Appendix C

UNDERWATER REMOTE SENSING SURVEY: DOLAN RESEARCH, INC.

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Mr. Ian Burrow
Hunter Research, Inc.
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Re: Executive Summary
Phase I Underwater Archaeological Investigations
Woodland Ferry Crossing
Nanticoke River
Sussex County, Delaware

Dear Mr. Burrow:

We successfully concluded the fieldwork portion of our Phase I Underwater Archaeological Investigations in the Nanticoke River at the site of the Woodland Ferry, Sussex County, Delaware. Our work task was to conduct a magnetic and acoustic remote sensing investigation across the width of the river at the crossing with a 250 foot buffer on either side of the centerline of the crossing route. The goal of the project was to locate and identify potentially significant remote sensing targets within the survey corridor that produced signatures suggestive of submerged cultural resources.

Description of Work Area

The Nanticoke River is approximately 480 feet wide where the Woodland Ferry uses a wire cable to cross it. Here, the river is tidal with a mean low water depth that averages approximately 14 feet. A large shoal extends away from the southern shoreline where the water depth ranges from zero feet to four feet at low tide. A series of abandoned wooden pilings (partially submerged) are located close to the northern shoreline on the upstream (east) side of the ferry.

Summary of Filed Survey and Equipment

Sonar and magnetic survey operations were conducted individually from a 22-foot aluminum vessel. Sonar data were gathered with a *Marine Sonic* two channel digital side scan sonar unit with a 600kHz side scan sensor. The sonar sensor was towed off the bow of the survey boat and was operated alternately at two different ranges (164' and 66' in either channel) in an effort to collect the most detailed acoustic data. *Marine Sonic* data acquisition software was used to merge the acoustic data with real-time positioning data.

Magnetic data were collected with a *Geometrics 881* cesium marine magnetometer, capable of +/- 1/10 gamma resolution. The magnetometer sensor was mounted on the bow of the survey vessel to allow access into the shallow waters along the southern shoreline of the Nanticoke River. The magnetometer collected data on the ambient magnetic field strength by measuring the variation in cesium electron energy states. As the sensor passed over objects containing ferrous metal, a fluctuation in the earth's magnetic field was recorded. The fluctuation was measured in gammas and is proportional to the amount of ferrous metal contained in the sensed object.

Hypack, a laptop PC-based software package in conjunction with a Differential Global Positioning System (DGPS) onboard the survey vessel provided positioning accuracy for the survey area of +/- three (3) feet. The computer converted positioning data from the DGPS to Delaware State Plane Coordinates in real time. These X,Y coordinates were used to guide the survey vessel precisely along predetermined tracklines. While surveying, vessel positions were continually updated on the computer monitor to assist the vessel operator, and the processed X,Y data were continually logged on computer disk for post-processing and plotting. Survey lanes were set up on 50' centers, parallel with the path of the ferry and perpendicular to the flow of the river.

Project horizontal reference is the Delaware Plane Coordinate System, NAD 83, in feet.

Data Products - Side Scan Sonar Data

The side scan sonar derives its information from reflected acoustic energy. Side looking sonar, which transmits and receives swept high frequency bandwidth signals from transducers mounted on a sensor that is towed from a survey vessel. Two sets of transducers mounted in an array along both sides of the towfish generate the short duration acoustic pulses required for high resolution images. The pulses are emitted in a thin, fan-shaped pattern that spreads downward to either side of the towfish in a plane perpendicular to its path. As the fish is towed along the survey trackline this acoustic beam sequentially scans the bottom from a point beneath the fish outward to each side of the trackline.

Acoustic energy reflected from any bottom discontinuities (exposed pipelines, rocks, or other obstructions) is received by the set of transducers, amplified and transmitted to the survey vessel via a tow cable. The digital output from state of the art units is essentially analogous to a high angle oblique photograph provided detailed representations of bottom features and characteristics. Sonar allows display of positive relief (features extending above the bottom) and negative relief (such as depressions) in either light or dark opposing contrast modes on a video monitor. Examination of the images thus allows a determination of significant features and objects present on the bottom within a survey area.

Raw sonar records were inspected for potential man-made features and obstructions present on the bottom surface. Sonar data were saved in files that covered approximately 800-feet along any survey lane. Individual acoustic data files were initially examined using SeaScan™ acoustic data review software to identify any unnatural or man-made features in the records. Once identified, acoustic features were described using visible length, width, and height from the bottom surface. Acoustic targets are normally defined according to their spatial extent, configuration, location and environmental context. The coordinates of the acoustic features also were recorded.

Later, raw sonar data files were edited using software from Chesapeake Technology™ to remove the water column from the records and the processed sonar files were compiled into a geo-referenced sonar mosaic (Figure 1). The mosaic was then overlaid onto background plans of the ferry crossing (Figure 2).

Data Products - Magnetic Data

Magnetic data were edited for detailed analysis. Also, the editing process was used to remove background noise and to create a magnetic contour map. Both dock slips on either shoreline of the project area featured high levels of magnetic background noise. Additionally, the ferryboat was moored in the slip on the northern shoreline during our surveys, adding to the magnetic disturbance on that side of the river. Despite these background disturbances, a magnetic contour map with 10 gamma intervals was generated for the project area (Figure 3).

Magnetic data editing consisted of using *Hypack's* single-beam editing program to review raw data (of individual survey lines) and to delete any artificially induced noise or data spikes. Once all survey lines for an area were edited, the edited data were converted to an XYZ file also using Hypack (Easting, and Northing Delaware State Plane Coordinates (NAD83), and magnetometer data – measured in gammas). Next, the XYZ files were imported into a Triangular Irregular

Network (TIN) modeling program in Hypack) that was used to contour the data in 50-gamma intervals. A second major analytical technique employed included the subtraction of general background from each successive data sample to develop the actual field gradient. The gradient is the vertical difference (z) between samples. By subtracting successive data samples one from the other the effects of diurnal change is completely eliminated. The resulting data represents only the localized changes in the magnetic background created by ferrous objects (i.e. anomalies) or geological features. When graphically represented by contouring, only the intensity of variation is represented.

Figure 3. Woodland Ferry Magnetic Contour Map @ 10 Gamma Intervals

Notes:

1) Magnetic data is reduced to pole: all positive reading are depicted as red and negative readings as blue

Findings

Analysis of magnetic signatures identified during the survey was based on several criteria. After magnetic data were contour plotted, each anomaly was analyzed according to: magnetic intensity (total distortion of the magnetic background measured in gammas); pulse duration (detectable signature duration); signature characteristics (negative monopolar, positive monopolar, dipolar, or multi-component); and spatial extent (total area of disturbance). Acoustic (side scan sonar) targets were analyzed according to their spatial extent, configuration, location and environmental context. Magnetic records were correlated with the acoustic targets to provide any further information on the identity of the material generating the remote sensing signatures. Additional investigation or avoidance was recommended for target signatures with the potential to yield submerged cultural resources.

A complete listing of all magnetic and acoustic targets is presently being compiled. As expected, there was larger scale magnetic disturbance around both of the berthing docks – particularly the north dock where the ferryboat was berthed. In addition, there was one large magnetic anomaly identified on either side of the ferry centerline (#1 & #2). However, the intensity of their signatures suggests they are likely related to modern debris.

Preliminary inspection of the remote sensing records confirms the presence of no potentially significant remote sensing targets. Despite this lack of potentially significant remote sensing targets, a program of manual underwater testing with archaeologists equipped with SCUBA equipment may be advisable to detect and identify inundated/submerged cultural features along the shorelines that were not detectable with remote sensing equipment.

Within the next four weeks we anticipate submitting the Draft Archaeological Report with a complete listing and evaluation of each of the remote sensing targets.

Respectfully submitted,

DOLAN RESEARCH, INC.

J. Lee Cox, Jr.
President