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September 10, 2019

Wes Haskettt
Interim Town Manager
Town of Southern Shores
5375 N. Virginia Dare Trail
Southern Shores, NC 27949

**Subject: Borrow Area A Investigations**

Dear Mr. Haskett:

This letter report serves as the deliverable listed as "Borrow Area A – Dive Investigation Report" in Exhibit C of the agreement executed on April 3, 2019 between the Town of Southern Shores and Aptim Coastal Planning & Engineering of North Carolina, Inc. (APTIM). Task 2 as described in Exhibit A of the agreement (Scope of Services), has been completed. This Task was associated with investigations of Borrow Area A. As you may recall, during construction of the 2017 beach nourishment, several pieces of ordnance were retrieved by the contractor that were dug up in one particular load from Borrow Area A. After taking proper safety precautions, the contractor informed APTIM that they would no longer be dredging in that particular dredge cut to minimize the risk of dredging up similar materials. Attachment 1 includes several photos of the ordnance retrieved by the contractor.

Figure 1 shows a map of Borrow Area A indicating the portion of the borrow area excluded by the dredgers during the remaining portion of the 2017 project. The 2017 project completion report indicated Borrow Area A contained approximately 12,829,500 cy of material within the permitted portion of the borrow area following construction of the 2017 project (APTIM, 2018). The excluded portion of the borrow area shown in Figure 1 represents approximately 3,648,800 cy of that total amount or approximately 28% of the volume remaining in Borrow Area A.

APTIM began looking into geophysical and remotely sensed data collected during the borrow area investigation of Borrow Area A, even as the project progressed in 2017. The sidescan sonar surveys indicated an anomaly in proximity to the track line of the dredge load that retrieved the ordnance that could have been associated with a modern debris field. This anomaly was described in the cultural resource survey (TAR, 2015), but given its characterization of modern marine debris, no buffer was established around the target.

As part of the 2019 monitoring survey and analysis, the Town of Southern Shores contracted with APTIM to perform investigations near the anomaly identified in the sidescan sonar records for Borrow Area A. This letter report describes the methodology used to conduct the investigation and results and conclusions

of the investigation. This investigation benefits each of the four (4) Towns that obtained permits to use Borrow Area A during the 2017 project. In this regard, the cost of the investigation was split equally in four (4) ways between the Towns of Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills.

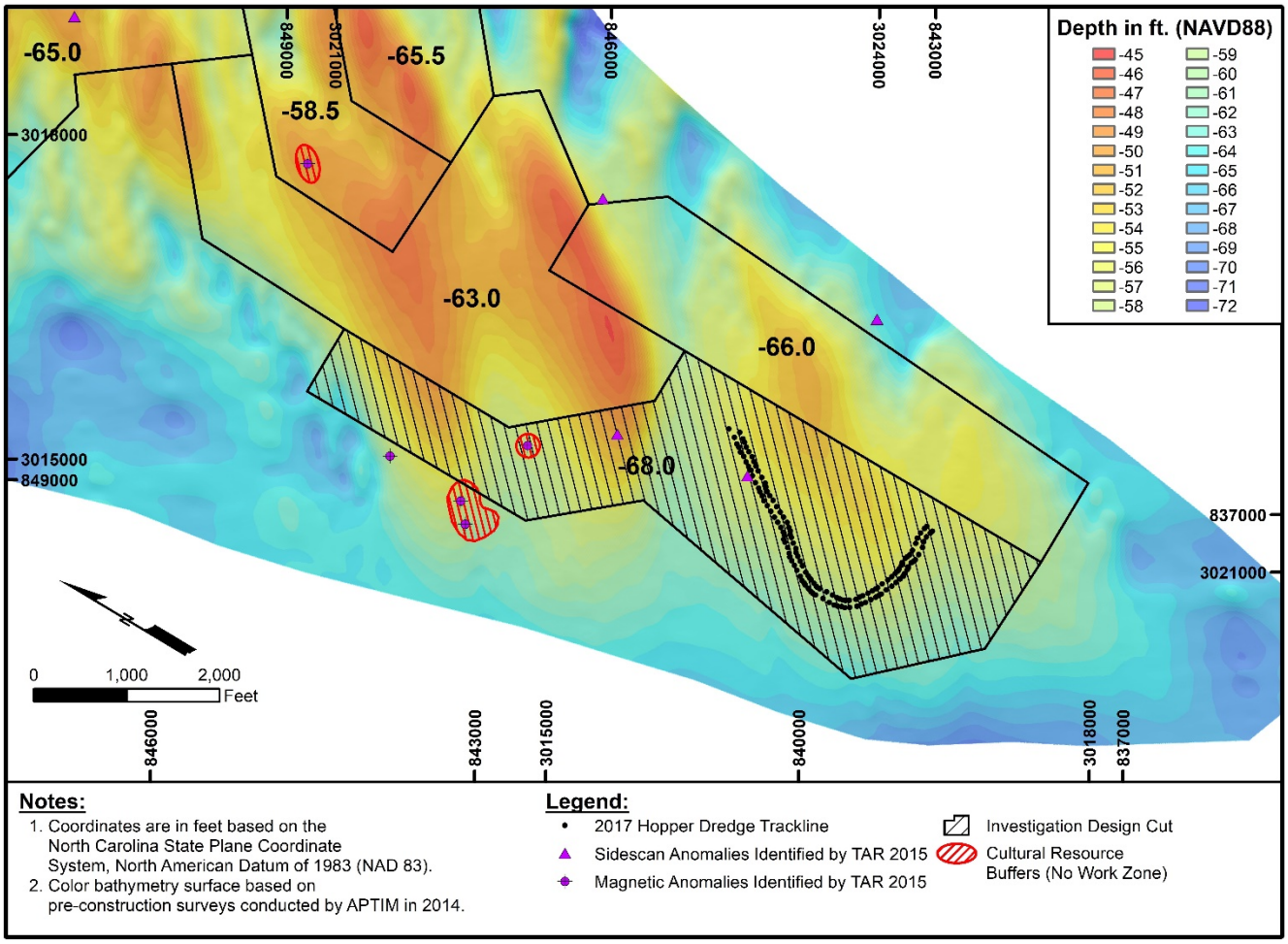


*Figure 1: Map of Borrow Area A indicating the area excluded by the dredgers during the remaining portion of the 2017 project.*

## Methodology:

APTIM survey crews transited and mobilized for the Dare County operations on May 15, 2019. Between May 15 and May 30, APTIM field crews completed the field investigation surveys of the targeted portion of Borrow Area A. Although the investigation was initially proposed to employ SCUBA diver investigations during the final planning stages of the work, APTIM dive safety officers expressed concern about using scientific divers to conduct the bottom survey within the vicinity of where the potential munitions may have been recovered. The scope of work was modified to use a suite of geophysical equipment including an EdgeTech 4125 sidescan sonar system and a Geometrics G-882 Digital Cesium Marine Magnetometer interfaced with Hypack Inc.'s Hypack 2018® software to conduct a reconnaissance survey over the area. The reconnaissance geophysical survey was followed with seafloor surface investigations using a SeaViewer Underwater Video System (SeaDrop 950). The seafloor underwater video investigations focused on anomalies identified through analysis of the geophysical data. A detailed description of the methodology associated with each aspect of the investigation is provided below.

**Navigation Systems:** The navigation and positioning system deployed for this survey was a Trimble real-time kinematic (RTK) global navigation satellite system (GNSS) with dual-frequency receivers.

Horizontal and vertical positioning checks were conducted before and after the survey within the project area to confirm network and survey accuracy. The base station transmits carrier phase and Doppler shift corrections via radio link to a receiver onboard the survey vessel. The receiver on the survey vessel can then apply the carrier phase and Doppler shift corrections to the position of the vessel as measured by global positioning system (GPS) satellites. Navigation data were collected at 1 hertz (Hz) or faster to minimize position interpolation when assigning the position to the various geophysical data.

Magnetometer and sidescan sonar systems were interfaced with an onboard computer, and the data was integrated in real time using Hypack Inc.'s Hypack 2018® software. Hypack 2018® is a state-of-the-art navigation and hydrographic surveying system. The location of each of the towfish tow-point on the vessel and the length of cable deployed between the tow-point and each towfish in relation to the RTK GNSS was measured, recorded and entered into the Hypack 2018® survey program. Hypack 2018® then incorporates these values and monitors the actual position of each towfish in real time. Online screen graphic displays include the pre-plotted survey lines, the updated boat track across the survey area, adjustable left/right indicator, as well as other positioning information such as boat speed, quality of fix measured by Position Dilution of Precision (PDOP), and line bearing. The digital data is merged with positioning data (RTK GNSS), video displayed and recorded to the acquisition computers hard disk for post processing and/or replay.

**Magnetometer Survey:** High-resolution magnetic remote sensing was used to identify metallic objects that may correspond to ordnance similar to the unexploded ordnance (UXO) recovered during the construction project in 2017. A Geometrics G-882 digital cesium marine magnetometer, capable of a plus or minus 0.1 gamma resolution, was used to perform the reconnaissance investigation for magnetic anomalies within the investigation areas. Figure 2 shows the as-run tracklines along which data were collected during the geophysical reconnaissance survey, which included acquisition of both magnetometer and sidescan sonar data.

To produce a magnetic record of sufficient resolution, the sensor was deployed and maintained in the water column no more than 6 meters (m) off the seafloor (approximately 19.7 feet, (ft)). A digital recorder provided a continuous record of the magnetic background and target signatures. Positioning data generated by the navigation system was tied to the magnetometer records by regular annotations to facilitate target location and anomaly analysis. Annotations in the dataset included line number, date and time of start and end of each line, and target identification.

Upon completion of the reconnaissance magnetometer survey, the data were examined by APTIM staff. The magnetic data were then processed and interpreted for any and all magnetic anomalies that differed for the natural magnetic environment. Results were presented as a plan view map of the survey area depicting each individual magnetic anomaly. Magnetic anomalies were processed using Hypack 2018® and compared to previously collected data from for analysis purposes. Anomalies or targets were then selected based on anomaly magnitude and duration.

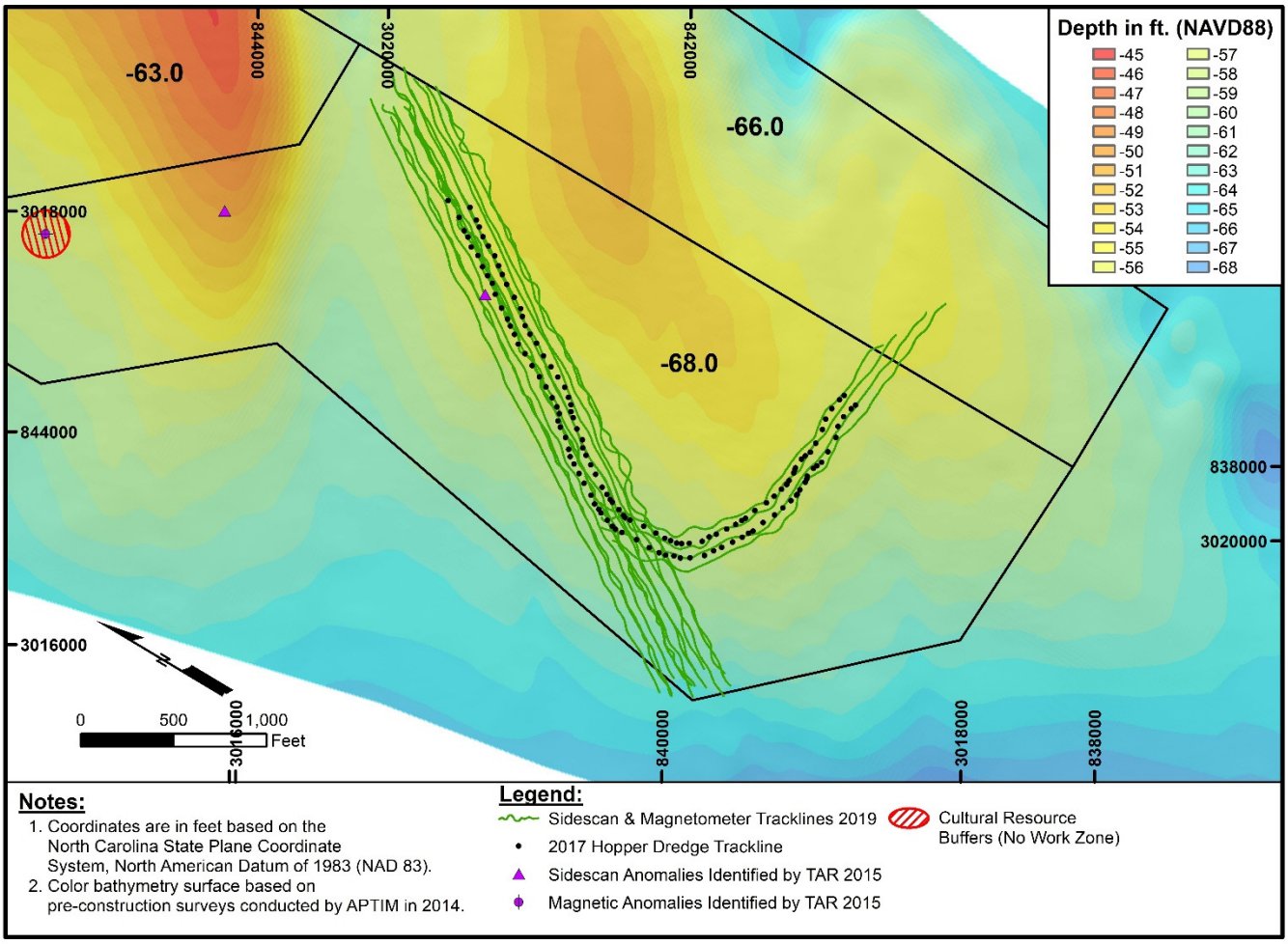


*Figure 2: Map showing the location of the tracklines along which magnetometer and sidescan sonar data were collected during the investigation in May 2019.*

**Sidescan Sonar Survey:** An EdgeTech 4125 high resolution sidescan sonar system (600/1600 kilohertz (kHz)) was used to conduct the investigation. This system uses full-spectrum chirp technology to deliver wide-band, high-energy pulses coupled with high resolution and signal to noise ratio echo data. The sonar packages included a portable configuration with a laptop computer running EdgeTech's Discover® acquisition software. The EdgeTech 4125 600/1600 kHz dual frequency towfish was run in high definition mode to collect sonar data at both high and low frequencies. The dual frequency sonar provides a more complete sidescan sonar return that aids interpolation at the outer portions of the swath, which in turn provides a more complete data set.

During the investigation, the sidescan sonar was towed from the survey vessel at a position and depth that limited exposure to sources of interference and provided the best possible record quality. The digital sidescan sonar data was merged with positioning data (DGPS via Hypack 2018®). Position data appeared in the video display and was logged to disk for post processing and/or replay. The acoustic data was recorded digitally according to areas of interest.

Post collection processing of the sidescan sonar data was completed using Chesapeake Technology, Inc.'s SonarWiz.MAP software. This software allows the user to apply specific gains and settings in order to produce enhanced sidescan sonar imagery that can be interpreted and digitized for specific benthic habitat features and debris throughout the survey area. The first step in processing was to import the data into the software and bottom track the data.

All individual sidescan sonar line imagery and mosaics were reviewed in waterfall display mode and any "target" areas were identified for a closer inspection. Once target areas were identified, the survey data was further inspected for any potential anomalies on the seafloor. A snapshot image of each target was saved in a target database along with geotiffs for each target. A target is any feature of interest, in this case those with a potential to be associated with UXO or manmade marine debris, warranting more detailed sidescan sonar review to complete target determination (Figure 3). Target sites were then compared to the magnetometer data (Figure 3).

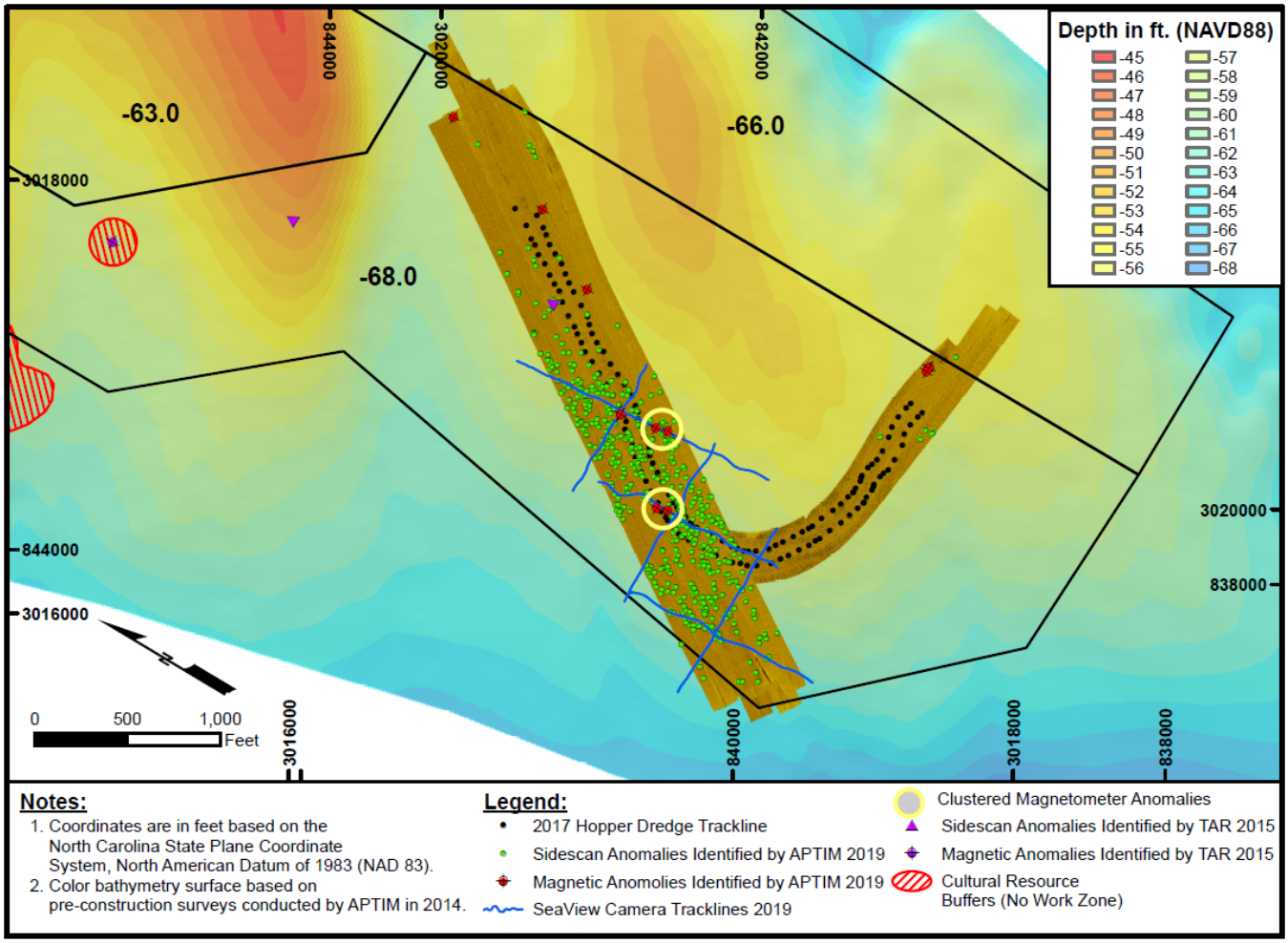


*Figure 3: Map showing the location of magnetometer and sidescan sonar anomalies as well as tracklines along which underwater video was collected n in May 2019.*

**SeaViewer Underwater Video System:** A SeaViewer Underwater Video System was used to further investigate sonar targets identified during the geophysical investigation. Underwater video transects were planned around the sonar target concentrations. Survey lines were then run over areas of interest with the underwater video system to identify any potential hazardous items that might be similar to, or indicative of, the presence of previously recovered UXO material. Figure 3 is a map of the extent of the sidescan sonar mosaic, magnetometer anomalies, and sonar targets, as well as, tracklines along which underwater video data were collected.

The underwater video methodology was adapted based on boat speed and depth of water to achieve greater resolution. Video was captured by attaching the SeaViewer camera system to a towline such that it was oriented at an angle to face toward the bottom while being towed. The camera system was lowered to the bottom and then towed at slow speeds to maximize the resolution of the video. The video was monitored in real-time in an attempt to identify unique bottom features and to correlate sidescan sonar signatures to

actual bottom types. Each video was saved as a separate video file and once the data acquisition phase was complete, commercial software was used to review and analyze the captured videos in slow motion. Video and screenshots from the video were further examined in an attempt to correlate sonar anomalies to bottom features and to determine if bottom features were natural or manmade debris. Figure 4 shows a screen shot of one of the underwater video images showing a gravely bottom over sand with worm tubes and shells.

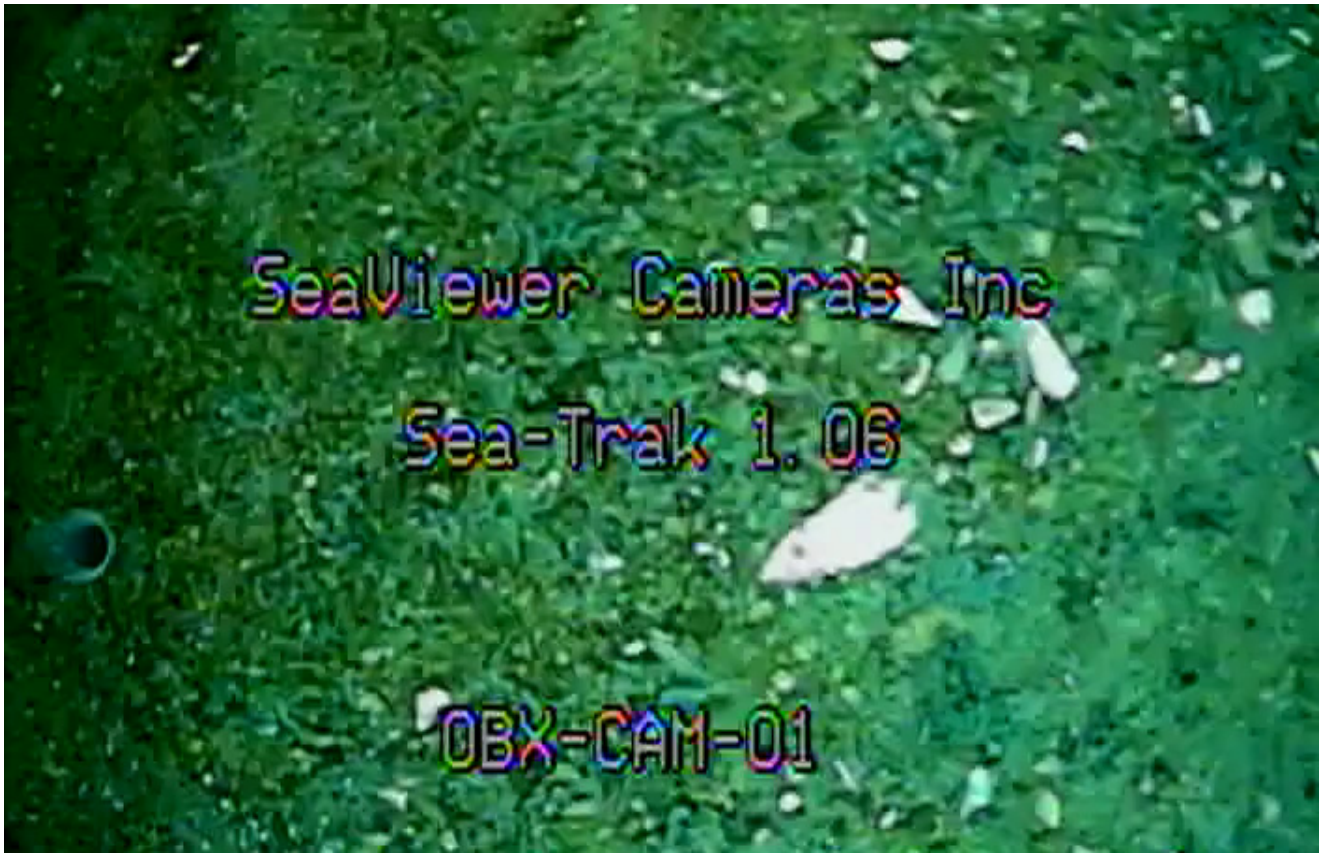

*Figure 4: Screen capture of underwater video showing deposits of coarse shell hash, shell fragments and whole shells as well as worm tubes.*

**Conclusions**

Prior to conducting the geophysical and underwater video survey in May 2019, APTIM staff revisited datasets from the previously collected cultural resource survey (TAR, 2015). APTIM staff hypothesized that the sonar anomalies identified shared similar characteristics of modern debris. These debris may be a result of overboard material dumping, creating a submerged debris field. Staff also hypothesized that perhaps the ordnance retrieved by the dredge contractor in 2017 was associated with this or similar debris fields.

Analysis of the sidescan sonar data resulted in the identification of many bottom features characterized as "pock marks". Some of the features appeared to be depressions in the otherwise rippled sand; whereas others appeared to be raised features above the otherwise rippled sand. Figure 3 illustrates the entirety of the sidescan sonar targets at the survey site. The features appeared to be concentrated in the central to southwest portion of the area surveyed in May 2019. Figure 5 shows an example of the pock marks as observed in the sidescan sonar data processing software. To investigate this further, the Seaview camera was used to resolve some of representative pock mark areas, particularly those with correlated magnetometer anomalies.

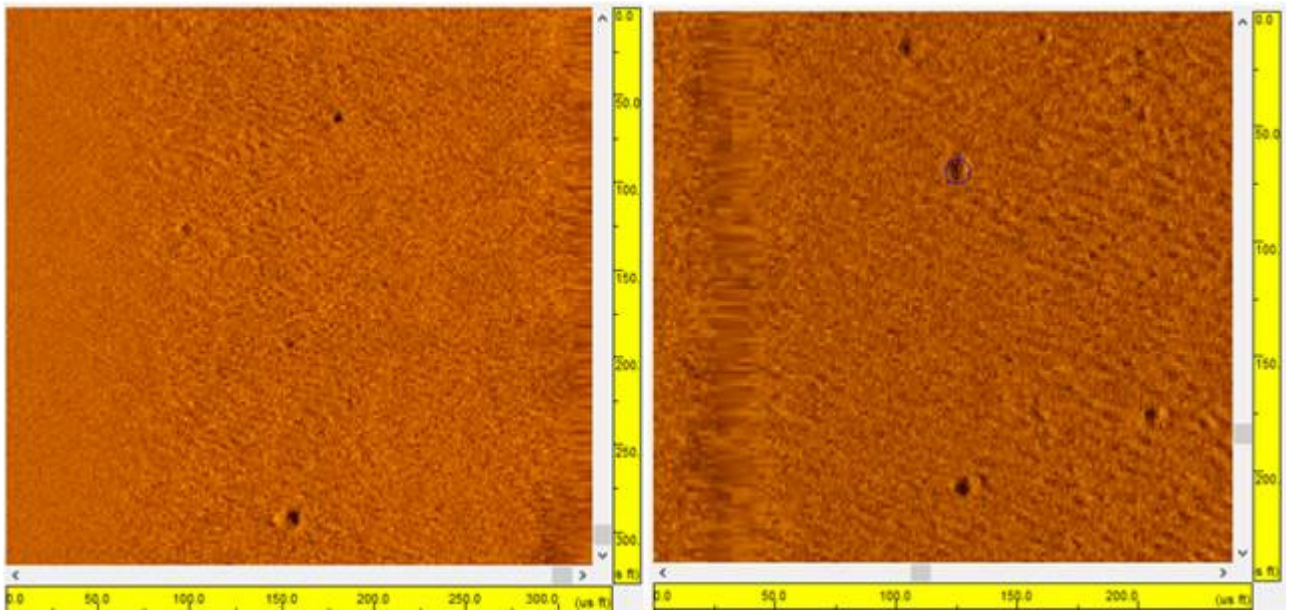

*Figure 5: Sidescan sonar imagery showing examples of "pock mark" features.*

Analysis of the magnetometer data resulted in the identification of eight (8) anomalies of 3.6 gammas and less. The anomalies were scattered sporadically throughout the survey site. Typically, magnetometer anomalies of five (5) gammas and less indicate minute ferrous items at the surface or buried. The magnetic anomalies intensities, as indicated with the use of the Geometrics 882, are proportional to the weight of the object at a given distance (Breiner, 1980). For example, a five (5) gamma magnetometer anomaly, as indicated in Geometrics' nomogram for gammas vs distance, may indicate a one (1) pound piece of iron six (6) ft. from the magnetometer or a two (2) pound piece of iron 12 ft. away from the magnetometer, further illustrating the minute size of the anomalies detected. Despite the large area covered, there were two regions where magnetic anomalies were observed to be clumped together (two magnetic anomalies). These two regions were observed in a large cluster of pock marks. Although the magnetic anomalies depict low gammas, they are highlighted as areas of interest due to their proximity to one another and their correlation to the sidescan sonar pock marks (Figure 3).

Analysis of the video imagery collected by the underwater video surveys yielded mixed results. Several features that may have been representative of the pock mark features were captured on video. These features appear to be areas with dense shell hash and the presence of worm tubes growing up out of the substrate. Figure 4 shows an example of what is believed to be representative of the pock mark areas. The clarity of the water and the limitations of the video system provided approximately 10 feet of visibility on the bottom, which limits the ability to characterize with certainty the sidescan sonar targets and magnetometer anomalies.

The collection and analysis of data obtained in May 2019 by APTIM did not conclusively identify any modern marine debris fields or ordnance. Although a large concentration of small bottom features were identified through the use of the sidescan sonar, the relatively minimal number of magnetic anomalies identified in the same area suggests that these features are associated with little to no ferrous material. Furthermore, the underwater video surveys did not appear to capture evidence of any manmade marine debris during any of the surveys conducted as part of this investigation.

**Recommendations**

APTIM used a suite of remote sensing systems to conduct an investigation of the area in proximity of where several pieces of munition were recovered on July 28, 2017, during the construction of the 2017 beach nourishment project. The goal of this survey was to confirm the presence of a marine debris field associated with the munitions, in order to better define avoidance areas for future projects.

The analysis of data collected through the course of this investigation did not conclusively confirm the presence of a marine debris field associated with munitions. APTIM recommends that the information obtained from this investigation be provided to prospective dredge contractors during the bidding phase of the proposed 2022 dredge project. Furthermore, APTIM recommends that any future geotechnical or geophysical data obtained in this vicinity to support sand source delineation for the proposed 2022 project, be evaluated in terms of whether the information provides insight into the origin of the munitions.

Please let me know if you have any questions or comments about the information contained in this letter.

Sincerely,
**APTIM COASTAL PLANNING & ENGINEERING OF NORTH CAROLINA, INC.**

Kenneth Willson
Program Manager

**References:**

APTIM, May 2018. Aptim Coastal Planning & Engineering of North Carolina, Inc., *2017 Dare County Beach Nourishment Project – Project Completion Report,* Wilmington, NC.

Breiner, S. 1980. Magnetic Search in the Marine Environment. Geometrics, Inc. MM-TRI. https://www.geometrics.com/resources/?_sft_product_line=magnetic.

Tidewater Atlantic Research, Inc. (TAR), April 2015. *A Phase 1 Remote-Sensing Archeological Survey of Two Proposed Borrow Areas Offshore of Dare County, North Carolina*. Washington, NC. 100 pgs.

**ATTACHMENT 1**

**PHOTOS OF ORDNANCE RETRIEVED BY DREDGE CONTRACTOR DURING 2017 PROJECT**