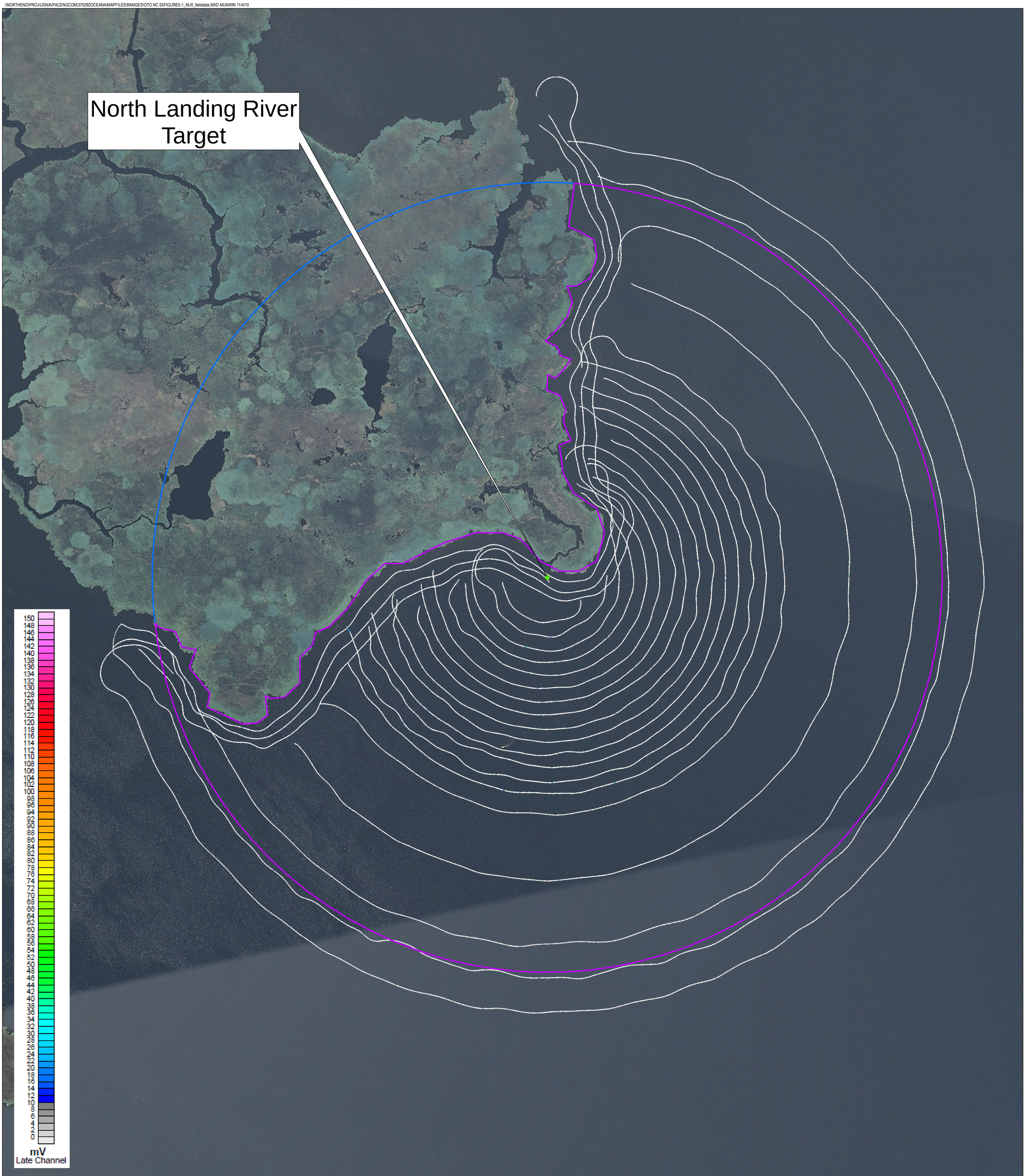
Range are from 2 to 21 feet and for Lewis Point range from 14 to 19 feet (**Figures 2-4** and **2-5**).

5.2 Conceptual Site Models

The data presented in the previous sections, along with the results of the SI, were used to update the conceptual site model (CSM) profile presented in the PA Report (Malcolm Pirnie, 2009) and to develop a graphical CSM. The CSM is a useful engineering management tool that helps to manage site information and guide decision making throughout the environmental restoration process. CSMs are used to scope investigations, support potential risk management decisions, and aid in defining the effectiveness of potential remedial alternatives. Each CSM summarizes the site conditions, the distribution of potential MEC and MC, potential receptors and exposure pathways, and land use data for the site.

A CSM was originally presented for each range in the PA Report (Malcolm Pirnie, 2009) as a table and flow diagram. For this report the CSM has been updated to a graphical model format. The graphical CSMs for the NLRT Site, the NCST Site, the PPBR Primary Targets, and PPBR Lewis Point Target are presented in **Figures 5-9**, **5-10**, **5-11**, and **5-12** respectively. The data presented on the current CSM has been updated from the information provided in the PA Report to reflect any new information obtained during the SI, including anomaly concentrations, updates to transport mechanisms (based on the Tier I Sediment Transport Evaluation [**Appendix A**]) and receptors observed during the field activities. For the three OTO ranges, human exposure pathways include direct contact with MEC during commercial and recreational activities that could result in unintentional detonation of the item, contact with MC that has leached from MEC into the sediment and surface water, and ingestion of fish, shell fish, and other edible items from the Sound environment. Similarly, marine organisms may be impacted if an item detonates or exposed to MC if the organism ingests the Sound water and sediment, which can bioaccumulate through the food chain as they are eaten by higher level species feeding in or on the Sound.

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE5-1_NLR_fielddata.MXD MUNWIN 11/4/10



Legend

- Investigation Area
- Site Boundary
- Target Location

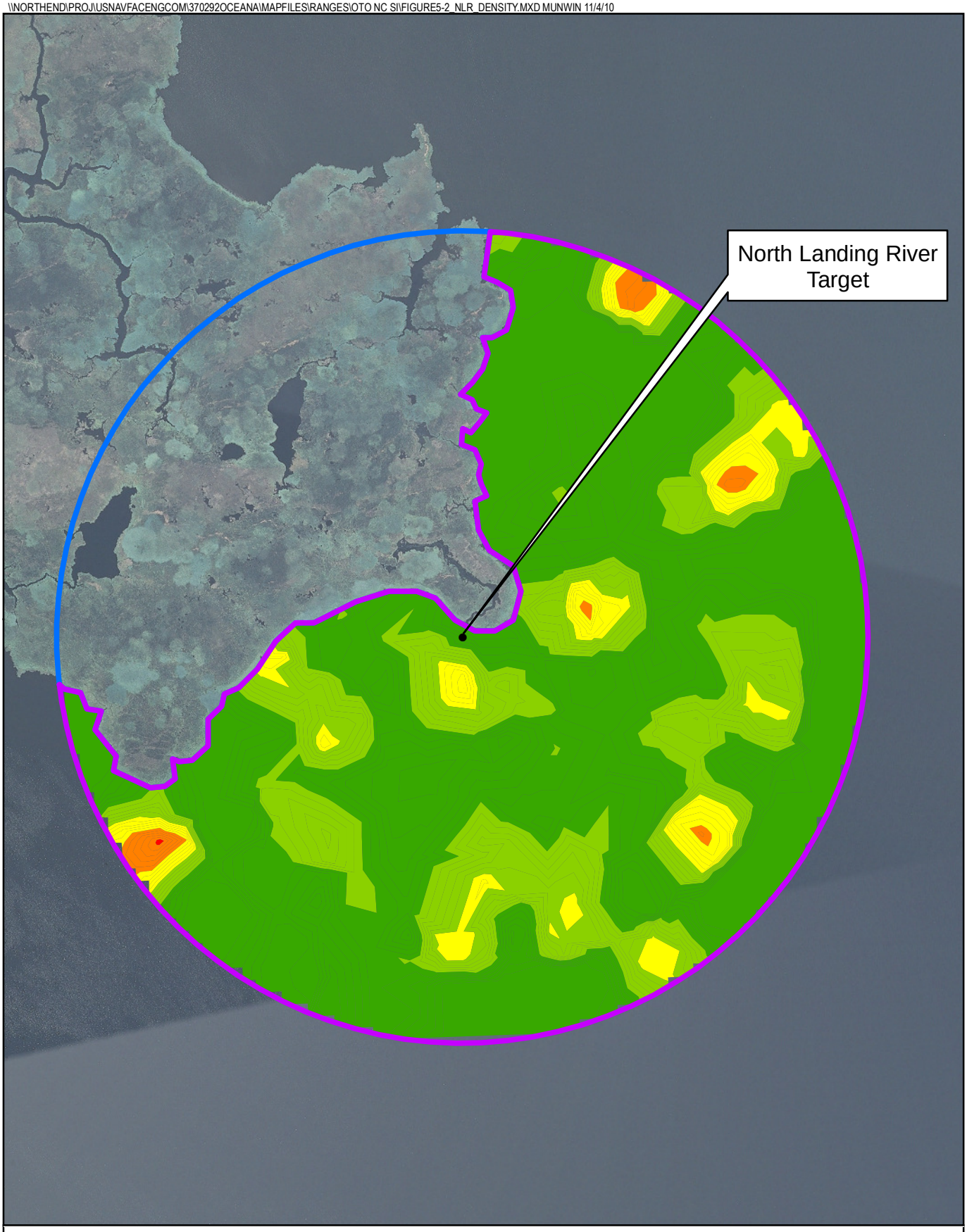
N
W E
S

0 250 500 750 1,000
Feet

Figure 5-1
North Landing River Target
Field Data
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE5-2_NLR_DENSITY.MXD MUNWIN 11/4/10



Legend

- Investigation Area
- Site Boundary
- Target Location

Anomalies Per Acre

- 0 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25

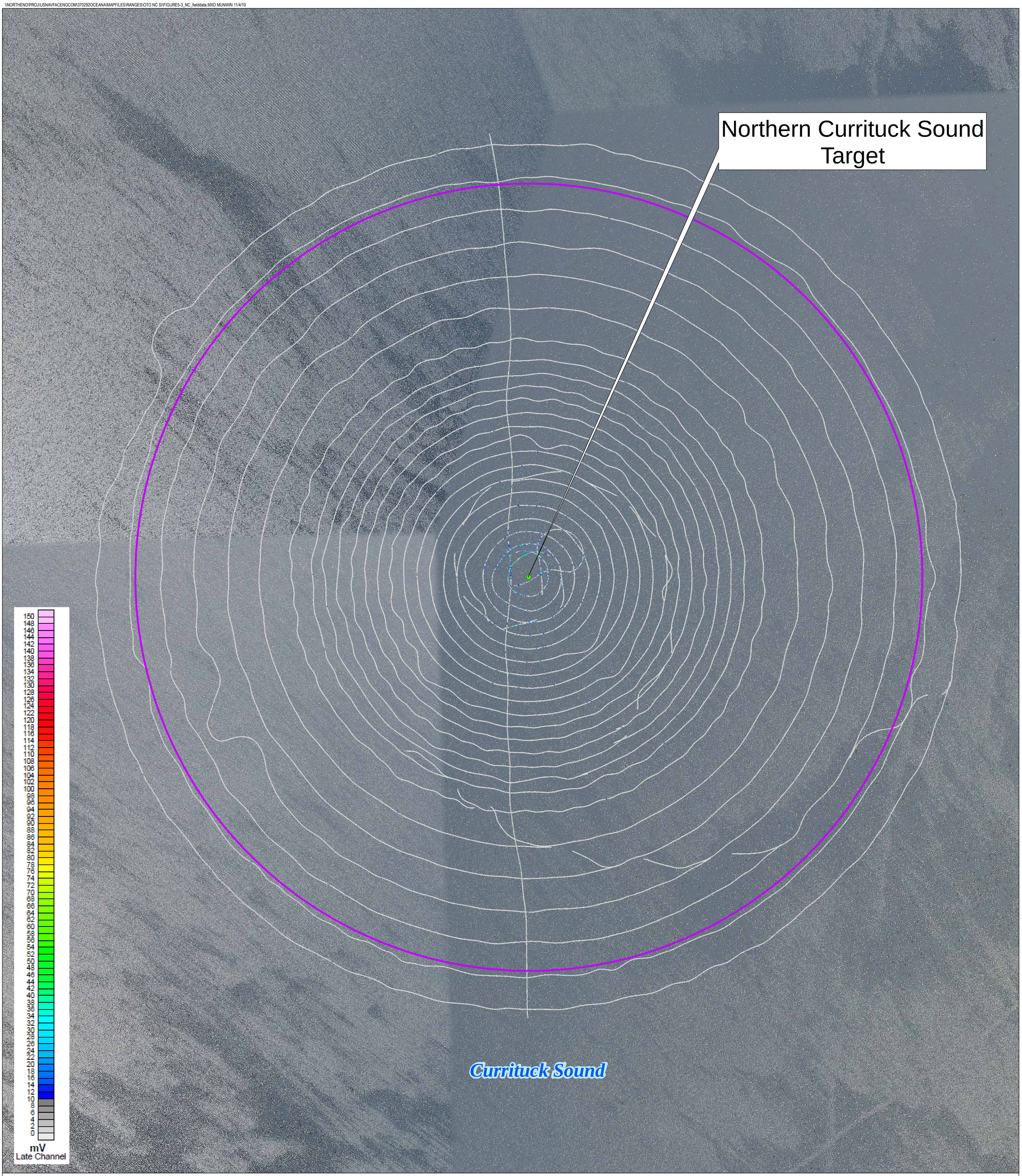
N
W E
S

0 500 1,000
Feet

Figure 5-2
North Landing River Target
Anomaly Density Map
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE5-3_NC_fielddata.MXD MUNWIN 11/4/10



Legend

Investigation Area

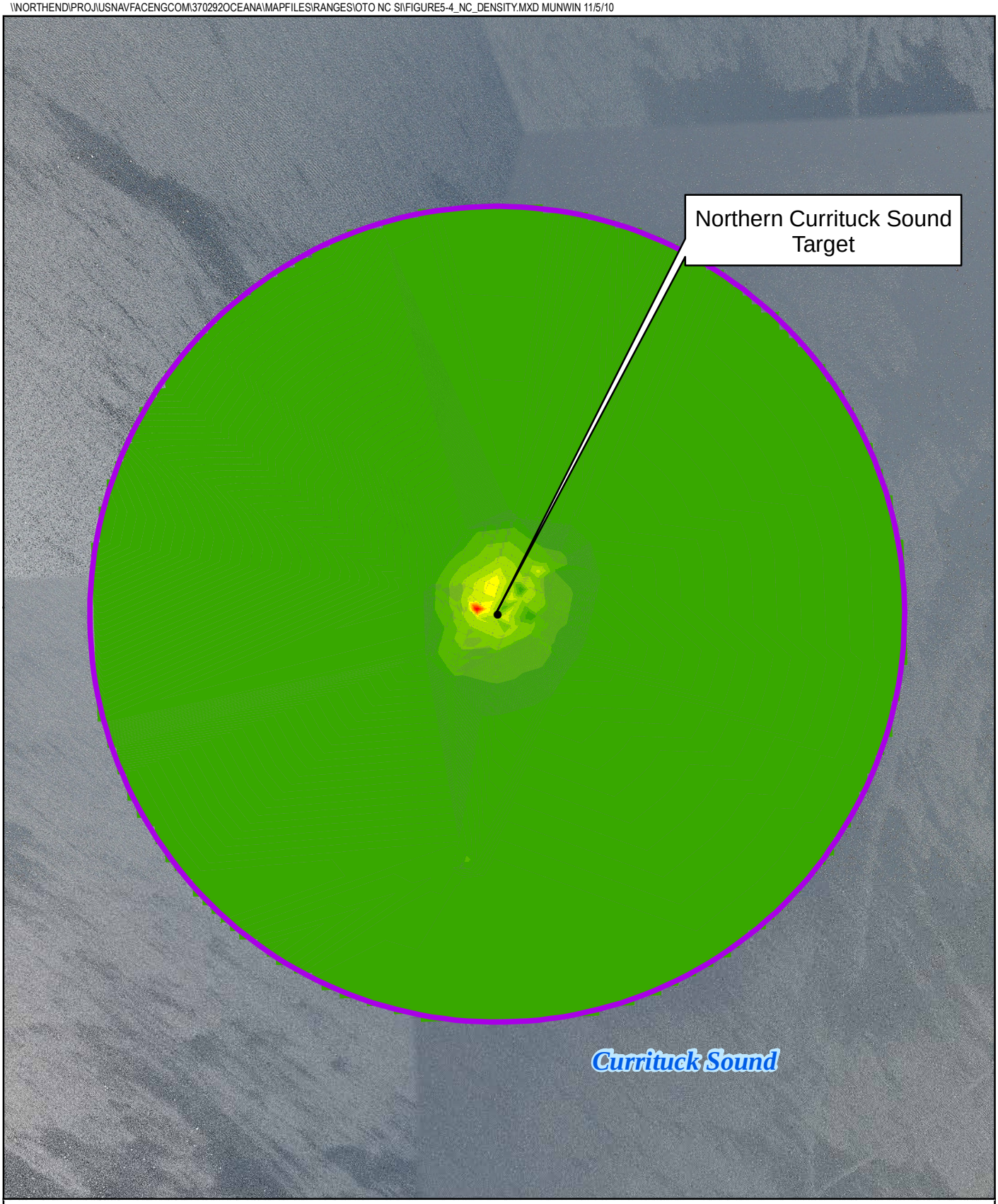
Target Location

N
W E
S

0 250 500 7501,000
Feet

Figure 5-3
Northern Currituck Sound Target
Field Data
NAS Oceana
Virginia Beach, Virginia

CH2MHILL



Legend

- Investigation Area
- Target Location

Anomalies Per Acre

- 0 - 60
- 61 - 120
- 121 - 180
- 181 - 240
- 241 - 300
- 301 - 360
- 361 - 420
- 421 - 480
- 481 - 540
- 541 - 600
- 601 - 660

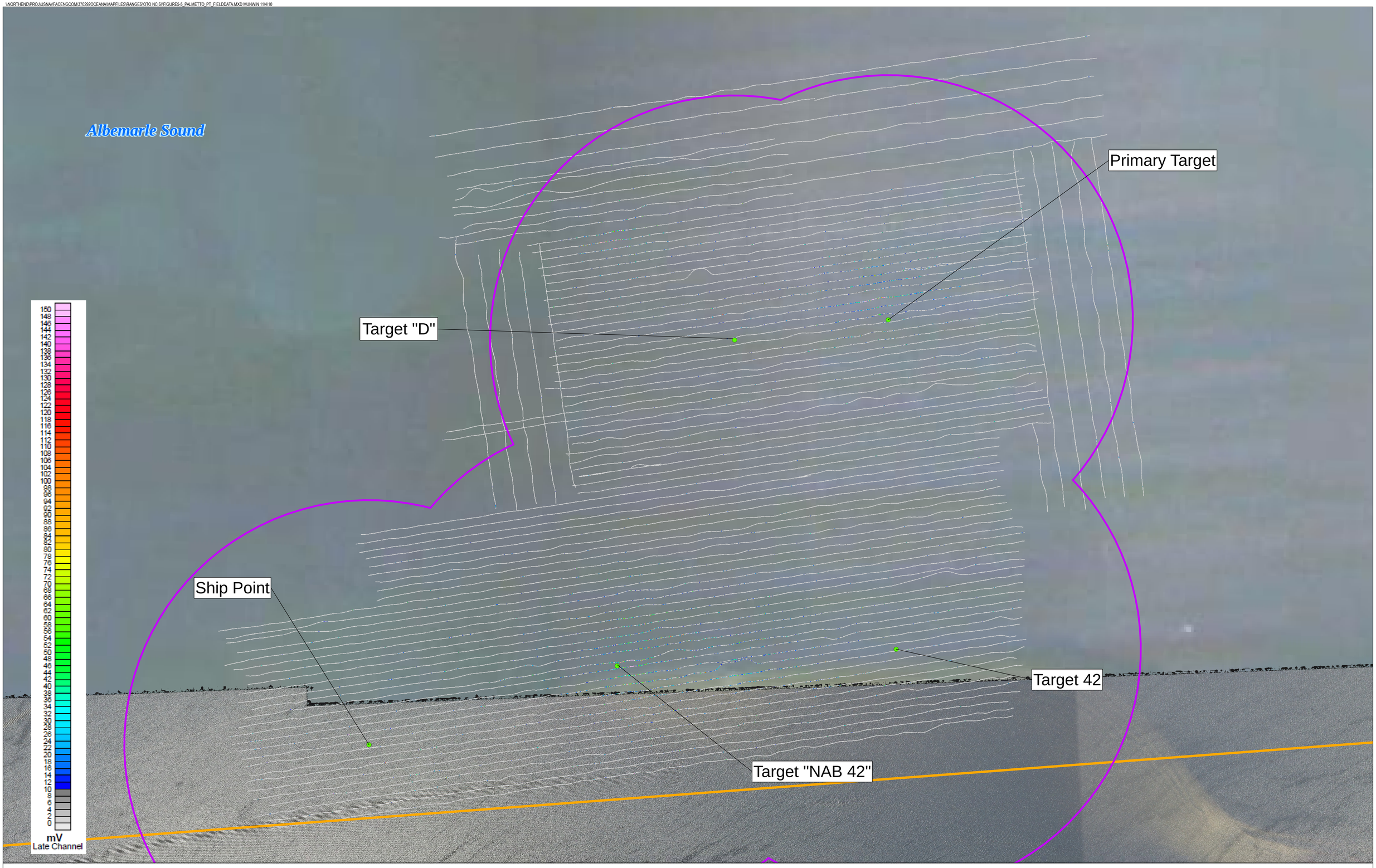
N
W E
S

0 500 1,000 Feet

Figure 5-4
Northern Currituck Sound Target
Anomaly Density Map
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE5-5_PALMETTO_PT_FIELDDATA.MXD MJNWIN 11/4/10



Legend

- Palmetto Point Range Area Boundary
- Investigation Area
- Target Location

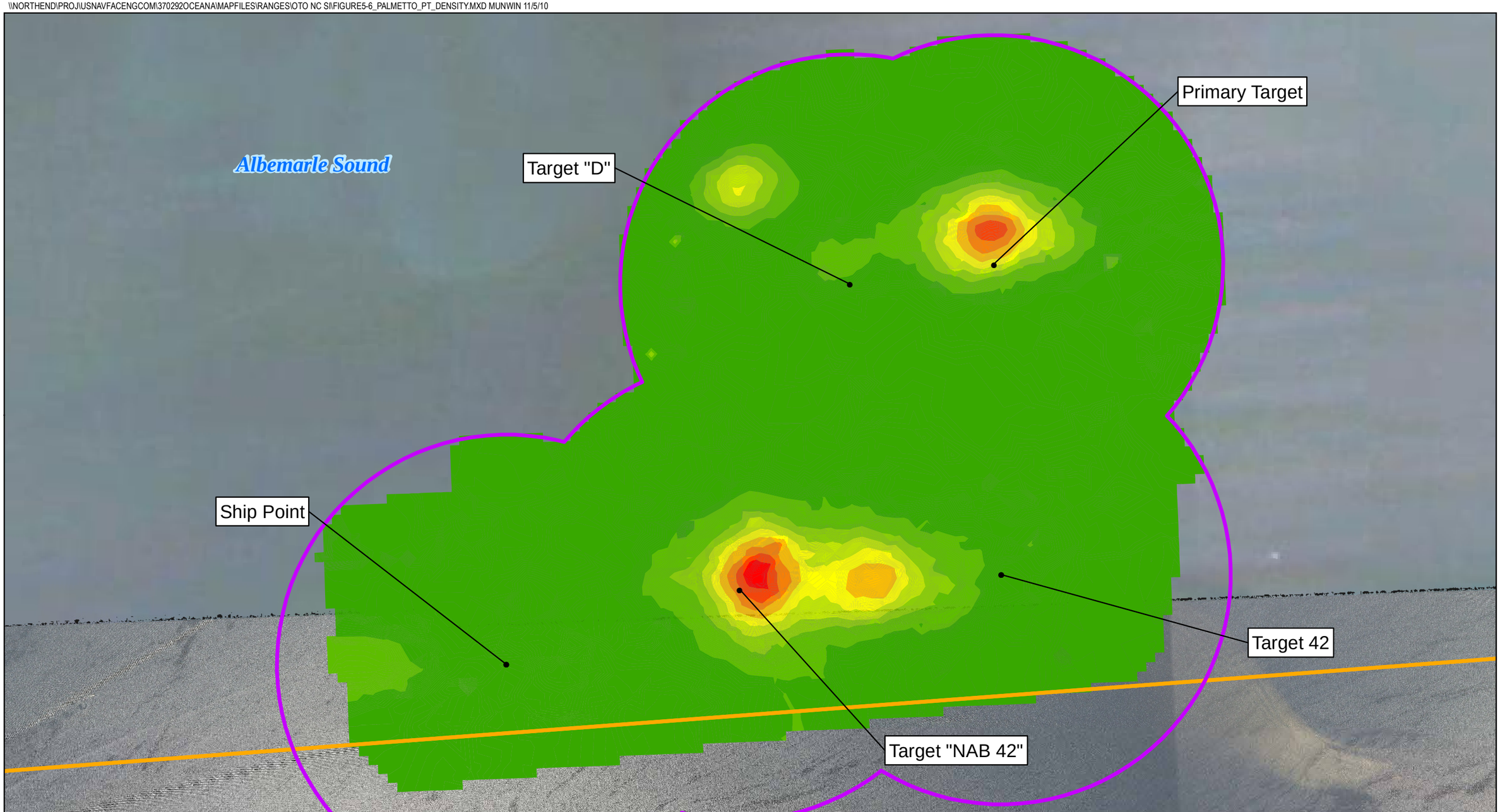
N
W E
S

0 800 1,600
Feet

Figure 5-5
Palmetto Point Bombing Range
Field Data
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC S\\FIGURE5-6_PALMETTO_PT_DENSITY.MXD MUNWIN 11/5/10



Legend

- Palmetto Point Range Area Boundary
- Investigation Area
- Target Location

Anomalies Per Acre

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180

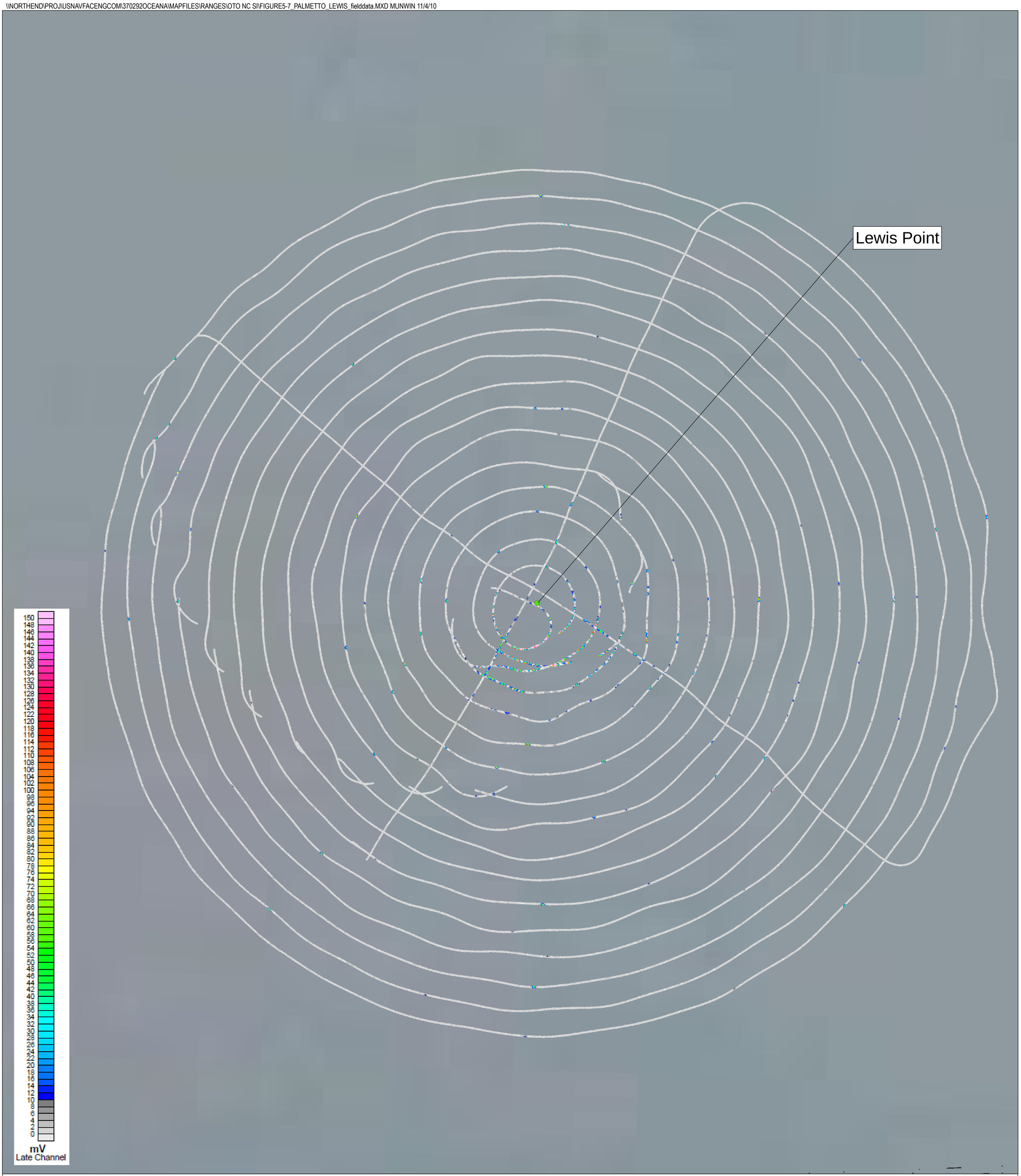
N W E S

0 1,250 2,500 Feet

Figure 5-6
Palmetto Point Bombing Range
Anomaly Density Map
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE5-7_PALMETTO_LEWIS_fielddata.MXD MUNWIN 11/4/10



Legend

- Target Location

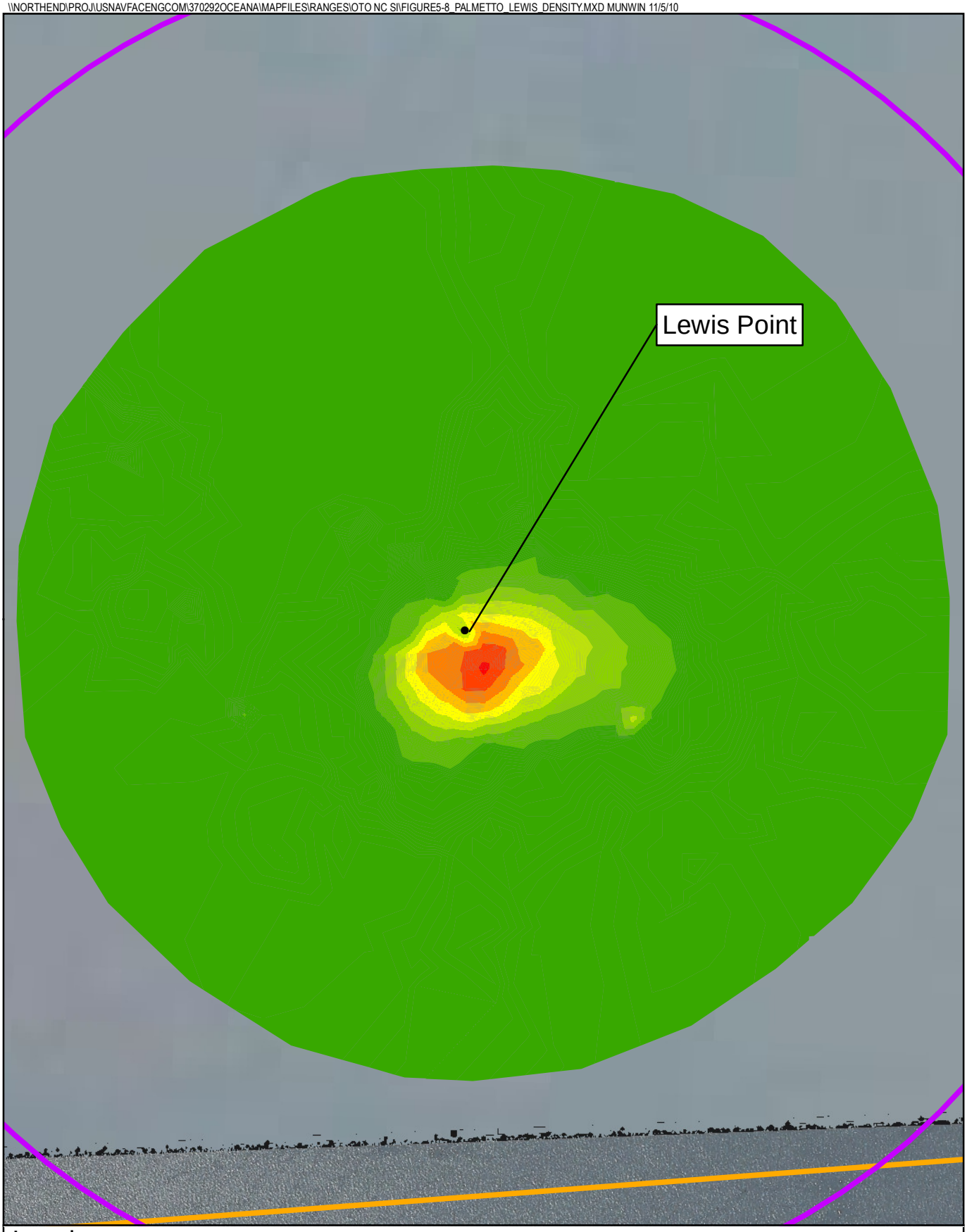
N
W E
S

0 125 250 375 500
Feet

Figure 5-7
Palmetto Point – Lewis Point
Field Data
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

\\NORTHEND\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\OTO NC SI\FIGURE5-8_PALMETTO_LEWIS_DENSITY.MXD MUNWIN 11/5/10



Legend

- Palmetto Point Range Area Boundary
- Investigation Area
- Target Location

Anomalies Per Acre

- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180

N
W E
S

0 300 600
Feet

Figure 5-8
Palmetto Point - Lewis Point
Anomaly Density Map
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

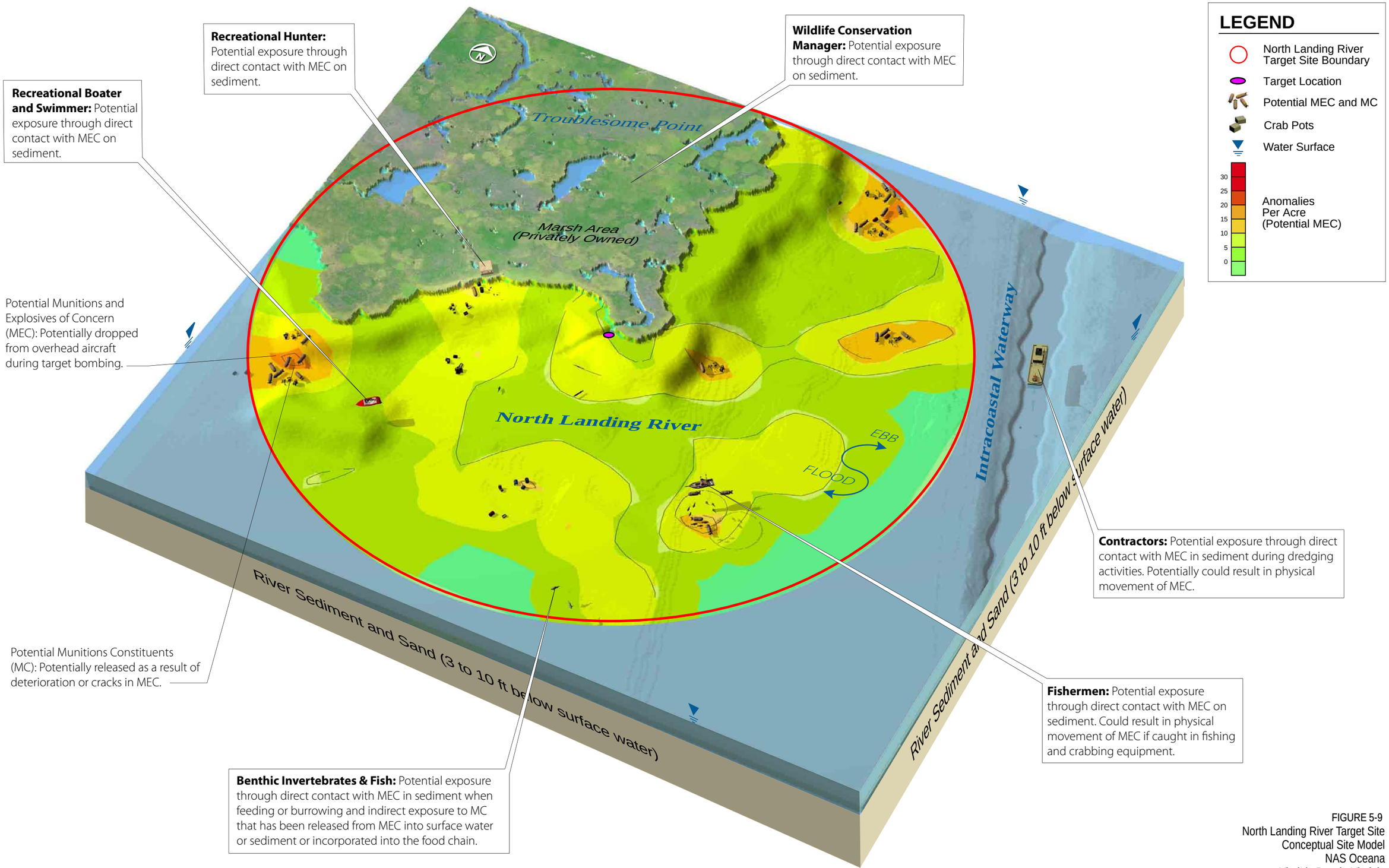


FIGURE 5-9
North Landing River Target Site
Conceptual Site Model
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

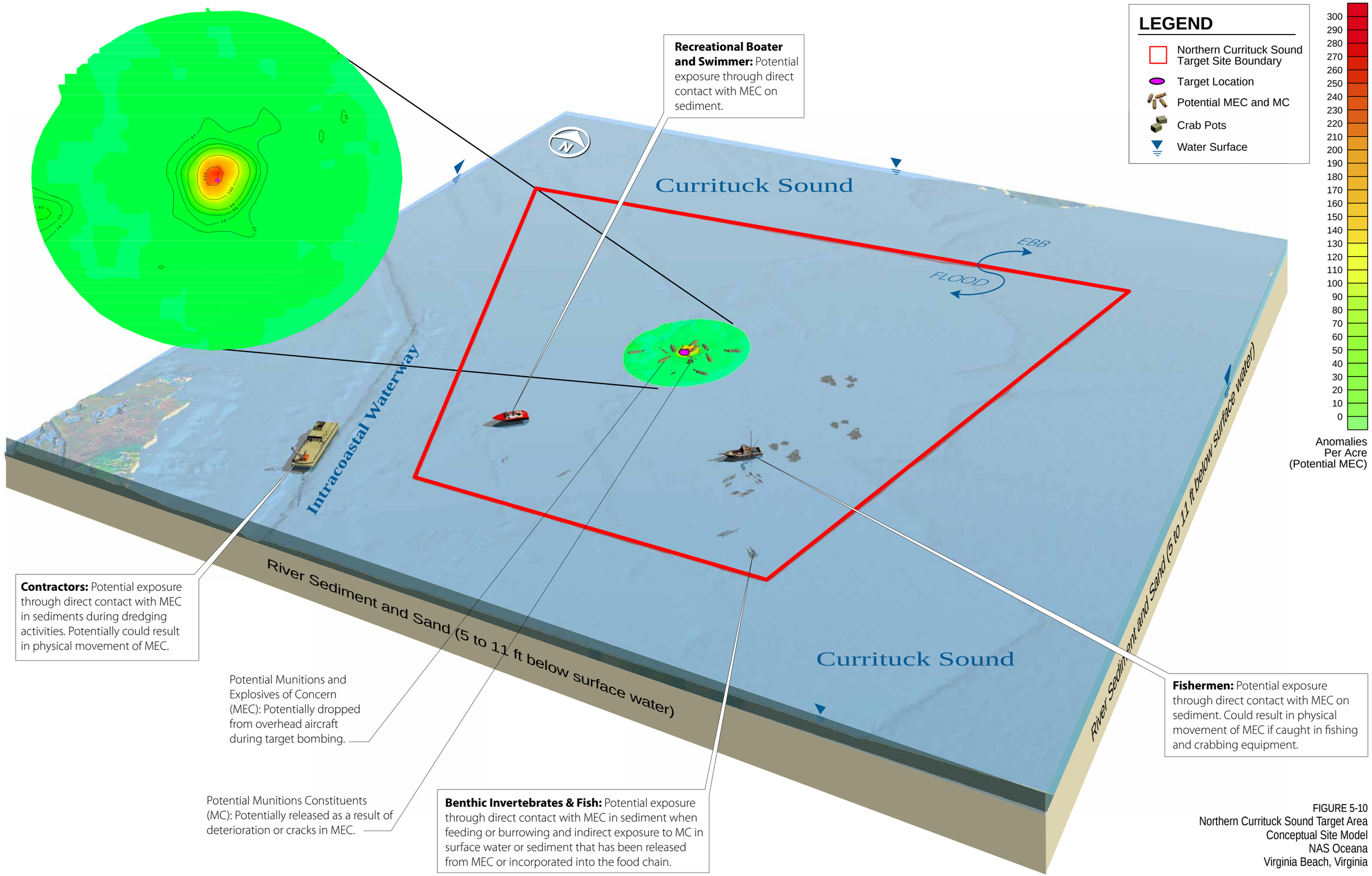


FIGURE 5-10
Northern Currituck Sound Target Area
Conceptual Site Model
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

ES101410011943GNV NAS_Oceana_NCurrituck_Sound_CSM_ver9.ai DD/LED

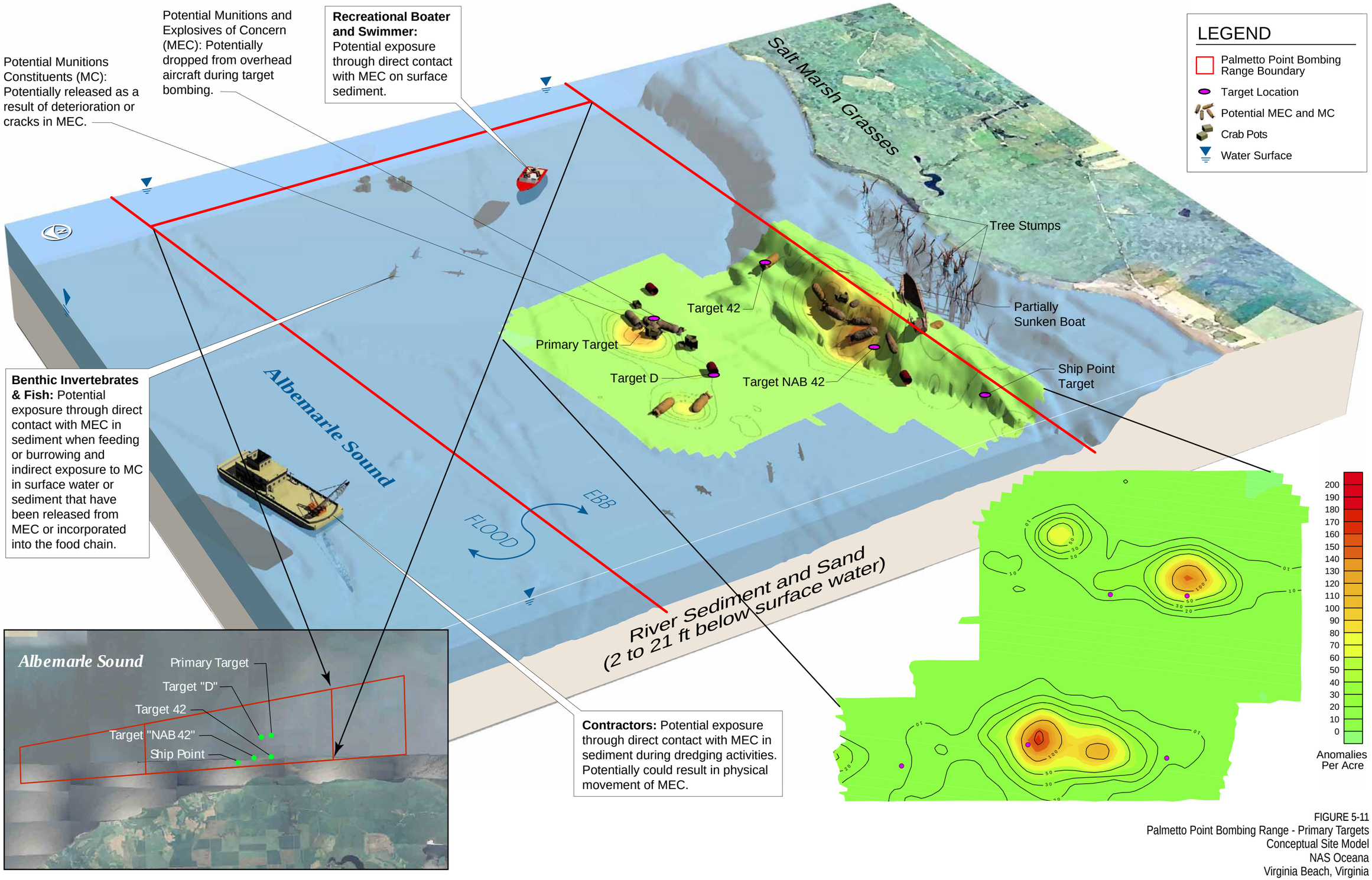


FIGURE 5-11
Palmetto Point Bombing Range - Primary Targets
Conceptual Site Model
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

ES101410011943GNV NAS_Oceana_Palmetto_Point_CSM_ver8.ai DCD/LED

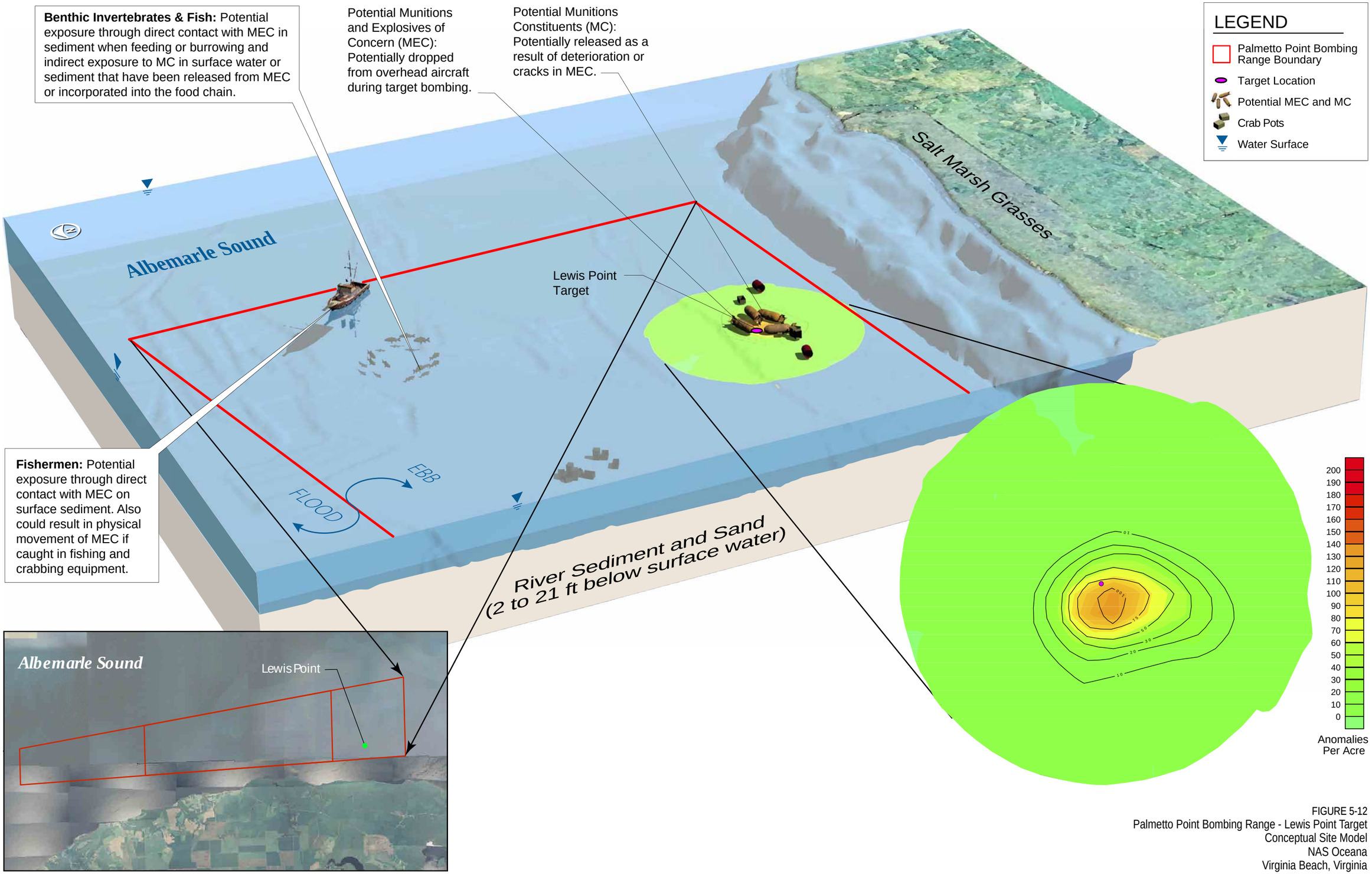


FIGURE 5-12
Palmetto Point Bombing Range - Lewis Point Target
Conceptual Site Model
NAS Oceana
Virginia Beach, Virginia

ES101410011943GNV NAS_Oceana_Palmetto_Point_CSM_ver8A.ai DCD/LED

CH2MHILL

SECTION 6

Conclusions and Recommendations

The SI resulted in the identification of 4,507 anomalies within the investigation areas of the Oceana OTO North Carolina sites. The majority of these anomalies are concentrated around presumed target locations, which is indicative of range usage at certain target location. However, it should be noted that these anomalies only represent a metallic response and have not been confirmed to be MEC- or range-related. The results of this SI alone cannot be used to confirm the presence of MEC at the sites. Additional investigation would be necessary to confirm the nature of the items in the areas of the detected anomalies.

Based upon the results of the DGM investigation, a significant number of anomalies were detected at each of the ranges. The lowest concentrations were observed at the NLRT Site and the highest concentrations were observed at the PPBR Site.

Therefore, additional investigation may be necessary to inspect and identify anomalies at each of the sites. Inspection of a representative sample of anomalies present at the site may aid in the determination of whether or not additional anomalies should be investigated. As part of this investigation, anomalies would have to be inspected and identified to determine if the anomalies are MEC or range related. As previously discussed, this investigation was performed as an initial data gathering and cannot be used to identify specific anomalies. The data provides concentration areas may be useful in identifying areas to investigate, but not individual anomalies. Additional data collection may be necessary to reacquire and inspect the individual anomalies. If a significant number of the items identified are determined to be MEC, MC sampling of the sediments may also be necessary. Finally, the Munitions Response Site Prioritization Protocol scoring should be revised and updated based upon any changes to the initial scoring which are impacted by future investigations.

6.1 North Landing River Target Site

Due to the anomalies being scattered throughout the area, evidence of a specific target location was not observed and the coordinates identified in the PA do not exhibit evidence of significant range use. Additionally, there are no visual remnants of a target at the location provided. However, a number of anomalies were detected throughout the site. As discussed in the *Tier I Sediment Transport Evaluation Technical Memorandum* (**Appendix A**), the lack of tides and current speeds found in the Northern Currituck Sound implies that any potential MEC (if present at the site) is unlikely to be moved by currents, except possibly in extreme storm conditions, such as Nor'easters and hurricanes. MEC is likely to be buried if it remains in place; however, a long period of time would be required to completely isolate the MEC beneath newly deposited sediment.

Therefore, investigation in select locations within high density anomaly areas is recommended to determine if the anomalies at the site are MEC/range related debris or not. Based upon the findings of the anomaly inspections, it may be recommended that right of entry to Troublesome Point be pursued for investigation of the land portion of the site,

which could not be performed during this investigation. Additionally, if MEC is identified, determining the nature and extent of the MEC and MC in the sediments may be necessary.

6.2 Northern Currituck Sound Target Site

According to the data collected during the DGM investigation, there is a significant concentration of anomalies in the vicinity of the target location identified in the PA, suggesting the target coordinates are accurate and the anomalies surrounding the target are likely range related. However, there is no visual evidence of a hard target that remains at the site. Therefore, it is unknown if there are any target remnants which may present a navigational hazard. The high response concentration of anomalies is confined to a relatively small elliptical area, approximately 235 yards, around the target center. As discussed in the *Tier I Sediment Transport Evaluation Technical Memorandum* (**Appendix A**), based on lack of tides and current speeds found in the Northern Currituck Sound it is suggested that MEC (if present at the site) is unlikely to be moved by currents, except possibly in extreme storm conditions, such as Nor'easters and hurricanes. Net sedimentation in the Currituck Sound is not known but is likely to be low given the need for only infrequent dredging in the Atlantic Intracoastal Waterway adjacent to the sites. MEC is likely to be buried if it remains in place; however, a long period of time would be required to completely isolate the MEC beneath newly deposited sediment.

Therefore, investigation in select locations within high density anomaly areas is recommended to determine if the anomalies at the site are potentially MEC/range-related debris or not. If the anomalies are identified as MEC, determining the nature and extent of the MEC and MC in the sediments may be necessary.

6.3 Palmetto Point Bombing Range

Of the five targets in the main target area, significant anomaly concentrations were detected in three locations: Target NAB 42, Primary Target, and an area approximately 630 yards northwest of Target D. The anomaly concentrations surrounding these three targets (total area approximately 199 acres) likely indicates range related usage. Ship Point Target and Target #42 do not exhibit evidence of a significant concentration of anomalies related to range use. There is a high density area between Target NAB 42 and Target #42, with two separate areas of metal protruding above the water surface. This metal is likely related to a former hard target and may be a hazard to navigation. Additionally, there were clusters of poles observed above the water surface near Target #42 and the Lewis Point target, but there is no evidence of anything beneath the water which may present a hazard to navigation. Signage or buoys may be necessary in the vicinity of these targets to serve as a warning to boaters.

At the Lewis Point target, the data collected shows that the identified target location is located slightly northwest of the high response area detected during the investigation. The anomaly concentration is confined to a relatively small area (approximately 110 yards) just to the southeast of the target and extending eastwards, which is indicative of range related use.

As discussed in the *Tier I Sediment Transport Evaluation Technical Memorandum* (**Appendix A**), as a result of weaker wind driven currents at the site, MEC (if present at the

site) is unlikely to be transported away from their original location within the range. The primary source of sediment into the Albemarle Sound is from shoreline erosion. The net sediment accumulation rate is approximately 0.05 in./yr, which translates to an accumulation of approximately 2.6 inches of sediment over the past 50 years. MEC is likely to be buried if it remains in place; however, it will take a long period of time before the MEC is completely isolated beneath deposited sediment.

Therefore, investigation in select locations within high density anomaly areas (near Target NAB 42, Primary Target, the area northwest of Target D, and Lewis Point) is recommended to determine if the anomalies at the site are MEC/range related debris or not. If the anomalies are identified as MEC, determining the nature and extent of the MEC and MC in the sediments may be necessary. Additionally, placing signage or buoys near the hard targets may be necessary to warn boaters of the potential navigational hazards associated with the former targets.

SECTION 7

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Appendix A
Tier I Sediment Transport Evaluation Technical Memorandum

Tier 1 Sediment Transport Evaluation, Three Other-than-Operational Water Ranges in North Carolina, Naval Air Station Oceana, Virginia Beach, Virginia

PREPARED FOR: Mary Margaret Kutz/NAVFAC Midlant

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DATE: October 1, 2009

PROJECT NUMBER: 381273.XO.WP.DR

1. Introduction and Background

CH2M HILL has been tasked with performing Site Inspections (SIs) of three other-than-operational ranges (water ranges) in North Carolina that are associated with Naval Air Station (NAS) Oceana in Virginia Beach, VA. A preliminary assessment (PA) of the ranges was completed in 2009 (Malcolm and Pirnie Inc., 2009). The North Landing River (NLR) Target Site, Northern Currituck Sound (NCS) Target Site, and Palmetto Point Bombing Range are all located in a large, shallow estuary to the west of the North Carolina Outer Banks (Figure 1). The NLR and NCS target sites are located in Currituck Sound, and the Palmetto Point Bombing Range is located in Albemarle Sound. Both of these water bodies are part of the Albemarle Estuarine System (AES) (Corbett et al., 2007). This sediment transport evaluation assesses how the hydrodynamics of the AES over the past 40 to 50 years may have influenced the transport and fate of the ordnance that was dropped on the ranges. Geophysical surveys of the target sites will be performed as part of the SI to determine the areal distribution of metallic anomalies near the known target locations and evaluate the potential presence or suggested absence of munitions and explosives of concern (MEC) at the sites.

This sediment transport evaluation follows guidance provided in the *User's Guide for Assessing Sediment Transport at Navy Facilities* (Blake et al., 2007) and focuses on two management questions related to sediment transport in the vicinity of the three water ranges:

- Will sediment transport lead to the redistribution of munitions and explosives of concern (MEC) within the danger zone of each range, or movement of MEC to outside of the range boundaries?
- Will natural processes lead to the burial and isolation of MEC by newly deposited sediment?

These questions are addressed in this evaluation using Tier 1 analysis methods. A Tier 1 evaluation is based on available data from regional studies and other publicly available sources, and relatively uncomplicated data analysis methods. This memorandum is organized according to the framework provided in Section 1.1 of the User's Guide. Section 2 presents a site description and a sediment transport conceptual site model (CSM) for each range. Section 3 discusses the application of the results to sediment management questions. Conclusions and recommendations are presented in Section 4, and references are provided in Section 5.

The NLR target site is a former air-to-ground land/water range, with approximately 60 percent of the site in open water less than 5 feet deep and 40 percent in coastal marsh. The site encompasses 696 acres and is located approximately 20 miles south of NAS Oceana. Target site boundaries are shown in Figure 2, and a navigational chart is provided in Figure 3. The site was used as a target and bombing area by naval aircraft for day and night operations in the 1950s and 1960s. Suspect munitions are limited to miniature bombs (subscale practice munitions) containing small signal charges that produced smoke puffs for marking points of impact. According to the PA, practice bombs utilized at the site were between 5 and 25 pounds in size. Based upon a helicopter reconnaissance conducted by CH2M HILL in May 2009, no target remnants are visible at the water surface. It is unknown whether any remnants of the target are present beneath the water surface.

The NCS target site is a former air-to-ground range located within northern Currituck Sound. The depth of water in the restricted area is approximately 3 to 6 feet. The site encompasses 3,831 acres and is located approximately 25 miles south of NAS Oceana. Site boundaries are shown in Figure 4, and a navigational chart is provided in Figure 5. This site also was used as a target and bombing area by naval aircraft for day and night operations in the 1950s and 1960s, and the suspect munitions are limited to small practice bombs between 5 and 25 pounds in size. No target remnants were visible at the water surface during the May 2009 helicopter reconnaissance.

The Palmetto Point Bombing Target is located on the south side of central Albemarle Sound. This former range was utilized for loft and high altitude bombing and rocket proficiency practice. The range is approximately 18,440 acres and is located 55 miles south-southeast of NAS Oceana. Water depths within the site are from 3 to 20 feet, increasing in depth to the north. The site boundaries are shown in Figure 6, and a navigational chart is shown in Figure 7. The range was used by naval aircraft for from approximately 1957 to 1998. Potential target locations have been identified and are shown in Figure 7. Of the six identified targets, three are in relatively shallow water (5 to 6 feet deep) and three are in relatively deeper water (greater than 10 feet). The munitions used at the range were reportedly limited to non-explosive ordnance, although the range was authorized for live ordnance use during times of war. According to the PA, the majority of the items were 25 pound practice bombs; however, 500, 1000, and 2000 pound practice bombs were also used. A site visit and boat reconnaissance was performed in July 2009. Remains of only one target were visible at the water surface.

Because the items used at all three ranges were practice bombs, they would not likely have fragmented upon impact. Therefore, the majority of the MEC present at each site is expected to be intact bomb bodies and relatively small amounts of bomb-related scrap.

2. Site Description

Sediment transport is caused by interactions between hydrodynamic forces (e.g. tides, currents, waves, gravitational forces) and bottom sediments. The following sections describe the regional setting, the bottom sediment characteristics, and the hydrodynamic forces near each site and present a sediment transport CSMs.

2.1 Regional Setting

The AES is comprised of drowned river valleys formed in response to the post-glacial rise in sea level that flooded the stream valleys of the coastal plain drainage system (Corbett et al., 2007; Riggs and Ames, 2003). The AES includes Albemarle Sound and its tributaries, Currituck Sound, Croatan Sound, and Roanoake Sound (Figure 1). These water bodies are dominated by fresh water due to protection from the Atlantic Ocean by the Outer Banks, which form a continuous barrier island. The nearest inflow of saline water into the estuary is through Oregon Inlet, approximately 25 miles southeast of the mouth of Albemarle Sound. There are virtually no astronomical tides in the AES because of the lack of free exchange with the ocean. Therefore, circulation is driven predominately by freshwater inflow and winds (Corbett et al., 2007).

Currituck Sound is shallow, with an average depth of 5 feet and a maximum depth of 13 feet. The sound trends in a north-south direction for 36 miles from the Virginia/North Carolina state line to the confluence with Albemarle Sound. The Atlantic Intracoastal Waterway passes through Currituck Sound to the east of the NLR target site and to the west of the NCS target site (Figures 3 and 5 respectively). The waterway has been dredged only infrequently since 1947, with the last major dredging event occurring in 1965[1]. However, the U.S. Army Corps of Engineers (USACE) Wilmington District anticipates that dredging will be needed in the future. The navigational charts show that dredged material was placed on the east sides of the dredged channel. No dredged material appears to have been placed within the boundaries of the NLR and NCS target sites.

Albemarle Sound trends in an east-west direction and is approximately 55 miles long. The sound is 8 miles wide in the vicinity of the Palmetto Point bombing range. The sound has a shallow perimeter platform that slopes gradually from the shoreline to a depth of 3 to 7 feet below mean sea level, then slopes more abruptly to the floor of the basin at 12 to 24 feet deep (Riggs and Ames, 2003). No dredging is performed for navigational purposes in Albemarle Sound.

2.2 Sediment Characteristics

Wells (1989) created a sediment distribution map of the AES based on the grain size distribution of sediment samples from a number of different studies. Both the NLR and NCS target sites are shown as being composed of silt, although few samples were collected in northern Currituck Sound. The land portion of the NLR target site is a coastal marsh, and the sediments in the adjacent water portion are most likely organic-rich sandy muds primarily derived from eroding marsh peat, similar to sediments further north in the North

[1] Currituck Sound Restoration Project meeting presentation, October 2006
http://www.saw.usace.army.mil/Currituck/PCT%20Meetings/2006_10_25-26%20PCT%20Mtg/Dredging.pps

Landing River (Riggs et al., 2003). Fine-grained sediments near the NCS target site also are likely to be derived primarily from the erosion of marsh shoreline, although no specific information about sediment characteristics in vicinity of the NCS site was found. The sediment type in Currituck Sound changes to sand immediately south of the NCS target site.

The composition and distribution patterns of sediments in Albemarle Sound were defined based on the analysis of 248 sediment samples (Riggs, 1996). Within the boundaries of the Palmetto Point bombing range, fine to medium sands are present along the shoreline perimeter platform to a depth of about 5 to 6 feet. The sands grade into organic-rich mud on the slope down to the central basin. The major source of sediment is the erosion of the shoreline by wave activity (Wells, 1989). Shoreline recession provides sand to the perimeter platform, and mud and organic detritus to the central basin. Fine-grained suspended sediment from rivers also accumulates in central basin, although the river inflows have a low sediment load (USGS, 1992). The shoreline erosion rate measured at Woodard's Marina in the immediate vicinity of the Palmetto Point bombing range (Figure 6) was estimated to be 2.4 feet/year from 1963-1998 (Riggs and Ames, 2003).

The sediment type in Albemarle Sound is controlled by the wave base, which is a function of fetch (i.e., distance over which the wind blows) and water depth. Sediments within the range of the wave base have the potential for being resuspended during high energy storm events (Riggs and Ames, 2003). Following resuspension, the winnowing action of waves and wind currents sort the fine and coarse sediment. The finer-grained sediments are eventually transported to and deposited in the deeper central basin, or flushed from system by river discharge and wind tides, probably to Pamlico Sound (Corbett et al., 2007).

The net sediment accumulation rate measured in a sediment core from the middle of Albemarle Sound directly north of the Palmetto Point target site was estimated as 0.11 to 0.15 cm/year based on radioisotope profiling (lead-210 and Cesium-137) (Corbett et al., 2007). Estimates of sediment accumulation rates at the NLR and NCS sites were not available.

2.3 Hydrodynamic Processes

As previously noted, the AES is large, shallow, fresh, and virtually unaffected by astronomical tides. It is probably the least studied system of its type in the United States (Corbett et al., 2007). Previous research has focused on descriptive rather than dynamic aspects of the system, and little specific information about or direct measurements of waves and currents in northern Currituck Sound or Albemarle Sound was found.

Circulation in the AES is driven by primarily by the wind. The wind pushes the water in the direction that the wind is blowing, resulting in a lower water level on the upwind side and a higher water level on the downwind side, which creates a sloping platform of water. The slope in the water surface creates a pressure gradient that generates wind tides and currents.

The direction, intensity, and duration of the wind determines the current and tide levels. Prevailing winds in coastal North Carolina are from the south and southwest from April through August, and from the north and northwest from September through February (Wells, 1989). The n'oreasters that occur in the fall and winter have winds from 25 to 50

miles per hour that may last several days. Wind speeds are greater in the tropical storms and hurricanes that occur in summer and fall.

In Currituck Sound, northerly winds push water to the south, out of the sound. Southerly winds push water to the north, into the sound. Normal wind tides are minor, but increase to 2 to 5 feet in a nor'easter and 10 feet or greater in a hurricane (Riggs and Ames, 2003). A n'oreaster of several days will cause strong south-flowing currents that shift back when the wind ceases. The wind direction in a tropical storm or hurricane depends on the storm track. Winds are from the north if the path of the storm is seaward (east), from the south if the storm track is landward (west), and reverse if the storm path is directly through the estuary. Information or data on measured or predicted current velocities in northern Currituck Sound was not available. However, several hydrodynamic models that include Currituck Sound are in development and model results may be able to provide more specific information in the future[2] about current velocities under various storm conditions.

The NLR and NCS target sites may be exposed to significant wave activity when winds are from the south due to the large fetch (distance of water over which the wind blows). Waves generated by northerly winds will be smaller due to the limited fetch. However, the presence of fine-grained sediments at both the NLR and NCS sites indicates that wave and current activity is not sufficient to frequently resuspend and winnow out the fine-grained particles, which would leave a sandy bottom.

Information about the direction and magnitude of wind-induced currents was not available for Albemarle Sound. Northerly winds would push water towards the shoreline south of the Palmetto Point bombing range and generate waves that would cause shoreline erosion and resuspend sediment within the wave base. South winds would generate limited wave activity due to the limited fetch.

2.4 Sediment Transport Conceptual Site Models

A sediment transport CSM for the NLR and NCS target sites is provided in Figure 8. These sites are located in northern Currituck Sound, a shallow freshwater estuary with no astronomical tides. The surrounding land is a comprised of low-relief coastal marshes. Bottom sediments at the NLR target site are most likely composed of organic rich sandy mud primarily derived from the erosion of the adjacent coastal marsh in storm events. Sediments at the NCS target site also appear to be fine-grained. The net sediment accumulation rate is not known, but is likely to be low based on the low rates measured elsewhere in the AES (Corbett et. Al, 2007) and the infrequent need for maintenance dredging in the Atlantic Intracoastal Waterway.

Circulation in northern Currituck Sound is driven primarily by the wind. Wind speeds are highest during storm events, with n'oreasters occurring in the fall and winter and tropical storms and infrequent hurricanes in occurring in the summer and fall. Wind-generated currents are to the south in n'oreasters, and to north or south in tropical storms or hurricanes depending on the storm track. Although no current velocity information was

[2] The USACE Engineer Research and Development Center is developing a coupled hydrodynamic and water quality model as part of the Currituck Sound Restoration Project (http://www.saw.usace.army.mil/Currituck/), and the National Oceanic and Atmospheric Administration (NOAA) Office of Coast Survey is developing a Coastal Flooding Model to help evaluate the effects of sea level rise (http://www.nauticalcharts.noaa.gov/csdl/sealevelrise.html)

available for northern Currituck Sound, current velocities were measured near the Wright Memorial Bridge at the south end of Currituck Sound (Figure 1) from February 2006 through July 2007 (USGS, 2008). Velocities were generally less than 0.1 m/sec at this location, with a maximum velocity of 0.7 m/sec.

Intact bodies of 5-lb and 25-lb bombs have about the same weight as 12-cm and 20-cm diameter spherical cobbles respectively (assuming a cobble density of 2.65 g/cm^3). Using a Hjulstrom diagram, which shows the relationship between the speed of a current and the size of particles that can be moved by it, currents of approximately 0.4 m/sec and 0.5 m/sec would be required to move intact 5-lb and 25-lb bomb bodies, respectively. These threshold velocities were exceeded at the Wright Memorial Bridge location for only two 6-hour periods in the 1.5 year data collection period. Current speeds in northern Currituck Sound are likely to be less than at the Wright Bridge location, which has a sandy bottom and is less protected. This information suggests that bomb bodies at the NLR and NCS target sites are unlikely to be moved by currents except possibly in extreme storm conditions.

A sediment transport CSM for the Palmetto Point bombing range is provided in Figure 9. The Palmetto Point range is located on the south shore of central Albemarle Sound, which is also a shallow freshwater estuary with no astronomical tides. The sediment type within the boundaries of the range is fine to medium sand at depths of less than about 5 to 6 feet, grading to fine-grained organic rich mud on the slope down to the central basin. Shoreline erosion is the primary source of sediment to the sound. The net sediment accumulation rate is approximately 0.13 cm/year in the central basin north of the range, which translates to the accumulation of about 3 inches of sediment over the past 50 years.

Circulation near the Palmetto Point range is driven primarily by the wind, with prevailing winds from the north in the fall and winter and from the south in the summer. Wind-generated currents are expected to be minimal except possibly in storm events. Waves generated by northerly winds would resuspend bottom sediments at depths within the wave base. The coarser sediments (sands) likely experience only local transport and redistribution, whereas the finer sediments (silt, clay and organics) are winnowed out and deposited in the central basin or eventually transported to Pamlico Sound (Corbett et al., 2007). The 25 pound (and larger) intact bomb bodies within the range are unlikely to be transported away from their original location due to their substantial size and weight and absence of significant currents.

3.3 Sediment Management Questions

This section addresses the sediment transport questions that are likely to influence management decisions for the NLR and NCS target sites, and the Palmetto Point bombing range.

1. **Will sediment transport lead to the redistribution of MEC within the danger zone of each range, or movement of MEC outside of these areas?**

   Little to no redistribution of MEC would be expected at the NLR and NCS target sites under normal conditions because of the lack of tides and currents within northern Currituck Sound. High winds during storm events can result in storm tides and wind-driven currents that force water into or out of Currituck Sound, depending on the wind direction. Limited existing data suggest that current velocities are unlikely to be

sufficient to move intact 5-pound and 25-pound bomb bodies except possibly in extreme storm conditions.

The Palmetto Point bombing range is on the southern shore of Albemarle Sound, on a sloping bottom consisting of a shallow, sandy platform at depths of less than 5 to 6 feet and finer-grained sediments on the slope down to the central basin. The shallow sandy fringe on the south side of the range is exposed to wind and wave action from the north. Although near shore sediments may be resuspended during high wind/wave conditions and fine-grained particles (i.e., silts and clays) winnowed and transported to deeper areas, the intact 25-lb (and larger) bomb bodies near the shallow targets are likely to remain in place due to their large size and weight. The bomb bodies near targets at depths below the wave base are also unlikely to be transported away from their point of origin due to the lack of sufficient and sustained current velocities.

2. **Will natural processes lead to the burial and isolation of MEC by newly deposited sediment?**

Although the AES is a net depositional environment, net sedimentation rates are low, ranging from 0.08 – 0.57 cm/year (Corbett et al., 2007). In the center of Albemarle Sound north of the Palmetto Point bombing range, the net sedimentation rate is approximately 0.13 cm/year, which translates to about 3 inches of sediment accumulation over the past 50 years. The net sedimentation rate in northern Currituck Sound is not known, but is likely to be low given the need for only infrequent dredging in the Atlantic Intracoastal Waterway adjacent to the sites. Although intact bomb bodies are likely to be gradually buried if they remain in place, a long period of time would be required to completely isolate the MEC beneath newly deposited sediment.

4. Conclusions and Recommendations

The Tier 1 sediment transport evaluation for the NLR and NCS target sites and the Palmetto Point bombing range indicates that sediment transport may occur in the vicinity of the targets, but intact bomb bodies are unlikely to be mobilized except possibly in extreme storm conditions. However, the hydrodynamic environment in the AES is not well studied or understood, and the Tier 1 evaluation should be considered an initial, simplified assessment of site conditions. The geophysical surveys planned as part of the SI should confirm the location and distribution of the MEC. If a more detailed and site-specific evaluation of sediment and MEC transport is warranted, then a Tier 2 study including site-specific current and wave measurements and predictive modeling evaluation could be performed.

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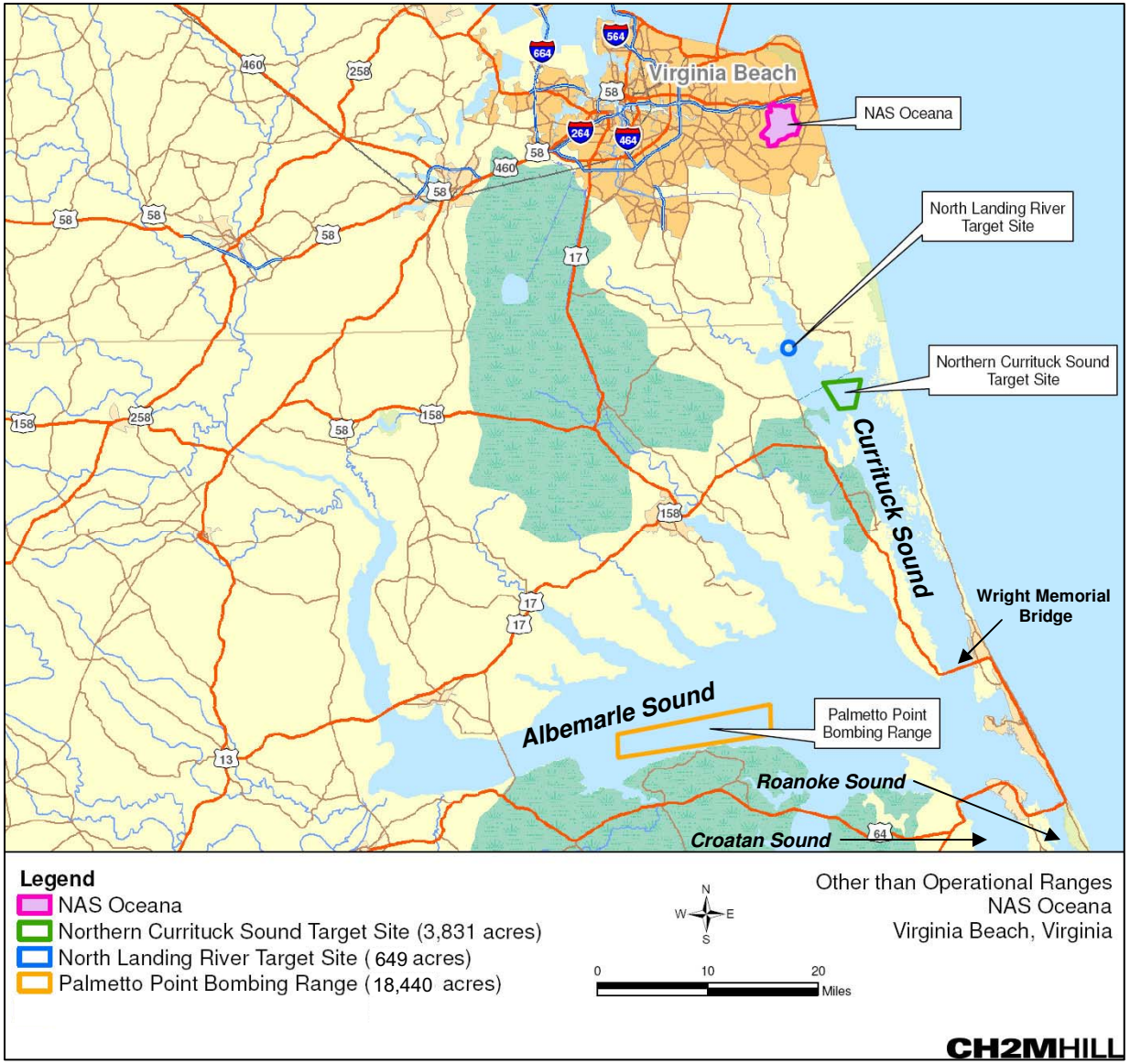
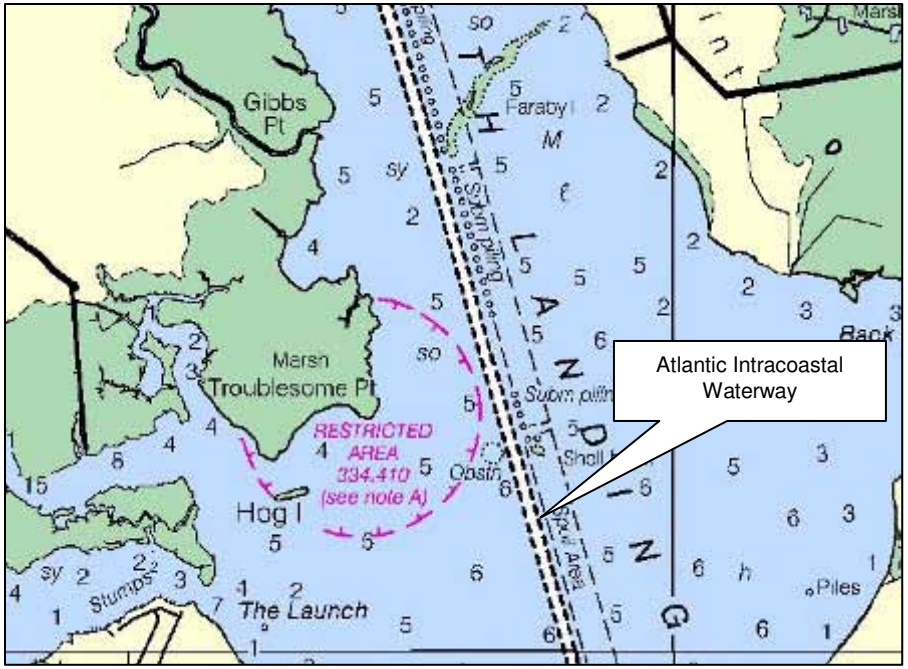


FIGURE 1

NAS Oceana Water Range Site Location Map

FIGURE 2
North Landing River Target Site Location Map



Note: Radius of restricted area is 1000 yards.

FIGURE 3
North Landing River Target Site Navigational Chart

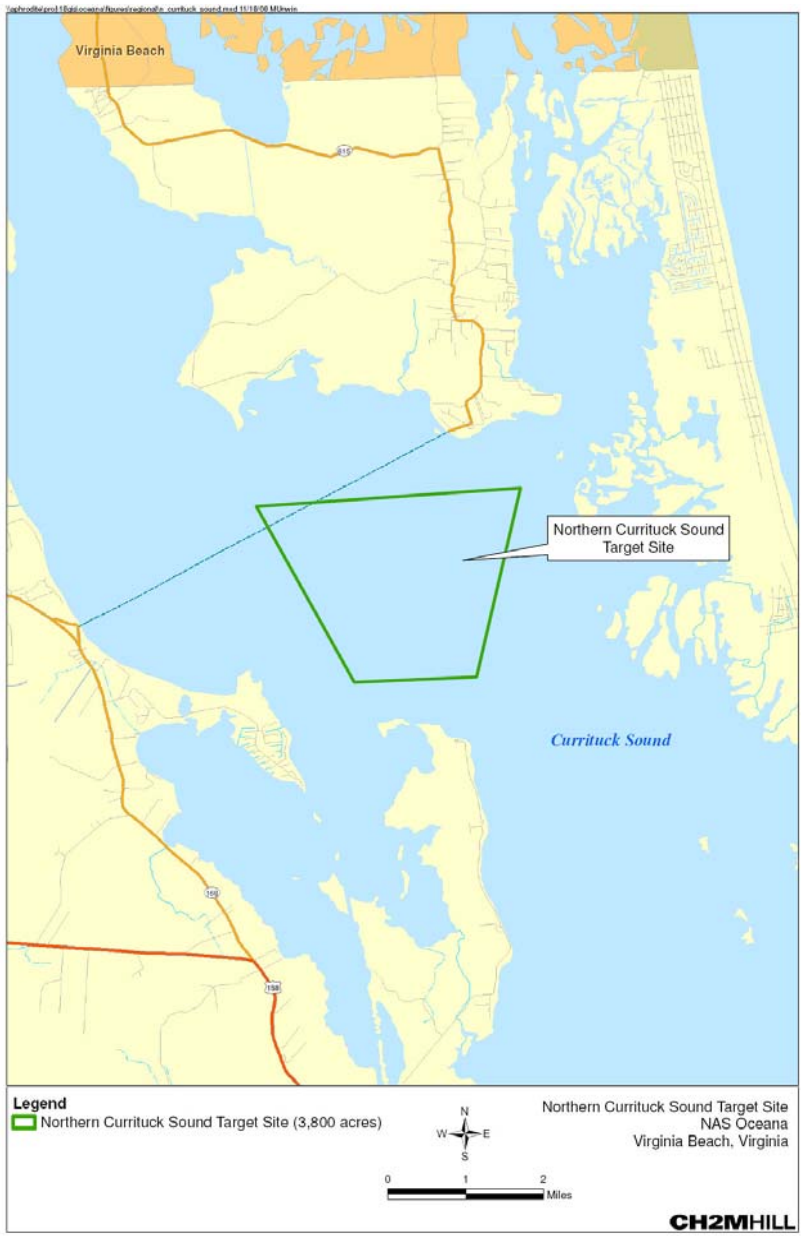
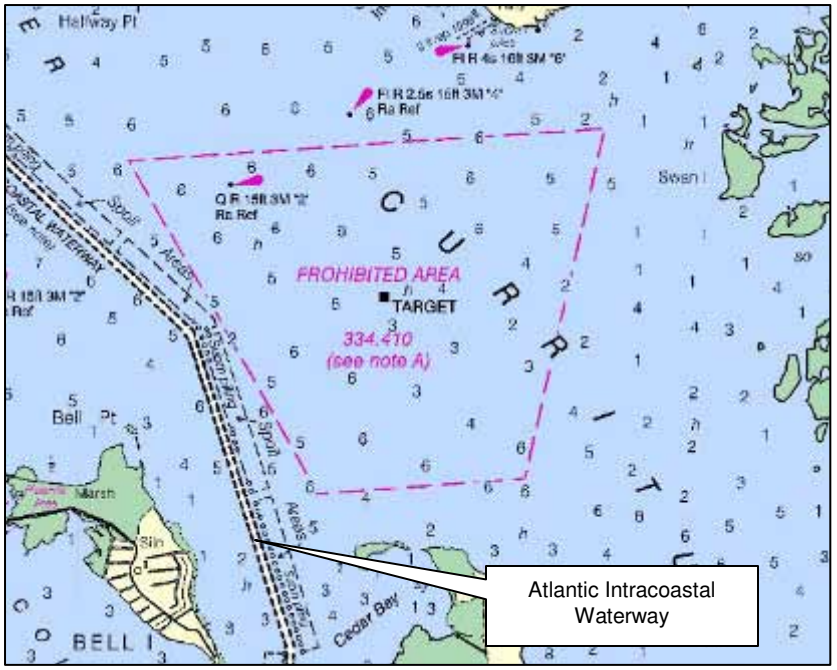


FIGURE 4
Northern Currituck Sound Target Site Location Map



Note: length of northern boundary is about 7600 yards.

FIGURE 5
Northern Currituck SoundTarget Site Navigational Chart

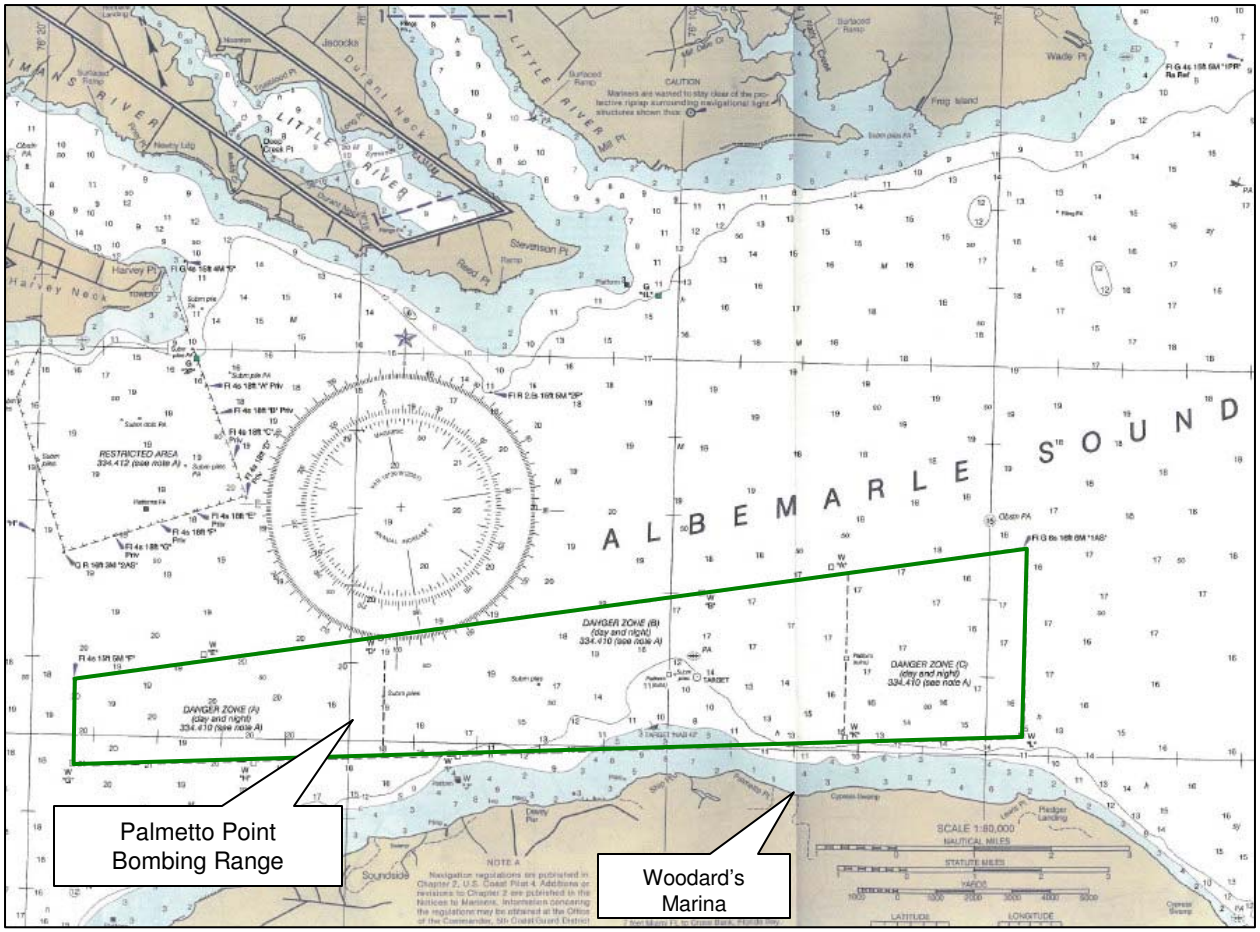
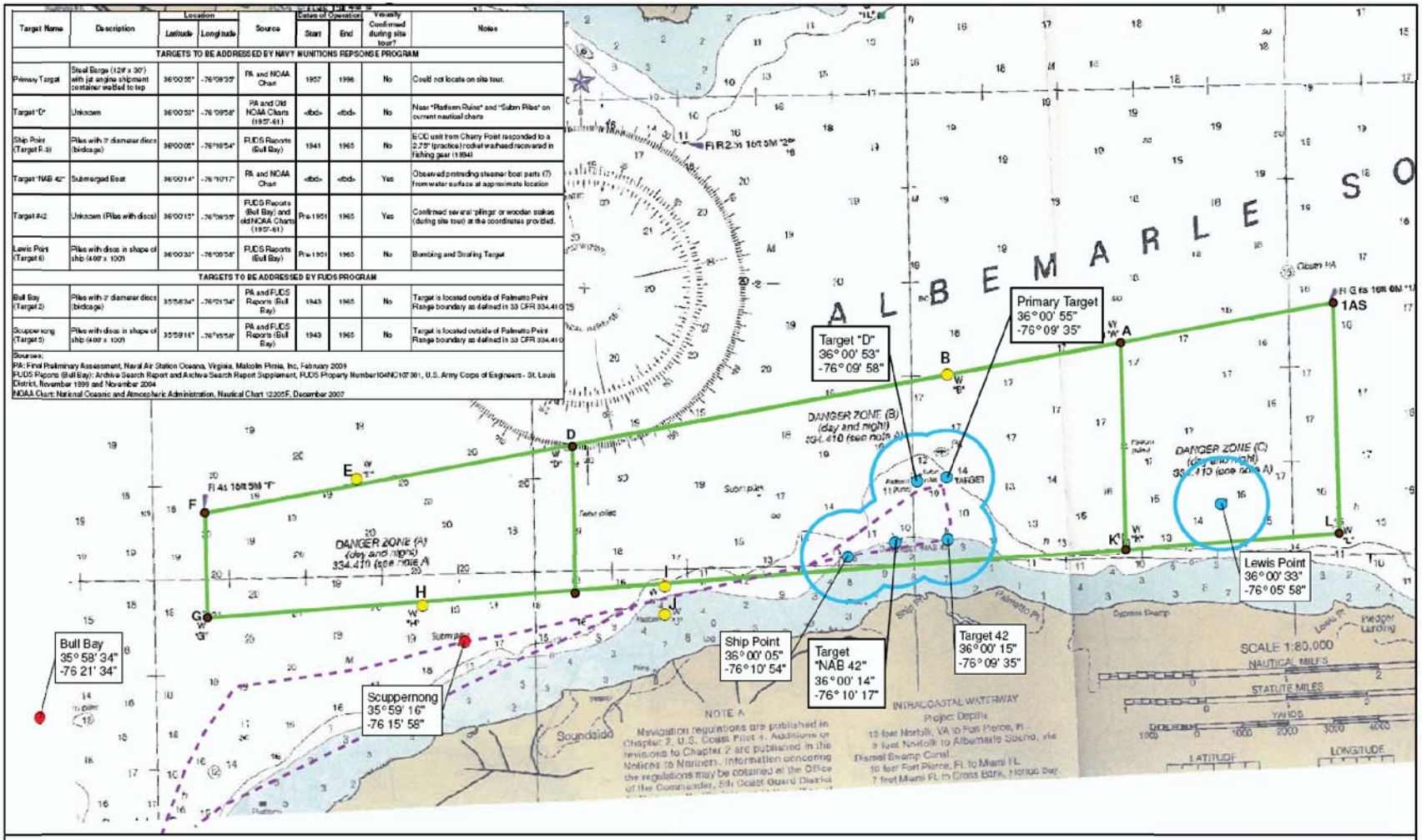


FIGURE 6
Palmetto Point Bombing Range Location Map

Target Name	Description	Location		Source	Dates of Operation		Visually Confirmed during site tour?	Notes
		Latitude	Longitude		Start	End		
TARGETS TO BE ADDRESSED BY NAVY MUNITIONS REPSONSE PROGRAM								
Primary Target	Steel Barge (120' x 30') with jet engine shipment container welded to top	36°00'55"	-76°09'35"	PA and NOAA Chart	1957	1996	No	Could not locate on site tour.
Target "D"	Unknown	36°00'53"	-76°09'58"	PA and Old NOAA Charts (1957-61)	<tbd>	<tbd>	No	Near "Platform Ruins" and "Subm Piles" on current nautical charts
Ship Point (Target R-3)	Piles with 3' diameter discs (birdcage)	36°00'05"	-76°10'54"	FUDS Reports (Bull Bay)	1941	1965	No	EOD unit from Cherry Point responded to a 2.75" (practice) rocket washed recovered in fishing gear (1994)
Target "NAB 42"	Submerged Boat	36°00'14"	-76°10'17"	PA and NOAA Chart	<tbd>	<tbd>	Yes	Observed protruding steamer boat parts (?) from water surface at approximate location
Target #42	Unknown (Piles with discs)	36°00'15"	-76°09'35"	FUDS Reports (Bull Bay) and old NOAA Charts (1957-61)	Pre-1901	1965	Yes	Confirmed several pilings or wooden stakes (during site tour) at the coordinates provided.
Lewis Point (Target 6)	Piles with discs in shape of ship (400' x 100')	36°00'33"	-76°05'58"	FUDS Reports (Bull Bay)	Pre-1901	1965	No	Bombing and Strafing Target
TARGETS TO BE ADDRESSED BY FUDS PROGRAM								
Bull Bay (Target 2)	Piles with 3' diameter discs (birdcage)	35°58'34"	-76°21'34"	PA and FUDS Reports (Bull Bay)	1943	1965	No	Target is located outside of Palmetto Point Range boundary as defined in 33 CFR 334.410
Scuppernong (Target 5)	Piles with discs in shape of ship (400' x 100')	35°59'16"	-76°15'58"	PA and FUDS Reports (Bull Bay)	1943	1965	No	Target is located outside of Palmetto Point Range boundary as defined in 33 CFR 334.410

Sources:
PA: Final Preliminary Assessment, Naval Air Station Oceana, Virginia, Malcolm Pirnie, Inc, February 2009
FUDS Reports (Bull Bay): Archive Search Report and Archive Search Report Supplement, FUDS Property Number I04NC107301, U.S. Army Corps of Engineers - St. Louis District, November 1999 and November 2004
NOAA Chart: National Oceanic and Atmospheric Administration, Nautical Chart 12205F, December 2007



Legend
- Palmetto Point Range Area (18,440 acres)
- Approximate Boat Reconnaisance Path
- Estimated Anomaly Concentration Area (1,000-yard radius around potential target) Area = 2,830 acres

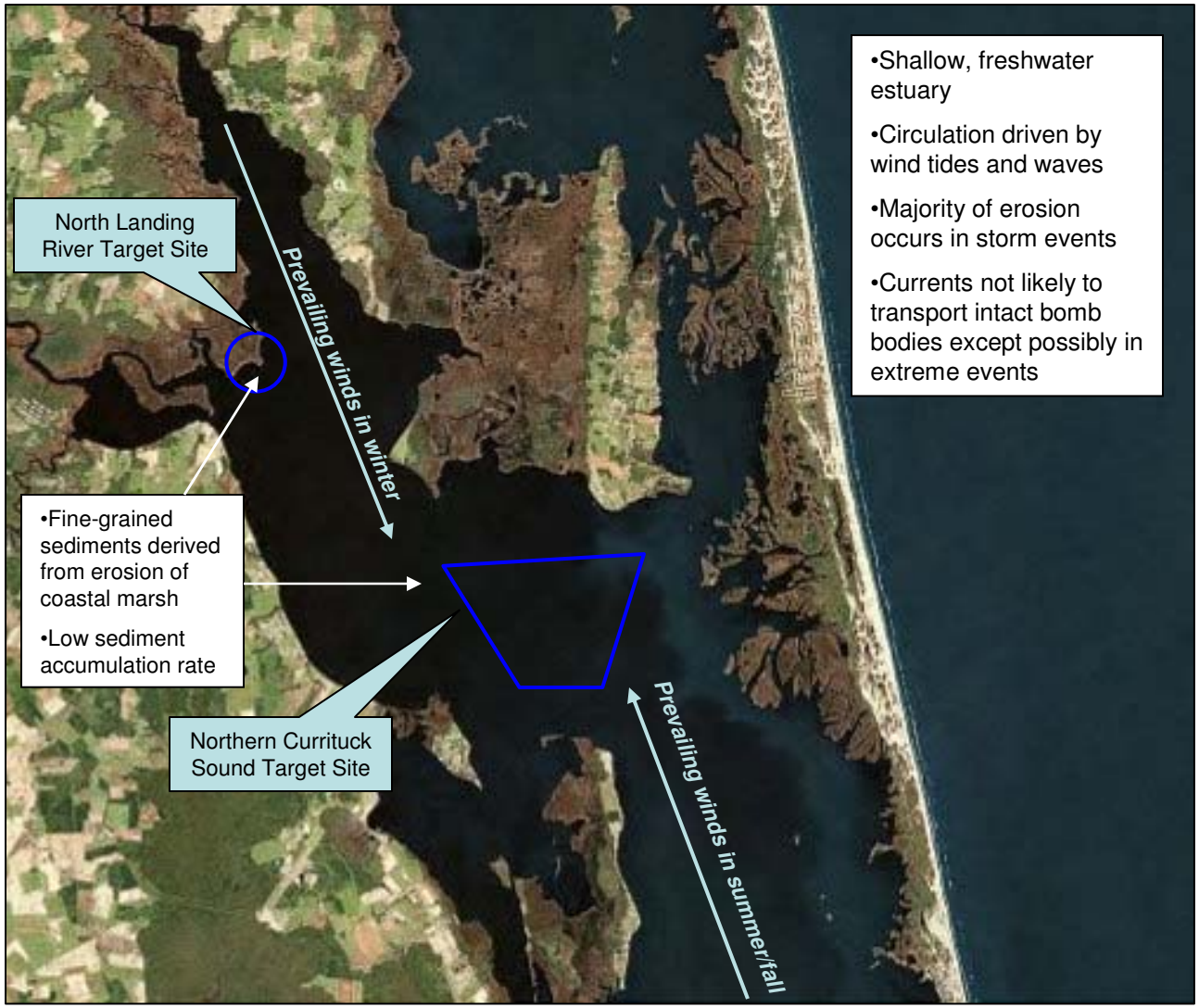
N
W E
S

0 0.85 1.7 Miles

Target Map for the Site Inspection
Palmetto Point Bombing Range
NAS Oceana
Virginia Beach, Virginia

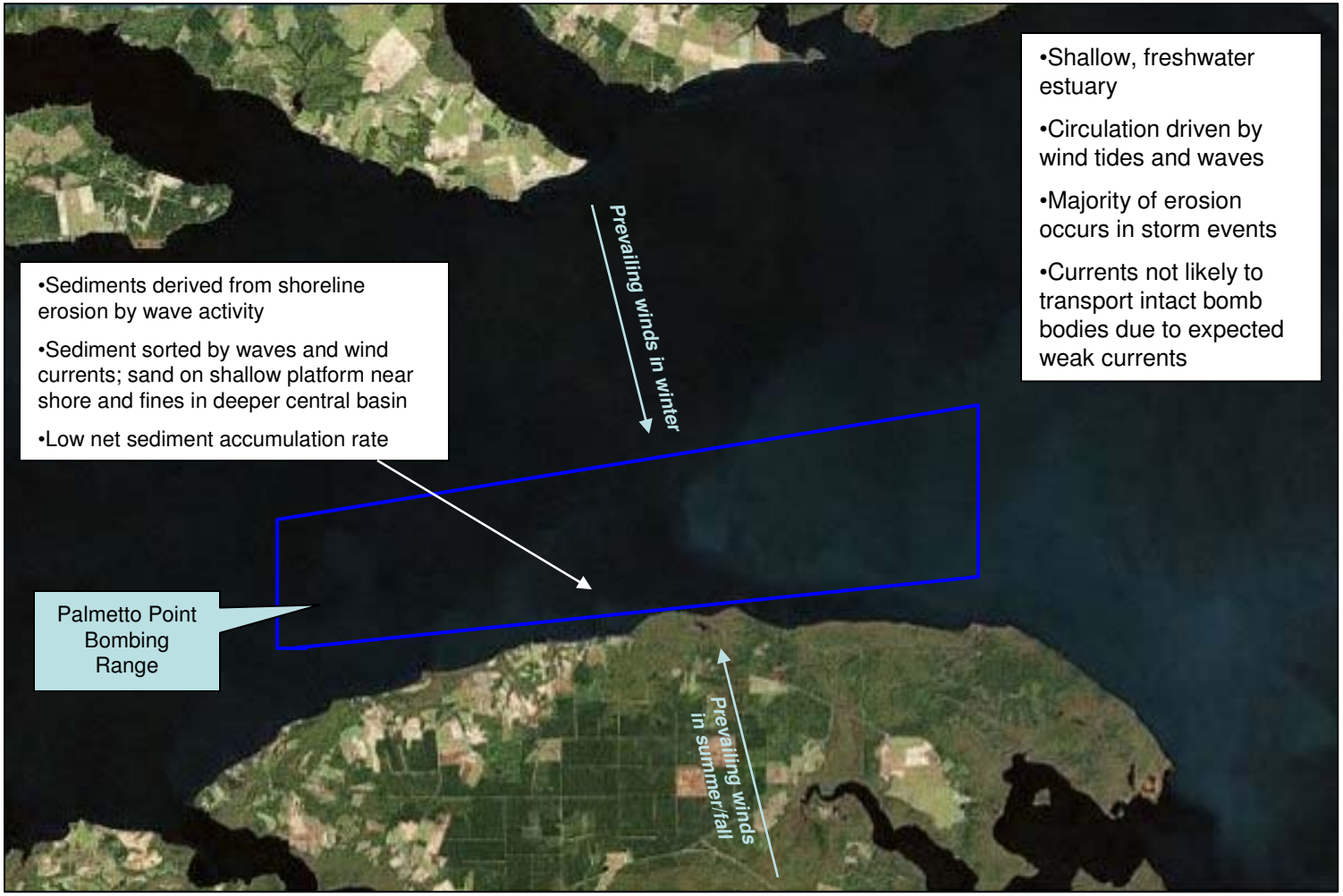
CH2MHILL

FIGURE 7
Palmetto Point Bombing Range Navigational Chart and Identfiied Targets



Base map obtained from www.bing.com

FIGURE 8
Sediment Transport Conceptual Site Model for North Landing River and Northern Currituck Sound Target Sites



Base map obtained from www.bing.com

FIGURE 9

Sediment Transport Conceptual Site Model for Palmentto Point Bombing Range

Appendix B
NAEVA Geophysical Investigation Report

NAeVA GEOPHYSICS INC.

THE LEADER IN SUBSURFACE DETECTION

Subsurface Geophysical Surveys

GPR
MAGNETICS
ELECTROMAGNETICS
SEISMICS
RESISTIVITY
UTILITY LOCATION
UXO DETECTION
BOREHOLE CAMERA
STAFF SUPPORT

GEOPHYSICAL INVESTIGATION REPORT

Phase I Site Inspection of the Other-than-Operational Water Ranges North Carolina

Naval Air Station Oceana
Virginia Beach, Virginia

Contract Task Order 0028

Under the
NAVFAC CLEAN 1000 Program
Contract N62470-08-D-1000

Dates of Investigation:
August 10th – September 1st, 2010

FINAL SUBMITTAL
November 4, 2010

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APPENDICES & DVD

Appendix A: Summary of IVS Results
Appendix B: Example QC Test Results

Contents of DVD: Project deliverables

- Field Documents
  - Boat Inspections
  - Daily Safety Meeting Sheets
  - Float Plans
- IVS
  - Processed ASCII XYZ files
  - Summary result worksheets
- Mosaics –Geosoft maps, grid, and PDF files
  - Bathymetric
  - VSP Calculated Anomaly Density
  - Anomaly Distribution
- Preprocessed Data
  - Preprocessed data XYZ files
  - Raw data delivery reports
  - Static and Pressure tests processed XYZ, Geosoft Maps and PDF plots
- Processed Data
  - Final processed XYZ files by grid block
  - Final data delivery reports
  - Static and Pressure test processed XYZ, Geosoft map, and PDF plots
  - PDF and Geosoft map color coded gridding of instrument response data
  - Target lists in XYZ and Excel formats
  - Geosoft grid files
- Raw Data
  - All native files created by collection software
  - All converted XYZ files
- Report –Report in Microsoft Word and PDF formats
  - VSP files

ACRONYMS AND ABBREVIATIONS

3Dg	3D Geophysics.com
ASCII	American Standard Code for Information Interchange
AHA	Activity Hazard Analysis
APP	Accident Prevention Plan
cm	Centimeter
CTO	Contract Task Order
DGM	Digital Geophysical Mapping
DQOs	Data Quality Objectives
EM	Electromagnetic
FTP	File Transfer Protocol
GIS	Geographic Information System
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
ISO	Industry Standard Object
IVS	Instrument Verification Strip
MEC	Munitions and Explosives of Concern
MRSIMS	Munitions Response Site Information Management System
µs	Microsecond
mV	Millivolts
NAD83	North American Datum of 1983
NAEVA	NAEVA Geophysics, Inc
NAS	Naval Air Station
Navy	United States Navy
NCST	Northern Currituck Sound Target
NGS	National Geodetic Survey
NLRT	North Landing River Target
NMEA	National Marine Electronics Association
OPUS	Online Positioning User Service
OSHA	Occupational Safety and Health Administration
OtO	Other-than-Operational
PA	Preliminary Assessment
PPBR	Palmetto Point Bombing Range
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance / Quality Control
QAPP	Quality Assurance Project Plan
QC	Quality Control
RI	Remedial Investigation
RTK	Real Time Kinematic
SI	Site Inspection
SOPs	Standard Operating Procedures
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan

UHF	Ultra High Frequency
UTM	Universal Transverse Mercator
UUTA	Underwater UXO Towed Array
UXO	Unexploded Ordnance
VSP	Visual Sample Plan

1.0 INTRODUCTION

NAEVA Geophysics, Inc. (NAEVA) was contracted by CH2M HILL to conduct Digital Geophysical Mapping (DGM) in support of a Site Inspection (SI) at three Other-than-Operational (OtO) water ranges associated with Naval Air Station (NAS) Oceana, Virginia Beach, Virginia. NAEVA employed 3D Geophysics (3Dg), out of Chaska, Minnesota, as a subcontractor to support this effort. Field operations were conducted from August 10th through September 1st, 2010.

1.1 BACKGROUND AND OBJECTIVES

The Department of the Navy issued Contract Task Order (CTO) 028 to CH2M HILL under contract N62470-08-D-1000 to conduct an SI to evaluate the potential presence of munitions and explosives of concern (MEC) at three OtO water ranges (CH2M HILL, 2010a). These sites are off-installation, former targets used by the United States Navy (Navy) for air-to-ground training exercises in the Currituck and Albemarle Sounds. The three sites include the Northern Currituck Sound Target Site (NCST), North Landing River Target Site (NLRT), and the Palmetto Point Bombing Range (PPBR). Based on information gathered during the Preliminary Assessment (PA), the NCST site and the NLRT site were used from approximately 1950 until the mid-1960s, and the PPBR was used from 1957 until 1998. Records indicate that only practice ordnance were used at NCST and NLRT sites. Live ordnance use was authorized at PPBR during times of war; however, no evidence or documentation was identified during the PA to suggest live ordnance use at the site (CH2M HILL, 2010b).

The SI is the second component of the overall site evaluation, following the PA. It is not intended as a full-scale Remedial Investigation (RI) to determine nature and extent of contamination, rather its purpose is to augment the data collected in the PA to identify whether further response action or investigation is required (CH2M HILL, 2010b). The objective of the SI is to evaluate the potential presence of MEC in the former underwater target areas by identifying geophysical anomalies on the seafloor or shallowly buried within the sediments.

1.2 SCOPE OF WORK

Geophysical operations included the following tasks:

- preparation of Activity Hazard Analysis (AHAs), Standard Operation Procedures (SOPs), and Accident Prevention Plan (APP) including a Site Safety and Health Plan (SSHP);
- review and comment on the Quality Assurance Project Plan (QAPP);

- mobilization of all personnel and equipment;
- digital geophysical mapping of transects within the designated areas of each of the three sites, data processing and anomaly selection, and preparation of data deliverables.

All DGM activities followed well defined Quality Control (QC) procedures in order to establish confidence in the accuracy of the geophysical data. Data were collected along proposed transects and safety was not compromised by the large amount of underwater obstructions (sunken ships and associated debris).

All data were processed, interpreted and uploaded to the CH2M HILL File Transfer Protocol (FTP) site on schedule and in the formats specified in the work plan.

1.3 SITE LOCATION AND DESCRIPTION

NCST and NLRT sites are located in the Currituck Sound near Coinjock, North Carolina. The PPBR is located in the Albemarle Sound near Columbia, North Carolina.

The NCST site is a former air-to-ground water range located within the northern portion of Currituck Sound. The depth of water within the prohibited area is reportedly three to six feet. The site encompasses 3,831 acres and is located approximately 25 miles south of NAS Oceana **(Figure 1)**. The approximate target location, according to 33 CFR 334.410, is easting 415618.293 and northing 4034766.939 North American Datum of 1983 (NAD83) Universal Transverse Mercator (UTM) Zone 18N, meters). The site was used as a target and bombing area by naval aircraft for day and night operations in the 1950s and 1960s. Suspected munitions consist of small practice bombs between 5 and 25 pounds (CH2M HILL, 2010a). No target remnants are visible at the water surface and nothing was observed that would pose a navigation hazard to boaters. Debris fields were observed at the center of the target, however all observed objects appeared to be near the surface of the seafloor.

The NLRT site is a former air-to-ground land/water range with approximately 60 percent of the site located in open water that is reportedly less than 5 ft deep and 40 percent located in a coastal marsh known locally as “Troublesome Point”. The site encompasses approximately 649 acres and is located approximately 20 miles south of NAS Oceana **(Figure 1)**. Approximate location of the target, according to 33 CFR 334.410, is easting 407975.366 and northing 4041747.992 (NAD83 UTM Zone 18N, meters). The site was used as a target and bombing area by naval aircraft for day and night operations in the 1950s and 1960s. Suspect munitions consist of small practice bombs between 5 and 25 pounds (CH2M HILL, 2010a). There are no target remnants visible above the water surface and nothing was observed that would pose a navigation hazard to

boaters. A few objects were observed scattered across the investigation area, however all appeared to be near to the seafloor.

The PPBR site is located on the south side of central Albemarle Sound. The former range was utilized for loft and high altitude bombing and rocket proficiency practice. The range, as defined by 33 CFR 334.410, is approximately 18,440 acres and is located 55 miles south-southeast of NAS Oceana **(Figure 1)**. However, only 2,830 acres were proposed to be investigated during this SI, which includes a 1,000 yard radius around each of the potential hard targets locations (**Table 1**). Based on historical documents and other reports, six hard targets were identified. Of the six hard targets, three are in relatively shallow water and three are in water deeper than ten feet. The depth of water within the site is reportedly 3 to 15 feet, increasing in depth to the north (toward the center of the sound). The range was used by naval aircraft from approximately 1957 to 1998 and the munitions used at the range were reportedly limited to non-explosive ordnance, although the range was authorized for live ordnance use during times of war. Suspected munitions include 25, 500, 1000, and 2000 pound practice bombs (CH2M HILL, 2010a). Metal remnants at two locations, between Target "NAB 42" and Target #42, are visible above the water surface, and multiple clusters of poles can be observed near the Lewis Point Target. The two locations of metal remnants only stick above the water surface a few feet and may pose a navigation hazard to boaters.

Target Name	**Easting** (NAD83 UTM Zone 18N, meters)	**Northing** (NAD83 UTM Zone 18N, meters)
Primary Target	395494.936	3986264.928
Target "D"	394918.457	3986210.177
Ship Point	393498.706	3984748.106
Target #42	395480.267	3985032.463
Target "NAB 42"	394428.396	3985014.227
Lewis Point (Target 6)	400919.261	3985524.099

Table 1: Palmetto Point Bombing Range Target Locations (CH2M HILL, 2010b)

2.0 EQUIPMENT

The equipment used for the investigation at OtO water ranges included the Geonics EM61-Flex3 electromagnetic metal detector, Underwater UXO Towed Array (UUTA), Trimble 5700 Real Time Kinematic (RTK) Global Positioning System (GPS), and a Trimble AgGPS FmX navigation system.

2.1 GEONICS EM61-FLEX3

The EM61-Flex3 is a high-resolution time-domain electromagnetic instrument designed to detect, with high spatial resolution, shallow ferrous and non-ferrous metallic objects. The EM61-Flex3

system is based on the standard Geonics EM61-MK2 metal detector. The EM61-Flex3 consists of four air-cored receiver coils, a grand air-cored transmitter coil, a digital data recorder, batteries and processing electronics (Geonics, 2009). The 1.0 x 0.2 meter receiver coils are arranged side by side and are enclosed by the transmitter coil (Figure 2). The EM61-Flex3 acquires up to 16 readings per second for each time gate. The EM61-Flex3 transmitter generates a pulsed primary magnetic field, which then induces eddy currents in nearby metallic objects. Each of the spatially separated receiver coils measures these eddy currents. The EM61-Flex3 offers the ability measure the eddy currents at two operator selected time gates (196 microsecond (µs) and 446µs). Secondary voltages induced in both coils are measured in millivolts (mV). Data are collected using the MLFXmarine acquisition program (Geomar Software, Inc.) and temporarily stored in a Panasonic ToughBook laptop computer.

2.2 UUTA

The Electromagnetic (EM) system was deployed using an UUTA developed by 3Dg. The UUTA includes an EM coil support platform (whale tail) and a rigid down-rigging system **(Figure 3)**. The downrigger is equipped with a control surface (hydrofoil or 'elevator'), which allows the system operator to control the height of the coil above the sea bottom during data acquisition. Several sensors are integrated with the UUTA to provide position control of the Flex3 coil platform. A pressure transducer on the platform accurately measures the depth of the receiver coils. An inclinometer measures the exact angle of the downrigger and is used to determine horizontal offset of the coil platform from the boat. A bow-mounted, side-scan sonar and bottom finder are used to map the sea bottom depth and image potential bottom obstructions during the survey.

The UUTA uses two RTK receivers to accurately measure the exact position and heading of the boat. The rigid downrigger is designed to keep the sensor platform in line with the keel of the boat and the two RTK GPS receivers. In this way, accurate geolocation of the platform can be achieved. The MLFXMarine (Geomar Software, Inc.) acquisition program captures the GPS, pressure transducer, inclinometer, and sonar bottom depth data and then calculates the position of the sensor platform **(Figure 4)**. The sonar transducer is mounted on the bow of the boat and provides the system operator immediate warning of changes in seafloor contour and other obstructions. Bow imaging of the seafloor topography allows the system operator time to adjust and maintain the optimum sensor height above bottom. The system operator adjusts the sensor height by using a control wheel to change the angle of attack of the elevator **(Figure 5)**. When boat speed and elevator angle remain constant the depth of the sensor platform does not change.

The UUTA was deployed using a 22-foot jet boat **(Figure 6 & 7)**. When fully loaded with crew and equipment, the boat drafts less than two feet in the water.

2.3 TRIMBLE 5700 RTK GPS

A Trimble 5700 RTK GPS base station and rovers were used for the real-time acquisition of positional data during geophysical data collection. The GPS base station was used in conjunction with the two rovers which were mounted as described in the previous section. Real-time corrections were broadcast to the roving GPS units via a radio link using a Trimble HBP450 Ultra High Frequency (UHF) radio modem. This system provides positional corrections at a rate of one Hz, with an accuracy of three centimeter (cm) horizontal and five cm vertical when a minimum of five satellites are available. GPS base station locations were obtained by setting up the base unit and recording a minimum of four hours of static readings. These readings were then uploaded to the Online Positioning User Service (OPUS) and a solution (corrected position) was returned. **Table 2** lists the different base station locations that were used. The corrected base location used for the NCST and NLRT areas was checked against an existing National Geodetic Survey (NGS) established control point and was within 0.001 meters.

ID	**X** NAD83 UTM Zone 18N, meters	**Y** NAD83 UTM Zone 18N, meters	**Elevation** Ellipsoid Height (m)	**Comments**
MM_Base	414972.319	4023398.486	-37.881	Base at Midway Marina and Motel
RV_Park_Base	417123.464	4031533.988	-37.845	Base near the boat launch at the RV park (Hampton Lodge Camping Resort) at the end of Waterlily Road
NT_Base	397978.511	3983386.232	-37.858	Base at the former Navy observation tower on Palmetto Peartree Preserve
Mansion_Base	392542.527	3983167.967	-39.625	Base at the Mansion on the sound off of Soundside Road

Table 2: GPS Base Station Locations

A Yagi-Uda Antenna **(Figure 7)** was necessary for radio communication coverage of the sites being investigated because of their large size. The Yagi is a directional antenna that transmits the radio energy along a preferential direction rather than the typical radio antenna that transmits the signal in 360 degrees. The energy is transmitted along a defined azimuth and thus increases the range of transmission along that path. The GPS positions were streamed into a Panasonic Toughbook once per second using a National Marine Electronics Association (NMEA)

GGA/GSA message and were recorded simultaneously with the EM61-Flex3data in the MLFXMarine acquisition program. A GPS QC check was performed at the beginning of each day to ensure accuracy. All GPS points and map data are presented in the NAD83 UTM, Zone 18N, meters.

2.4 TRIMBLE AGGPS FMX DISPLAY

Navigation is facilitated by the Trimble AgGPS FmX **(Figure 8)** integrated navigation system and the bow-mounted RTK GPS. The FmX display allows the creation of virtual grids based on operator-defined lines, circles, or ovals ("AB lines"). The AB lines are set by placing two points in the field or by importing a Geographic Information System (GIS) ".shp" file. Once a line has been established, the FmX processor can calculate a virtual transect design using operator supplied line spacing. Circular transects are defined by a center (point) and line spacing. The FmX display also provides a light bar display to assist the boat operator in guiding the UUTA along the virtual survey lines. The FmX provides a swath coverage display that shows the boat operator the current survey line and previous lines on which data have already been collected.

3.0 METHODOLOGY

3.1 DGM SURVEY ACTIVITIES

Data was collected using an evenly spaced transect pattern. All transects were spaced 100 feet apart for the first 500 yards from the center of the potential target location, then the spacing was increased to 250 feet out to a total distance of 1000 yards from the center of the potential target. For all targets, the initial 500 yards from the center of the target were collected first starting on the furthest transect out. After the 500 yards were collected and it was decided to continue collecting the outer transect, data was collected from the inside out.

A variety of transect designs (lines versus circles) were discussed with CH2M HILL prior to the start of the survey, to facilitate increased productivity. For sites with single targets, such as NCST and PPBR Lewis Point Target, a concentric circle transect design was used. Since NLRT is located adjacent to land, concentric circles could not be implemented; therefore, the transect design was modified to concentric semi-circles. At PPBR, five of the six target radii overlapped; the most efficient transect design for this area was parallel lines.

Prior to the start of the project, CH2M HILL requested that the interior lines (first 500 yards from the target location) be collected first and the data turned over within 24 hours so that an assessment could be made to determine if the remaining data (500 to 1000 yards) would be beneficial for the SI. All data were preliminarily turned over to CH2M HILL within the

requested time frame so that this determination could be made. In some instances (NLRT and PPBR) collection was halted at the 500 yard radius or the design was altered to help ensure that all geophysical transects were of value.

All geophysical data were collected as described in Section 2.0.

3.2 DATA PROCESSING AND INTERPRETATION

3.2.1 Data Storage and Initial Editing

Data were temporarily stored in a Panasonic Toughbook laptop using Geomar MLFXmarine software and then downloaded into another laptop computer for further on-site processing using Geomar MultiFXmarine and Geosoft Oasis Montaj software version 7.2.

Daily logs and field notes were input digitally into a Trimble GeoXT device supplied by CH2M HILL using the Munitions Response Site Information Management System (MRSIMS) series of forms. Initial data processing was performed by the field team, which included reviewing the data for integrity and completeness, and creating positioned XYZ files for each data file and QC test for use in further processing. Raw geodetic (Latitude-Longitude WGS84) coordinates were converted to projected UTM Zone 18 North NAD83 coordinates for the XYZ files.

3.2.2 Preprocessing

Converted raw data files were imported into Geosoft's Oasis Montaj to perform the following:

- Review and finalize all QC tests Instrument Verification Strip (IVS), static, pressure) prior to processing of the DGM data for that day
- Evaluate GPS accuracy and positioning
- Evaluate data density and coil height
- Apply auto leveling and instrument drift corrections
- Apply default lag correction
- Generate preliminary contour map(s) from gridded data

3.2.3 Final Processing

After completion of preprocessing, the data were further evaluated and processed to generate final processed data files. Final processing steps included:

- Evaluation and refinement of auto leveling and instrument drift corrections in the late channel
- Evaluation and refinement of lag correction in the late channel
- Additional digital filtering and enhancement, as necessary, in late channel

- Targeting of data, as described in Section 3.2.4
- Generation of formatted American Standard Code for Information Interchange (ASCII) files containing processed data by grid block
- Generation of final maps for each grid block showing contoured gridded data, target locations, and culture

3.2.4 Analysis and Target Selection

The UX-Detect module within Oasis Montaj identifies peak amplitude responses associated with, but not limited to, MEC items. Initial target selections were made based on the minimum curvature gridded data. Data profiles corresponding to the anomalies selected by Geosoft were then analyzed by trained geophysicists, with the targets evaluated as to their validity and position, as single-source anomalies that may generate multiple target designations depending on shape and orientation. Targets found to be invalid or incorrectly located were removed or adjusted. Additionally, anomalies that were not selected by the UX-Detect module, yet deemed to represent a potential MEC target, were manually selected. All targets were selected from final processed data from the late channel of the EM61-Flex3, roughly equivalent to Channel 3 of the bottom coil of the EM61-MK2.

Final processed XYZ (ASCII) files and geophysical maps were created for each grid block. Individual target lists were created for each transect. For all target lists, targets were sorted from highest response amplitude to lowest. All anomalies occurring at or above the targeting threshold of 10 mV in the late channel were identified using a unique ID number. Additionally, any well formed (multiple point) anomaly at or above 5 mV in the late channel, which was determined to be the noise threshold, was also selected as a target.

Each target list provides a Target ID, Grid ID, Easting (x) and Northing (y) UTM coordinate location for each target, anomaly type, and the recorded peak response in the late channel in millivolts. All raw and processed data have been submitted to CH2M HILL's project geophysicist and can be found on the enclosed DVD.

3.2.5 Visual Sample Plan (VSP)

A free software program called Visual Sample Plan (VSP) was used to create anomaly density maps (which are identified and discussed in the Results section). This program was developed by the Pacific Northwest National Laboratory to design and analyze transect surveys with applications toward Unexploded Ordnance (UXO) cleanup. The Geostatistical Mapping module was used to generate a continuous estimate of anomaly density across the entire study areas using the surveyed transect data that only covered a relatively small portion of the sites. The required

inputs are the actual transect path, selected anomalies along those transect paths, and a search window diameter. Transect paths and anomaly locations were imported directly into the software.

Different search window sizes were used for the sites; 125 meter window for NCST and NLRT, 225 meter window for the five clustered targets at PPBR, and a 150 meter window for the Lewis Point target at PPBR. The anomaly density at each search window location was used as input to the geostatistical mapping procedure to estimate the continuous anomaly density over the entire site. The results were put through a variogram model, which describes how the variability of a set changes spatially, and kriged, which minimizes variance. The kriged estimates were exported from VSP as an ASCII file and converted from a raster file into shapefiles in ArcCatalog. These shapefiles were then imported into a Geosoft database, the data was gridded and maps produced. All VSP associated files can be found on the enclosed DVD.

4.0 RESULTS

4.1 SUMMARY OF WORK PERFORMED

The digital geophysical mapping of the three OtO water ranges in North Carolina took place from August 10th through September 1st. The NCST and the NLRT were the priority target sites because they are located within a prime duck hunting location for local sportsmen. Therefore, activities were performed in this area first so that all data could be collected and the crew could demobilize prior to the start of duck hunting season. The majority of NCST was surveyed first since it is a single target with no obstructions. Next, the water portion of the NLRT site was surveyed. After NLRT was complete, it was determined that a few additional transects in the center of the NCST target needed to be surveyed. Once data collection at NLRT and NCST sites was completed, the crew mobilized to Columbia, North Carolina to collect data from the PPBR.

Throughout the field event, two work days were lost due to equipment issues. The crew also demobilized for four days while waiting for a replacement EM61-Flex3 coil set. The EM61-Flex3 marine system is a prototype system and is not readily available. One and one-half days were lost due to weather (the sea state was too high to allow for collection of data). Average daily production rate counting only days of operation was 18.7 miles. The average daily production rate including down days (weather or equipment issues) was 14.7 miles. Both actual daily production rates are higher than the original estimated production rate of 12 miles per day.

A total of 206 linear miles of data were collected and 4507 targeted anomalies were detected at all three sites. At the NCST site, 41.6 linear miles of data were collected, yielding 829 anomalies. There were 27.4 linear miles of data collected and 197 anomalies targeted at the NLRT site.

Palmetto Point was divided into two areas; the first area included the five targets in the west side of the range (Target "D", Primary Target, Ship Point, Target "NAB 42", and Target #42) and the second area included only the single target in the east (Lewis Point). At the first area of PPBR site, there were a total of 117.6 linear miles of data collected with 3152 anomalies targeted. This mileage was less than originally scoped (134 miles) based on the diminishing number of anomalies outside of the 500 yard radius and the significant number of cypress tree stumps in the south that posed a safety hazard for navigation and data collection in this area. For the second area, the Lewis Point target, 19.5 linear miles of data were collected with 277 anomalies targeted. This also was less mileage then originally scoped (41 miles) due to the lack of anomalies detected outside of the initial 500 yard radius. As a result, it was determined that significant data had been collected and additional data collection was unnecessary.

4.2 MOBILIZATION AND SITE SETUP

Prior to mobilization an AHA, SOPs, and an APP including an SSHP were provided to CH2M HILL. All personnel mobilized to the site had current 8-hour and/or 40-hour Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Response (HAZWOPER) training and medical monitoring examinations in accordance with OSHA 29 CFR 1910.120 and 29 CFR 1910.134. NAEVA mobilized one field person and 3Dg mobilized three personnel on August 8th to Coinjock, North Carolina for the NCST and the NLRT field activities. Equipment for NCST and NLRT was stored at Midway Marine and Motel. August 9th was spent investigating GPS base station locations, recording static readings with the GPS base that were later uploaded to OPUS to provide a corrected control point, as explained in Section 2.3, and setup of the boat and UUTA. Following a half day of initial safety briefings, site orientation, and installation of an IVS (discussed in Section 5.1), production surveying began on August 10th. Site-specific health and safety briefs were given each morning and a float plan was filed for each day of on-the-water activities by NAEVA's Site Safety and Health Officer (SSHO). These are included on the enclosed DVD.

All personnel mobilized to Columbia, North Carolina on the evening August 18th to begin investigations at the PPBR targets. August 19th was spent investigating GPS base station locations, recording static readings with the GPS base that were later uploaded to OPUS, and setup of the boat and UUTA. No water work was permitted this day due to other military operations in the Albemarle Sound. Establishment of the IVS and data collection started on the August 20th.

4.3 DGM SURVEY

Of the 206 miles surveyed at the three OtO ranges in North Carolina, a total of 4507 targets were identified. 206 miles with a 2 meter wide coil (swath of 6.4 feet) corresponds to 163.8 acres collected, and an average of 27.5 anomalies per acre

Northern Currituck Sound Target

A total of one and one half days across three different days were spent surveying NCST. The majority of site data (21 out of the 24 transects) was collected in one day. Of the remaining three transects, two were collected on the same day as the installation and collection of the IVS and the remaining transect was collected on the final day of surveying, prior to mobilizing to Palmetto Point.

A total of 41.6 miles were surveyed at NCST with 829 anomalies identified **(Figure 10)**. The 41.6 miles corresponds to 33.1 acres collected with an average anomaly density of 25 per acre. However, the higher density of anomalies is skewed toward the target area (the center of the investigation area), with the number of anomalies significantly diminishing away from the target. Based on the VSP calculations the high response area for NCST was estimated to extend out to the 30 anomaly per acre contour**,** which approximately corresponds to the 700 feet transect from the center of the target **(Figure 10 and Figure 11)**. Analysis of the high response area shows 37% of the total anomalies at the site are located within the first 300 feet from the center of the target and 80% of the total anomalies at the site are located within the first 700 feet from the target. Based on analysis of transects outside of the delineated high response area shows that 95% of the anomalies are located within the first 1500 feet from the target. **Table 3** presents a depiction of the anomaly concentrations within each transect of the high response area.

Transect	Total Miles	Total Acres	Total Targets	Anomalies /Acre	Comments
NC-01	0.24	0.19	111	577.94	~150 radius circle from center of target
NC-02	0.36	0.28	95	333.45	~200 radius circle from center of target
NC-03	0.47	0.37	102	275.12	~300 radius circle from center of target
NC-04	0.59	0.47	69	146.53	~400 radius circle from center of target
NC-05	0.70	0.55	67	120.74	~500 radius circle from center of target
NC-06	0.85	0.68	30	44.24	~600 radius circle from center of target
NC-07	0.97	0.77	31	40.26	~700 radius circle from center of target
NC-24	1.28	1.02	61	59.84	N-S Line ~ 150 to the west of the center of the target
NC-25	0.30	0.24	93	394.63	A looping line through the center of the target
Total	**5.75**	**4.58**	**659**	**221.42**	

Table 3: Number of Anomalies/Acre by transect within the High Response Area

Near the center of the target, multiple debris fields were observed real time with the side scan sonar. There were multiple crab pot buoys within the area, a few were located within the proposed transect line paths and were avoided during data collection (resulting in slight deviations from the proposed transects). Water depths at NCST ranged from five to eleven feet which was greater than the reported depths of three to six feet **(Figure 12)**.

North Landing River Target

A total of one day across two different days were spent surveying NLRT. The majority of site (19 out of the 21 transects) was surveyed in one day. All transects could have been surveyed in one complete day, however due to increasing sea state the tiller (used to steer the boat when the system is deployed) on the front of the boat broke on transect 19. The remaining two transects were collected on the final day of surveying, prior to mobilizing to Palmetto Point.

NLRT abutted the land (Troublesome Point) making the surveying conditions more challenging. The winds and current on the day that the site was surveyed were blowing/flowing towards land, thus making turning around near shore difficult. Of the 27.4 miles surveyed, 197 anomalies were identified **(Figure 13)**. This mileage equates to 21.8 acres collected and an average of 9 anomalies per acre. The anomalies were spread out evenly across the site **(Figure 14)**. Only a few of the outer transect lines were collected due to the low number of anomalies identified near the target location. Water depths at NLRT ranged from three to ten feet which was greater than the reported depths of less than five feet **(Figure 15)**.

Palmetto Point Bombing Range

The majority of the inner transects (initial 500 yards) were collected first at the five clustered targets. Some of the inner transects that went directly or nearby the metal remnants sticking above the water surface were collected last. This was decided after the equipment was damaged during the collection of one of the lines. Then the inner transects of the Lewis Point target were collected, followed by the outer transects and remaining inner transects at the five cluster targets. None of the outer transects were collected at the Lewis point target.

At the five clustered targets, a total of 117.6 miles were surveyed and 3152 anomalies were identified **(Figure 16)**. The 117.6 miles corresponds to 93.5 acres and an average of 33.7 anomalies per acre. However, the majority of these anomalies are clustered within three areas (as depicted on **Figure 16**); Target "NAB42", Primary Target, and ~575 meters NW of Target "D". The high response areas were estimated out to the 30 anomaly per acre contour based on the VSP calculations **(Figure 17).** This correlates to an area of approximately 125.8 acres (2000 ft east-west and 1000 ft north-south radius) for Target "NAB42", 55.8 acres (1400 ft east-west and 700

ft north-south radius) for the Primary Target, and 17.1 acres (500ft radius) for the area NW of Target "D". Within these three areas 33.2 of the total 117.6 linear miles (equivalent to 26.4 of 93.5 acres) of data were collected and 1,899 of the 3,152 anomalies were identified, equating to an average anomaly density of 67 anomalies per acre. Therefore, 60% of the total anomalies at the site were detected within 22% of the survey area. Target "NAB42" has an anomaly density of 73.6 per acre, Primary Target has an anomaly density of 73.7 per acre and the area NW of Target "D" has an anomaly density of 54.4 per acre. The remaining anomalies decrease as you move away from the high response areas, with very few in the space between the center of the five clustered hard target locations.

Near the center of the high response areas, multiple debris fields were observed real time with the side scan sonar. Metal remnants at two locations, between Target "NAB 42" and Target #42 and within the high response area associated with "NAB42", are visible above the water surface, and multiple clusters of poles can be observed near the Lewis Point Target. There were multiple crab pot buoys within the area, a few were located within the proposed transect line paths and were avoided during data collection (resulting in slight deviations from the proposed transects).Water depths at PPBR ranged from two to twenty-one feet which was greater than the reported depths of three to fifteen **(Figure 18)**.

The Lewis Point target was a single target located 2.8 miles east of the clustered PPBR targets. A total of 19.9 miles were survey and 329 anomalies were identified **(Figure 19)**. This mileage equates to 15.8 acres and an average of 21 anomalies per acre. However, the higher density of anomalies is skewed south of the center of the target location and trending linearly off to the east, with the number of anomalies significantly diminishing further out from this high response area. Based on the VSP calculations the high response area was delineated at the 30 anomaly per acre contour **(Figure 20),** which approximately corresponds to the 800 feet transect from the center of the target to the east, the 500 foot transect to the south, the 300 foot transect to the west and the 200 foot transect to the north **(Figure 19)**. Within this area, 3.4 out of the total 19.5 linear miles of data collected and 221 out of the total 329 anomalies were identified equating to an average anomaly density of 81 per acre. Analysis of the high response area shows 67% of the total anomalies at the site are located within the first 500 feet from the center and 87% of the total anomalies at the site are located within the first 1100 feet from the approximate center of the high response area. . The anomalies diminish in frequency as the distance from the high response area is increased. Since very few anomalies were identified outside of the high response area, data collection was stopped at the initial 500 yard buffer. Water depths around Lewis Point ranged from 14 to 19 feet which was greater than the reported depths of three to fifteen **(Figure 21)**.

Noise levels across all sites were generally low. A few datasets contained slightly elevated noise levels due an increased sea state, however below the targeting threshold.

4.4 DATA PROCESSING AND INTERPRETATION

All data were processed as described in Section 3.2. Any anomalies suspected as originating from noise, below the 5mV threshold, (e.g., channel readings out of phase) rather than metallic objects are noted in the target lists included on the DVD. Also included in the DVD are processing reports that summarize all processing information including: down-line data density statistics, leveling, lag, gridding parameters used in processing, and any additional notes for each dataset. Processors examined all data prior to NAEVA demobilizing from the site.

The enclosed DVD contains all raw and processed data, including processing reports, QC test results, target lists, and color contour maps for each grid block.

5.0 QUALITY CONTROL (QC)

To establish confidence in the data reliability, QC tests were conducted throughout the project. Tests were conducted prior to and after all data collection sessions. All QC tests for the EM61-Flex3 were conducted after a minimum 15 minute warm-up period for the electronics and coils.

5.1 SYSTEM VALIDATION – INSTRUMENT VERIFICATION STRIP (IVS)

Prior to beginning the main survey of the transect lines and everyday thereafter, a modified IVS was surveyed. The purpose of surveying the IVS was to demonstrate the proper function of all instrumentation, methods, and personnel prior to the initiation of fieldwork and to document the site-specific noise and capabilities of the EM61-Flex3 system.

One IVS was established for NCST and NLRT and a separate IVS was established for PPBR. A 5 lb dumb bar weight **(Figure 22)** was installed by placing the weight over a 10-foot Polyvinyl Chloride (PVC) pipe that had a survey rod with GPS antenna inside so that when the pipe/survey rod was level the weight was dropped and a GPS coordinate was recorded. Prior to placing an item, the area was surveyed to verify the location was free of metal objects. However, due to the difficulty of positioning the boat back over an exact location, a few of the IVSs have additional anomalies along the lines. **Appendix A** contains a spreadsheet summary of the IVS results.

Data Quality Objectives (DQOs) evaluated in the IVS and associated QC tests included positioning repeatability, system data repeatability, and dynamic detection repeatability. As defined in the QAPP, positional error at known monuments did not exceed 10.2 cm (4 inches) and the response to a standardized item did not vary more than ± 20%. Summary of all QC results can be found in **Appendix B.** Other DQOs evaluated in production data included: downline data

density having sufficient data collected such that at least 98% of possible sensor readings captured within 25 cm or lesser spacing between points and no readings will fall outside of 61cm, and 97% of the data will be collected within 5ft of the bottom and of the allowable 3% outside no segment length will exceed 10m. All DQO's were met. The horizontal positioning had to be accurate enough to allow reacquisition and selected targets lie within 3 meter of IVS seed item. All peak responses in the late channel over the seeded objects were within specifications.

5.2 QC Test Descriptions and Acceptance Criteria

In addition to the IVS, the following QC procedures were performed and documented during the data collection process and reviewed by a qualified geophysicist on a daily basis. Sample graphical displays of the QC data and summary of the results are included in **Appendix B**.

GPS Check Point: At the beginning of the day after setting up the base station and before collecting any data, the UUTA bow and stern GPS antennas were mounted on a survey pole and placed at a known point to check the accuracy. The measured positions were compared to the reported location to check for proper operation. The locations were stored in a Panasonic Toughbook laptop and documented in a daily DGM form on the PDA. Positional discrepancies within 10 cm were considered acceptable.

Static Background and Static Spike: Static tests were performed on land prior to deployment of the system in the water by positioning the survey equipment in an area free of metallic response and collecting data for a 3-minute period. During this time, the instrument was held in a fixed position. A static test is the primary measurement of instrument functionality and consists of one minute without a spike, one minute with a spike (a test jig with two small Industry Standard Objects (ISOs) mounted 35.84 cm below the coils on a two plastic sawhorses), and then one minute without a spike. The purpose of the static test is to determine whether unusual levels of instrument or ambient noise exist and to check for consistent response. The acceptance criterion was that the spike response after background correction be within ± 20% of the previous day's measured response; Static tests were plotted on a scale of ± 4 mV so that any abnormally high data spikes could be observed. The static background and static spike tests were conducted at the beginning and end of the day.

Pressure Test: Prior to data collection the accuracy of the pressure sensor (i.e. EM sensor platform depth) was tested. Two data points were recorded during the test to verify the functionality of the pressure sensor. The test was conducted on land prior to deployment of the system in the water. The acceptance criterion was that the pressure sensor's depth results were within 6 inches of the known depth.

Repeat Data: As a result of the difficulty to accurately repeat a line of data in the water, the IVS data were used to verify repeatability of the data. Because of the difficulty of flying the system along the exact same line and height twice in the dynamic marine environment, and because instrument response is very sensitive to the distance of a metallic object from the coil, this test was evaluated qualitatively.

5.3 QC TEST RESULTS

QC data were evaluated using Geosoft's Quality Assurance/Quality Control (QA/QC) software. Static and Pressure test profiles were plotted on a scale of ± 4 mV from the mean. The following provides a summary of the QC results:

1. **GPS Check Point:** All recorded points were well within tolerance. The average variance from the reported location was 1.43 cm.
2. **Static Background / Spike Test:** All static and spike tests were within acceptance criteria.
3. **Pressure Test:** All pressure test measurements were within acceptance criteria.
4. **Repeat Data:** Repeat lines generally showed acceptable repeatability. Discrepancies in the response on repeat lines were a result of line path or coil height deviation.

6.0 CONCLUSIONS

All tasks involved in the DGM of the three North Carolina OtO water ranges at NAS Oceana were completed as scoped. Supporting QC data and all other DQOs as outlined in the MEC-QAPP plan were within specifications. The survey covered approximately 206 linear miles of transects across the three sites (eight targets), in water depths ranging from 2 feet to 21 feet. Although there was some downtime due to weather, equipment issues, and time spent travelling to each site, the crew was able to exceed the estimated production levels and complete the project ahead of schedule.

NCST: The data collected during this investigation shows that the identified target location from the CFR for NCST is accurate and the majority of the geophysical anomalies are confined to a relatively small area (~700ft) from the identified target location as shown on **Figure 10**. Based on the analysis of the density maps, 80% of the anomalies are located within the first 700 feet from the target and 95% of the anomalies are located within the first 1500 feet from the target.

NLRT: The results from this investigation do not indicate the presence of a target within the vicinity of the identified surveyed location (although survey activities were not performed on the land portion of the site); anomalies are scattered throughout the surveyed area.

PPBR: Out of the five western identified targets for PPBR, only the Primary Target location appears to be accurate with respect to the location stated in the QAPP. Ship Point Target does not exhibit significant evidence as a bombing area. Anomalies are sparsely distributed throughout the area in the vicinity of this target. For Target "NAB 42" and Target #42, there is a high target density area between the two with two separate areas of metal protruding above the water surface at the location of the hard targets. The data collected around the location identified as Target "D" does not indicate the presence of a bombing target as the anomalies are too sparsely distributed. However, there is an area approximately 575 meters to the northwest of Target "D" that could be the actual location of the target. These three high response areas are shown in **Figure 16**. The high response areas consist of 22% of the total data collected and contain 60% of the total selected anomalies at the site.

PPBR – Lewis Point: The data collected for the eastern target in the PPBR, Lewis Point, shows that the identified target location from the CFR is relatively accurate and the geophysical anomalies are confined to a relatively small area on the south and east of the identified target location. Based on analysis of the density maps, 67% of the anomalies are located within 500 feet of the center of the high response area and 87% of the anomalies are located within 1100 feet of the high response area, as depicted on **Figure 19**.

7.0 REFERENCES

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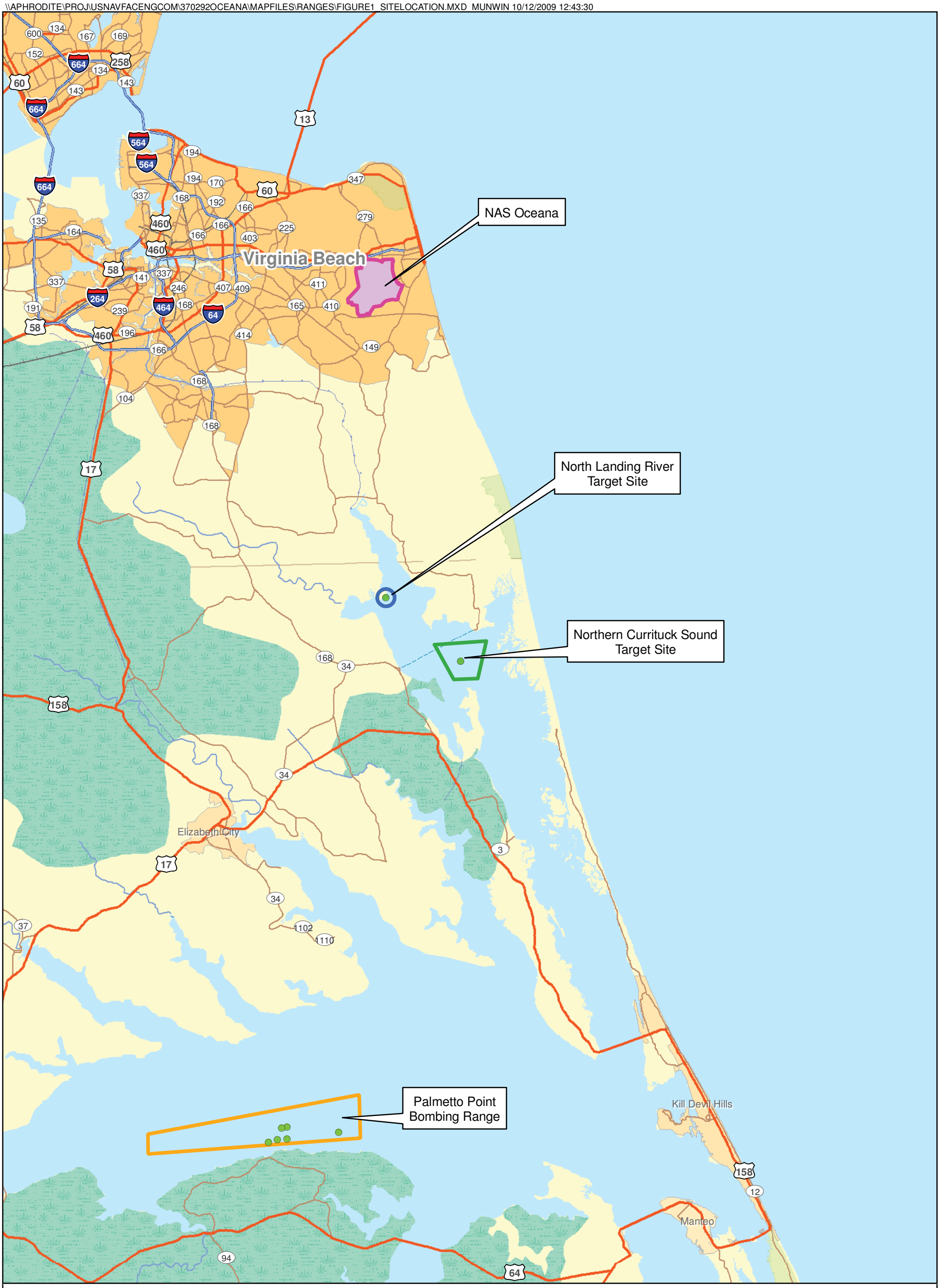
FIGURES

\\APHRODITE\PROJ\USNAVFACENGCOM\370292OCEANA\MAPFILES\RANGES\FIGURE1_SITELOCATION.MXD MUNWIN 10/12/2009 12:43:30



Legend

- NAS Oceana
- Northern Currituck Sound Target Site (3,831 acres)
- North Landing River Target Site (649 acres)
- Palmetto Point Bombing Range (18,440 acres)
- Target Location

N W E S

0 6 12 Miles

Figure 1
Site Location Map
NAS Oceana
Virginia Beach, Virginia

CH2MHILL

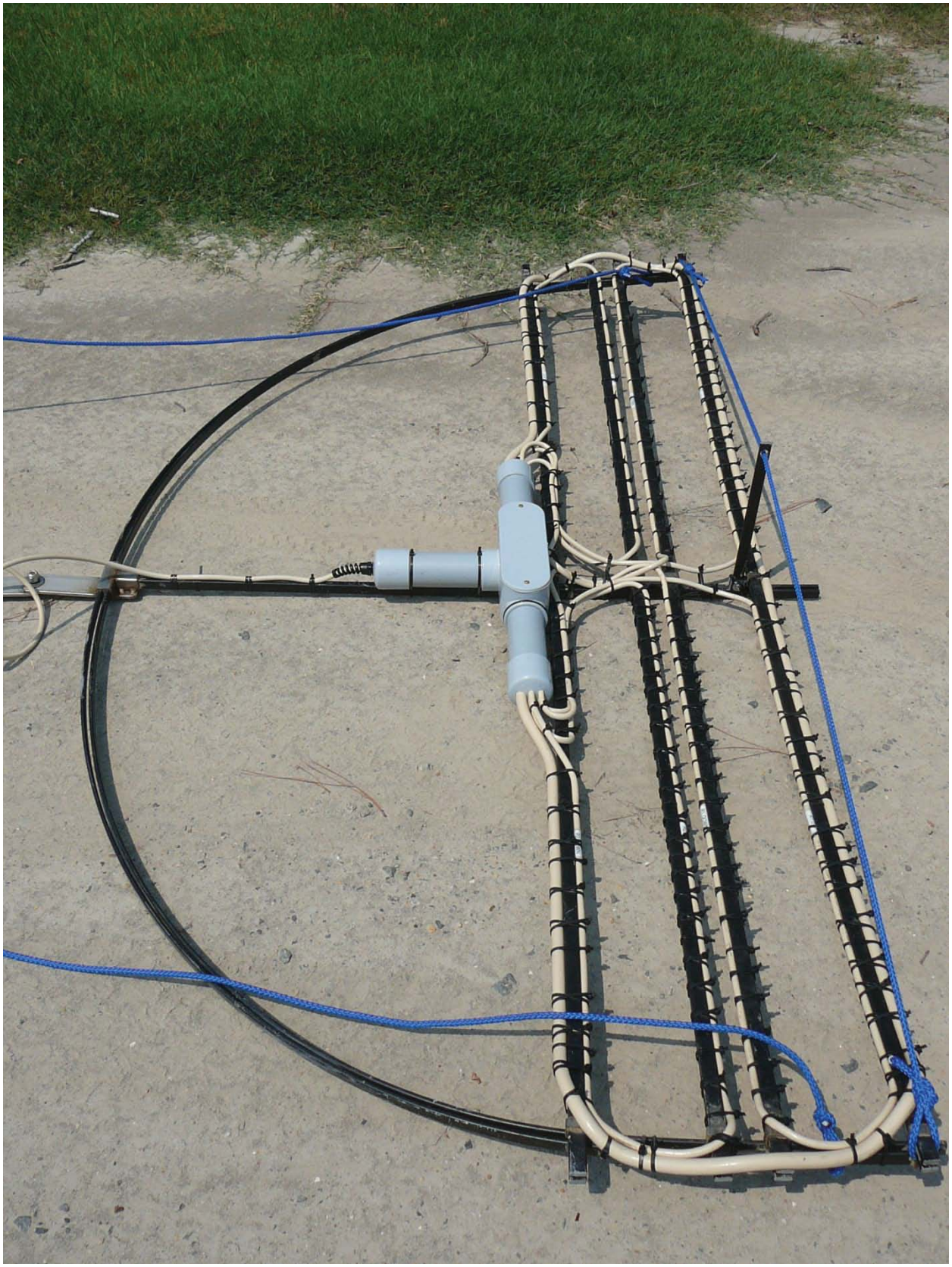


Figure 2: Geonics EM61-Flex3

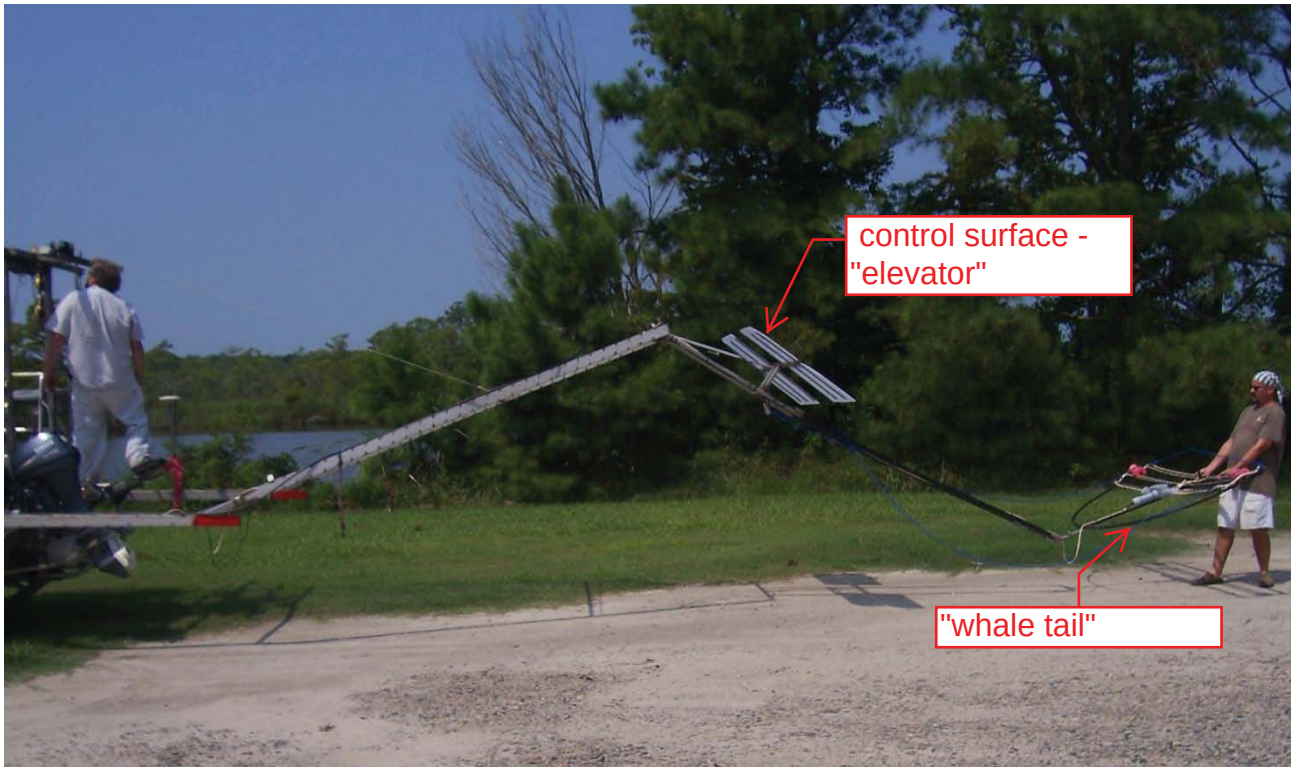


Figure 3: Underwater UXO Towed Array (UUTA)

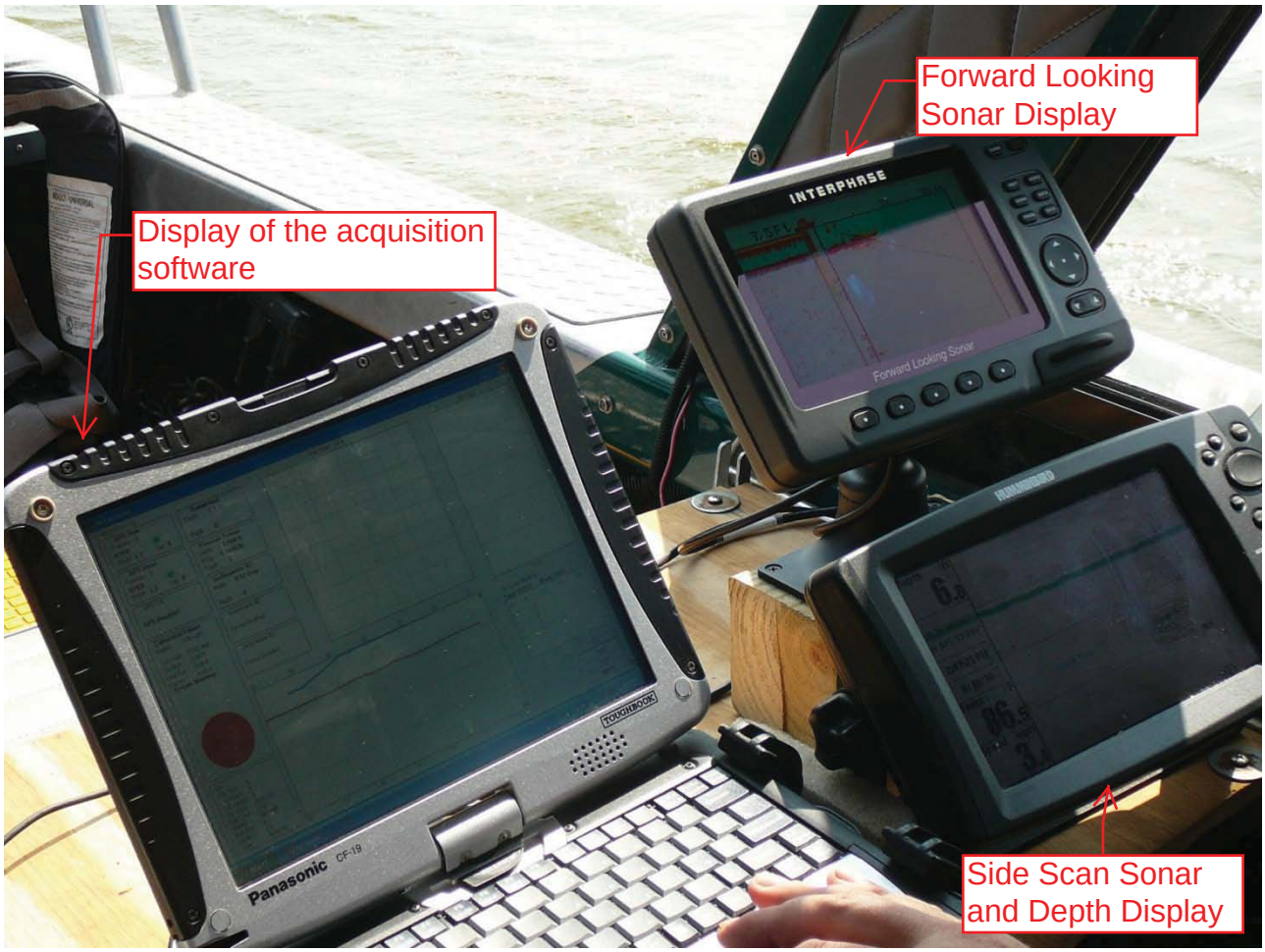


Figure 4: UUTA Control "Captain" Area

Figure 5: UUTA Elevator Control

Figure 6: Marine Tow Vehicle - 22 foot Jet Boat

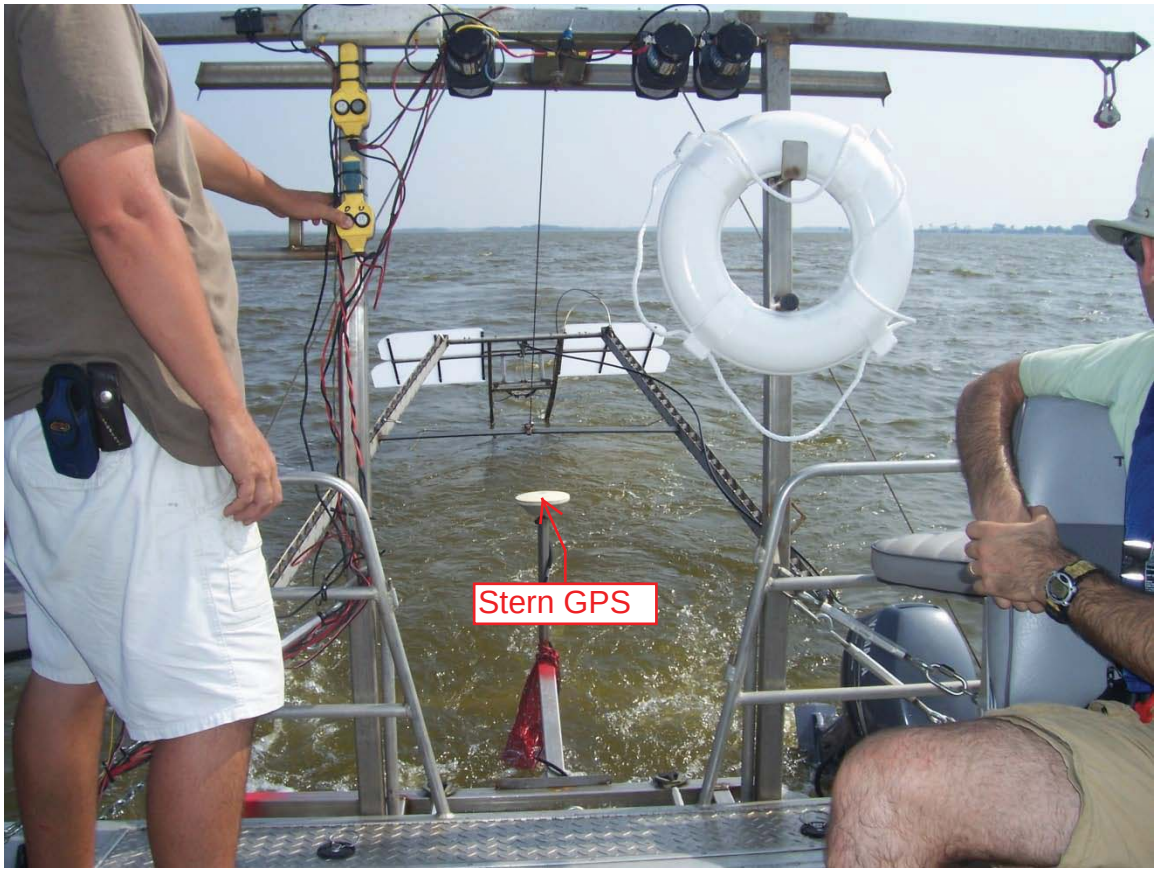
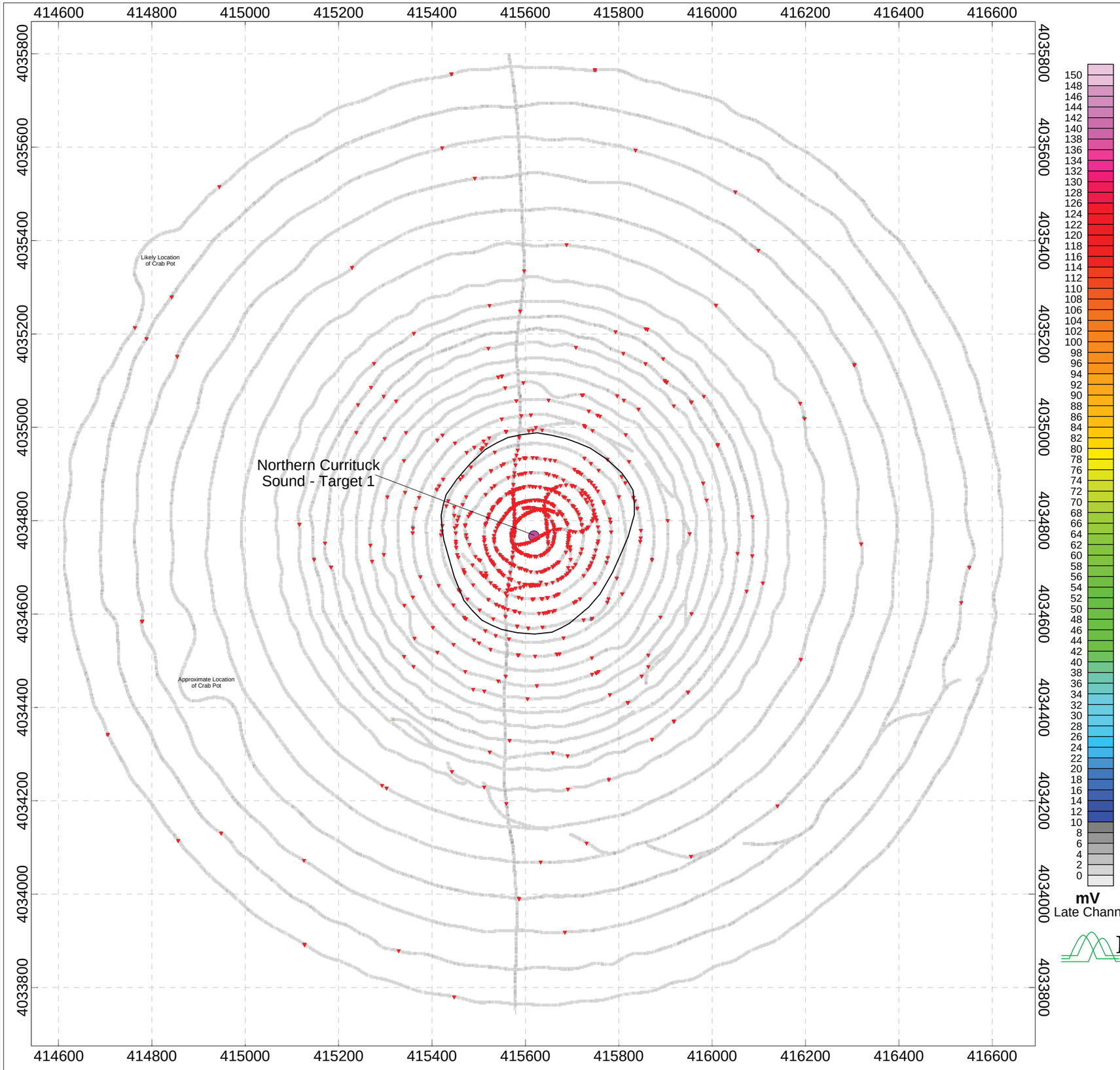
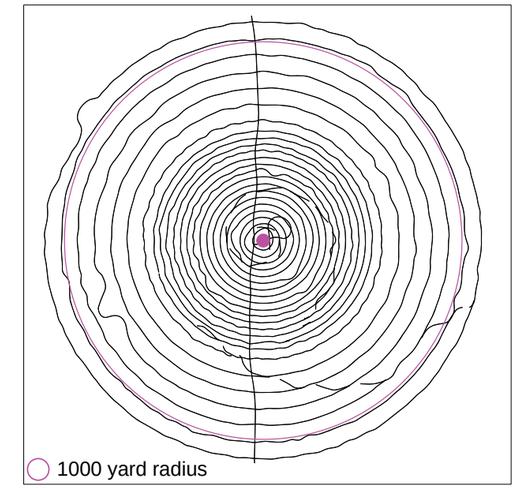


Figure 7: System being deployed

Figure 8: Yagi-Udi Directional Antenna

Figure 9: Trimble AgGPS FmX Display





Legend

- Site Target
- Selected Target (See individual Block Target Pick List For Response, Location and ID Number)
- Bouy — Culture, if noted
- High Density Response Area (Based on VSP Calculation of Areas greater than 30 Anomalies/Acre)

100 0 100 200 300 400
(meters)
NAD83 / UTM zone 18N

Figure 10

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

3Dgeophysics.com

Client: CH2M HILL

EM61-FLEX 3
Anomaly Distribution Mosaic
Northern Currituck Sound Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/14/2010 - 08/18/2010
Date of Map Creation: 08/20/2010

Map Approver: J. Guillard

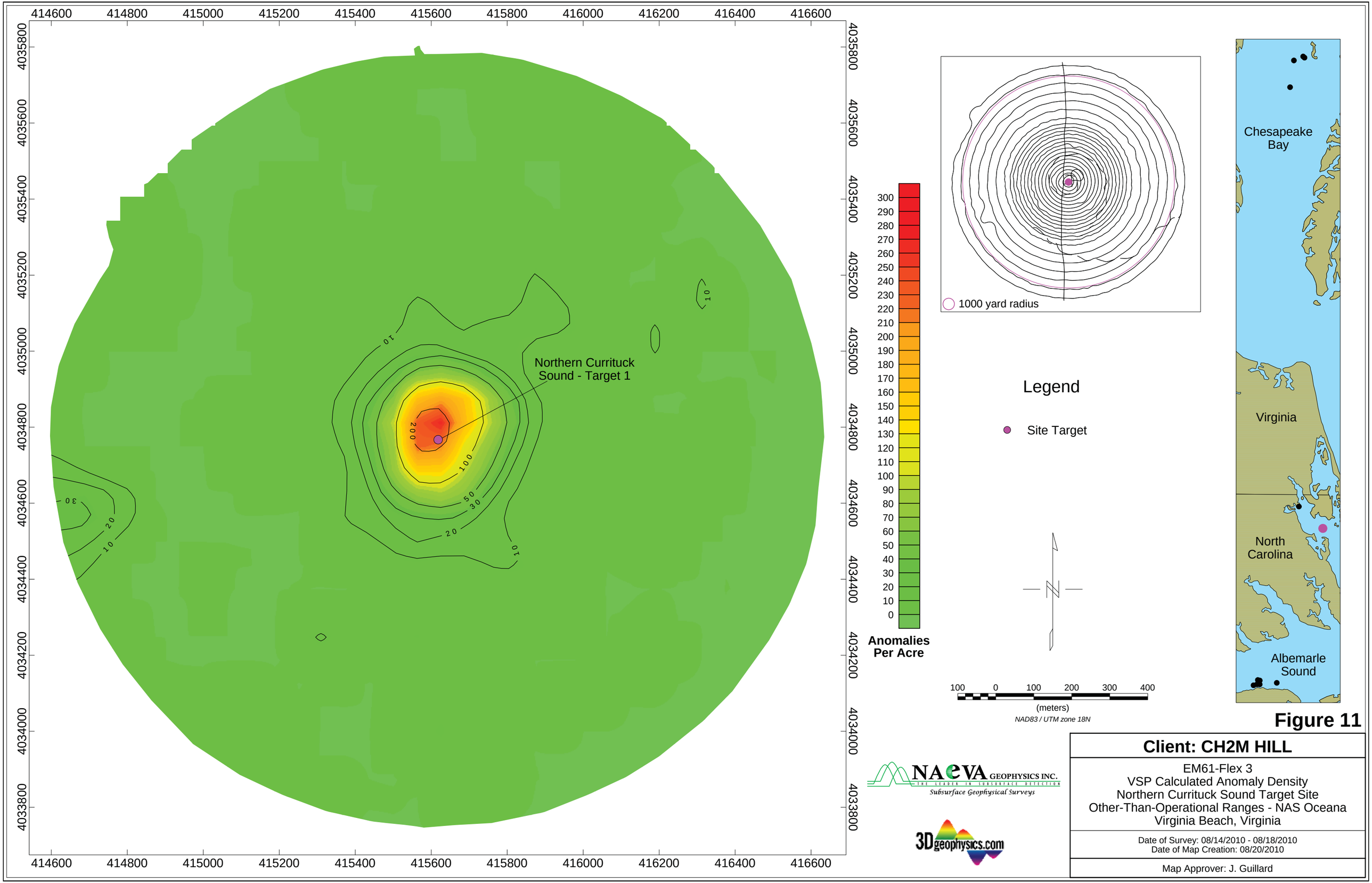


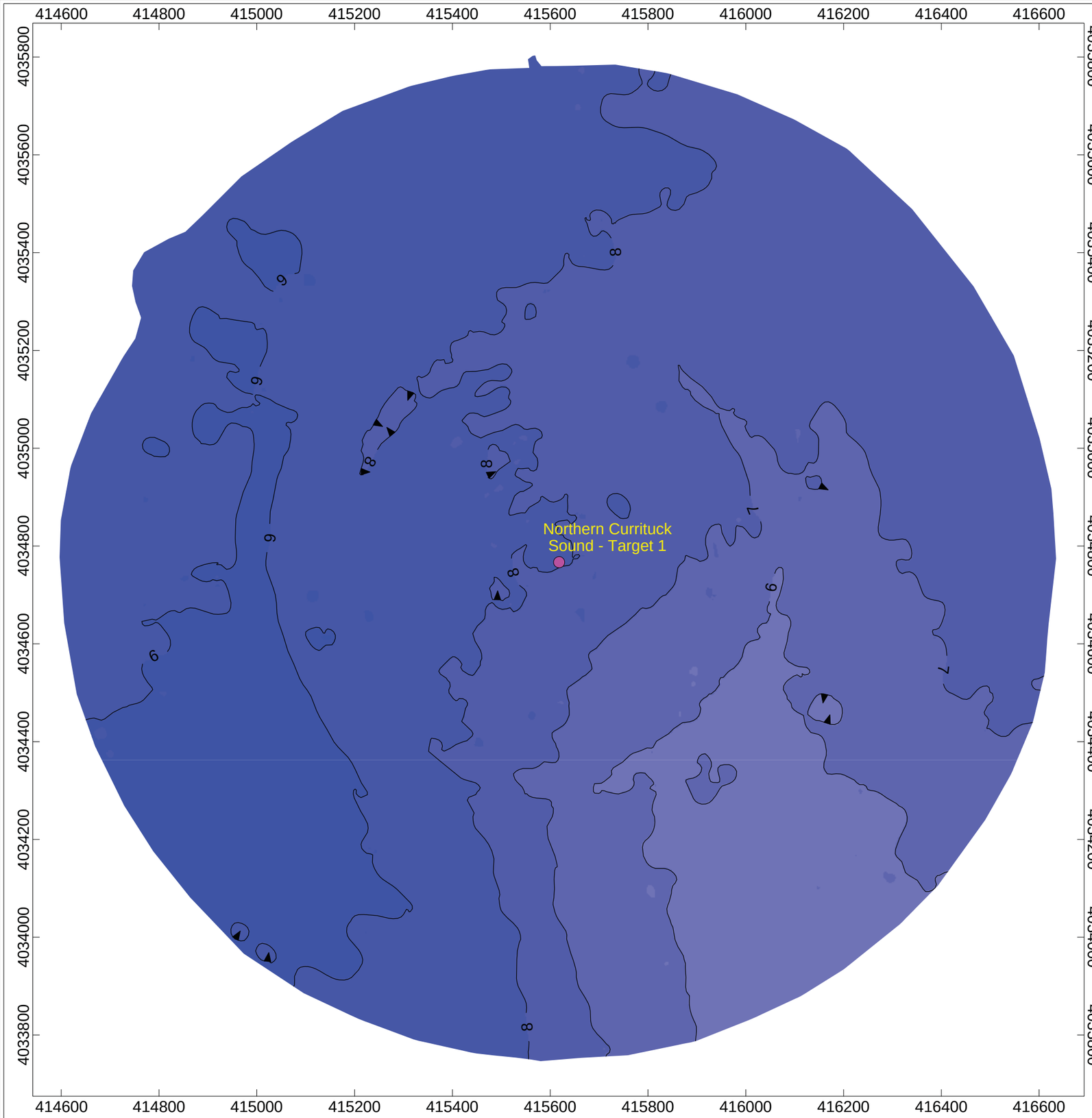
Figure 11

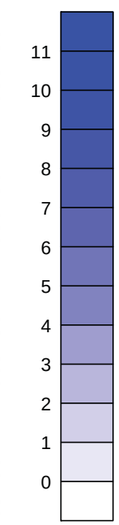
Client: CH2M HILL

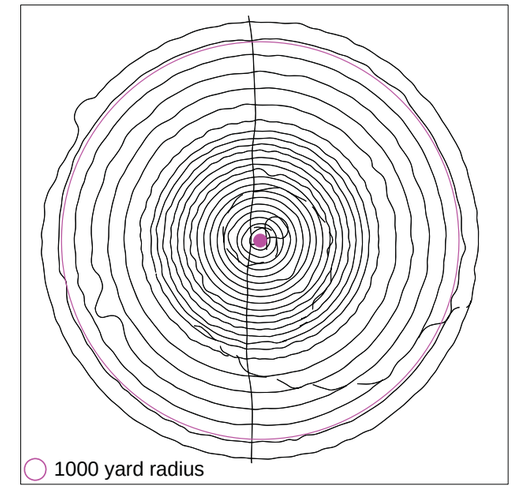
EM61-Flex 3
VSP Calculated Anomaly Density
Northern Currituck Sound Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/14/2010 - 08/18/2010
Date of Map Creation: 08/20/2010

Map Approver: J. Guillard



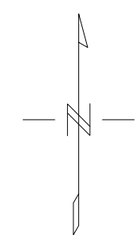




Legend

Site Target

NOTE: Depths are interpolated between the transect lines.



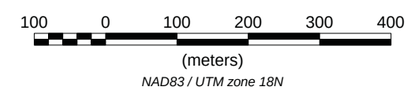


Figure 12

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

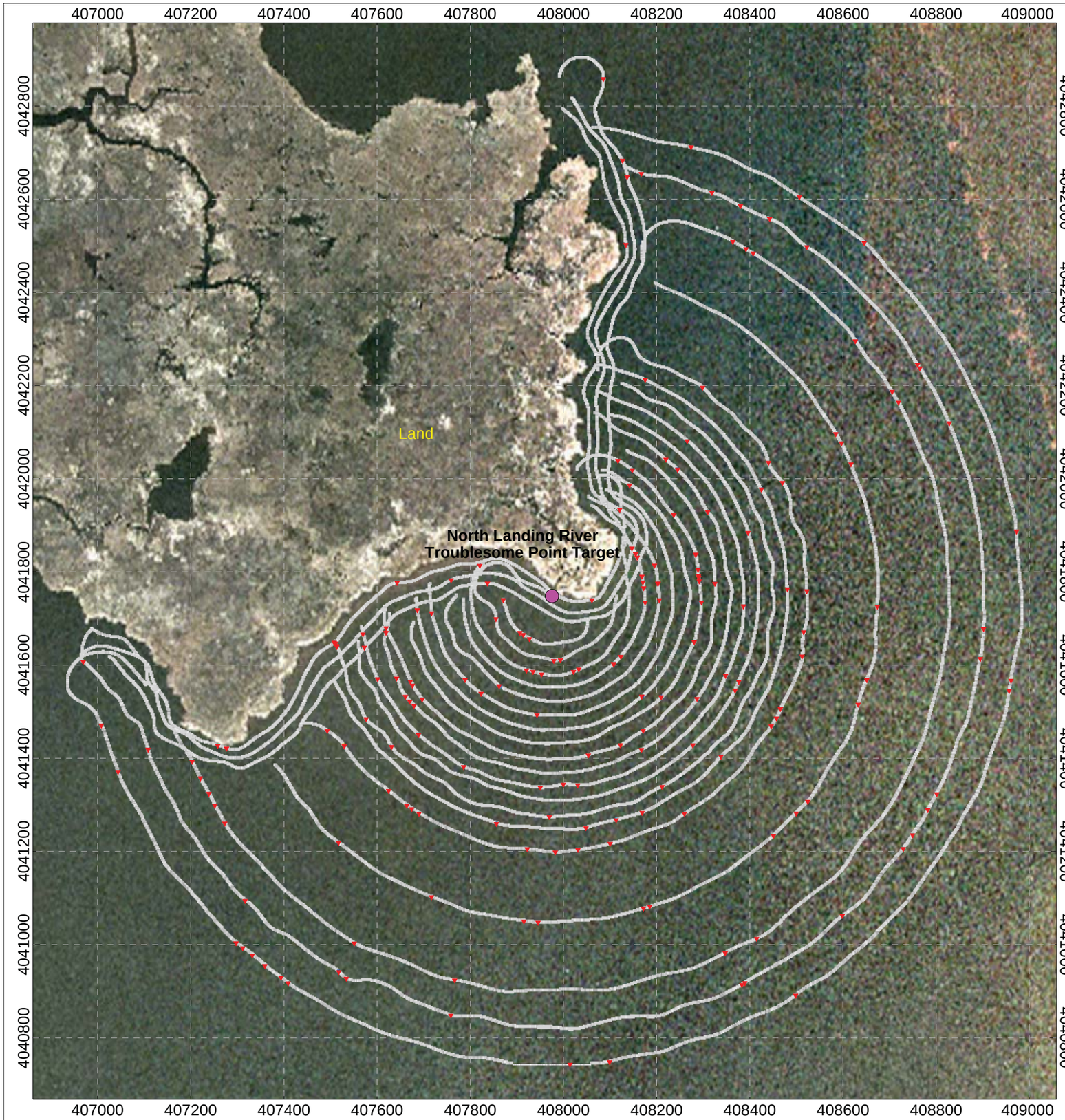
3Dgeophysics.com

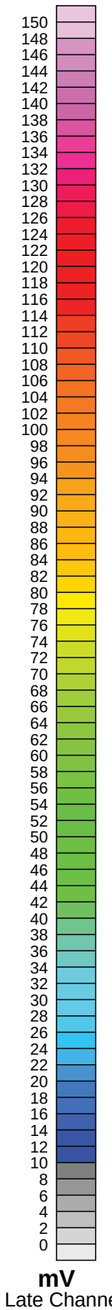
Client: CH2M HILL

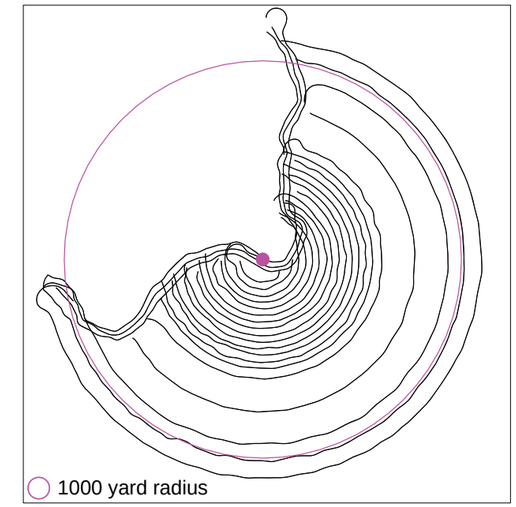
Humminbird 997c SI Combo
Bathymetric Mosaic
Northern Currituck Sound Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/14/2010 - 08/18/2010
Date of Map Creation: 08/20/2010

Map Approver: J. Guillard







Legend

- Site Target
- Selected Target (See individual Block Target Pick List For Response, Location and ID Number)
- Bouy — Culture, if noted

100 0 100 200 300 400 500
(meters)
NAD83 / UTM zone 18N

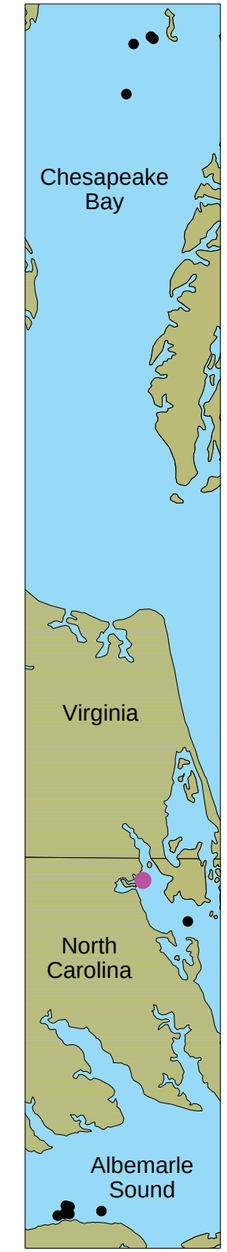


Figure 13

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

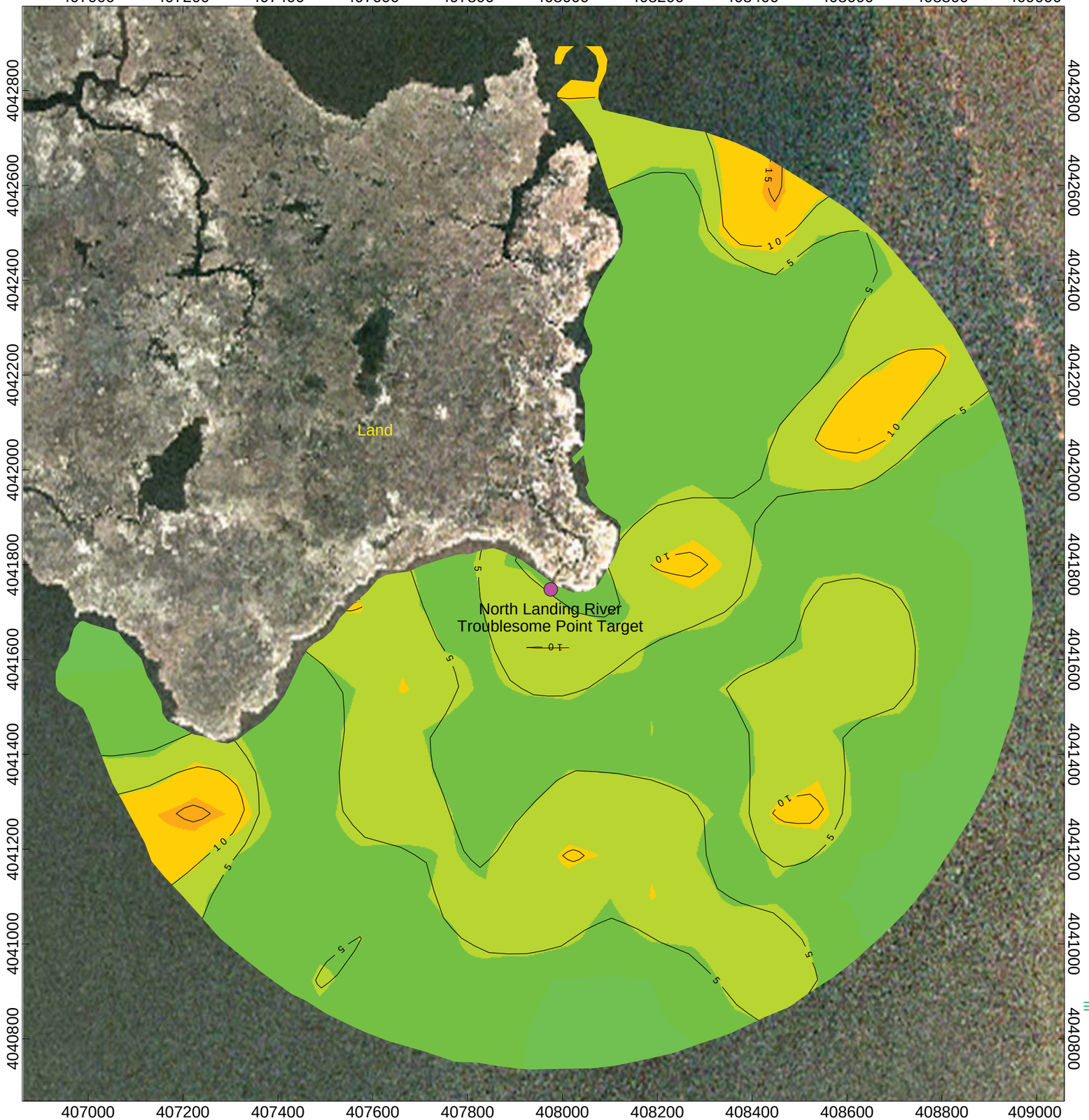
3Dgeophysics.com

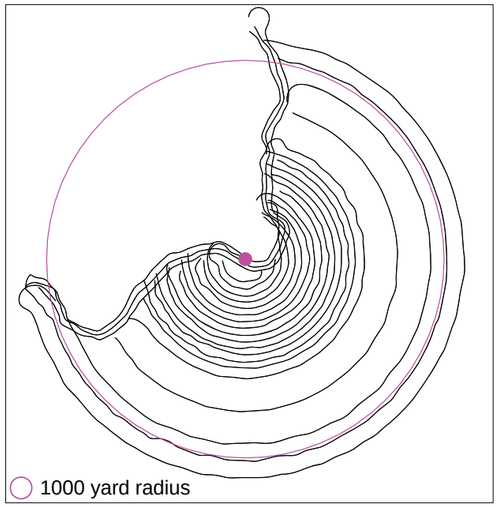
Client: CH2M HILL

EM61-FLEX 3
Anomaly Distribution Mosaic
North Landing River - Troublesome Point Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/14/2010 - 08/18/2010
Date of Map Creation: 08/20/2010

Map Approver: J. Guillard





Legend

- Site Target

30
25
20
15
10
5
0

Anomalies Per Acre

100 0 100 200 300 400 500

(meters)

NAD83 / UTM zone 18N

Figure 14

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

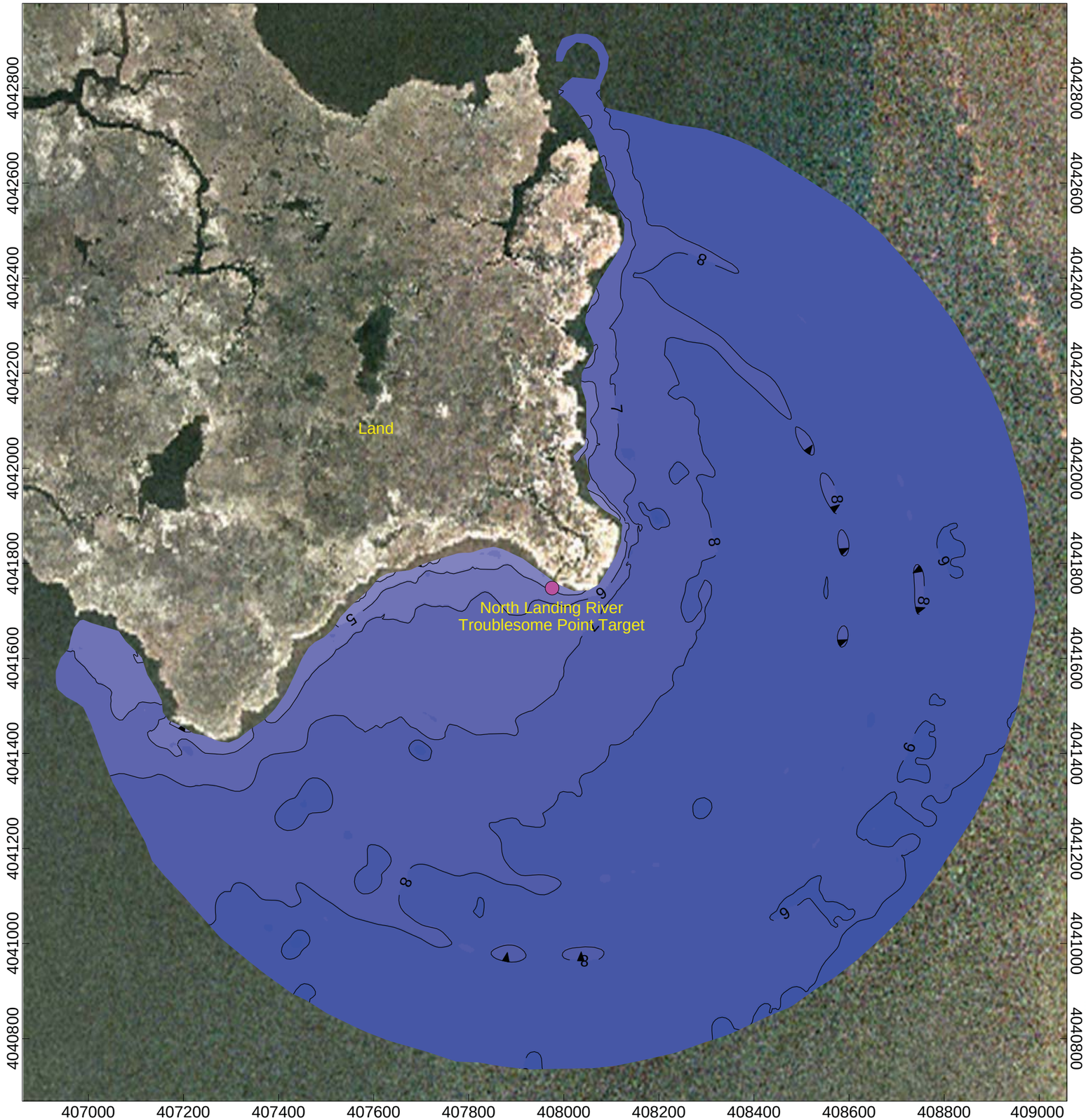
3Dgeophysics.com

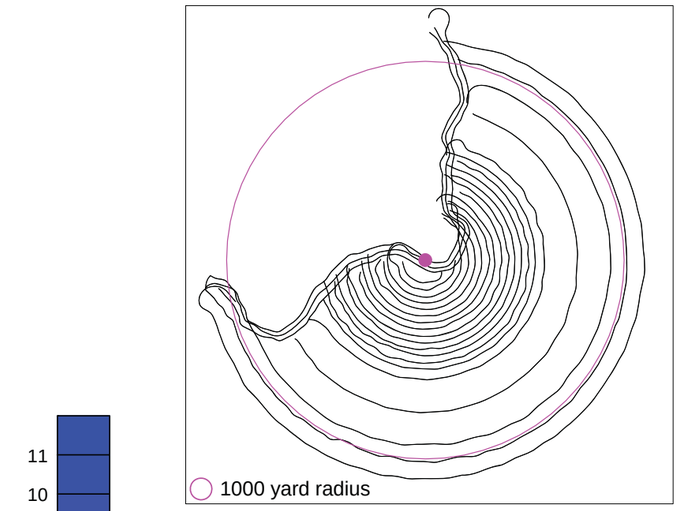
Client: CH2M HILL

EM61-Flex 3
VSP Calculated Anomaly Density
North Landing River - Troublesome Point Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/14/2010 - 08/18/2010
Date of Map Creation: 08/20/2010

Map Approver: J. Guillard





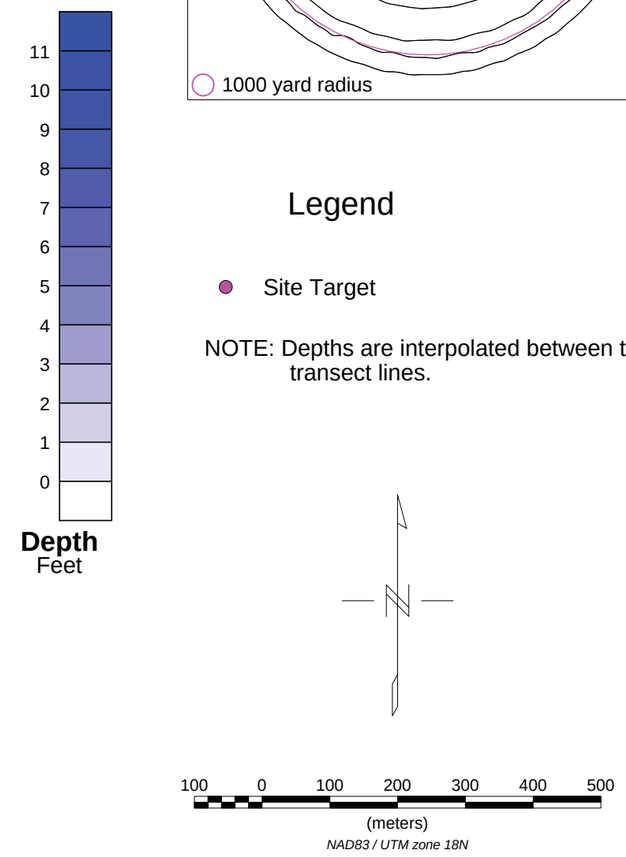


Figure 15

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

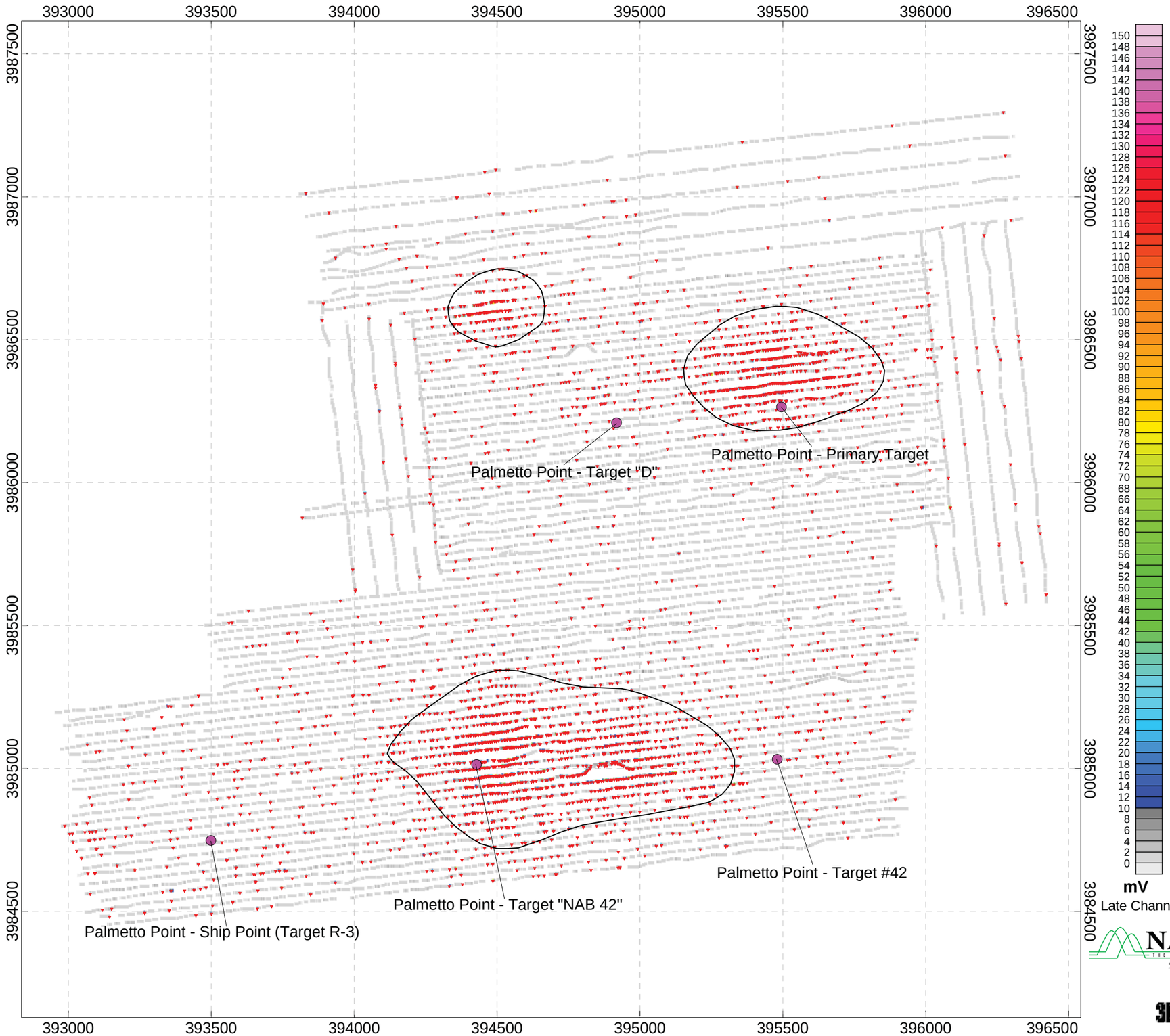
3Dgeophysics.com

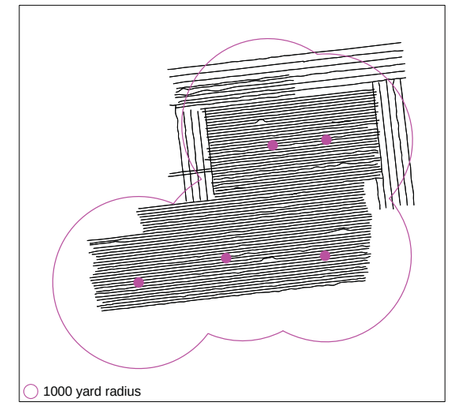
Client: CH2M HILL

Humminbird 997c SI Combo
Bathymetric Mosaic
North Landing River - Troublesome Point Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/14/2010 - 08/18/2010
Date of Map Creation: 08/20/2010

Map Approver: J. Guillard





Legend

- Site Target
- Selected Target (See individual Block Target Pick List For Response, Location and ID Number)
- Bouy — Culture, if noted
- High Density Response Area (Based on VSP Calculation of Areas greater than 30 Anomalies/Acre)

250 0 250 500 750

(meters)

NAD83 / UTM zone 18N

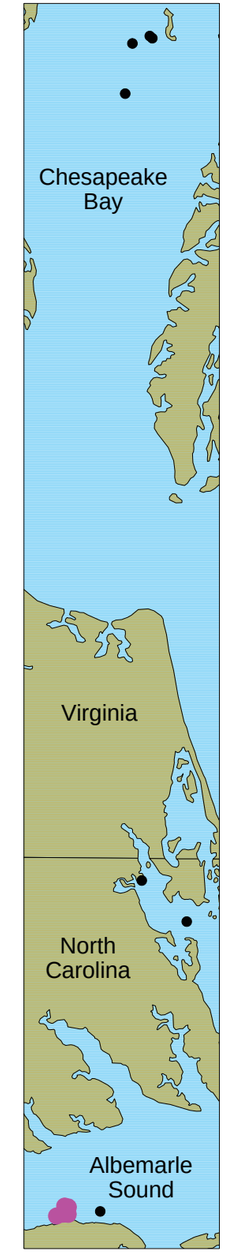


Figure 16

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

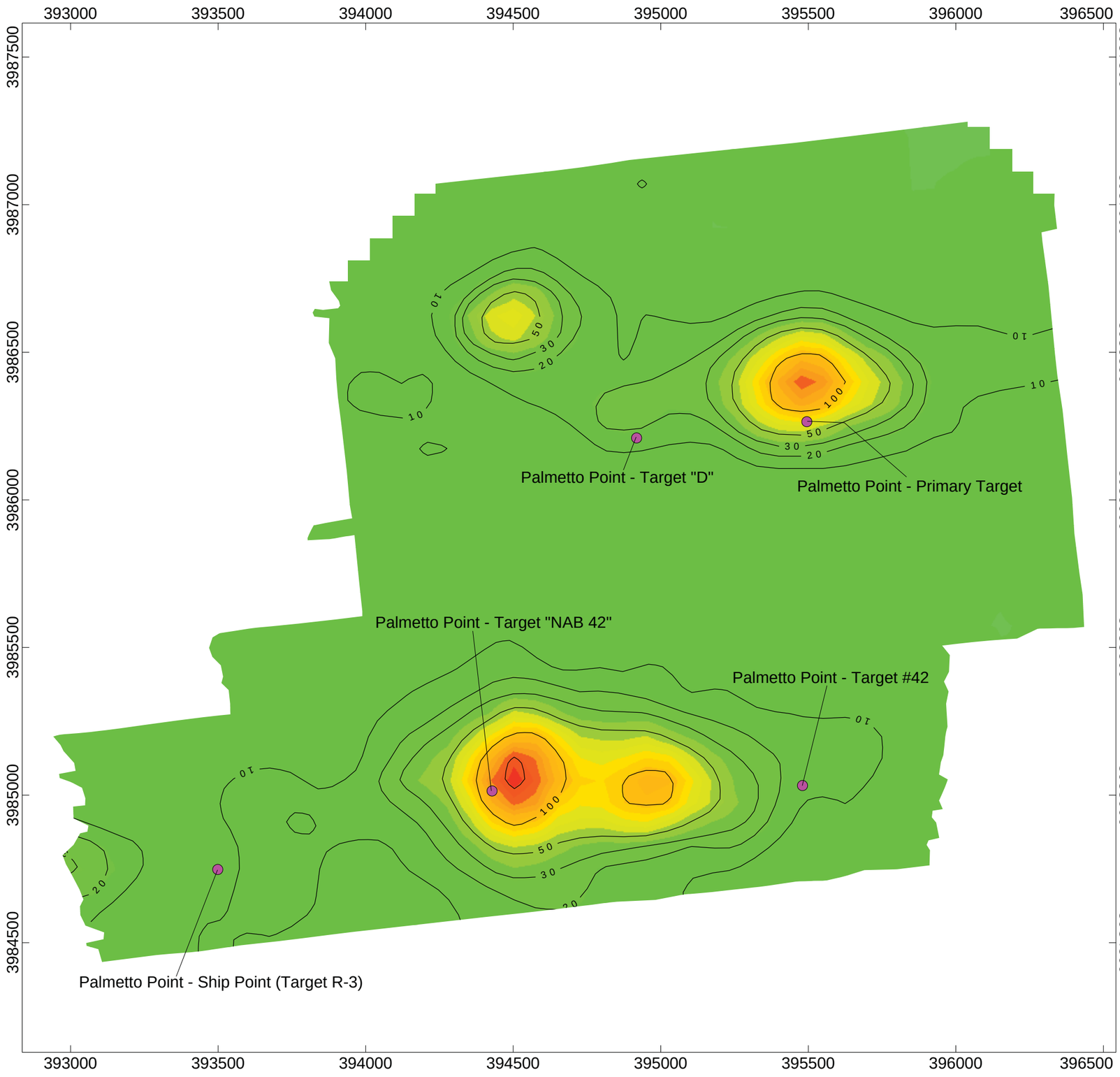
3Dgeophysics.com

Client: CH2M HILL

EM61-FLEX 3
Anomaly Distribution Mosaic
Palmetto Point Bombing Range Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/20/2010 - 09/01/2010
Date of Map Creation: 09/07/2010

Map Approver: J. Guillard



Legend

Site Target

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

Anomalies Per Acre

250 0 250 500 750

(meters)

NAD83 / UTM zone 18N

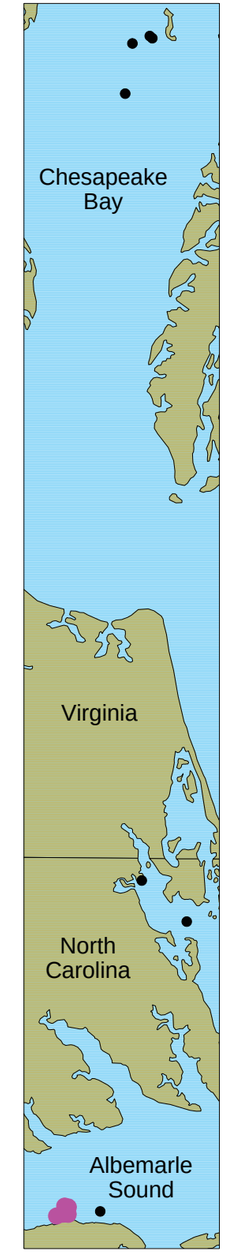


Figure 17

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

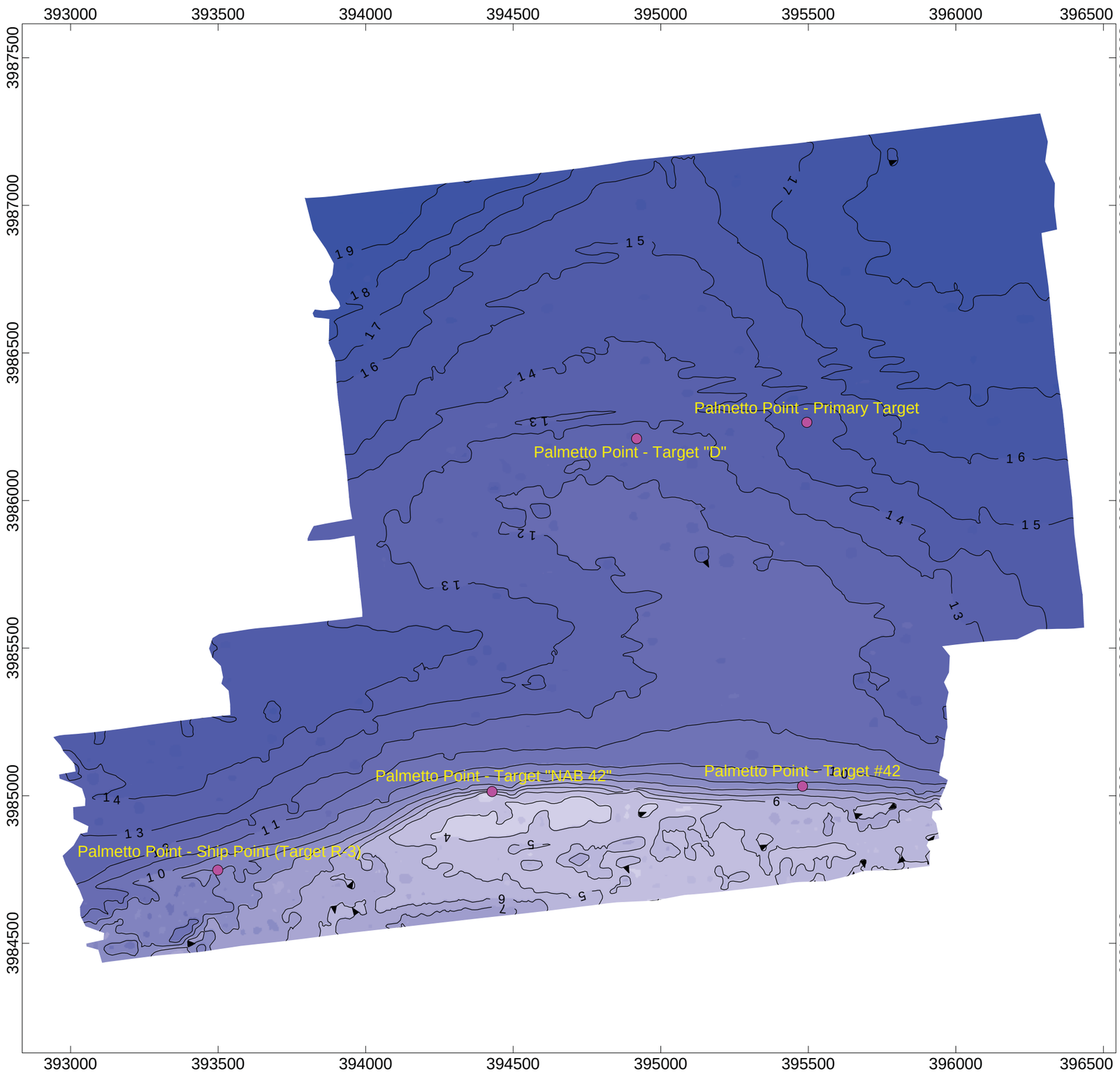
3Dgeophysics.com

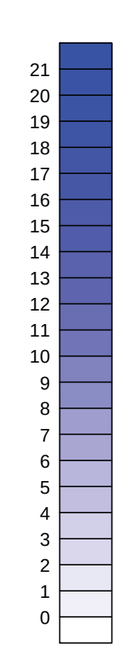
Client: CH2M HILL

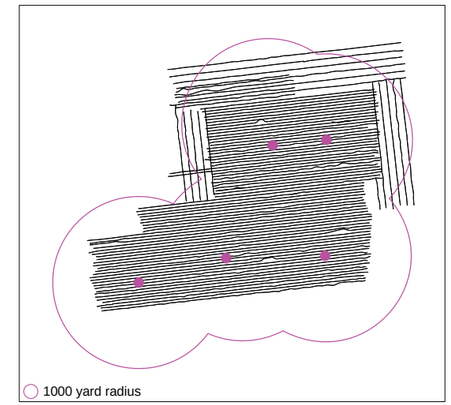
EM61-Flex 3
VSP Calculated Anomaly Density
Palmetto Point Bombing Range Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/20/2010 - 09/01/2010
Date of Map Creation: 09/07/2010

Map Approver: J. Guillard



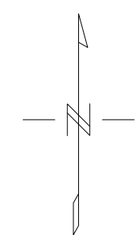


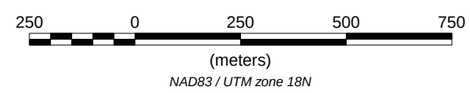


Legend

Site Target

NOTE: Depths are interpolated between the transect lines.





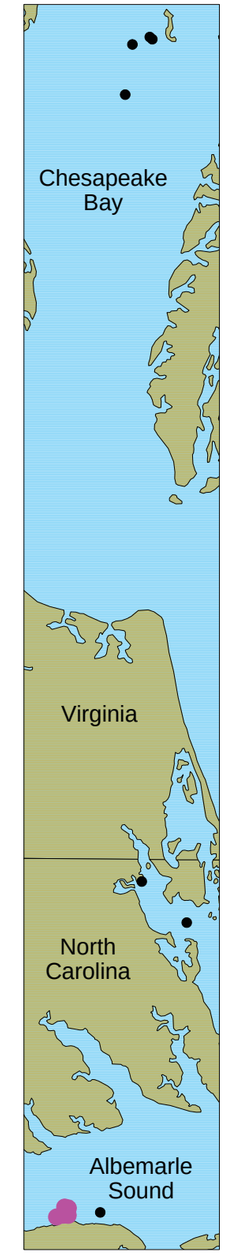


Figure 18

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

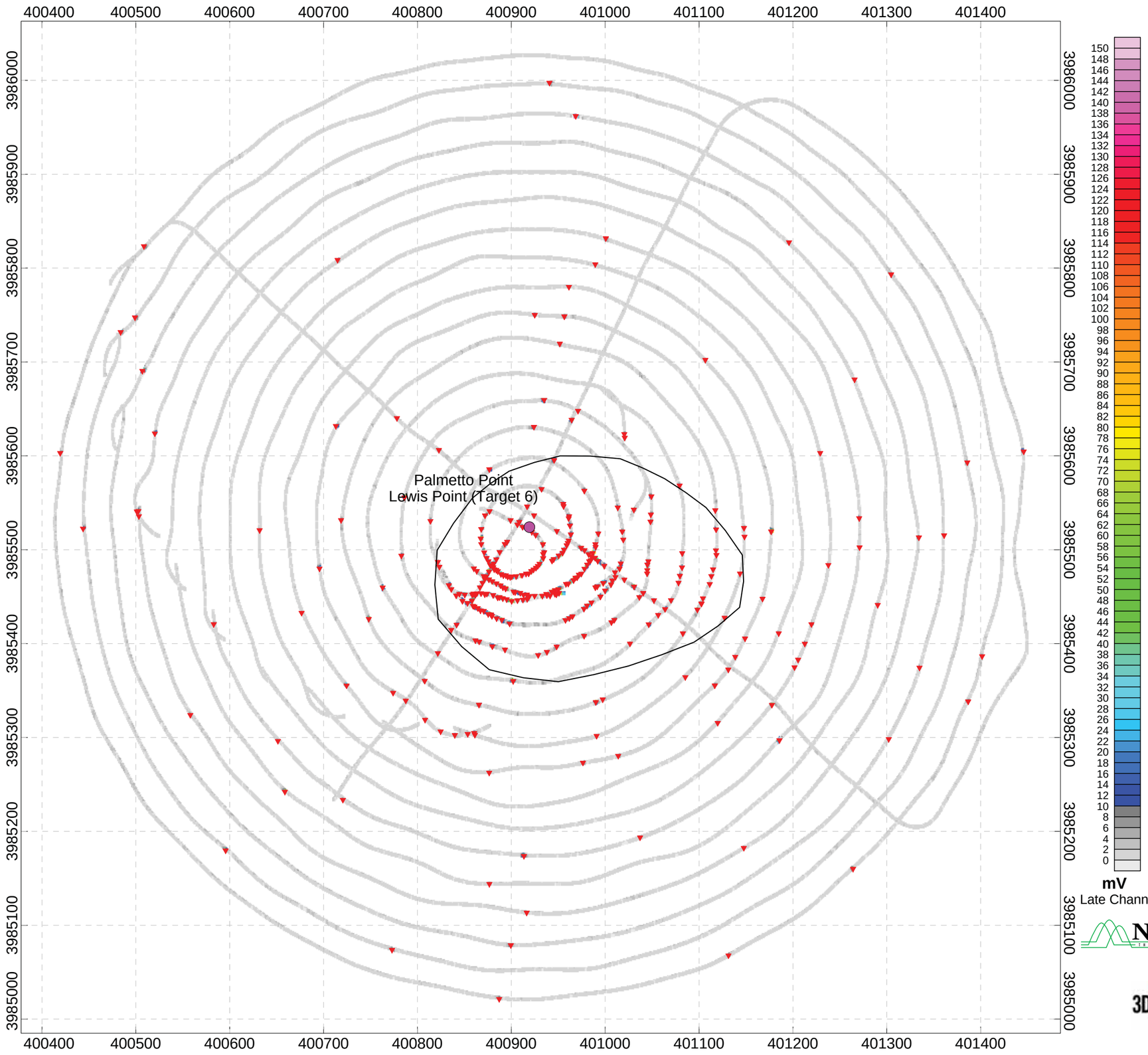
3Dgeophysics.com

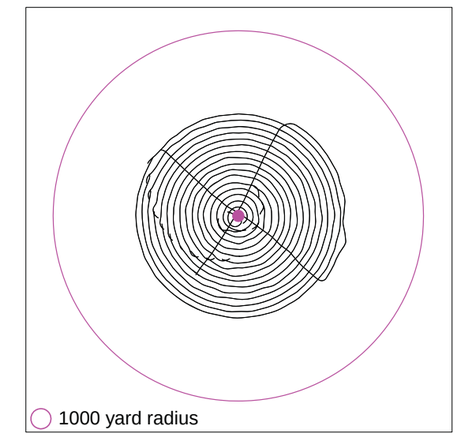
Client: CH2M HILL

Humminbird 997c SI Combo
Bathymetric Mosaic
Palmetto Point Bombing Range Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/20/2010 - 09/01/2010
Date of Map Creation: 09/07/2010

Map Approver: J. Guillard





Legend

- Site Target
- Selected Target (See individual Block Target Pick List For Response, Location and ID Number)
- Bouy — Culture, if noted
- High Density Response Area (Based on VSP Calculation of Areas greater than 30 Anomalies/Acre)

50 0 50 100 150 200
(meters)
NAD83 / UTM zone 18N

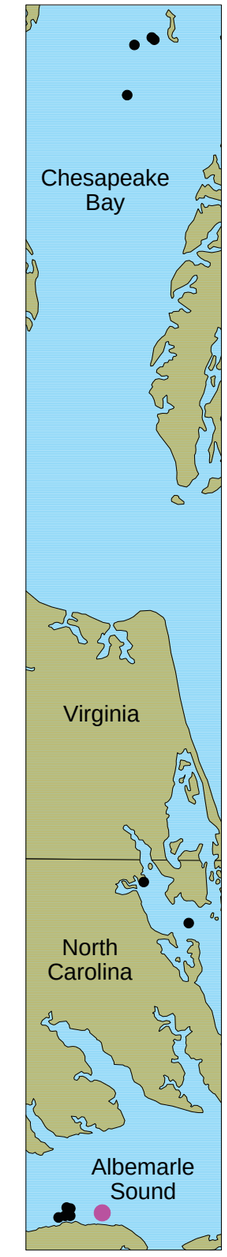


Figure 19

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

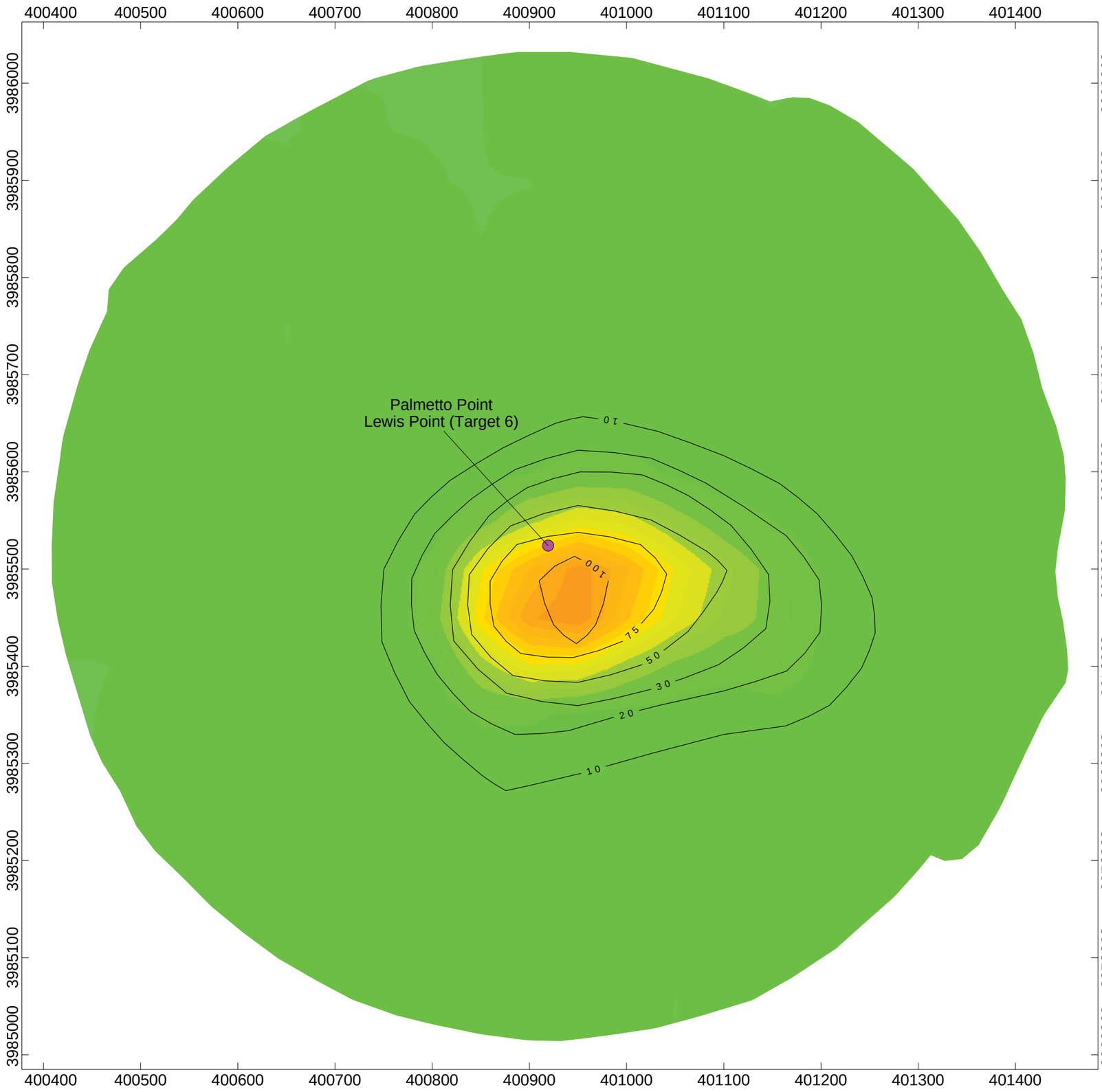
3Dgeophysics.com

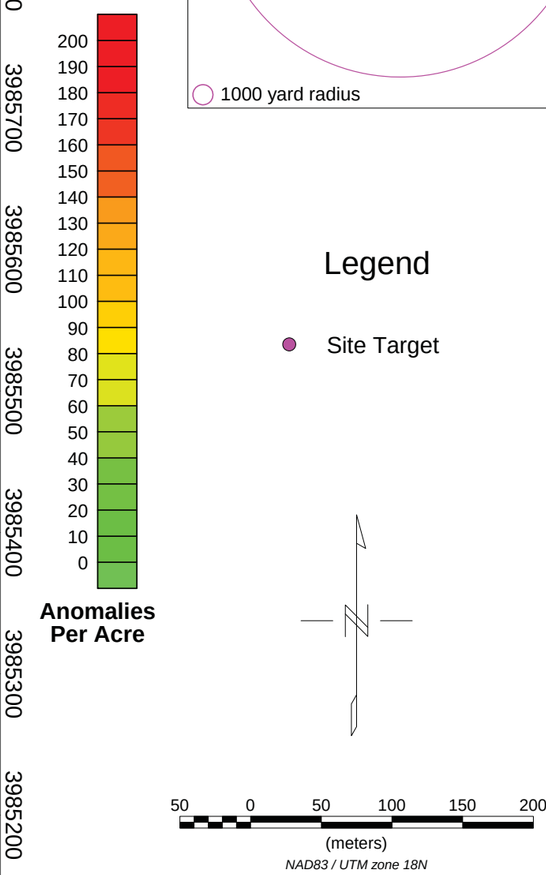
Client: CH2M HILL

EM61-FLEX 3
Anomaly Distribution Mosaic
Palmetto Point - Lewis Point Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/29/2010 - 08/30/2010
Date of Map Creation: 09/02/2010

Map Approver: J. Guillard





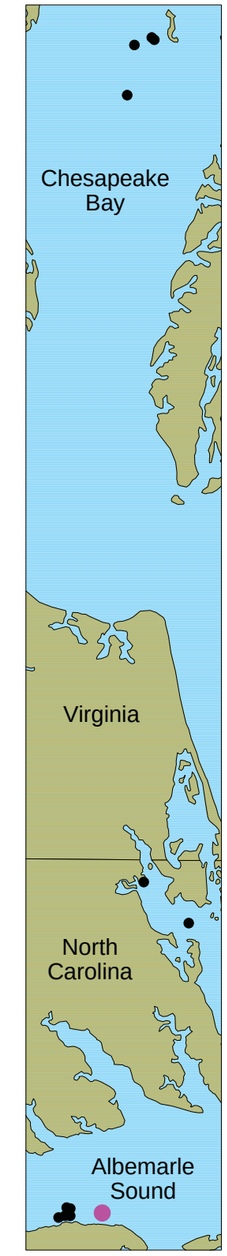


Figure 20

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

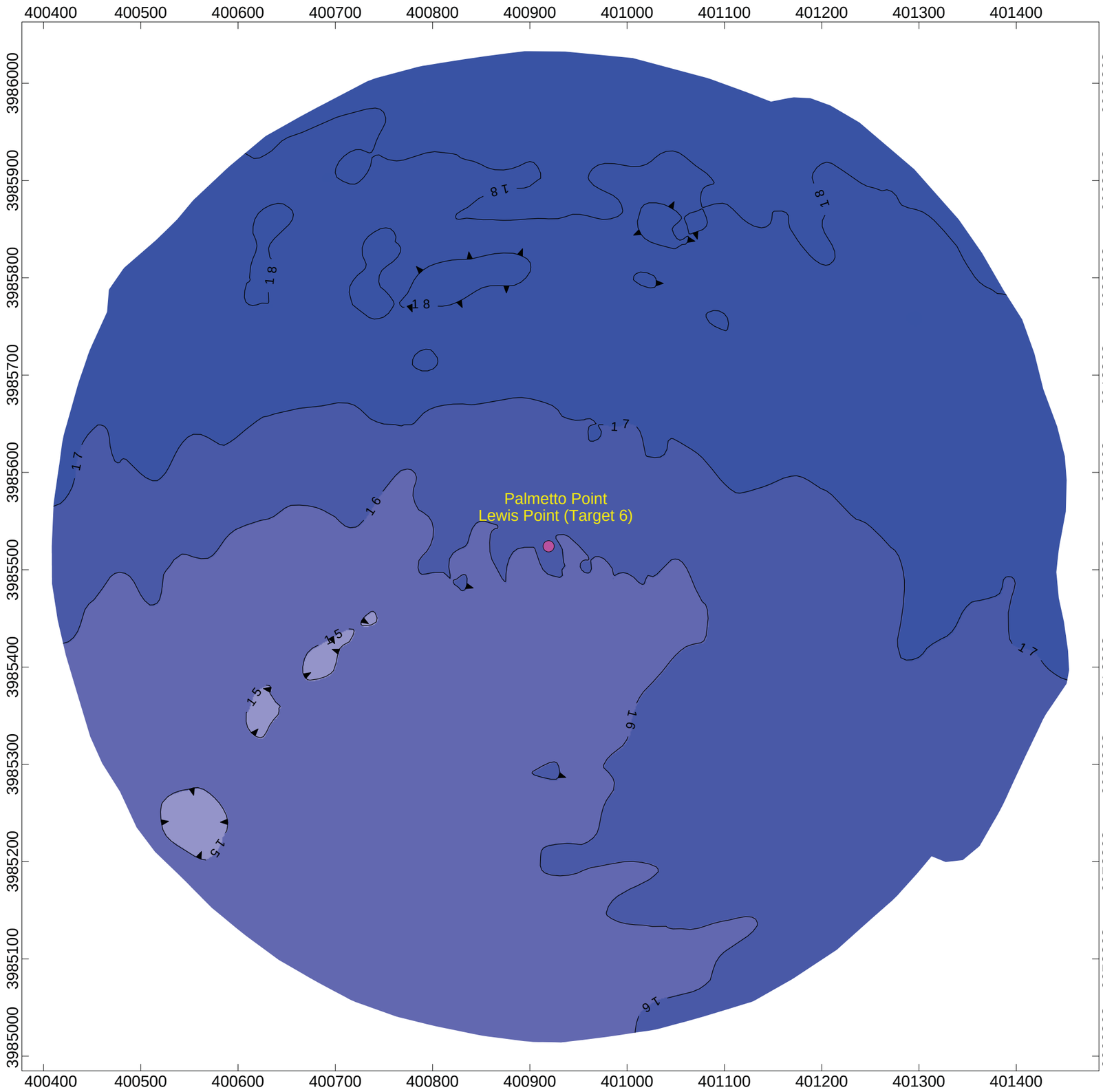
3Dgeophysics.com

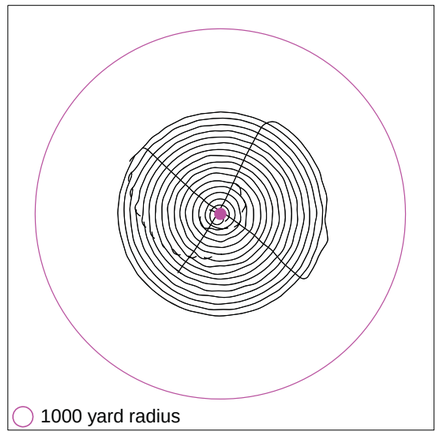
Client: CH2M HILL

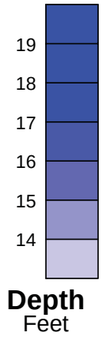
EM61-Flex 3
VSP Calculated Anomaly Density
Palmetto Point - Lewis Point Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/29/2010 - 08/30/2010
Date of Map Creation: 09/02/2010

Map Approver: J. Guillard



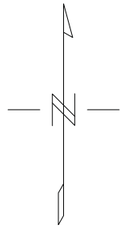


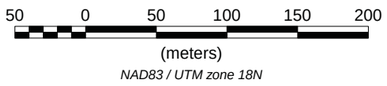


Legend

Site Target

NOTE: Depths are interpolated between the transect lines.





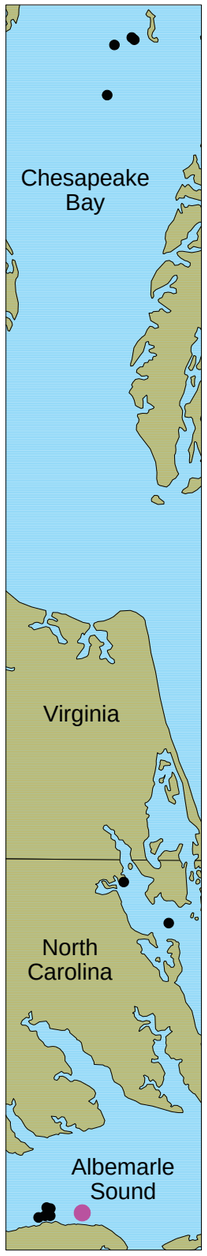


Figure 21

NAeVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

3Dgeophysics.com

Client: CH2M HILL

Humminbird 997c SI Combo
Bathymetric Mosaic
Palmetto Point - Lewis Point Target Site
Other-Than-Operational Ranges - NAS Oceana
Virginia Beach, Virginia

Date of Survey: 08/29/2010 - 08/30/2010
Date of Map Creation: 09/02/2010

Map Approver: J. Guillard

Figure 22: Example of IVS object

APPENDIX A

Summary of IVS Results

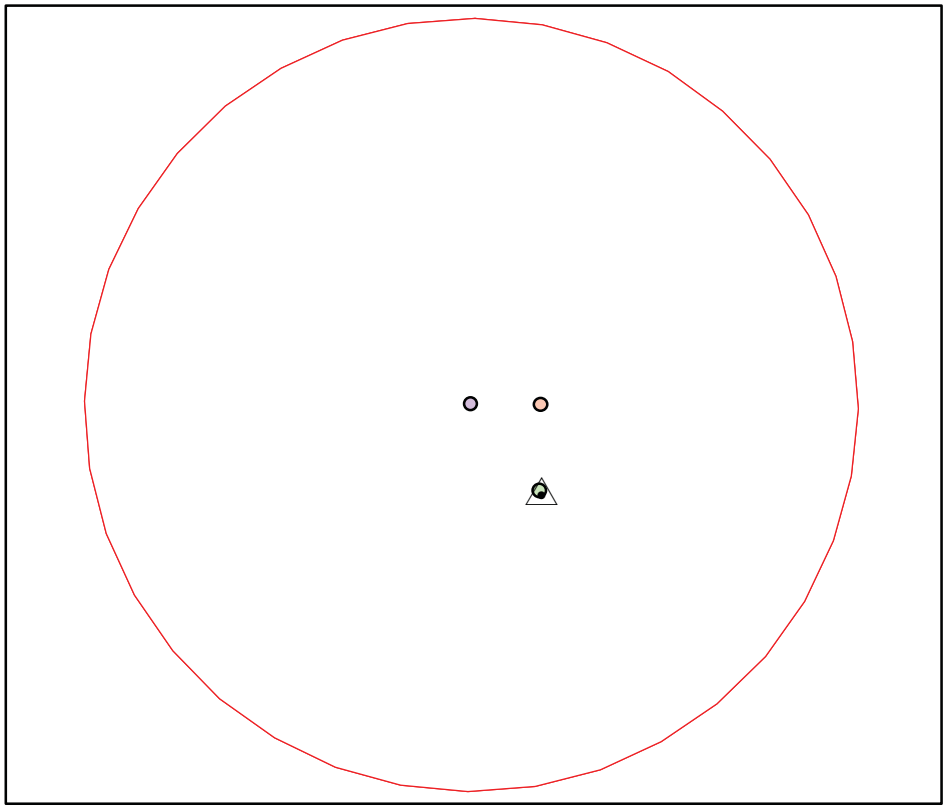
Date / File Name	X_UTM	Y_UTM	Coil_Height (ft)	ChL_mV	Offset from idealized seed location	Pass/Fail Based on 3m radius	Latency (sec)	Comments
0814IVS - Pass 3	415574.40	4033428.40	2.01	23.45	0.26	Pass	0.50	Pass 1 & 2 were not over Item
0815IVS - Pass 2	415575.20	4033429.00	1.35	6.74	1.01	Pass	0.50	Pass 1 was not over Item and Pass 2 was North of Seed Item
0816IVS - Pass 2	415574.80	4033428.4	1.77	11.9	0.30	Pass	0.50	Pass 1 was not over Item
0818IVS -Pass 1	415574.80	4033428.20	1.53	6.79	0.23	Pass	0.50	
0820IVS - Pass 1	389894.60	3983751.00	2.51	22.99	0.49	Pass	0.50	Passes 2,3 & 5 not over item
0826IVS - Pass 1	391819.40	3984182.00	2.40	57.06	0.60	Pass	0.50	
0828IVS - Pass 1	391820.60	3984183.40	2.36	41.04	1.32	Pass	0.50	
0829IVS - Pass 1	391818.40	3984182.60	1.73	1.55	1.57	Pass	0.50	Line was collected west of the Seed Item – did not pass over
0830IVS - Pass 3	391820.40	3984181.40	2.16	5.58	0.98	Pass	0.50	Passes 1 & 2 not over item
0831IVS - Pass 1	391819.80	3984183.60	2.65	21.61	1.35	Pass	0.50	
0901IVS - Pass 1	391821.40	3984181.80	2.16	5.36	1.53	Pass	0.50	Line was collected north of the Seed Item – did not pass over

APPENDIX B

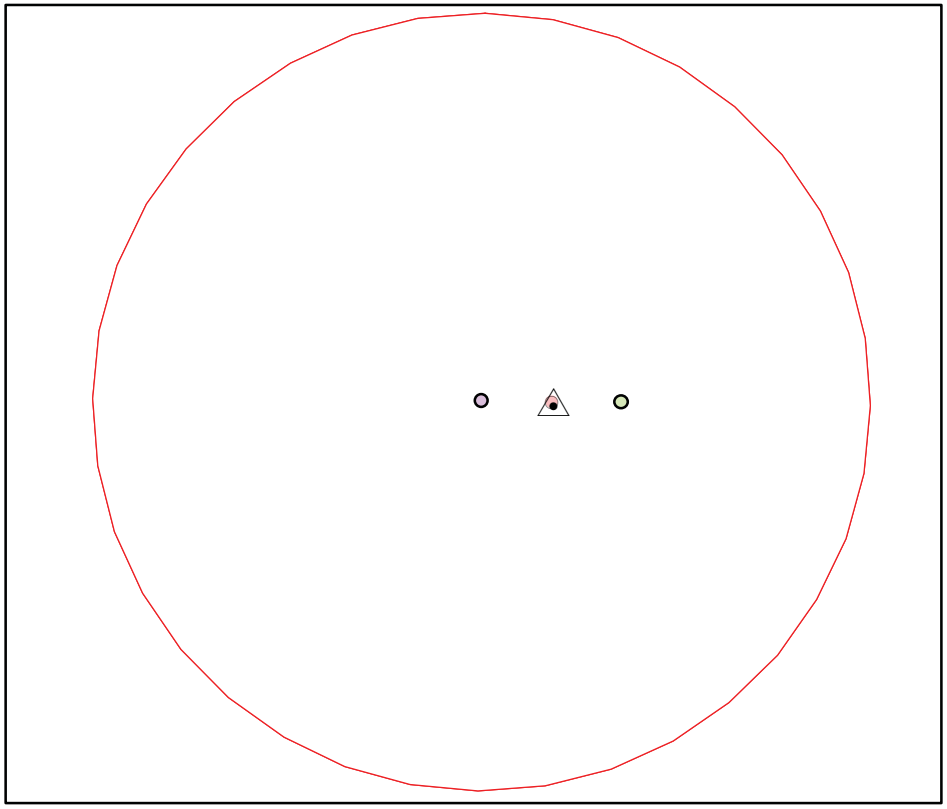
Summary of GPS QC Check Results

ID	GPS Location	X UTM	Y UTM	Offset Distance	Average	Comments
gps_081410	bow	417149.1655	4031482.7082		0.017	1st point at location, used as control
gps_081510		417149.1832	4031482.6858	0.029		
gps_081610		417149.1834	4031482.7080	0.018		
gps_081810		417149.1834	4031482.7080	0.018		
gps_081410	stern	417144.9976	4031489.3600		0.018	1st point at location, used as control
gps_081510		417145.0334	4031489.3596	0.036		
gps_081610		417145.0155	4031489.3598	0.018		
gps_081810		417145.0155	4031489.3598	0.018		
gps_082010	bow	398174.2970	3981748.1869		0.012	1st point at location, used as control
gps_082110		398174.3150	3981748.1867	0.018		
gps_082010	stern	398182.0716	3981746.7656		0.018	1st point at location, used as control
gps_082110		398182.0899	3981746.7876	0.029		
gps_082610	bow	392607.1706	3983124.7598		0.020	1st point at location, used as control
gps_082810		392607.1657	3983124.7812	0.022		
gps_082910		392607.1657	3983124.7812	0.022		
gps_083010		392607.1657	3983124.7812	0.022		
gps_083110		392607.1657	3983124.7812	0.022		
gps_090110		392607.1657	3983124.7812	0.022		
gps_082610	stern	392606.8726	3983132.8397		0.020	1st point at location, used as control
gps_082810		392606.8857	3983132.8609	0.025		
gps_082910		392606.8857	3983132.8609	0.025		
gps_083010		392606.8855	3983132.8387	0.013		
gps_083110		392606.8857	3983132.8609	0.025		
gps_090110		392606.8857	3983132.8609	0.025		

Bow GPS



Stern GPS



0 2.5 5 10

Centimeters

Legend

- gps_081410
- gps_081510
- gps_081610
- gps_081810
- 10cm Max Offset

N

NAeVA GEOPHYSICS INC.

THE LEADER IN SUBSURFACE DETECTION

Subsurface Geophysical Surveys

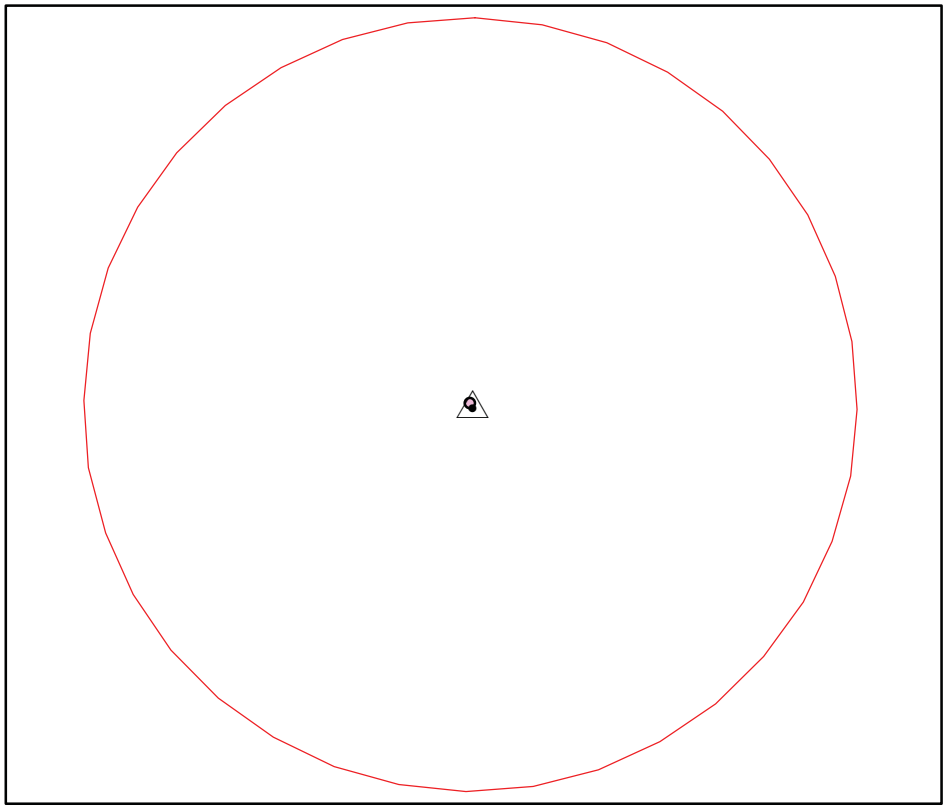
3Dgeophysics.com

Daily GPS Quality Control Check
Northern Currituck Sound &
North Landing River Targets
Other-Than-Operational Ranges - NAS Oceana

Date of Survey: 08/14/2010 - 08/18/2010

Date of Map Creation: 10/08/2010

Bow GPS



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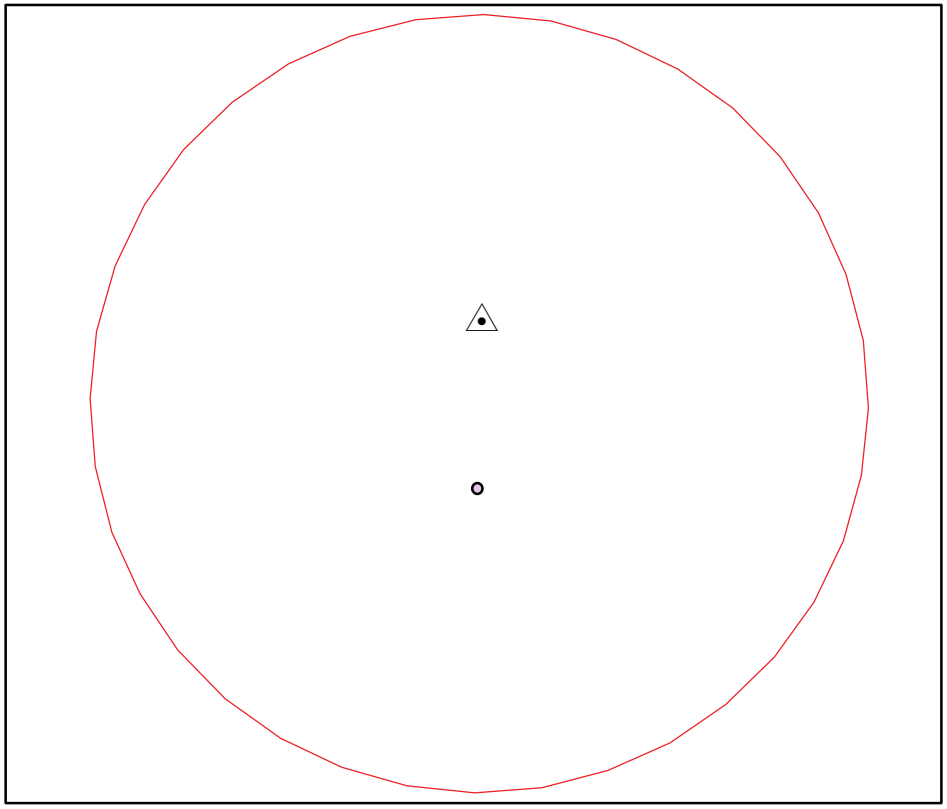

0 2.5 5 10

Centimeters

Legend

- gps_082010
- gps_082110
- 10cm Max Offset

N

NAeVA GEOPHYSICS INC.

THE LEADER IN SUBSURFACE DETECTION

Subsurface Geophysical Surveys

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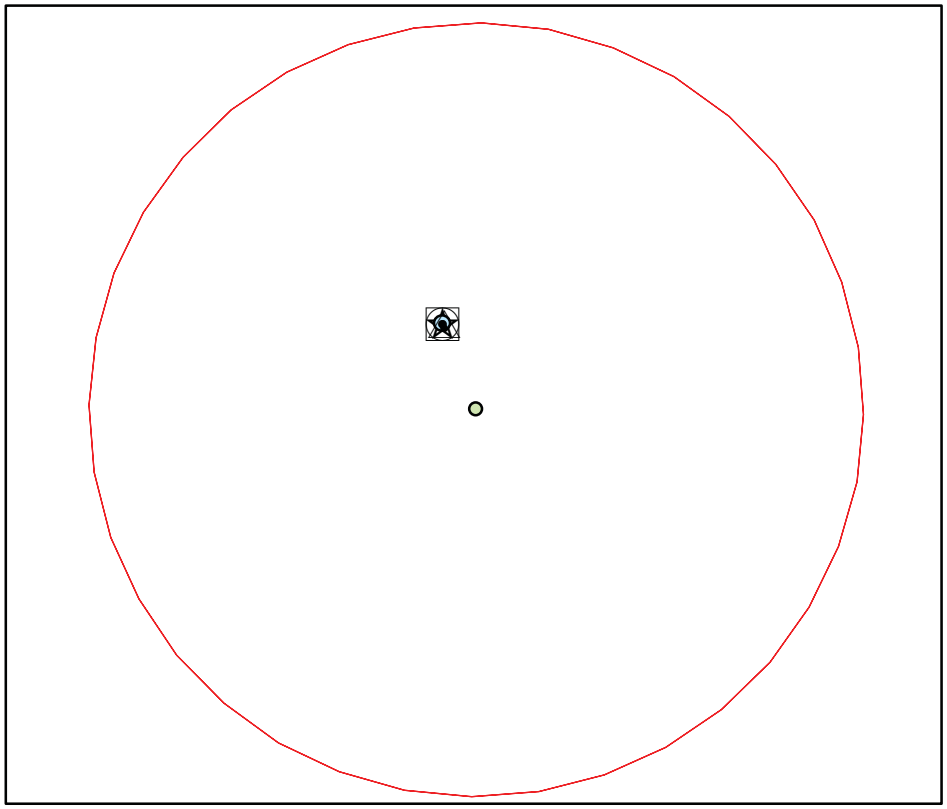
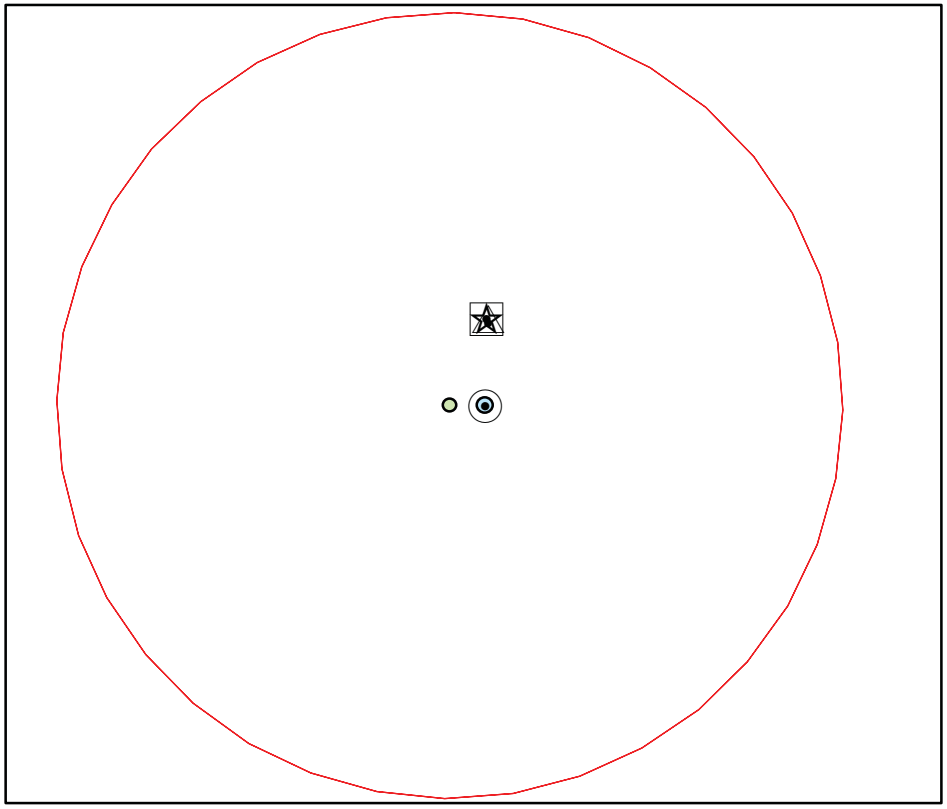
Daily GPS Quality Control Check
Palmetto Point Bombing Range Target Site
Other-Than-Operational Ranges - NAS Oceana

Date of Survey: 08/20/2010 - 08/21/2010
Date of Map Creation: 10/08/2010

Bow GPS



Stern GPS



0 2.5 5 10

Centimeters

NAeVA GEOPHYSICS INC.

THE LEADER IN SUBSURFACE DETECTION

Subsurface Geophysical Surveys

3Dgeophysics.com

Legend

- gps_082610
- gps_082810
- gps_082910
- gps_083010
- gps_083110
- gps_090110
- 10cm Max Offset

N

Daily GPS Quality Control Check
Palmetto Point Bombing Range Target Site
And Palmetto Point LEWIS Target Site
Other-Than-Operational Ranges - NAS Oceana

Date of Survey: 08/26/2010 - 09/01/2010

Date of Map Creation: 10/08/2010

Summary of Static Test Results

File name / Date	Coil 1 Response (ChL)	Coil 1 Percentage	Coil 2 Response (ChL)	Coil 2 Percentage	Pass/Fail Coil1	Pass/Fail Coil2	Pass/Fail ALL	Comments
0810QC1	68.07	0%	67.25	0%				Height is fixed at 35.56cm (14 in)
0810QC2	68.92	1%	63.08	6%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0811QC1	68.21	0%	67.68	1%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0814QC1	61.18	10%	69.69	4%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0815QC1	65.92	3%	64.63	4%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0815QC2	62.46	8%	71.94	7%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0816QC1	61.91	9%	62.72	7%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0818QC1	70.22	3%	64.95	3%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0818QC2	60.49	11%	64.86	4%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0820QC1	65.53	4%	69.46	3%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0820QC2	63.18	7%	67.25	0%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0826QC1	68.32	0%	69.83	4%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0826QC2	68.36	0%	65.10	3%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0828QC1	72.23	6%	67.40	0%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0828QC2	73.14	7%	73.03	9%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0829QC1	71.90	6%	74.06	10%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0829QC2	71.67	5%	74.67	11%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0830QC1	71.13	4%	72.66	8%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0830QC2	72.66	7%	74.27	10%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0831QC1	69.90	3%	69.21	3%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0831QC2	71.82	6%	69.30	3%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0901QC1	70.46	4%	68.40	2%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)
0901QC2	72.66	7%	70.26	4%	Pass	Pass	Pass	Height is fixed at 35.56cm (14 in)

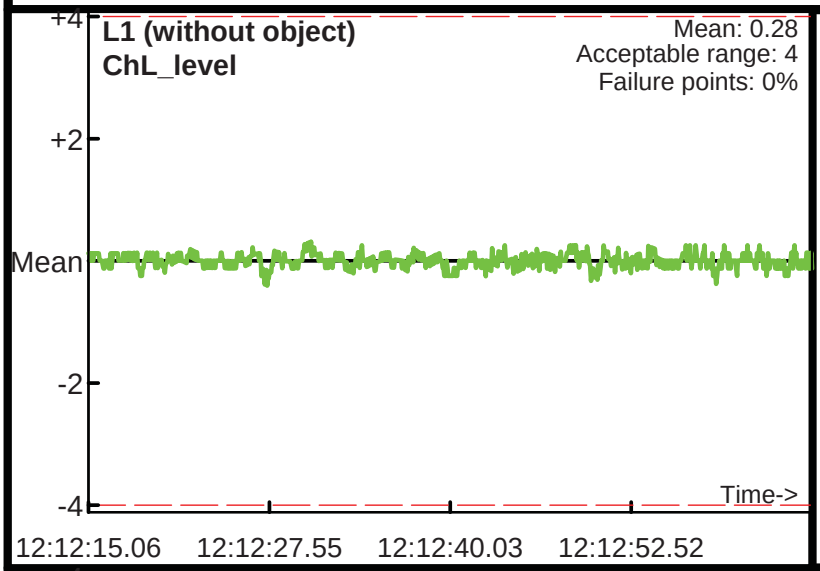
Static Calibration Test

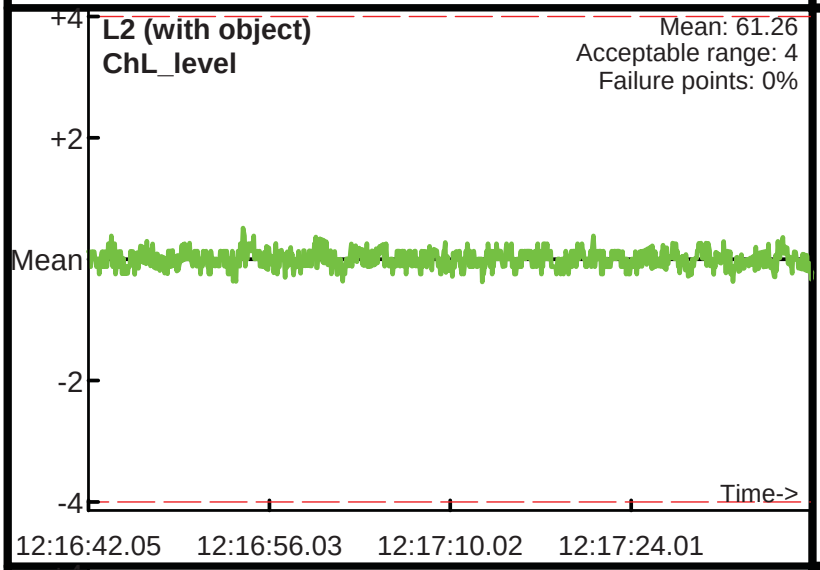
Mean Response Values
ChL_Level Without Object: 0.09
ChL_Level Signal Strength With Object: 61.18

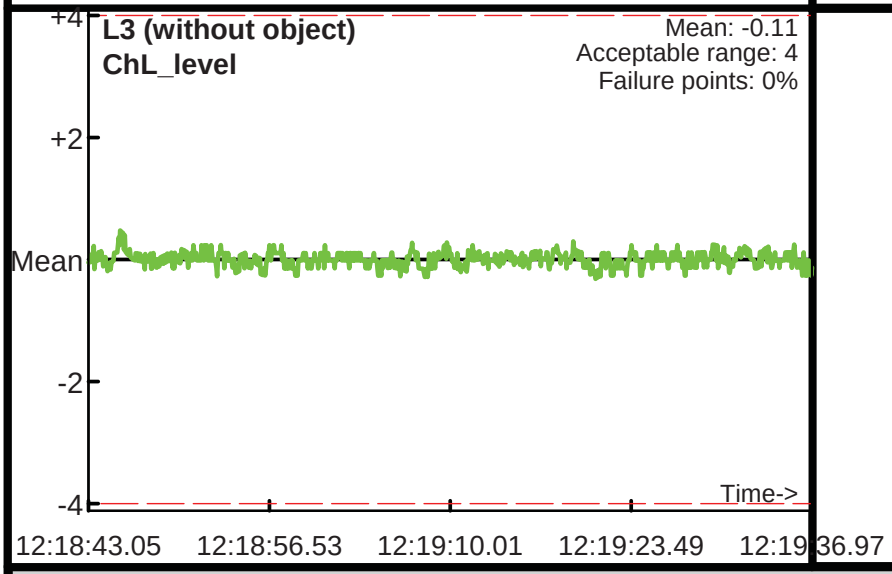
Project: NAS Oceana
Equipment: EM-61 FLEX 3
Grid/Location: Northern Currituck Sound

Outside range
Acceptable limits

QC1 Coil 1 test
Operator: Geo1
Date: 8/14/2010







Database: \0814QC1.gdb
Line Name: L1 L2 L3

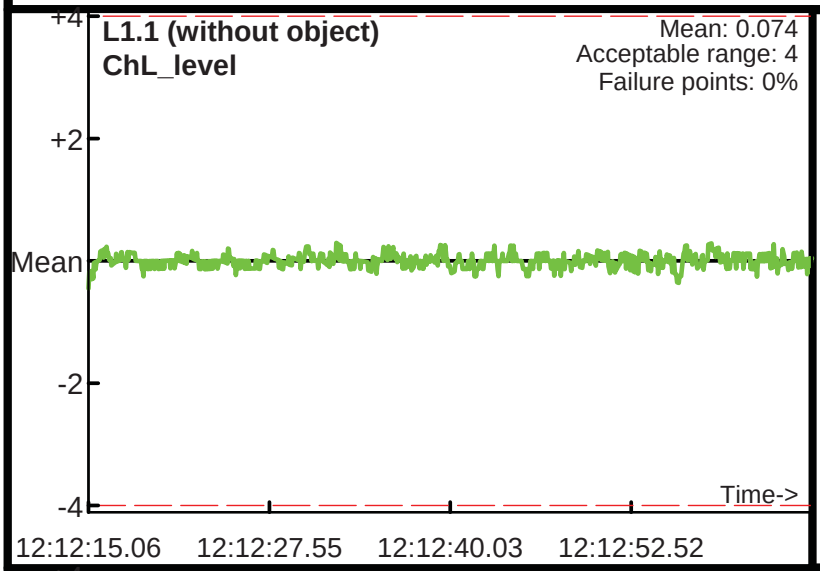
Static Calibration Test

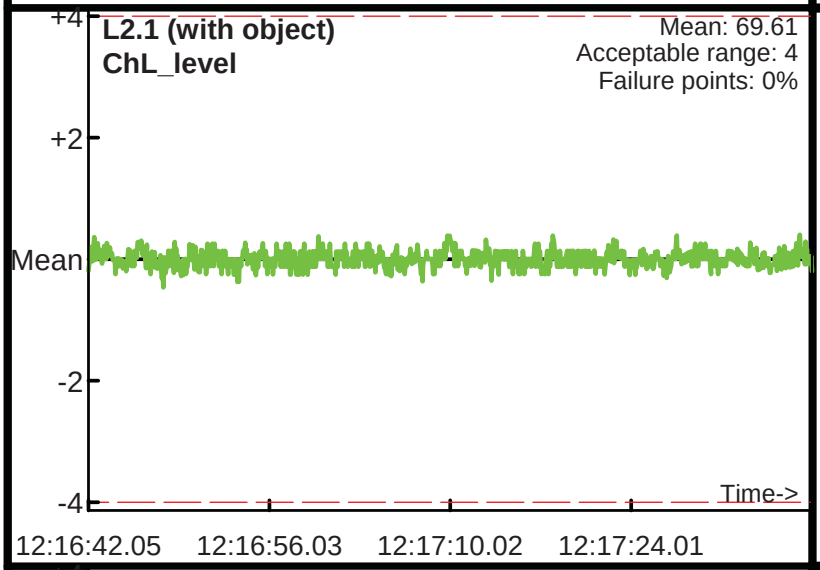
Mean Response Values
ChL_Level Without Object: -0.08
ChL_Level Signal Strength With Object: 69.69

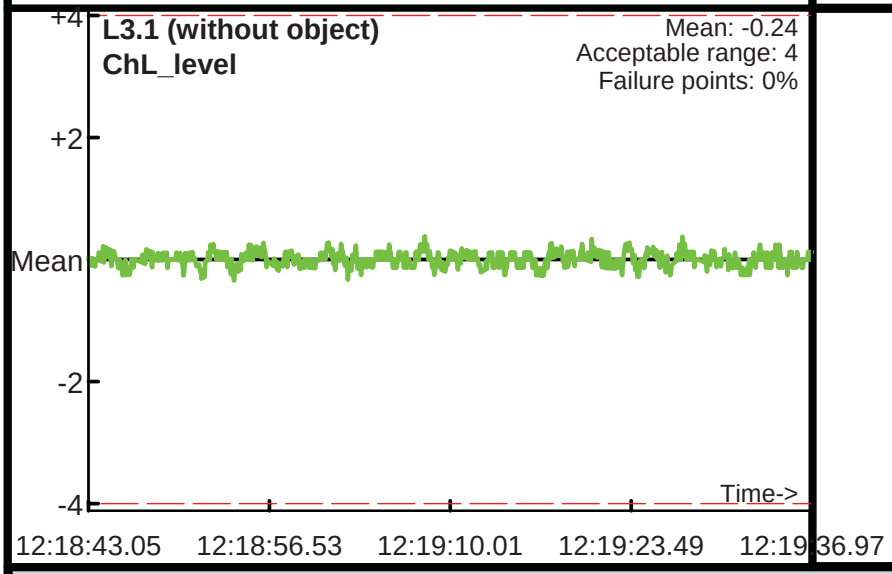
Project: NAS Oceana
Equipment: EM-61 FLEX3
Grid/Location: Northern Currituck Sound

Outside range
Acceptable limits

QC1 Coil 2 test
Operator: Geo1
Date: 8/14/2010







Database: .\0814QC1.gdb
Line Name: L1.1 L2.1 L3.1

Summary of Pressure Test Results

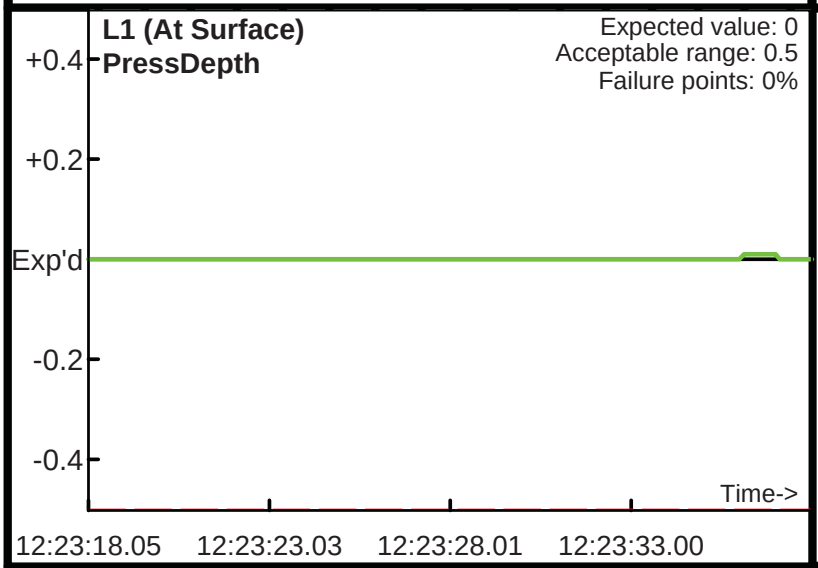
File name / Date	Coil 1 Depth 1	Coil 2 Depth 1	Coil 1 Depth 2	Coil 2 Depth 2	Coil 1 Pass/Fail	Coil 2 Pass/Fail	Comments
0814Pres	0.00	0.00	3.67	3.67	Pass	Pass	within 6in of 0 ft and 4 ft
0815Pres	-0.01	-0.01	3.95	3.95	Pass	Pass	within 6in of 0 ft and 4.3 ft
0816Pres	-0.02	-0.02	3.91	3.91	Pass	Pass	within 6in of 0 ft and 4.3 ft
0818Pres	-0.01	-0.01	3.87	3.87	Pass	Pass	within 6in of 0 ft and 4.3 ft
0820Pres	0.00	0.00	3.81	3.81	Pass	Pass	within 6in of 0 ft and 4.3 ft
0826Pres	0.02	0.02	3.97	3.97	Pass	Pass	within 6in of 0 ft and 4.3 ft
0828Pres	-0.01	-0.01	3.95	3.95	Pass	Pass	within 6in of 0 ft and 4.3 ft
0829Pres	-0.01	-0.01	3.90	3.90	Pass	Pass	within 6in of 0 ft and 4.3 ft
0830Pres	0.00	0.00	3.91	3.91	Pass	Pass	within 6in of 0 ft and 4.3 ft
0831Pres	0.00	0.00	3.89	3.89	Pass	Pass	within 6in of 0 ft and 4.3 ft
0901Pres	-0.01	-0.01	3.90	3.90	Pass	Pass	within 6in of 0 ft and 4.3 ft

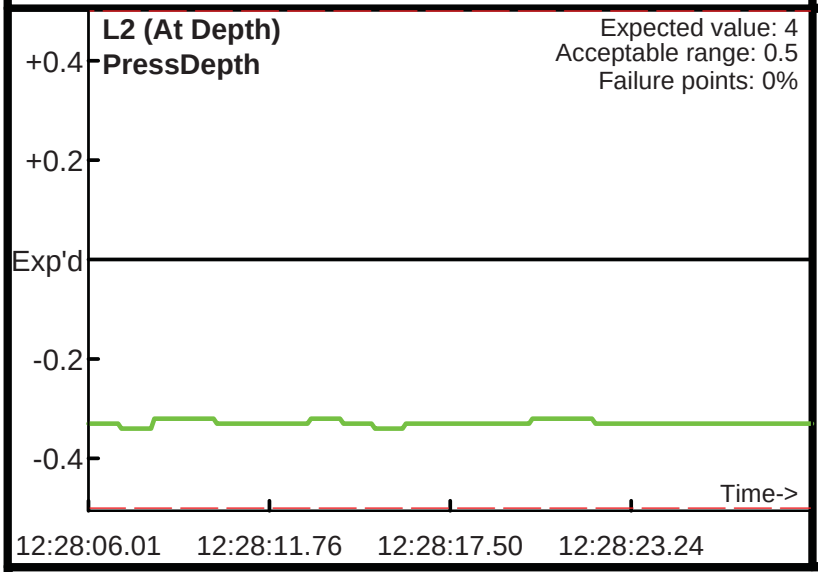
Pressure Test

Project: NAS Oceana
Equipment: EM-61 FLEX3
Grid/Location: Northern Currituck Sound

Outside range
Acceptable limits

QC Coil 1 test
Operator: Geo1
Date: 8/14/2010





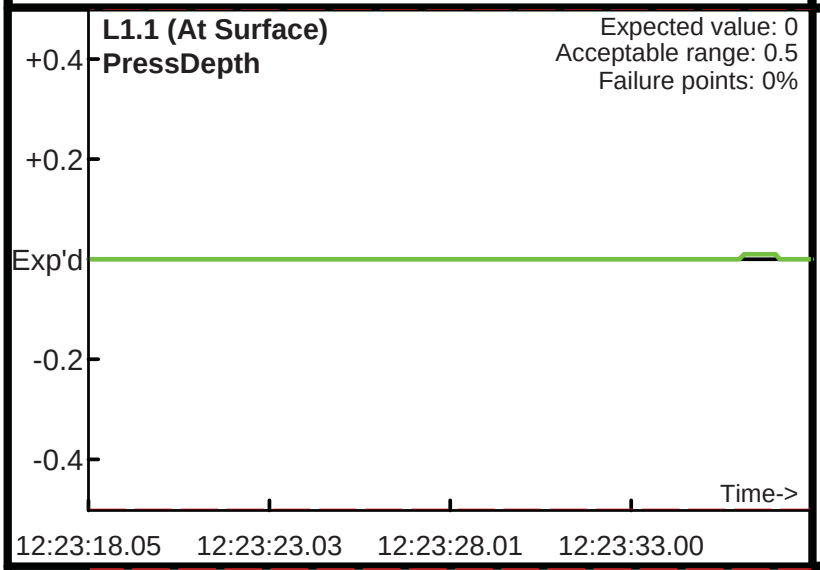
Database: \0814PRES.gdb
Line Name: L1 L1 L2

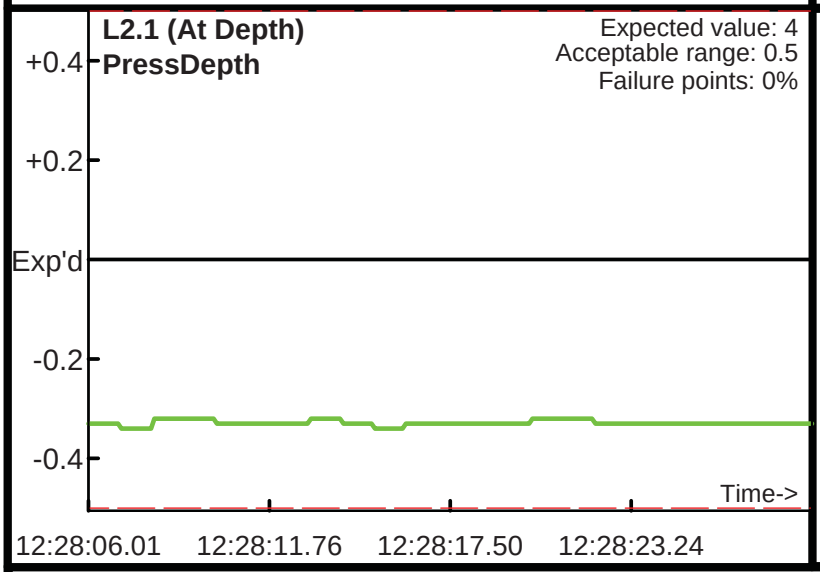
Pressure Test

Project: NAS Oceana
Equipment: EM-61 FLEX 3
Grid/Location: Northern Currituck Sound

Outside range
Acceptable limits

QC Coil 2 test
Operator: Geo1
Date: 8/14/2010





Database: .\0814PRES.gdb
Line Name: L1.1 L1.1 L2.1