APPENDIX K

GEOPHYSICAL SURVEY REPORT

CANADIAN SEABED RESEARCH LTD.

LAKE ERIE CONNECTOR
Marine Geophysical Survey Results

Nanticoke (Ontario) to Springfield Township (Pennsylvania)

FINAL REPORT

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LAKE ERIE CONNECTOR – Marine Geophysical Survey Report

Client: ITC Lake Erie Connector, LLC
CSR Report #: 1408-4
Confidentiality: Report distribution restricted to project participants approved by client.

ABSTRACT

ITC Lake Erie Connector, LLC (ITC) is proposing to develop the first direct connection between Ontario (Canada) and Pennsylvania (United States), allowing for the bi-directional flow of electric power. The high voltage direct current (HVDC) project will connect electric power generation in Ontario through a submarine transmission cable across Lake Erie to the PJM grid via the Erie West substation in Pennsylvania.

Canadian Seabed Research Ltd. was contracted by ITC to conduct a marine geophysical survey along the Survey Centreline of the LEC proposed cable route corridor. The survey included the acquisition of sidescan sonar, sub-bottom profiler, magnetometer, multibeam echosounder and single beam echosounder data.

The objective of the fall 2014 field work was to survey the Canadian and United States Nearshore & Approaches. Also, regional data was acquired over the Long Point Escarpment in order to evaluate the slope and geological conditions.

The objectives of the 2015 field work included surveying the Canadian and United States Landfalls using a small survey launch. Offshore data was also collected over a 500 m corridor along the Survey Centreline within areas not surveyed in 2014 and over a 200 m corridor in areas surveyed in 2014.

This report (CSR Report No. 1408-4) describes the geophysical data acquisition and interpretation for the area surveyed over the LEC Proposed Route within Lake Erie. The 15 Panel Map Sheets that accompany this report display the acquired data and geophysical interpretation from 2014 and 2015 surveys.

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Rev 1	September 11, 2015	Preliminary Interim Draft	PC	PC
Rev 2	November 27, 2015	Draft	CT / PC	CT
Rev 3	January 22, 2016	Final	CT / LM	CT

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REPORT CITATION

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STATEMENT OF QUALITY

Canadian Seabed Research Ltd. warrants that its service with respect to this study was performed with a degree of skill and care equal to or greater than that ordinarily exercised under similar conditions by reputable members of our profession practising in the same or similar locality. No other warranty, expressed or implied, is made or intended.

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1.0 INTRODUCTION

1.1 BACKGROUND

ITC Lake Erie Connector, LLC (ITC) is proposing to develop the first direct connection between Ontario (Canada) and Pennsylvania (United States), allowing for the bi-directional flow of electric power. The high voltage direct current (HVDC) project will connect electric power generation in Ontario through a submarine transmission cable across Lake Erie to the PJM grid via the Erie West substation in Pennsylvania.

Canadian Seabed Research Ltd. (CSR) was contracted by ITC to conduct a marine geophysical survey along the Survey Centreline of the LEC proposed cable route corridor, see Figure 1.1.1. The survey included the acquisition of sidescan sonar, sub-bottom profiler, magnetometer, multibeam echosounder and single beam echosounder data.

This report describes the geophysical data acquisition and interpretation for the area surveyed over the LEC Proposed Route within Lake Erie. The 15 Panel Map Sheets that accompany this report display the geophysical interpretation from data acquired in 2014 and 2015.

1.2 PRELIMINARY ROUTE SELECTION

The proposed LEC project will involve the installation of HVDC cables between Nanticoke (Ontario) and Springfield Township (Pennsylvania). Many factors such as geological, environmental, anthropogenic, commercial, route length and several others were considered in the selection of the Survey Centreline across Lake Erie. The selection of this route is discussed in CSR Report 1408-2; "Lake Erie Connector – Cable Route Desktop Assessment".

1.3 SURVEY OBJECTIVES

The main objectives of the survey were to identify and map surficial geology, lakebed features and sub-bottom conditions within the route corridor of the proposed HVDC submarine cable.

For the purpose of the geophysical survey and survey report, the proposed cable route corridor was broken into six general sections:

- Canadian and United States Landfall
- Canadian and United States Nearshore & Approaches
- Canadian and United States Offshore

Both the Canadian and United States Landfalls are located adjacent to the shoreline where the proposed cable will enter/exit the lake. The Canadian Landfall extends from the shoreline to kilometre posting (KP) 1.6, while the United States Landfall extends from KP 102.3 to the shoreline. The Landfall sections were surveyed using a small nearshore vessel due to the shallow water depths found close to shore. The Canadian Nearshore & Approaches extend from KP 1.6 to KP 21.0, while the United States Nearshore & Approaches extend from KP 84.7 to KP 102.3. The Canadian Offshore extends from KP 21.0 to the international border at KP 46.91, while the United States Offshore extends from KP 46.91 to KP 84.7. Figure 1.1.2 shows how the six sections are divided along the route.

For the fall 2014 survey, the priority areas were the Canadian and United States Nearshore & Approaches. Regional data over the Long Point Escarpment was also collected in order to evaluate the slope and geological setting of the escarpment. For the spring/summer 2015 survey, the priority areas were the Canadian and United States Landfalls as well as the Canadian and United States Offshore areas. A 200 m corridor was also re-surveyed over the Canadian and United States Nearshore & Approaches. This was done in order to collect higher resolution bathymetry and seismic data using the multibeam echosounder and chirp profiler equipment deployed on the 2015 survey.

The objectives of the route corridor survey were accomplished by the collection, interpretation and subsequent reporting of geophysical data. The survey was conducted over a 500 m wide corridor along the Survey Centreline of the LEC proposed cable route corridor. The following types of data were collected during the marine geophysical survey:

- Differential GPS navigation was constantly recorded to provide real-time geo-referencing for all data sets acquired during the survey.

- Sidescan sonar data were acquired to identify potential hazards exposed on the surface of the lakebed (shipwrecks, pipelines, boulders, debris, possible recent faulting, slumping, ice scouring) and to categorize surficial sediment types (bedrock, glacial till, sand, silt, clay, etc.).

- High-resolution seismic and chirp data were acquired throughout the geophysical program to identify soil types to a depth of at least 5 metres.

- Lakebed bathymetry data was continuously logged throughout the geophysical program using both single beam and multibeam echosounders in order to determine water depths (lakebed elevations) along the route.

- Magnetometer data were collected to identify surface and buried debris with ferrous content.

- Grab samples were collected during the small boat survey to ground truth the interpretation of the landfall surficial geology.

1.4 Report Overview

This section presents a general overview of the report structure. Table 1.1 defines the acronyms used throughout the report.

An introduction to the project and marine geophysical survey is provided in Section 1. Section 2 of the report provides information on the Lake Erie regional setting and geology. Section 3 includes a discussion of the survey operations including survey equipment and survey coverage. Section 4 includes a discussion on data processing and interpretation methodologies. The results of the interpretation and the geological conditions to be expected along the LEC Proposed Route are documented in Section 5 with a report summary in Section 6. Recommendations are included in Section 7. References are included in Section 8.

There are 8 appendices (Appendix I-VIII) and 15 Panel Map Sheets included with this report. The Panel Map Sheets have been included as Enclosures 1-15. Appendix I-VIII and Enclosure 1-15 have been submitted as stand-alone digital files.

Table 1.1 – Acronym Definitions

Acronym	**Definition**
ASI	Archaeological Services Inc.
B&V	Black and Veatch
CD	Chart Datum
CHS	Canadian Hydrographic Service
CSR	Canadian Seabed Research Ltd.
DFO	Department of Fisheries and Oceans
DGPS	Differential Global Positioning System
ft	Feet
GIS	Geographic Information System
GLERL	Great Lakes Environmental Research Laboratory
GPS	Global Positioning System
GSC	Geological Survey of Canada
HVDC	High Voltage Direct Current
HPR	Heave, Pitch and Roll
IGLD	International Great Lakes Datum
ITC	ITC Lake Erie Connector LLC
ka	Thousands of years before present
kHz	Kilohertz
km	Kilometre
KP	Kilometre Posting
KPa	Kilo-Pascal

Acronym	Definition
LEC	Lake Erie Connector
LPE	Long Point Escarpment
m	Metre
ma	Million years before present
m	Metres
MPa	Mega-Pascal
msec	Millisecond
NRC	Natural Resources Canada
NAD	North American Datum of 1983
Mi	Mile
NOAA	National Oceanic and Atmospheric Administration
OGS	Ohio Geological Survey
OPG	Ontario Power Generation
PC	Personal Computer
RD	Route Deviation
RMS	Root Mean Square
ROV	Remotely Operated Vehicle
RPL	Route Position List
RTK	Real Time Kinematic
SBP	Sub-Bottom Profiler
SGY	Society of Exploration Geophysicists Data Format
SSS	Sidescan Sonar
SVP	Sound Velocity Profile
TPU	Transceiver and Processing Unit
US	United States
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
ya	Years before present

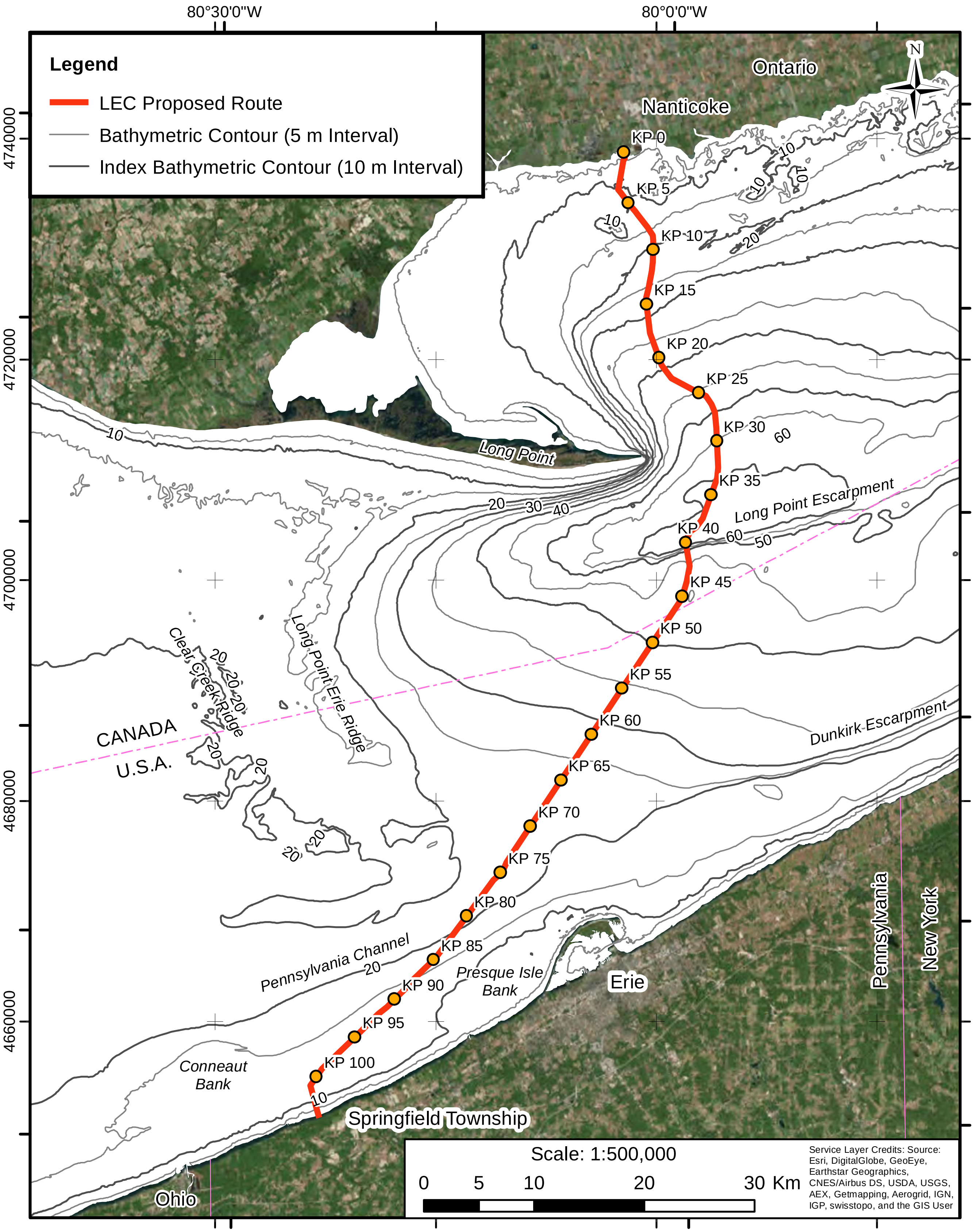


Figure 1.1.1 - LEC Proposed Route.

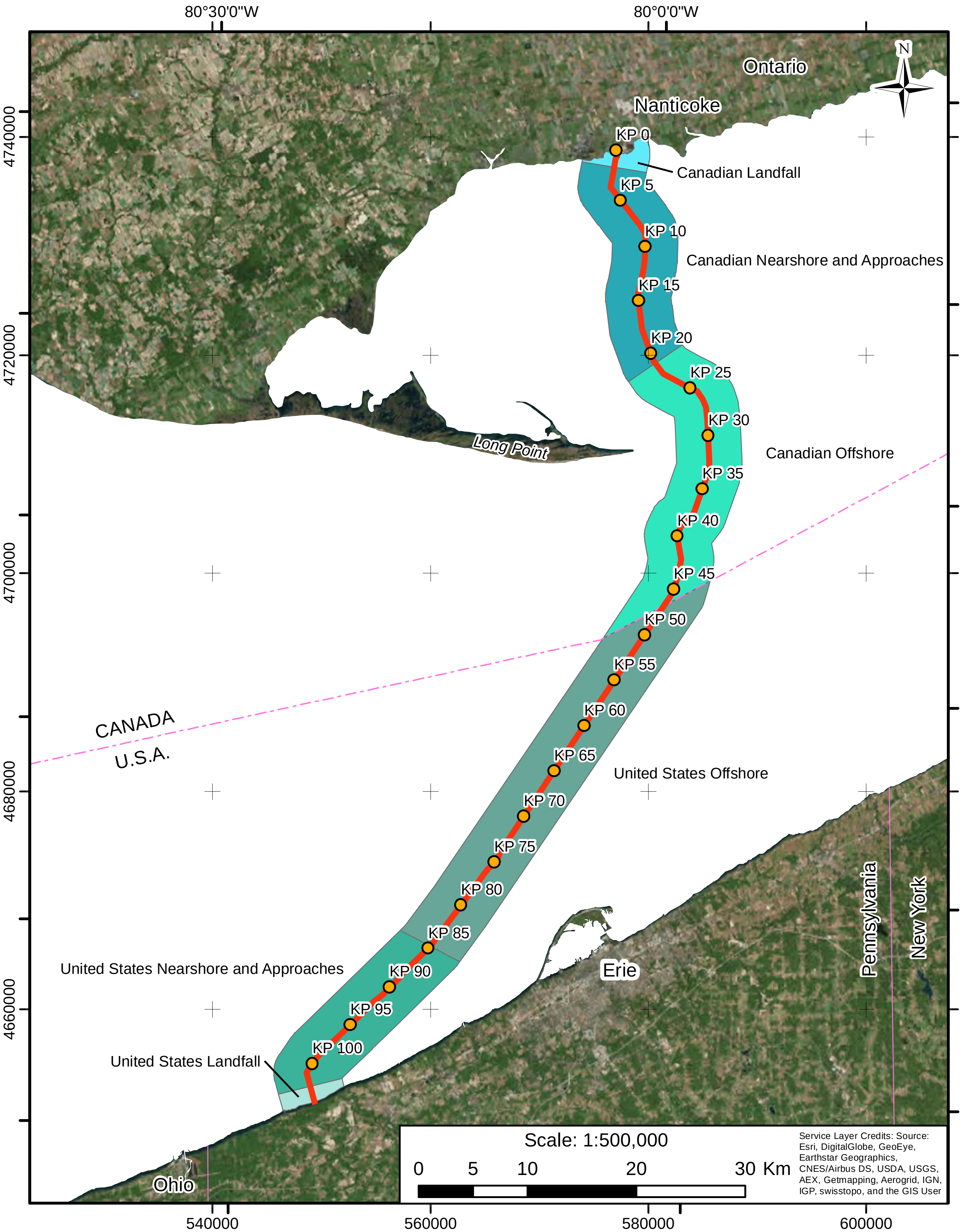


Figure 1.1.2 - LEC Survey Centreline route sections.

2.0 REGIONAL SETTING

Lake Erie is the second smallest (25,000 km^2) in area and the smallest (484 km^3) in volume of the Laurentian Great Lakes. It is also the shallowest Great Lake with a mean water depth of 19 m and maximum depth of 64 m. Lake Erie extends 141 km along an east-northeast axis and is approximately 34 km at the maximum width.

Lake Erie receives most of its inflow (approximately 90%) from the three upper Great Lakes (Superior, Michigan, and Huron) via connecting channels from southern Lake Huron. The connecting channels include St. Clair River, Lake St. Clair, and Detroit River. Overflow from Lake Erie's Eastern Basin drains via the Niagara River. A bedrock sill at the head of the Niagara River is the principal control of the lake level.

Although Lake Erie is noted for shallow depths and gentle bottom relief, it is divided into the Eastern, Central and Western Basins by two glacial terminal moraines composed of sand, gravel, and clay deposits. The locations of the basins are displayed in Figure 2.1. The Pelee moraine separates the Western and Central Basins while the Norfolk Moraine separates the Central and Eastern Basins, see Figure 2.2. The Norfolk moraine extends across Lake Erie from Long Point to the Pennsylvania Channel and is made up of the Long Point – Erie Ridge, the Clear Creek Ridge and the Pennsylvania Ridge, see Figure 2.3.

The Eastern Basin is best known for its deep water, its depositional environment and the potential for thicker fine-grained sediments. Along the eastern Canadian shore, a thin veneer of glacial drift covers relatively resistant limestone and dolomite forming a jagged coastline. Irregularities similar to that of the coast are observed lakeward as ridges and valleys. The Long Point Escarpment is one such feature that strikes in the same direction as the shoreline and is thought to delineate the boundary between a resistant lower Devonian limestone and softer less resistant upper Devonian shale.

The American shoreline of the Eastern Basin is much straighter than the Canadian shore and is nearly void of coves and inlets. Shore erosion in the zone of high wave energy has altered and reshaped the glacial drift and soft shales which characterize the American Lake Erie shoreline. This has resulted in the steepening, deepening and straightening within the nearshore zone. The onshore and nearshore sediment material eroded during this process are deposited further offshore (Holcombe et. al., 2005). A large portion of the Springfield Township bluffs have high rates of retreat (0.6–0.8 m/yr). Predominant littoral transport rates along the Pennsylvania shorelines are from east to west (Hapke et. al/,2009). Sediment transport within the lake is the result of both currents and storm related events. Numerous sediment transport features (consisting of mainly sand) have been observed in US waters offshore Erie, Pennsylvania. Sediment resuspension has been measured in the lake at a depth of 24 m.

Currents in Lake Erie generally flow from west to east, transporting water from Lake Huron to Lake Ontario. The majority of the water flow is along the southern portion of the lake through the Pennsylvania channel, evidenced by the smooth nature of the southern coastline. Secondary current patterns in Lake Erie are separate oscillatory trends in each of the three major basins. Though Lake Erie does not experience tides, the lake is a large enough body of water to experience substantial and regular surface seiches. Seiches are free oscillations of the lake surface that last about 14 hours when occurring along the long axis of the lake. This phenomenon occurs when winds or barometric conditions cause the lake surface to be tilted. The water then sloshes back and forth, eventually subsiding due to friction. Lake Erie is particularly prone to wind-caused seiches because of its shallowness and its elongation on a northeast-southwest axis, which frequently matches the direction of prevailing winds and therefore maximizes the fetch of those winds. These can lead to extreme seiches of up to 5 m (16 feet) between the ends of the lake.

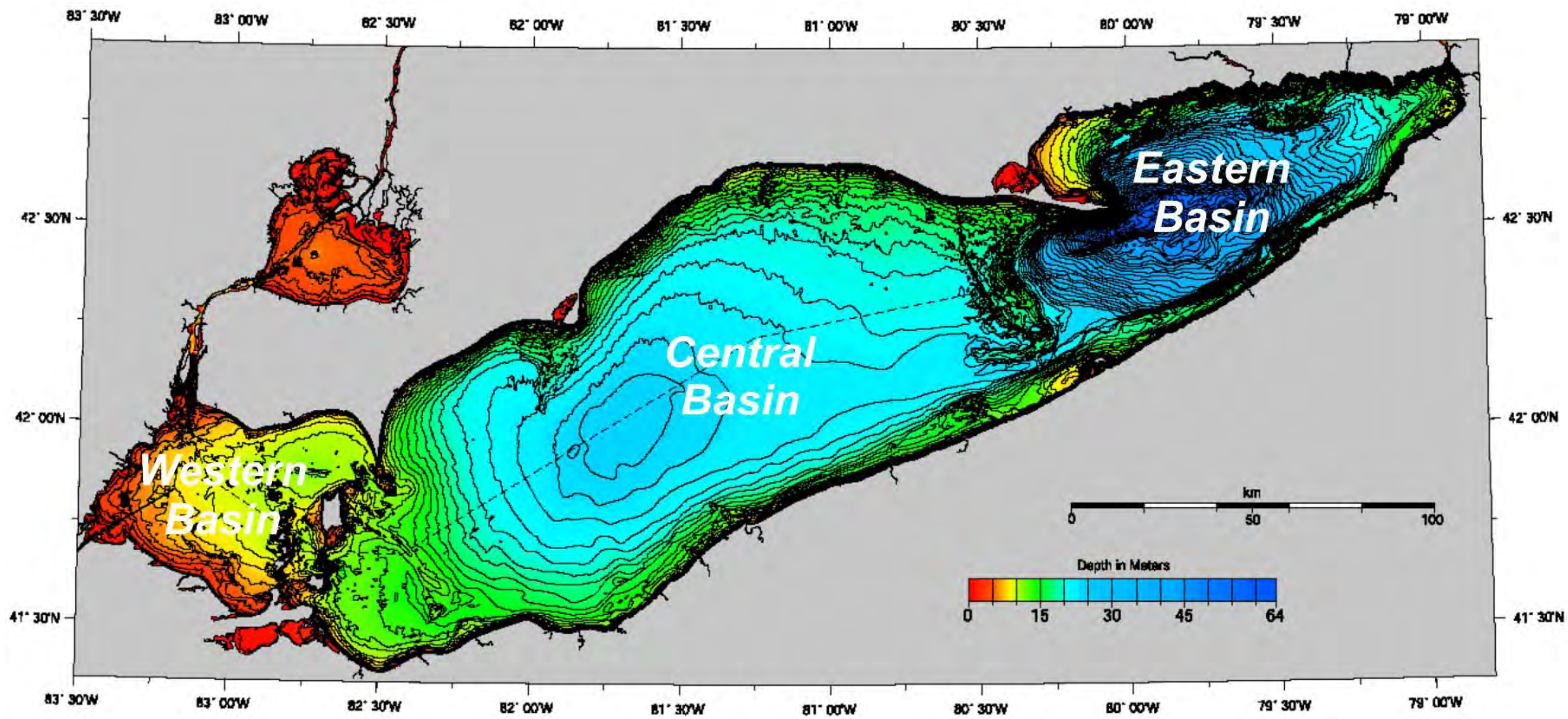


Figure 2.0.1 – Bathymetry of Lake Erie illustrating the locations of the Western, Central and Eastern Basins, from Holcombe et. al. (2005).

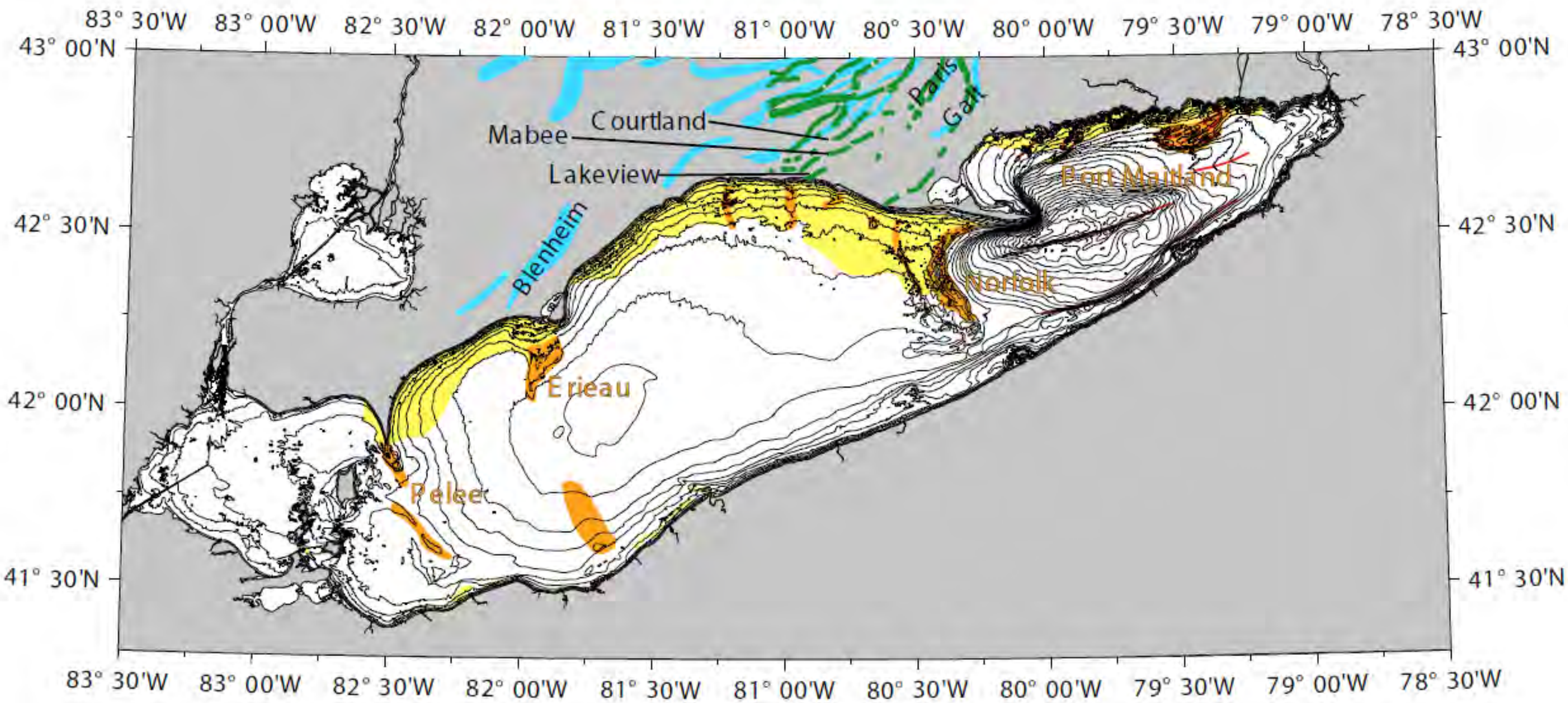


Figure 2.0.2 – Glacial Moraine locations within Lake Erie. The Pelee and Norfolk Moraines separate the three main basins. Areas where glacial drift is known to outcrop are shown in yellow (adapted from Rukavina, (1976) and Fuller and Fostwer (1998)). Southern Ontario onshore moraines from are displayed in blue (from Chapman and Putnam, 1961) and green (from Barnett, 1998), from Holcombe et. al. (2005).

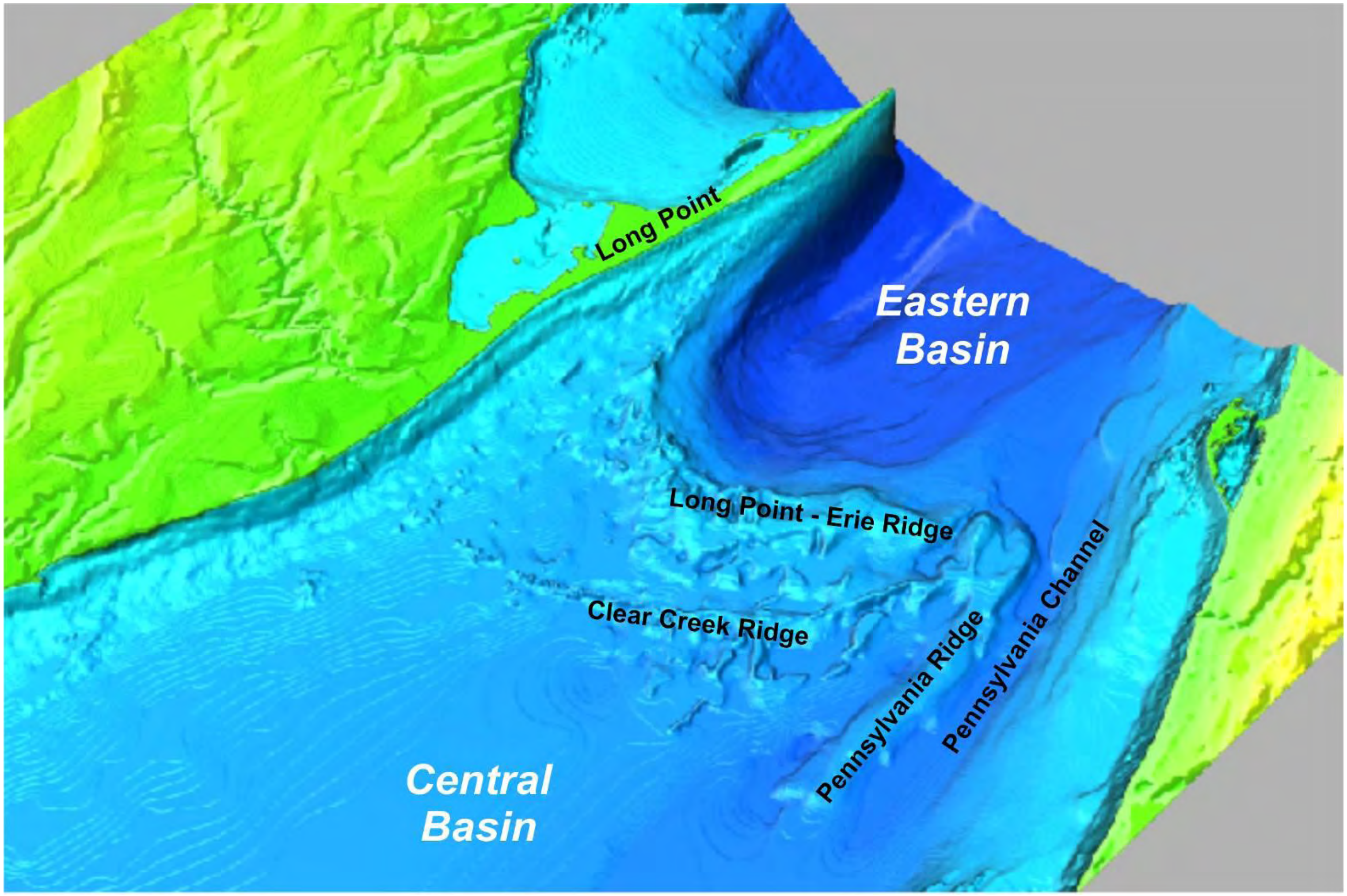


Figure 2.0.3 – Location of the ridges which make up the Norfolk terminal moraine, modified from Holcombe et. al. (2005).

2.1 Bedrock (Devonian) Geology

The geological history of Lake Erie and surrounding region began with recurring periods of deposition which included a variety of shallow marine, coastal and non-marine sedimentary rocks throughout most of Paleozoic time (250-500 ma).

Lake Erie itself is underlain by approximately 300 m of gently southward dipping Silurian and Devonian (350-400 ma) clastic (Shale) and carbonate (Limestone) strata. A simplified geological section across Lake Erie is displayed in Figure 2.1.1. Within the western portion of the lake the bedrock dips westward reflecting the structure of the Michigan Basin (Cameron, 1991). Devonian age shale bedrock dominates the Pennsylvania Lake Erie shoreline while Devonian limestone and dolomite occur within the Western Basin islands area and along the north shore of the Eastern Lake Erie Basin. Limestone and Dolomite are more resistant to erosion and form positive bedrock relief features within these areas.

During the Mesozoic and Cenozoic periods (250 ma to present), the region was elevated and exposed. It is generally believed that the bedrock surface was subjected to episodic or continual long-term erosion through the drainage of a river system and subsequent glacial activity played a major role in the shaping of the underlying bedrock (Cameron, 1991). There is evidence of pre-glacial drainage channels incised into the bedrock of the region. Pre-glacial drainage has been inferred beneath the shallow western end of Lake Erie, but glacial processes have removed evidence of these channels in the Central and Eastern Basins (Cameron, 1991). The bedrock was eroded by this sub-aerial exposure as well as by glaciers during the Wisconsinan period. As a result of these processes, the soft upper Devonian shale overlying the limestone was locally eroded throughout the Canadian Lake Erie Eastern Basin. The bedrock in the Eastern Basin is now in subsequent isostatic rebound. Glacial loading 13,000 to 16,000 years ago pushed down the tectonic crust under Lake Erie. The upward shifting or rebound of the stress relieved bedrock is being expressed as minor faults, fracture zones and the upward tilting of southern Ontario bedrock (Lambert and Vanicek, 1979). In the Eastern Basin the effects of isostatic rebound are said to be lessened by considerable infill of greater than 100 metres of glacial and post glacial sediments (Sly, 1976).

Generalized mapping of bedrock geological boundaries beneath Lake Erie have been compiled by Sanford and Baer (1981). Bedrock outcrop is generally limited to the inner one to five kilometres of the Lake Erie nearshore area.

2.1.1 Canadian Landfall

Bedrock at the Canadian Landfall is mainly composed of resistant Devonian cherty limestone (Dundee Limestone). Dundee limestone is defined as fine to medium crystalline brownish grey, medium to thick bedded dolomitic limestone with shaly partings, sand layers and local chert. The limestone outcrops intermittently along the eastern Canadian Lake Erie shore and dips gently southward (Carter, et al., 1987; Rickard and Fisher, 1970; Freeman, 1978; Sanford and Baer, 1981; Bolsenga and Herdendorf, 1993) at a slope of approximately 3.5 m/km. Nearshore the bedrock is generally covered by a veneer of glacial drift and intermittent sand. Bedrock ridges parallel to the shoreline can extend 2-4 km offshore to water depths of 5-10 m (Holcombe et. al., 2005). These ridges generally occur east of Nanticoke.

2.1.2 Offshore Lake Erie

Within the offshore area bedrock is overlain by a sequence of glacial and post glacial sediments. The north-facing Long Point Escarpment has relief of 15-20 m and extends longitudinally East-West approximately 50 km along the lakebed, see Figure 1.1.1. The escarpment has variable cover of silt and clay up to 70-80 m. Regional seismic reflection records show that the escarpment in the deepest part of the Eastern Basin mimics the underlying bedrock topography through differential compaction of overlying sediments (Cameron, 1991). The underlying bedrock lies 50-100 m below the present lakebed (Holcombe et. al, 2005), see Figure 2.1.2.

The escarpment probably lies along a boundary separating more resistant Devonian limestone and less resistant marine shales to the north. An alternative theory is the escarpment may coincide with a paleo-fault (Holcombe et. al, 2005). The escarpment also parallels the inferred direction of glacial ice movement. The glacial ice and meltwater likely further eroded the less resistant shale and possibly smoothed the more resistant limestone to the south.

2.1.3 United States Landfall

At the United States Landfall, the bedrock is mainly composed of Upper Devonian formations Girard shale and/or Northeast shale. The Girard shale is generally grey flaky shale while the Northeast shale is medium grey with thin siltstone and fine grained sandstone interbeds. The Northeast shale lies in a band along the Lake Erie shoreline. The unit thins and narrows to the west and is not exposed at the Ohio State line. The Girard shale overlies the Northeast shale and ranges in thickness from 50-200 feet. It forms a band roughly parallel to the Lake Erie shoreline widening and thickening to the west.

Shale bedrock extends 1-2 km offshore and is generally covered by a thin (<0.5 m) intermittent veneer of till, sand, or silt/clay. Cobbles and boulders may also be present. The bedding is relatively flat lying and the bedrock surface has a gentle slope to the north.

2.2 GLACIAL & POST GLACIAL (QUATERNARY) GEOLOGY

During the Quaternary (2 ma to present), the Lake Erie region underwent repeated episodes of glacial erosion and deposition associated with successive advances and retreats of glacial (Laurentide) ice sheets. Present day lakebed topography is the result of these repeated episodes of erosion of unconsolidated sediment deposits and bedrock, as well as re-deposition of the sediment during and after glaciation. The last ice advance, approximately 13,000 ya, reached into Lake Erie's Eastern Basin depositing glacial drift along the basin edges and bedrock highs. This last advance also deposited fine grained proglacial lake sediment into the deeper parts of the basin. The Long Point-Erie Ridge (Norfolk Moraine), which divides the Eastern Basin from the rest of the lake, has been interpreted as a terminal moraine formed during the last advance of glacial ice into the Eastern Erie Basin (see Figure 2.3). The upper surface consists of glacial clay and is capped with sand and gravel. The sand deposit is believed to have originated as a beach deposit during lower lake levels.

The post glacial period, defined as the Holocene, started when the glaciers began to retreat. Early Lake Erie came into existence about 12,500 ya when water levels were approximately 30 m higher than the present lake level. High lake levels in the Eastern Basin were maintained between 12,500 and 10,500 ya which resulted in continued deposition of fine grained sediment into the deepest part of the basin over glacial till.

At 10,500 ya the lake level began to fall which sub-aerially exposed the glacial and post glacial sediments such as those that form the Norfolk and Pelee moraines. Long Point-Erie Ridge which forms part of the Norfolk moraine extended across the width of the lake at low lake level, which allowed the Pennsylvania channel to balance water flow between the Eastern and the Central Basins (Cameron, 1991). Beach sand deposits were formed during this time at the paleo shoreline which was located at approximately 30 to 40 m present water depth. Fine grained sediments (clay/silt) continued to be deposited over glacial till in water depths > 40 m during this period especially in the deep Eastern Basin (Cameron, 1991). An erosional unconformity was developed during this time which separates the glacial and post glacial sediments. Lake Erie reached present levels beginning 9,000 – 10,000 ya (Barnett, 1985) which coalesced the water bodies of the three Lake Erie Basins (Cameron 1991). The deposition of fine grained sediment into the Eastern Basin continued during this time

The seismic stratigraphy of Lake Erie's Eastern Basin consists of two sequences separated by an erosional unconformity above 35 m water depth (Cameron, 1991). The lower sequence which overlies bedrock includes glacial till and glacio-lacustrine sediment. This lower sequence is overlain by post glacial sediments composed of clay, silt, and sand which have been influenced by fluctuating post glacial lake levels between 10,500 ya and the present (Cameron, 1991).

The glacial tills and glacio-lacustrine clays are similar in grain size. They are either red or brownish grey, cohesive, uniform in appearance and have abundant amounts of clay. The glacial till is interpreted to have formed as a result of subglacial melt-out and consists of gravel, sand and silt. The glacial till may also contain local areas of cobble and boulders. The glacio-lacustrine sediments which overlie the glacial till consist of laminated silt and clay but may contain local zones of sand and/or gravel.

2.2.1 Canadian Landfall

Onshore the overburden is composed of glacio-lacustrine clay (Haldimand Clay) which is massive to laminated and varved with occasional sand and gravel (ODM Map 2369, 1976). This unit was formed in a deep water glacial lake environment. It is underlain in some places by glacial till, which may vary in texture from silty sand to silty clay. Glacial sediments onshore at the landfall location range from 1 m to 8 m.

Glacial till within the nearshore areas is mainly comprised of silt and clay, however sandy material as well as gravel, cobbles and boulders also occur. This unit ranges in thickness from 3-5 m to a veneer (<0.5m) over bedrock within the Canadian nearshore area. Post glacial sediments within the Canadian Landfall range from clay to silt further offshore.

2.2.2 Offshore Lake Erie

Within the offshore area glacial sediments are generally overlain by a sequence of post glacial sediments composed of silt and clay. Within localized areas glacio-lacustrine sediments may occur at or near the lakebed surface. The lakebed in water depth greater than 30 m is covered with a soft dark grey silty clay or clay.

2.2.3 United States Landfall

Onshore the western portion of the shoreline from Conneaut Harbor to Presque Isle consists of underlying, somewhat stable, shale overlain by a glacial till unit, a laminated clay unit and a lacustrine sand/gravel unit, (Knuth 2001, Amin 1989, and D'Appalonia 1978). The bluffs along this shoreline typically have fairly uniform heights and stratigraphy (Knuth 2001).

Glacial till within the nearshore areas consists of a mixed composition comprised of silt, clay and sand, as well as gravel, cobbles and boulders. This unit commonly occurs as a veneer over bedrock within the United States nearshore area. Further offshore within the Pennsylvania Channel the lakebed consists of post glacial sand with a silt and clay component.

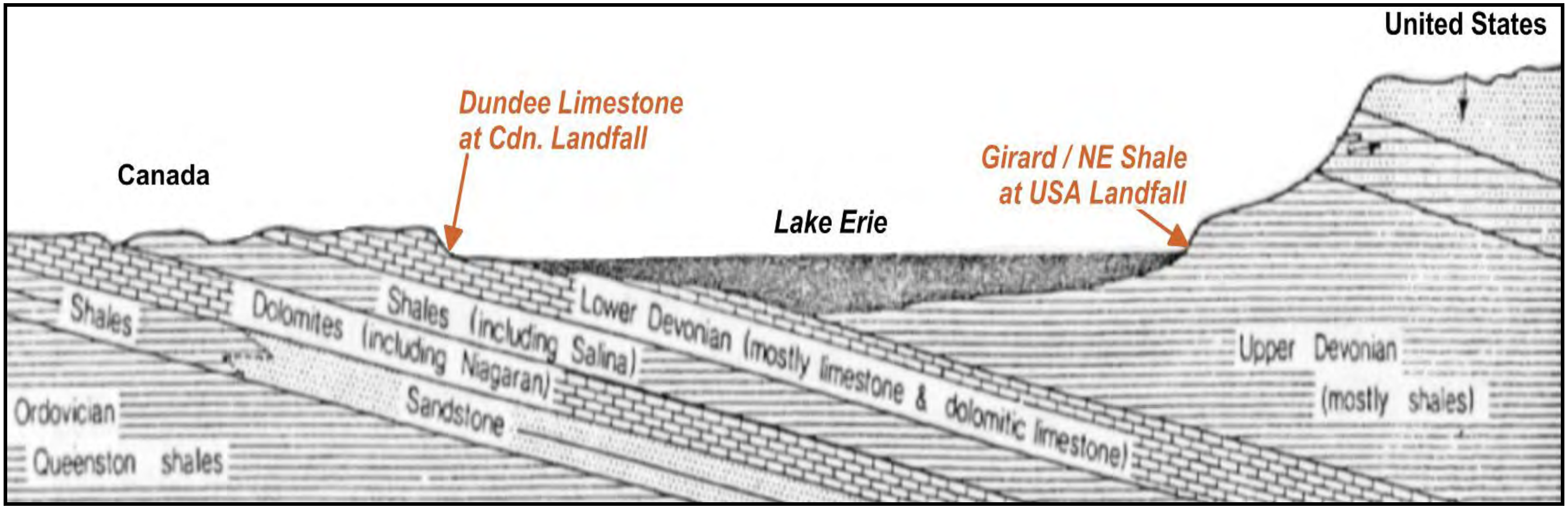


Figure 2.1.1 – Simplified bedrock stratigraphy across Lake Erie's Eastern Basin (from Hough 1958).

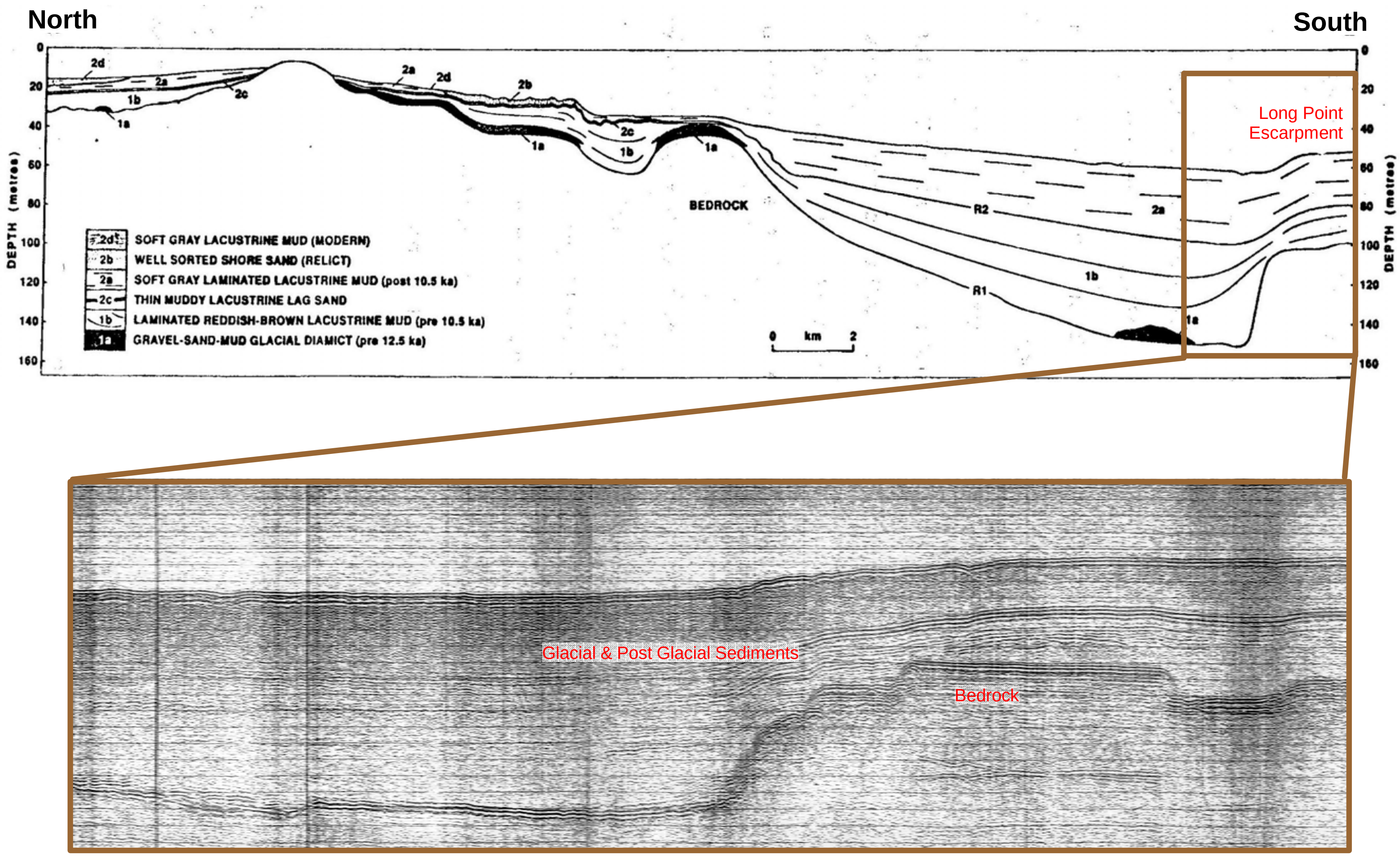


Figure 2.1.2 - Generalized cross-section of Glacial & Post-Glacial sediment over bedrock within the Canadian Eastern Basin (top) and seismic record acquired by the GSC in 1967 over the Long Point Escarpment (bottom). Generalized cross section obtained from Cameron (1991).

3.0 SURVEY OPERATIONS

The cable route marine geophysical survey was conducted during the fall of 2014 and the spring/summer of 2015. The 2014 survey was conducted from Nadro Marine's vessel *VAC* (Figure 3.1) and included the areas from the Canadian Nearshore to KP 21.00 and from KP 84.75 to the United States Nearshore area. Also during the fall 2014 survey, regional lines were surveyed over the Long Point Escarpment in order to evaluate the slope gradient and seabed geology of the escarpment.

The 2015 Landfall and Offshore surveys were conducted from CSR's survey launch *Seabed* and the *VAC* (Figure 3.2) respectively. Acquisition of data at the Canadian and United States Landfalls was completed between June 11th and June 30th from *Seabed*. Offshore operations were conducted between July 1st to August 23rd from the *VAC*. The offshore survey covered from KP 21.00 to KP 84.75. A 200 m corridor from the Canadian Nearshore to KP 21.00 and from KP 84.75 to the United States Nearshore area was also surveyed in 2015 from the *VAC*.

Nadro Marine's tug *VAC* has an overall length of 19.81 m (65') with a beam of 6.4 m (21') and is powered by three Detroit Diesel engines with a maximum output of 1000 horse power. The *VAC* is an ideal platform for conducting marine surveys in open water such as Lake Erie. It is outfitted with a 3-ton hydraulic crane which works well for deploying and retrieving geophysical equipment. CSR installed an over-the-side mounted high frequency single beam and multibeam transducer on the *VAC*. The open back deck of the vessel provided a large area for mounting winches, generators and storing equipment. Electronic equipment and data collection workstations were setup in the vessel's galley.

Figure 3.1 – Offshore geophysical survey operations were performed from the *VAC*

Seabed (Rosborough RF-18) is an ideal platform for conducting shallow water surveys. The vessel is small enough to be launched and operated in nearshore areas where shallow water survey data is required. The vessel has an enclosed wheel house and cuddy for housing electronic equipment. The vessel has an open back deck with a platform for mounting generators and secure over-the-side mounts for multibeam and single beam transducers. A custom aluminum A-frame for towing equipment also enhances the operational capabilities of the vessel.

Figure 3.2 – Landfall Geophysical Survey Operations were performed from the survey launch *Seabed.*

3.1 Survey Program

A summarized survey operation daily log is presented in *Appendix I – Daily Field Log*. The equipment towing configuration and vessel offsets can be found in *Appendix II – Vessel Offsets*. CSR mobilized the survey vessel *VAC* with positioning and geophysical equipment at Nadro Marine's dock in Port Dover, Ontario. *Seabed* was mobilized at Hoover's Marina in Nanticoke, Ontario. Survey operations were conducted during daylight hours with three CSR personnel for the offshore geophysical survey and two survey crew members for the Landfall surveys, see Table 3.1.1. The *VAC* operated from Port Dover (Ontario) and Erie (Pennsylvania) and Seabed operated from Nanticoke (Ontario) and Elk Creek (Pennsylvania).

Table 3.1.1 – CSR Survey Personnel

Name	Function	Affiliation
Colin Toole	Party Chief	CSR
Luke Melanson	Hydrographic Surveyor	CSR
Matt Savelle	Hydrographic Surveyor	CSR
Nick Wilmshurst	Electronics Technician	CSR
Scott Brown	Captain	Nadro Marine
Tim Ramm	Deckhand	Nadro Marine

3.2 Survey Reference

Horizontal positioning on each vessel was calculated using DGPS. The primary Coast Guard differential corrections were acquired from Youngstown, NY reference station. The geodetic parameters for the survey were as follows.

Vertical Datum:	Lake Erie Chart Datum (173.5 m or 569.2 ft. above IGLD 1985)
Horizontal Datum:	NAD83
Projection:	Universal Transverse Mercator, Zone 17
Central Meridian	81°W
False Easting:	500000.00
False Northing:	0.000000
Scale Factor:	0.999600
Latitude of Origin:	0.0
Linear Unit:	Metre

3.3 Survey Equipment

This section describes the positioning, bathymetry and geophysical equipment utilized during the survey. A summary of the equipment mobilized for each survey follows.

VAC – Fall 2014

SURVEY NAVIGATION
Hemisphere R100 DGPS Receiver
HYPACK Survey Navigation Software

SINGLE BEAM ECHOSOUNDER
Odom CV3 Dual Frequency Echosounder (50/200 kHz)
Applied Microsystems SVP
TSS Motion Sensor

SIDESCAN SONAR
Klein 3000 (100/500 kHz) Sidescan Sonar System
SonarPro Sidescan Acquisition Software

MAGNETOMETER
Marine Magnetics SeaSPY Marine Magnetometer

SEISMIC REFLECTION
EG&G 240 Low Frequency (400-14,000 Hz) Shallow Seismic System (Boomer)
Applied Acoustics CSP-300 Power Supply
Ministreamer with GeoSpectrum M5 Hydrophones
SonarWiz SBP Acquisition & Processing Software

Seabed – Spring/Summer 2015

<u>SURVEY NAVIGATION</u>
Hemisphere R100 DGPS Receiver
HYPACK Survey Navigation Software

<u>SINGLE BEAM ECHOSOUNDER</u>
Odom CV100 Dual Frequency Echosounder (33/200 kHz)
Odom Digibar SVP
TSS Motion Sensor

<u>SIDESCAN SONAR</u>
Klein 3000 (100/500 kHz) Sidescan Sonar System
SonarPro Sidescan Acquisition Software

<u>MAGNETOMETER</u>
Marine Magnetics SeaSPY Marine Magnetometer

<u>TIDE GAUGE</u>
HOBOware U20 Titanium Water Level Data Logger

VAC – Summer 2015

<u>SURVEY NAVIGATION</u>
Trimble 5700/5800 RTK-DGPS System
Hemisphere R100 DGPS Receiver
Hemisphere VS-330 GNSS Receiver & Survey Compass
HYPACK Survey Navigation Software

<u>MULTIBEAM ECHOSOUNDER</u>
Odom MB1 Survey Grade Multibeam Echosounder (170 to 220 kHz)
Teledyne-TSS DMS-05 Motion Sensor
Teledyne-Odom DigiBar-Pro Velocimeter
Applied Microsystems SVP
HYSWEEP Multibeam Acquisition System

<u>SIDESCAN SONAR</u>
Klein 3000 (100/500 kHz) Sidescan Sonar System
SonarPro Sidescan Acquisition Software

<u>MAGNETOMETER</u>
Marine Magnetics SeaSPY Marine Magnetometer

<u>SUB-BOTTOM PROFILER</u>
Klein 3000 Chirp Profiler (2-8 kHz)

TIDE GAUGE
HOBOware U20 Titanium Water Level Data Logger

3.3.1 Survey Positioning

Hemisphere VS-330 GNSS Navigation System
A real-time differential GPS system was utilized during the multibeam survey. CSR's integrated navigation system consisted of a *Hemisphere VS-330* DGPS system and the Hypack survey navigation package. The integrated navigation system included real time digital data logging of positional data, a left/right steering monitor for the helmsman, and an interface to the geophysical equipment so that all data was correctly geo-referenced. The *Hemisphere VS-330* is a dual antenna GPS system with a horizontal accuracy of 0.3 metres under ideal conditions. The secondary antenna (forward) is used to calculate heading to an accuracy of 0.09° RMS. The system was configured to receive Coast Guard differential corrections from Youngstown, NY which operates on a transmission frequency 322 kHz.

Positions for the multibeam bathymetry were calculated based on the offset from the primary Hemisphere GPS antenna (aft), to the multibeam transducer. Differential GPS positioning combined with vessel heading and offset measurements were also used to geo-reference the sidescan sonar and seismic data collected during the survey. Layback measurements were recorded by the operator during the survey for each line with offset corrections applied during processing and interpretation.

Figure 3.3.1 – Location of the Hemisphere GNSS antennas in relation to the multibeam over the side mount.

Hemisphere R100 DGPS
The Hemisphere R100 DGPS system was used during the fall 2014 survey and spring/summer 2015 Landfall survey. The system was configured to receive Coast Guard differential corrections from Youngstown, NY which operates on a transmission frequency 322 kHz. The Hemisphere R100 is a single antenna GPS system with a horizontal accuracy of 0.6 metres under ideal conditions.

Positions for the single beam bathymetry were calculated based on the offset from the Hemisphere GPS to the transducer. Differential GPS positioning combined with vessel heading and offset measurements were also used to georeference the sidescan sonar and sub-bottom data collected during the survey. Layback measurements were recorded by the operator during the survey for each line with offset corrections applied during processing and interpretation.

Trimble RTK
Vessel offsets and water level heights were acquired using a Trimble 5700/5800 RTK-DGPS system, see Figure 3.2.2. RTK-GPS accuracy depends on conditions such as multipath, obstructions, satellite geometry, atmospheric parameters and base station control quality. Under ideal conditions the system accuracy is as follows.

- Horizontal accuracy: 10 mm + 1ppm RMS
- Vertical accuracy: 20 mm + 1ppm RMS

Figure 3.3.2 – Trimble RTK base station setup.

Hypack/Hysweep Survey Acquisition Software
Hypack is a complete hydrographic survey navigation software package that includes: survey preparation, data collection, data editing, cross-section display, geodesy and exporting capabilities. In operational survey mode, the system supports a helmsman

display with survey line indicator, to assure survey lines are followed as accurately as possible. In addition to planned survey grid lines, the survey screen also displays bathymetric contours, coastline, navigational hazards, and target/sample locations. During survey operations, all navigation information was logged in Hypack to ensure simultaneous geo-referencing of all datasets.

3.3.2 Bathymetry Systems

Single beam Echosounder

Depth soundings were obtained using an Odom CV3 and CV100 single beam echosounder during the *VAC* 2014 and *Seabed* 2015 surveys respectively. The CV3 system included a dual frequency 50/200 kHz transducer mounted over the starboard side of the vessel (Figure 3.3.3). The CV100 system included a dual frequency 33/200 kHz transducer, see Figure 3.3.4. The topside control units processed the raw acoustic data and transmitted the raw depth readings to the recording computer running Hypack. The system was calibrated using sound velocity casts and the bar check method. The transducer depth was measured and the draft offset entered directly into the echosounders. Offsets from the DGPS antenna to the sounder transducer were applied within Hypack's single beam editor during post processing.

The water depth was determined from the 200 kHz data while the 33 and 50 kHz data provided information on the sub-surface geology as the lower frequency is able to penetrate fine grained sediment.

Vessel motion was recorded during the bathymetric survey using a TSS HPR (heave, pitch roll) sensor. This data, including sensor offset values, were applied to the bathymetry data during post processing

Sound velocity profiles were collected each day during the bathymetric survey using either a Teledyne-Odom Digibar SVP or an Applied Microsystems SVP Velocimeter. This information was applied to the bathymetric data set during post processing.

Figure 3.3.3 – CV3 single beam 50/200 kHz transducer and over-the-side mount location on the *VAC*.

Figure 3.3.4 – CV100 Single beam 33/200 kHz over-the-side mount location on Seabed.

Teledyne-Odom Multibeam Echosounder

Bathymetry was collected using an Odom MB1 multibeam echosounder. This multibeam operates at a user selectable frequency between 170 to 220 kHz, and a maximum swath width of 120 degrees. The system is capable of surveying the seafloor to a depth of 240 metres (at nadir) and has a maximum ping rate of 60 Hz. Note that the ping rate varies with depth.

The Odom MB1 multibeam system requires input from other sensors measuring variables such as vessel motion, navigation, and sound velocity. The MB1 system includes an internal sound velocity probe at the multibeam sensor head. The transducer depth was measured and the draft offset entered directly into the echosounder. Horizontal offsets from the DGPS antenna to the sounder transducer were entered into Hypack in order to calculate exact positions of the bathymetric data. The over the side multibeam mount is illustrated in Figure 3.3.5 and the location of the DMS-05 motion sensor is displayed in Figure 3.3.6.

Figure 3.3.5 – MB1 multibeam transducer over-the-side mount location on the *VAC*.

Figure 3.3.6 – MB1 multibeam transducer and DMS-05 motion sensor location on the *VAC*.

3.3.3 Sidescan Sonar

Acoustic imaging in the marine environment is used to provide wide area, high resolution images of the lakebed. The sidescan sonar data acquired allowed for the mapping and detection of objects on the lakebed at a resolution of approximately 0.1 metres in ideal conditions. With this magnitude of resolution, remote seabed interpretation can be achieved.

CSR provided a Klein 3000 dual frequency SSS system to complete the seabed imaging component of the LEC cable route assessment. The Klein 3000 consisted of a sonar instrumented towfish, a transceiver and processing unit (TPU) and a Windows based control unit computer running Klein's proprietary Sonar Pro acquisition software. Capable of simultaneous dual frequency operation (100/500 kHz) and constructed with advanced electronics and transducers, the Klein 3000 produced superior high resolution imagery of the seafloor. High frequency (500 kHz) ranges of between 75 and 200 metres on both the port and starboard channels allowed for wide area swath coverage and target detection over the route.

Frequency:	100 kHz and 500 kHz
Range Setting:	75 m and 100 m range; 200 m for regional LPE area
Target Resolution:	10-20 cm in ideal conditions
Rationale:	100% seafloor coverage; target detection & surficial geology mapping

During the 2015 *VAC* survey, the sidescan system was integrated with the Klein 3000 chirp profiler and marine magnetometer, see Figure 3.3.7. The towing configuration of the system from the *VAC* and Seabed are displayed in Figures 3.3.8 and 3.3.9 respectively.

Towing the Klein 3000 system has several advantages, including removing the sensor from the effects of the vessel motion and operating at a height above the seafloor which will optimize the acoustic returns. Layback was used to approximate the position of the SSS astern of the vessel. Layback is calculated using the offset between the navigation fix point and the sidescan sonar/chirp profiler tow point, the length of cable that has been deployed and the depth of the SSS below the surface. Using these parameters, the position of the towfish can be calculated using the Pythagorean Theorem. Where possible, feature matching between the sidescan, sub-bottom profiler and echosounder data was used to confirm layback calculations. Layback corrections were applied during interpretation and mapping of the data.

<u>SonarPro Acquisition Software</u>

SonarPro is a sidescan sonar acquisition software system, provided by Klein Associates Ltd. The program was used to operate the Klein 3000 sidescan sonar and chirp systems. The system provides navigational recording, target management, and real-time display of the sidescan data. SonarPro also provides the options to adjust the towfish sensors while data is being acquired; including range and transmit power, which is directly recorded with the raw data. The target management feature enabled the selection of seabed targets in both real-time and during playback following collection. The sidescan and chirp data were recorded to XTF format.

Figure 3.3.7 – Integrated Klein 3000 sidescan sonar, chirp and marine magnetics magnetometer.

Figure 3.3.8 – Klein 3000 sidescan sonar, chirp and magnetometer towing configuration on the *VAC*.

Figure 3.3.9 – Klein 3000 sidescan sonar and magnetometer towing configuration on seabed.

3.3.4 Marine Magnetometer

A marine magnetometer measures variations in the total magnetic field of the underlying seafloor. Magnetic fields are measured in Tesla (T) or more commonly NanoTesla (nT). Typically constructed in a towfish configuration, marine magnetometers are excellent at detecting the presence of ferrous iron on the seafloor. This results in a unique method of locating and mapping subsea features such as pipelines, shipwrecks, cables, metallic debris, etc.

CSR provided a Marine Magnetics SeaSpy Magnetometer for the survey, see Figure 3.3.10. The SeaSpy is a digital marine magnetometer that operates using an advanced Overhauser sensor. Measuring the ambient magnetic field using a specialized branch of magnetic resonance technology, the SeaSpy has an absolute accuracy of 0.2 nT. The sensor is capable of measuring a range of 18,000 nT to 120,000 nT in all directions resulting in no dead zones and reliable data.

During the 2015 *VAC* survey, the marine magnetometer was integrated with the Klein 3000 system, see Figure 3.3.7.

Figure 3.3.10 – Marine Magnetics SeaSpy magnetometer.

3.3.5 Sub-bottom Mapping Systems

Sub-bottom data was acquired using two systems, a shallow seismic system during the 2014 survey and a chirp profiler during the 2015 survey.

Shallow Seismic Boomer System

Sub-bottom data was collected as part of the fall 2014 geophysical survey using an *EG & G Boomer System* (Figure 3.3.11). The system was comprised of 4 separate components (boomer plate, power supply, hydrophone and recording computer). The energy source for the system was a CSP-P 350 power supply. The CSP-P supplied power to a 300 joule boomer plate which was towed in conjunction with a low frequency hydrophone streamer. The boomer plate was responsible for transmitting the sound energy through the water column and lakebed sediments. The hydrophone streamer received the reflected sound energy from the lakebed and transmitting the signal to the topside recording computer. The raw acoustic signal was recorded and processed on a topside computer running SonarWiz acquisition software. Acoustic frequency filters were applied to the raw data using both SonarWiz and an SPA-3a processing unit. The frequency filters essentially "cleaned" the data allowing for better visualization and interpretation of the sub-surface sediments. In addition to filter processing, the SPA-3a unit (made by IKB Technologies Ltd) also controlled the firing rate of the boomer system. Operating power was provided to the boomer system by a Honda EB5000 watt electrical generator supplying 240V.

SonarWiz is a sonar acquisition software package, provided by Chesapeake Technologies Inc. The program was used by CSR to process and record data acquired with the shallow seismic (sub-bottom profiler) system. DGPS positioning information was integrated with the data in real-time and recorded by SonarWiz in SGY format

Figure 3.3.11 – Shallow seismic boomer system

Chirp Profiler

The "chirp" sub-bottom profiler (SBP) is an upgrade option for the Klein 3000 SSS system. It mounts directly to the Klein 3000 tow vehicle and uses the existing physical connections and electrical communications to accommodate this added capability, see Figure 3.3.7. This option takes advantage of the existing Klein 3000 sidescan hardware by using the same tow cable, transceiver processor unit (TPU), PC workstation and towing systems. The "chirp" sub-bottom profiler consists of a subsea assembly used to contain the transmit projectors, receive hydrophone and SBP electronics. These components are enclosed in a fibreglass shroud with an integrated support structure to allow for combined transducer/electronics mounting and towing. The Klein 3000 tow vehicle installs into the rear portion of the shroud assembly where it interconnects with the SBP electronics. The amplifier modulates both amplitude and phase of the transmit waveform for pulse lengths up to 40 msec.

Specifications

Chirp Frequency: 2-8 kHz
Beam Angle: 20° along track; 40° cross track @ 5 kHz
Resolution: 12.5 cm or better
Power: 1 kwatt
Source Level: 204 db @ 1 m

3.3.6 Vibracorer

CSR conducted a vibracore sampling survey in conjunction with the marine geophysical survey during the summer of 2015. Field results from the vibracore program were used during the interpretation and mapping of the geophysical data. For this reason, the specifications for the vibracore have been included in this report

The Rossfelder P-3C modular vibracorer is the newest version of the P-3 vibracorer. It is designed for coring unconsolidated waterlogged sediments at sea, in lakes, rivers, harbours, ponds and wetlands. The P-3C pressure housing is rated for operation in depths down to 600m. The vibracorer head attaches to a 5 m long, 101.6 mm (4") diameter steel core tube. A core liner is inserted into the core tube, which is designed to collect the sediment sample. The vibracorer is supported by a buoyant frame which is optimal for an operation with limited deck space. The buoyant frame system consists of two thin wires held taunt underwater between the weight stand and the float package (Figure 3.3.12).

Specifications

Depth Capability: 600m
Vibrations per minute: 3,450vpm@60Hz or 2,850vpm@50Hz
Approximate weight: 68Kg in air, 32Kg submerged
Centrifugal Force

	At 60Hz	At 50 Hz
Low Setting	16 kN	10.9 kN
Med Setting	20kN	13.7 kN
High Setting	24kN	16.4 kN

The depth of the vibracorer head was measured using an in-house unit that relies on a MS5803-14BA pressure sensor. This pressure sensor is rated to ~130 m and can measure water pressure to the nearest centimetre. The unit is mounted to the head of the vibracorer and is designed to operate with a +5V power supply.

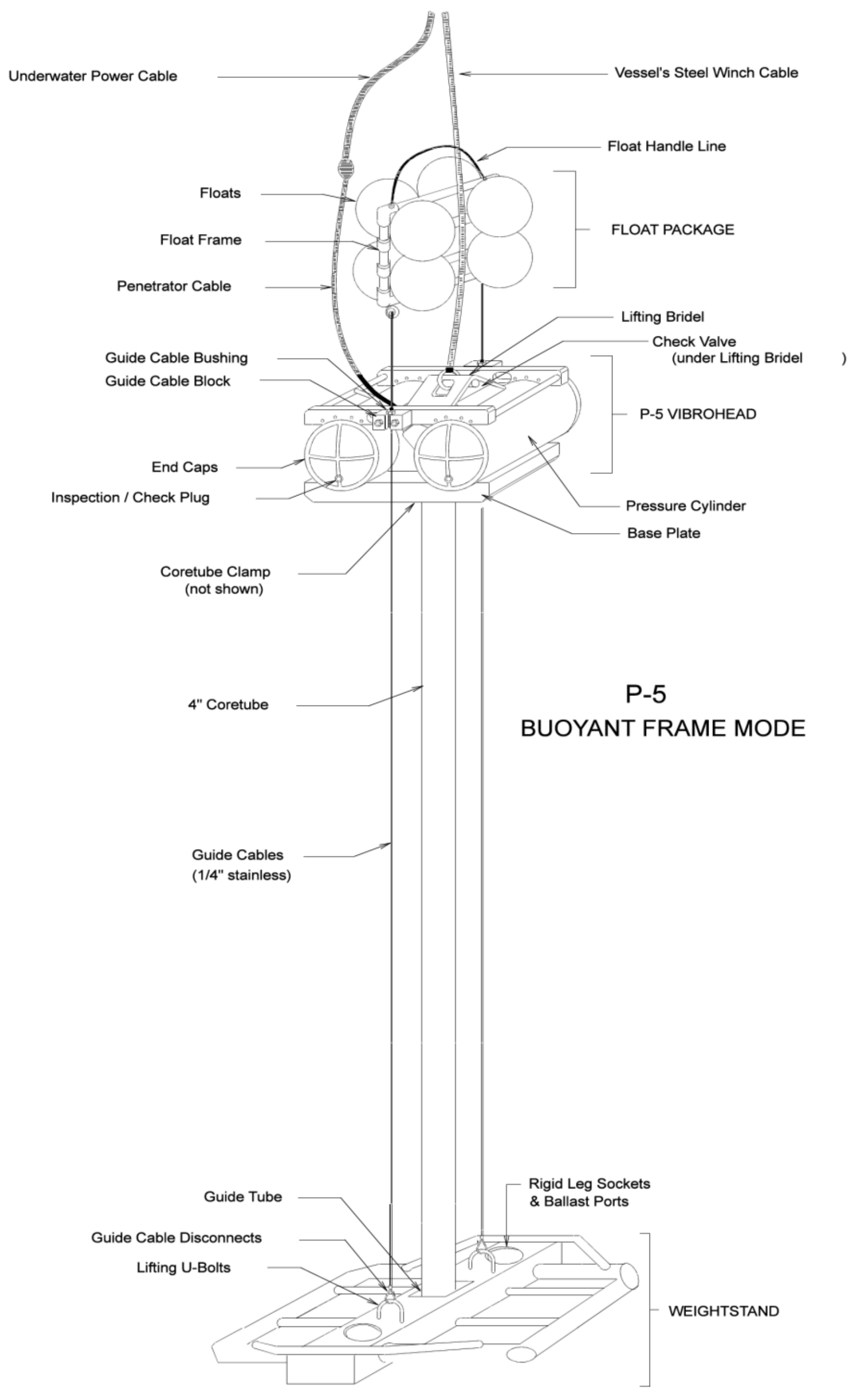


Figure 3.3.12 – Rossfelder P-5 Vibracorer with the buoyant frame, similar to the P-3 configuration

3.4 Calibrations and Equipment Check

During mobilization all hydrographic, geophysical and ancillary equipment were dry and wet tested at dockside prior to commencing each survey.

3.4.1 Single Beam Bar Check Calibration

CSR conducted a standard bar check to calibrate the single beam echosounder at the beginning of each survey day. The bar checks were conducted at the approximate start of each day's first survey line. The bar checks consisted of a horizontal plate being lowered at set intervals through the water column beneath the single beam transducer. Variables in the control software for the echosounder were then adjusted until the sounder was reading the correct depth to the calibration plate. Sound velocity data acquired at the beginning and end of each day was used during post-processing of the single beam data.

During the single beam survey, the TSS motion sensor was calibrated at dockside before departing for the survey area.

3.4.2 Sidescan Sonar Test

Prior to deploying the towfish from the vessel, a \`rub´ test was performed on deck to ensure the transducers and receivers were operating properly. Navigation data and towfish heading information were also confirmed prior to deployment.

3.4.3 Sub-bottom Systems Testing

Prior to collecting sub-bottom data, the chirp and boomer systems were configured and tested dock side at Nadro Marine's yard in Port Dover. The transmit and receive (hydrophone) components of the system were placed in the water at the dock. Once in the water the systems were \`fired´ to test the operation of the power source in conjunction with the receive components. The resulting data was recorded and reviewed on the topside computers. System noise was then mitigated through additional grounding of the system components and adjustment to the placement and orientation of the communication cables.

After confirmation that the sub-bottom systems were operating correctly at the dock, test lines were run in the survey area. During the test lines, frequency filters were manipulated to highlight the interpretable data and filter out non-valuable frequencies (noise). Time varied gain (TVG) was also adjusted for optimal data collection during the test lines.

3.4.4 Multibeam Calibration

The Hemisphere DGPS antennas were installed on the survey vessel aligned with the main axis of the boat. The antennas were installed above the multibeam transducer along a 2 m baseline separation. The convergence correction was calculated using RTK DGPS. The main axis of the survey vessel was shot with the RTK system while the boat was at dockside during mobilization. The static azimuth of the vessel was then compared to the measured azimuth from the heading system. The convergence factor was calculated and applied during post processing.

The DMS05 mount angle offsets were calculated according to the manufacturer's system calibration procedure. Calibration lines were surveyed during calm conditions within the survey area. The resulting mount angle offsets were then stored in the DMS05 and applied in real-time during the survey.

Prior to collecting bathymetry data each day, the multibeam system was calibrated using a procedure known as a patch test. The patch test was designed to precisely determine the static configuration of the sonar head (pitch, roll, and yaw) and the latency remaining between the reception of the DGPS fix and its integration by the acquisition system. The procedure for performing a patch test requires the survey vessel to collect data over a series of predetermined lines. The location and orientation of the test lines are selected based on seabed characteristics ideal for patch test value computations. For the variables of pitch, yaw and latency a seabed slope or feature is required. The roll variable is best computed from test lines collected over a flat seabed. Daily patch tests were completed during the survey.

3.5 Survey Coverage

The initial geophysical survey work from the *VAC* during the fall of 2014 was conducted within a 500 m corridor along the Survey Centreline of the proposed LEC cable route corridor over the following areas: Canadian Nearshore & Approaches, United States Nearshore & Approaches and the Long Point Escarpment.

The Canadian and United States Landfall surveys were conducted in 2015 from *Seabed* - a small survey launch in the areas not accessible to the *VAC*. The offshore survey work in 2015 from the *VAC* included a 500 m corridor from KP 21.00 to KP 84.75 and surveys over a 200 m corridor from the Canadian Nearshore to KP 21.00 and from KP 84.75 to the United States Nearshore area. Figures 3.5.1 to 3.5.7 show the geophysical survey track lines, the Survey Centreline and the LEC Proposed Route deviations. Route deviations are proposed changes to the Survey Centreline route deemed necessary based on the results of the marine geophysical survey. Each route deviation is described in detail in Section 5.5. Grab sampling was also conducted in both the United States and Canadian Landfall areas and a total of 62 vibracores were taken along the proposed cable route at roughly 2 km intervals.

3.5.1 Canadian Landfall

Survey coverage over the Canadian Landfall was focused on the Survey Centreline of the proposed LEC cable route corridor (Figure 3.5.1). The geophysical survey track lines over the Canadian Landfall consisted of 37 main lines predominantly spaced at 25 m, with the outermost lines spaced at 75m. The tie lines were surveyed at 50 to 100 m intervals, perpendicular to the main lines. This resulted in a 1175 m wide survey corridor. The main lines extended from the shoreline to KP 1.60.

3.5.2 Canadian Nearshore & Approaches

Survey coverage over the Canadian Nearshore & Approaches in the fall of 2014 was focused on the Survey Centreline of the proposed LEC cable route corridor (Figure 3.5.2). The geophysical survey track lines over this route section consisted of 6 main lines spaced at 100 m and tie lines surveyed at 500 m intervals perpendicular to the main lines. This resulted in a 500 m wide survey corridor. The main lines extended from KP 1.60 to KP 21.00. To increase data coverage nearshore, 50 m spaced lines were surveyed parallel to the main lines. These lines extended from KP 1.60 to KP 4.04.

Survey coverage over the Canadian Nearshore & Approaches in the summer of 2015 was focused on the Survey Centreline of the proposed LEC cable route corridor (Figure 3.5.2). The geophysical survey track lines over this route section consisted of nine main lines, spaced at 25 m. Tie lines were surveyed at 500 m intervals perpendicular to the main lines. This resulted in a 200 m wide survey corridor. The main lines extended from KP 1.63 to KP 21.00.

3.5.3 Canadian Offshore

Survey coverage over the Canadian Offshore focused on the Survey Centreline of the proposed LEC cable route corridor (Figure 3.5.3). The geophysical survey track lines over this route section consisted of seven main lines spaced at 75 m covering a corridor 500 m wide. Tie line intervals surveyed over this portion of the route were 500 m. The main lines in the Canadian Offshore portion of the survey extended from KP 21.00 to the Canada/United States international border at KP 46.91.

Regional geophysical data was collected over Long Point Escarpment in the fall of 2014 (Figure 3.5.3 and Figure 3.5.4). The Survey Centreline of the proposed LEC cable route corridor intersects the Long Point Escarpment at approximately KP 40. Reconnaissance lines oriented perpendicular to the slope spaced at 200 m were surveyed in order to evaluate the slope gradient and seabed geology of the escarpment. In total, six lines approximately 5.5 km in length were collected covering a 1 km wide corridor.

3.5.4 United States Offshore

Survey coverage over the United States Offshore focused on the Survey Centreline of the proposed LEC cable route corridor (Figure 3.5.4 and Figure 3.5.5). The geophysical survey track lines over this route section consisted of three separate line spacing arrangements, covering a corridor 500 m wide. From KP 81.10 to KP 84.70 the survey track lines consisted of 21 main lines, spaced at 25 m. From KP 74.10 to KP 81.10 the survey track lines consisted of 11 main lines spaced at 50 m intervals. From KP 59.10 to KP 74.10 the survey track lines consisted of 11 main lines, spaced at 50 m. The outermost lines of this route section were spaced at 225 m from the Survey Centreline. Finally, from the Canada/United States border (KP 46.91) to KP 59.10 the survey track lines consisted of 7 main lines spaced at 75 m. Tie line intervals surveyed over this route section were 500 m.

3.5.5 United States Nearshore & Approaches

Survey coverage over the United States Nearshore & Approaches in the fall of 2014 focused on the Survey Centreline of the proposed LEC cable route corridor (Figure 3.5.6). The geophysical survey track lines over this route section consisted of 6 main lines spaced at 100 m covering a corridor 500 m wide. Tie line intervals surveyed over this route section ranged from 500-2000 m due to weather and time constraints encountered in the field. The main lines over the US Nearshore & Approaches extended from KP 84.69 to KP 103.1 To increase the data coverage nearshore, two 50 m spaced lines were surveyed adjacent and parallel to the route centre line. These additional lines extended from KP 101.10 to KP 103.10.

Survey coverage over the United States Nearshore & Approaches in the summer of 2015 focused on the Survey Centreline of the proposed LEC cable route corridor (Figure 3.5.6). The geophysical survey track lines over this route section consisted of nine main lines, spaced at 25 m. Tie lines were surveyed at 500 m intervals perpendicular to the main lines. This resulted in a 200 m wide survey corridor. The main lines over the US Nearshore & Approaches extended from KP 84.69 to KP 103.10.

3.5.6 United States Landfall

Survey coverage over the United States Landfall was focused on the Survey Centreline of the proposed LEC cable route corridor (Figure 3.5.7). The geophysical survey track lines over this route section consisted of 41 main lines spaced at 25 m. The tie lines were surveyed at 50 m to 100 m intervals, perpendicular to the main lines. This resulted in a 1020 m wide survey corridor. The main lines extended from KP 102.30 to the shoreline.

3.5.7 Additional Survey Coverage

Survey coverage over a large multi-keel ice scour located between KP 83.00 and KP 84.00 consisted of 15 geophysical track lines, spaced at 35 m oriented with the long axis of the scour event (Figure 3.5.5 and Figure 3.5.6). One line was also surveyed following the trend of the three main keels. Tie line spacing over this region was 250 m.

Additional survey coverage over a glacial feature/possible diapir located between KP 14.30 and KP 17.50 was conducted with eight extra survey lines on both sides of the centreline, totaling 16 additional survey lines (Figure 3.5.2). These extra lines were spaced at 75 m intervals and extended from approximately KP 12.50 to KP 20.00.

For experimental purposes, a 3000 lb stockless anchor was dragged along the lakebed in an area of heavy gas concentrations, off the main route near KP 36.50. A total of 11 passes were completed with the anchor deployed. Over the anchor drag site, the geophysical survey track lines consisted of 3 main lines, oriented with the long axis of the anchor drag, spaced at 20-40 m. The tie lines were surveyed at 50 m intervals, perpendicular to the main lines.

Between KP 22.50 and KP 23.50 additional lines were surveyed in order to map a suspected uncharted pipeline. The additional track lines were run ranging from 150 to 1000 m spacing, based on findings from the previous lines. A total of 12 track lines were run in this area at a 45° angle off the centreline.

Additional lines were run in four separate locations in order to help trace potential route hazards that were difficult to identify based solely on the route data. From KP 20.80 to KP 22.40, seven survey lines were run perpendicular to the main route lines, spaced at 150 m. From KP 27.10 to KP 28.10, five survey track lines were run perpendicular to the main route lines, at 250 m spacing. Between KP 41.00 and KP 44.00, five survey lines were run at 250 m spacing, following the approximate trend of the main route lines. Finally, from KP 45.50 to KP 47.10, five survey lines were run at 250 m spacing parallel with the main route.

3.5.8 Ground Truthing

Surficial sediment sampling was conducted over both the United States and Canadian Landfall survey areas from “Seabed”. A total of eight grab samples were taken over the Canadian Landfall and four over the United States Landfall. The samples were taken using CSR design surficial sampling equipment. The sampler is a small cylinder that is dragged along the lakebed to collect surficial samples of sediments and/or organic materials. The bottom of the cylinder is capped and there are drainage holes to allow for water release upon retrieval. The sampler is weighted to lie flat on the lakebed to ease the collection process. The samples collected are described in Table 5.2.1.

Vibracore samples were also collected along the LEC Proposed Route from the “Ecosse” at approximately 2 km intervals. The positions, locations relative to the route and field data (unconfined compressive strength, undrained shear strength) are presented in Tables 5.2.2 & 5.2.3. Additional information is included in the Geotechnical Report (CSR Report 1408-5).

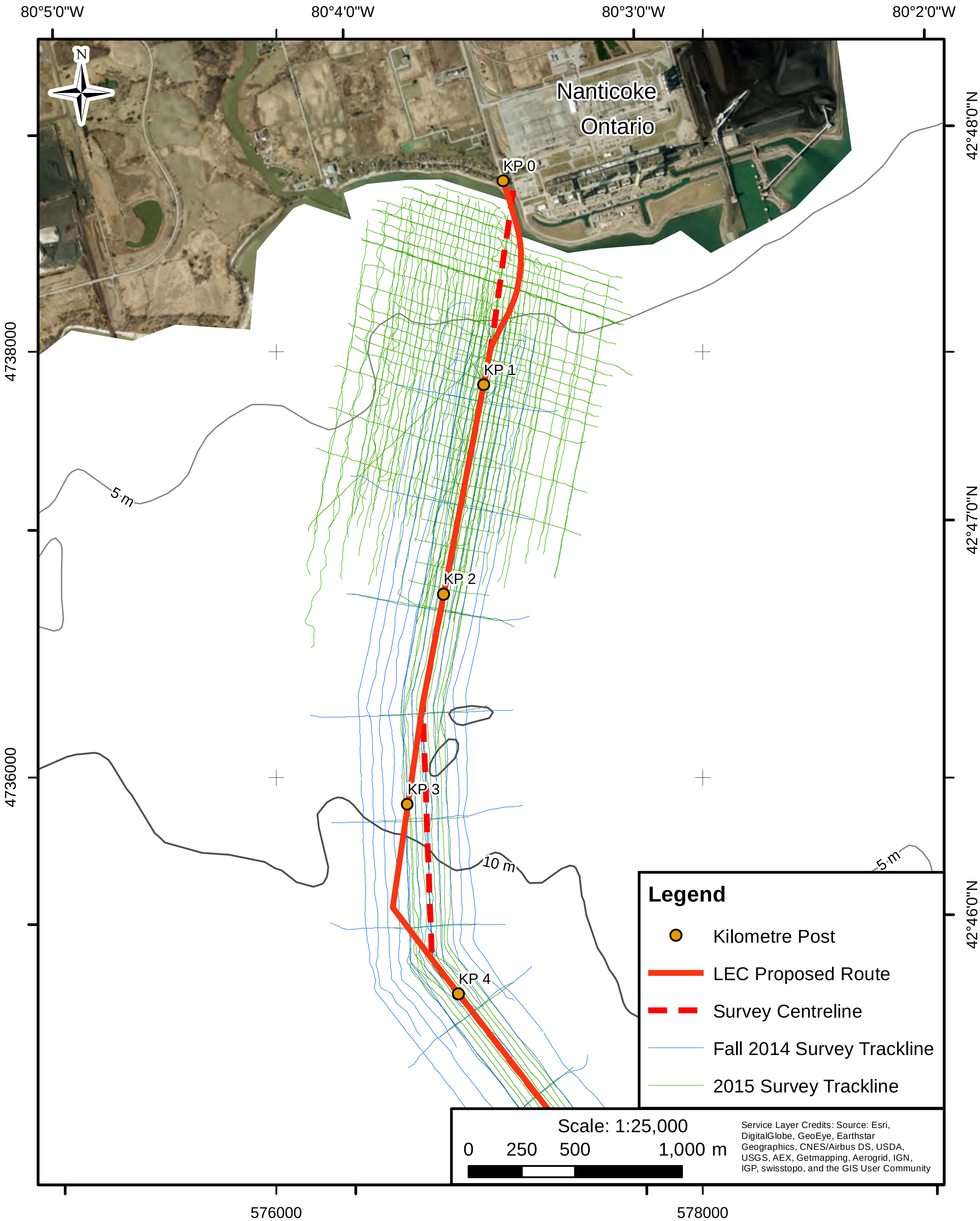


Figure 3.5.1 - Geophysical survey track lines along the Lake Erie Connector Proposed Cable Route over the Canadian Landfall.

Canadian Seabed Research Ltd.

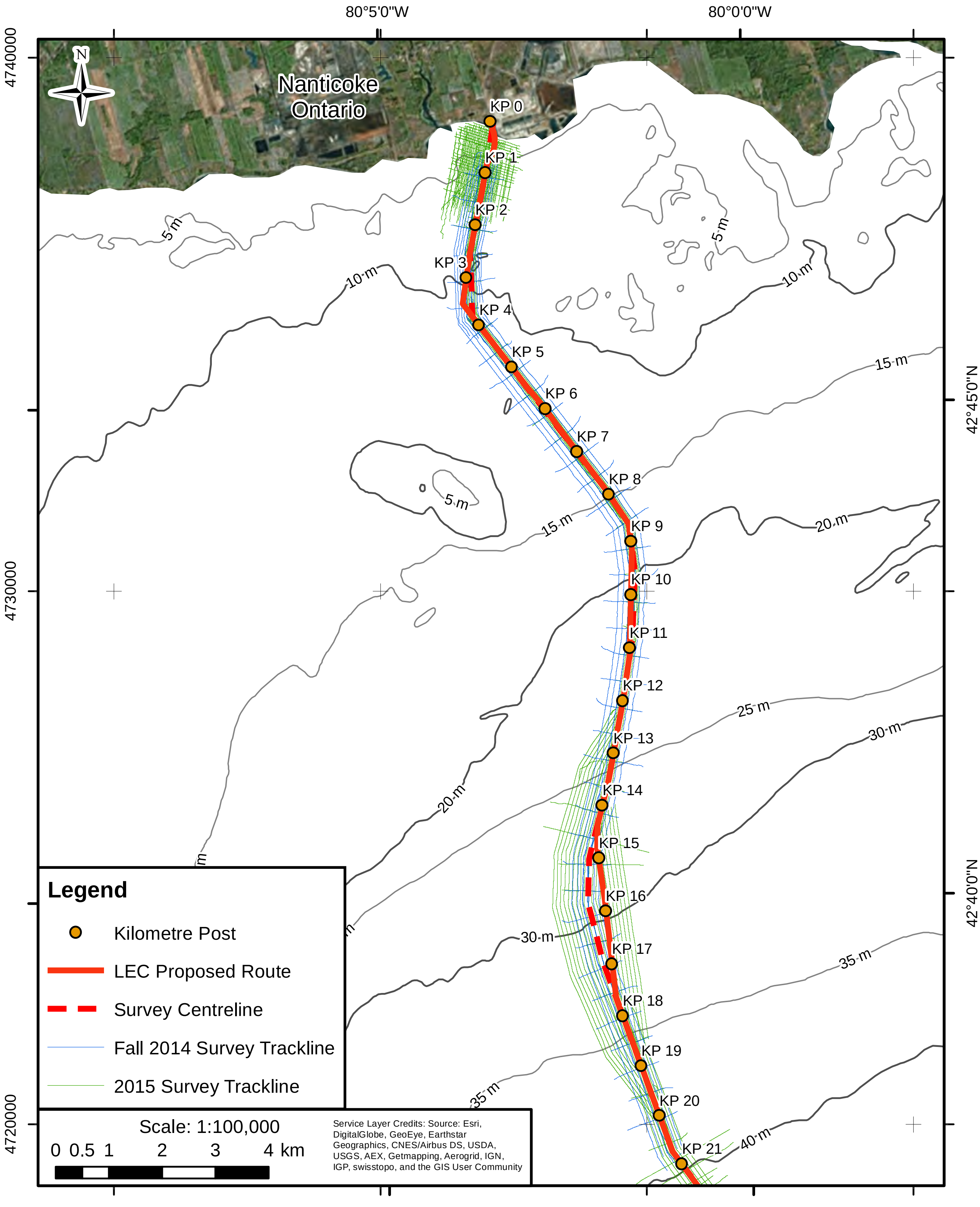


Figure 3.5.2 - Geophysical survey track lines along the Lake Erie Connector Proposed Cable Route over the Canadian Nearshore & Approaches and Landfall.

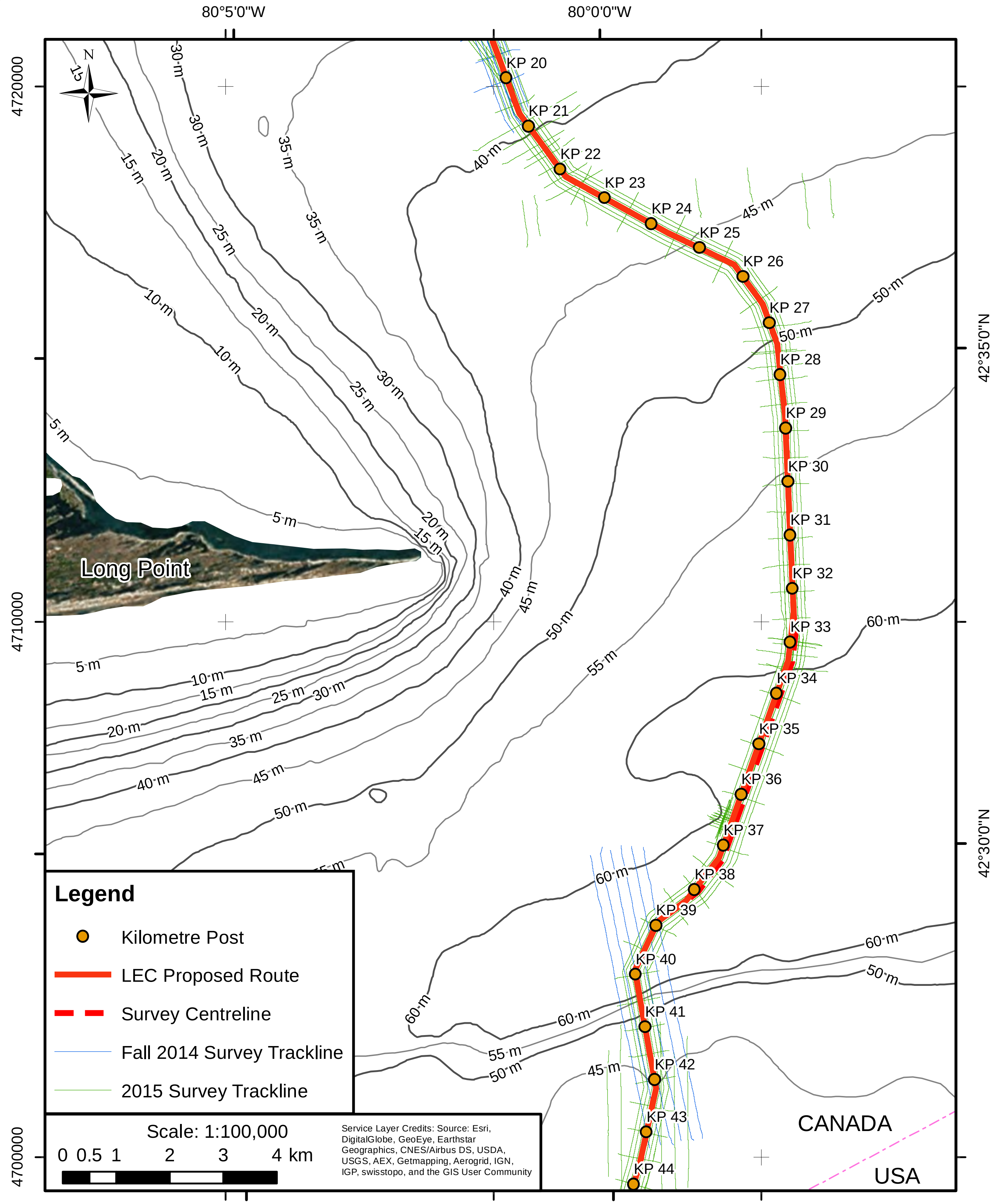


Figure 3.5.3 - Geophysical survey track lines along the Lake Erie Connector Proposed Cable Route over the Canadian Offshore and the Long Point Escarpment

Canadian Seabed Research Ltd.

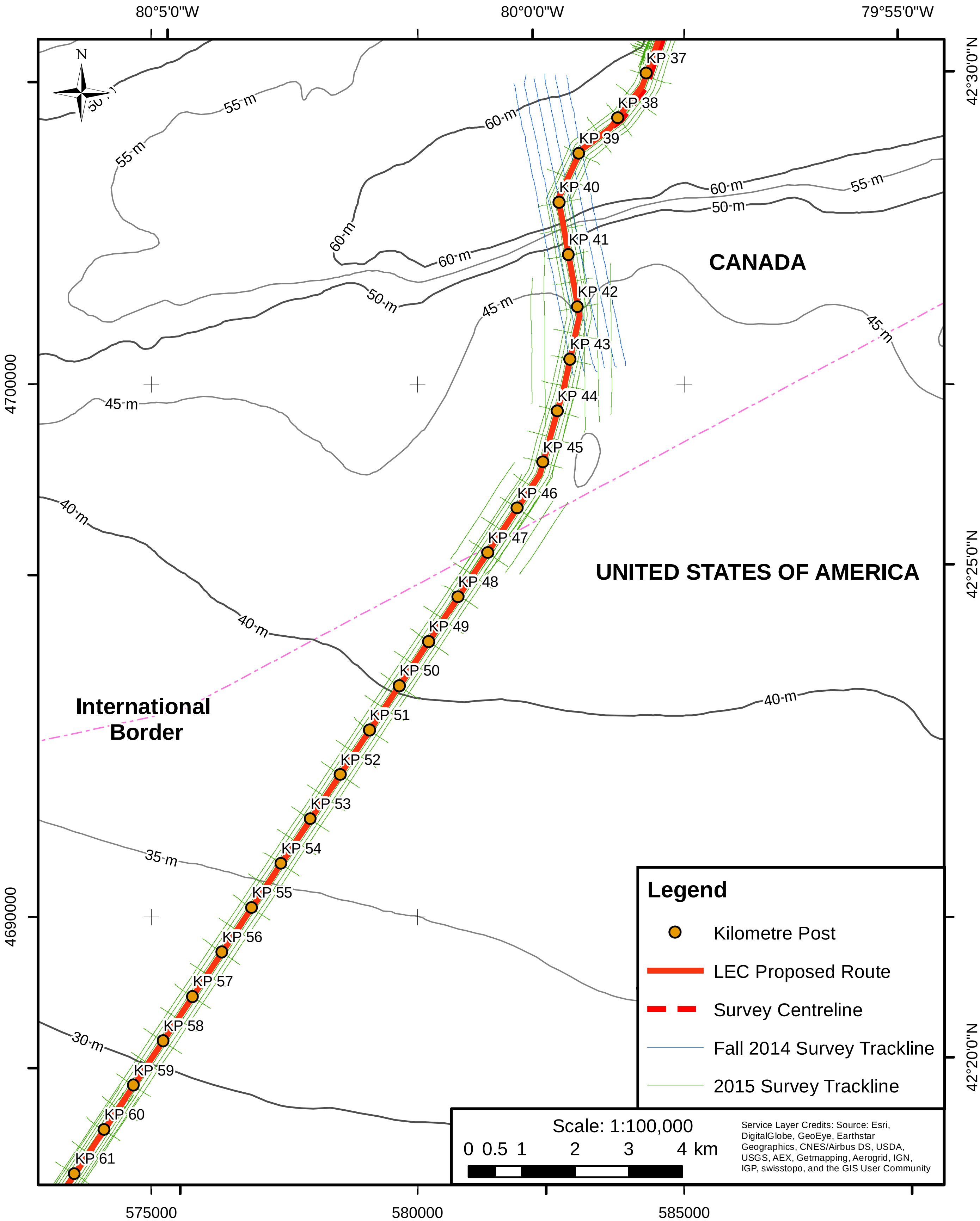


Figure 3.5.4 - Geophysical survey track lines along the Lake Erie Connector Proposed Cable Route over the Long Point Escarpment and United States Offshore

Canadian Seabed Research Ltd.

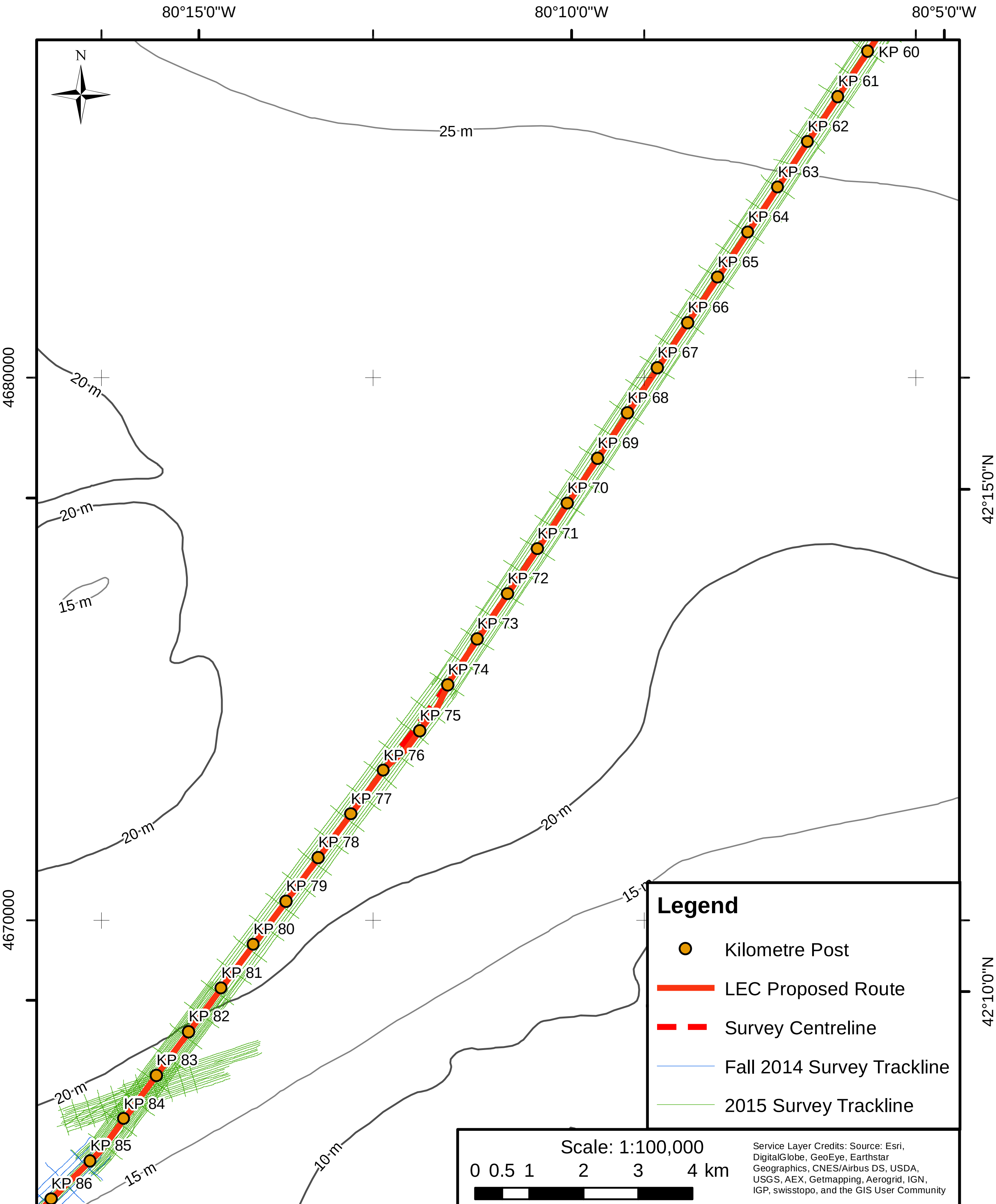


Figure 3.5.5 - Geophysical survey track lines along the Lake Erie Connector Proposed Cable Route over the United States Offshore.

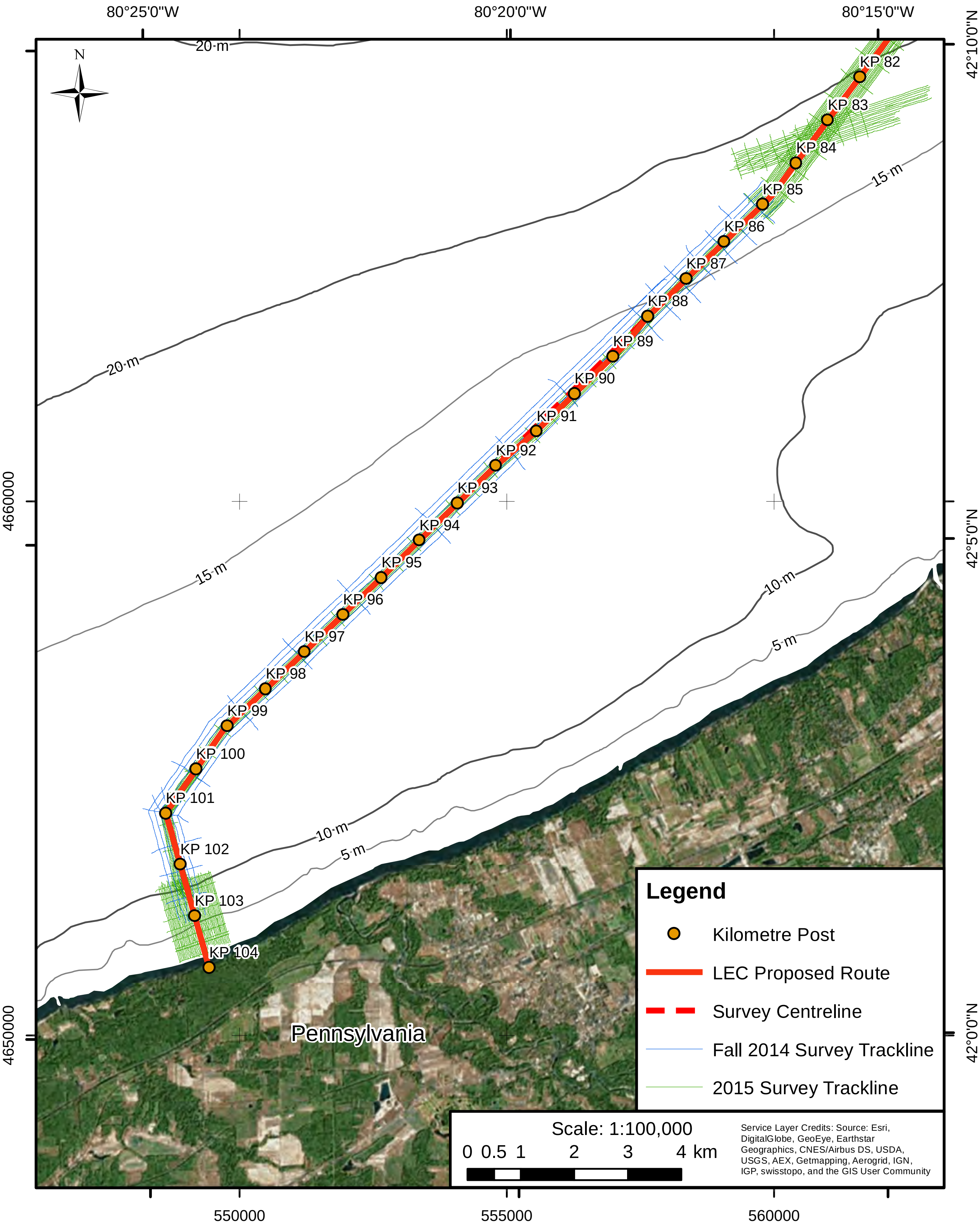


Figure 3.5.6 - Geophysical survey track lines along the Lake Erie Connector Proposed Cable Route over the United States Nearshore & Approaches and Landfall.

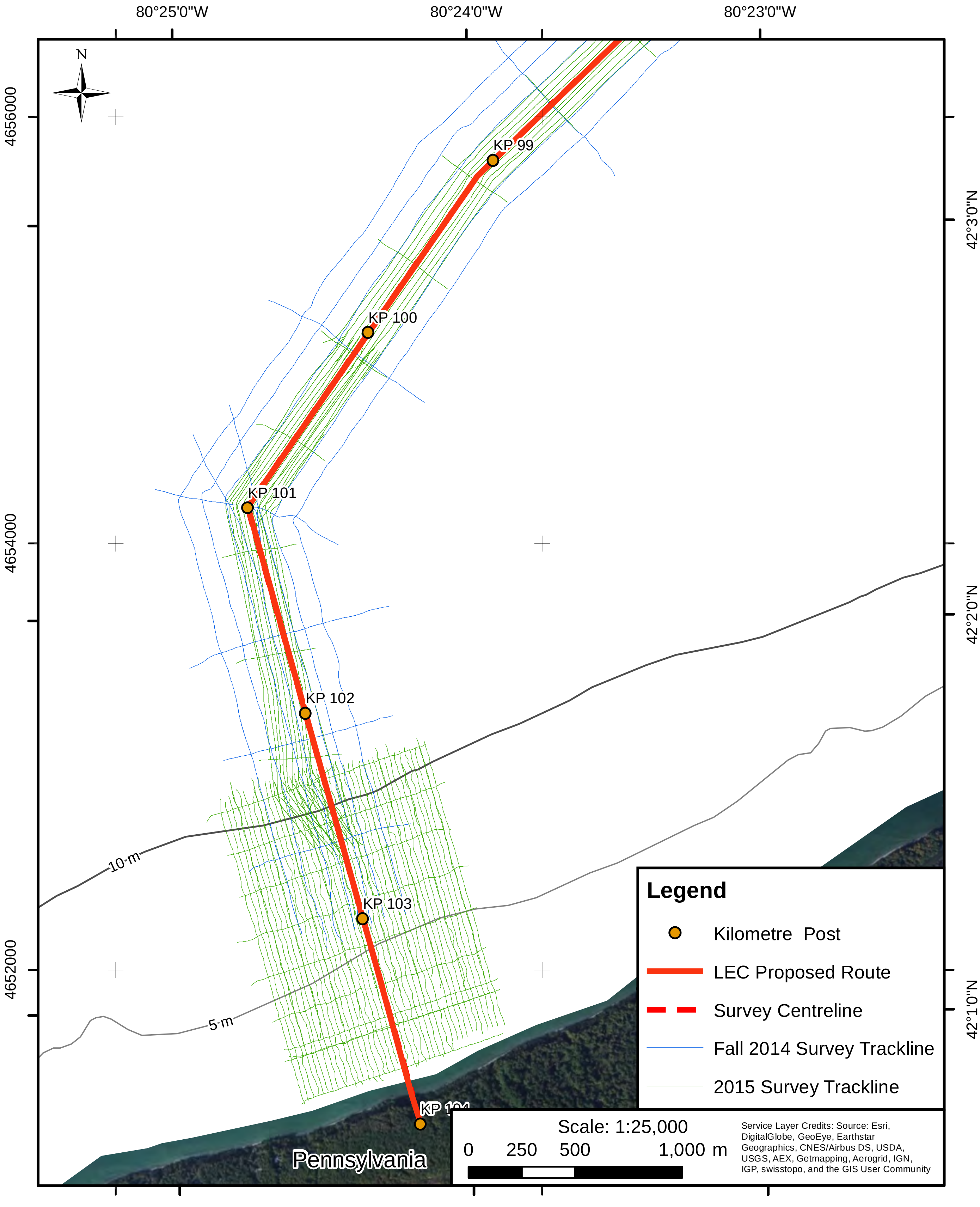


Figure 3.5.7 - Geophysical survey track lines along the Lake Erie Connector Proposed Cable Route over the United States Landfall.

4.0 GEODESY & DATA PROCESSING

4.1 GEODESY

All maps and figures are referenced to NAD83 UTM Zone 17. The bathymetry contours are referenced to Chart Datum. Chart datum is 173.5 m or 569.2 ft above the International Great Lakes Datum (IGLD) 1985. IGLD is referenced to mean sea level, as measured at Rimouski, Quebec, near the mouth of the St. Lawrence River.

4.2 BATHYMETRY

This section describes the steps involved in processing and integrating the multibeam and single beam soundings acquired during the survey.

4.2.1 Single beam Processing

The dual frequency single beam echosounder provided bathymetric sounding data (200kHz) and shallow sub-surface profiler data (33 and 50kHz). The raw 200 kHz single beam echosounder data collected during the survey were post-processed in Hypack using the single beam editor. The soundings were corrected for vessel motion, sound velocity variations, and reduced to Chart Datum (173.5 metres above International Great Lakes Datum (IGLD) 1985) within Hypack. Soundings collected in Canadian waters were reduced with observed lake level data from DFO Port Dover Lake Level Station 12710. Soundings collected in US waters were reduced with hourly observed lake level data from NOAA Erie Lake Level Station 9063038. The single beam processing involved the following steps.

- Sound velocity profile files were created for each survey day from the sound velocity casts performed during the survey.
- Tide files for each survey day were generated utilizing water level values obtained from DFO and NOAA.
- Sound velocity and tidal corrections were applied during data import.
- Each survey line seabed profile was reviewed on a line-by-line basis and erroneous soundings were removed.
- Edited sounding files were processed within Hypack at all survey line cross-over locations.
- The edited sounding data was then exported from Hypack in XYZ ASCII file format.

4.2.2 Multibeam Processing

The raw multibeam echosounder data collected during the survey were post-processed with hydrographic information processing software Caris. Caris is a comprehensive software package that allows for the integration of bathymetric data including raw sonar information, sound velocity, tide corrections and vessel offset information. The following steps were conducted to post-process the raw multibeam sounding data.

- The raw hysweep data (.hsx) was imported into CARIS HIPS and SIPS 9.0, and horizontal / vertical offsets applied.

- All patch test data acquired during the survey were reviewed independently by two multibeam processors. The average pitch / roll / yaw values from these redundancy checks were used during final processing of the data.
- Sound velocity profile files were created from each sound velocity cast performed during the survey.
- Tide files for each survey day were generated utilizing water level values obtained from DFO and NOAA.
- Both sound velocity and tide corrections were applied to the data during processing.
- The multibeam data was extensively examined for erroneous soundings and artifacts within CARIS.
- The processed data was exported as a 1 m resolution average BASE surface in ASCII XYZ format.

4.2.3 Bathymetry Contours and Profile

The processed 2015 multibeam data set was reviewed in Hypack. The 2014 and 2015 processed single beam soundings were merged with the 2015 multibeam dataset where multibeam data was not available. This merged data set was imported into Surfer 12 where 1 m x 1 m and 5 m x 5 m grid files were created using a kriging interpolation algorithm. The contours displayed in all enclosures were based on the 5 m x 5 m grid while the bathymetric profiles displayed in all enclosures were based on the 1 m x 1 m grid.

4.3 Sidescan Sonar Processing

During the survey, raw uncorrected sidescan data was recorded with SonarPro in XTF format. During post processing, the data were imported into the sonar processing software SonarWiz 5. After the raw acoustic data was layback corrected for position and enhanced through adjustments to the gain, color, contrast etc., the highest quality images were digitally pieced together creating a geo-referenced mosaic of the seafloor at 0.25 m and 1 m resolution.

The sidescan data were interpreted manually, using variations in the intensity and character of backscatter returns to identify and map surficial geological boundaries and seabed features. Typically, low-intensity returns (backscatter) are associated with smooth seafloor conditions and fine-grained surficial sediments. Higher levels of backscatter indicate increased bottom roughness, related to coarser sediments, boulders, bedrock outcrops, lakebed morphology, and anthropogenic debris. The size, shape, homogeneity, apparent relief, and acoustic character of specific return patterns were used to map surficial units and identify seabed features. The presence of sub-bottom reflectors below the lakebed provides information on the surficial and shallow geology. Areas where sub-bottom reflectors are obscured due to the attenuation of the profiler signal suggest coarse sediments or the presence of gas.

4.4 Magnetometer Processing

During post processing, the raw magnetometer data (NanoTesla) was georeferenced based on offsets from the DGPS antenna. The raw data was reviewed on a line by line basis within Hypack. Variations in the measured values are typically caused by ferrous objects which influence the magnetic field. It is the variations in magnetic values that indicate an anomaly is in the vicinity of the sensor. The location and magnitude of each magnetic anomaly were recorded and compared with the multibeam and sidescan sonar data.

4.5 Sub-Bottom Processing

The seismic boomer data was recorded in raw uncorrected SEGY data files while the chirp data was recorded along with the sidescan data in XTF format. Each raw dataset was post-processed with CODA Survey Engine. During this process layback was applied, gains were optimized and a sound velocity of 1600 m/s was used when interpreting and digitizing seismic reflectors.

The low frequency single beam echosounder data provided information on the upper sub-surface geology, shallow gas and identification of anthropogenic objects such as pipelines. The raw low frequency profiler data was collected using Odom's eChart software. During post processing the raw data was reviewed using eChart and Hypack software. The data provided high resolution target imaging in the near surface within the upper 3 to 5 metres in soft sediments such as silt and clay.

All sub-bottom data were interpreted using established seismo-stratigraphic techniques. Seismo-stratigraphic analysis involves the identification of seismic sequences, based on variations in acoustic character, and correlation of bounding reflectors throughout the survey area. Identification of probable sediment types is based on the geometry and internal characteristics of each sequence. Profiled units that were exposed at the lakebed were correlated with sidescan sonar data to assist the interpretation. The data was used in the interpretation and mapping of the sub-bottom geological conditions. It was also the system used to reveal areas of shallow gas accumulations.

5.0 RESULTS

The bathymetry, surficial geology with lakebed features and route profile with sub-bottom geology are presented as individual panels on the 15 Panel Map Sheets which accompany this report. Landfall areas are presented at a scale of 1: 5,000 and the remainder of the route is presented at a scale of 1: 10,000. Figure 5.1 displays the locations of the Panel Map Sheets along the LEC Proposed Route covered by the 15 maps. Panel Map Sheets 1 through 5 include the Canadian Landfall, Nearshore & Approaches. Panel Map Sheet 7 covers the area surveyed over the Long Point Escarpment and Panel Map Sheets 12 through 15 includes the United States Landfall, Nearshore & Approaches.

The following sections document the bathymetry, surficial geology and lakebed features, sub-bottom geology and commercial operations along the proposed LEC Proposed Route.

Eight route deviations (RD's) from the Survey Centreline have been proposed based on analysis of the geophysical data and route change requests made to CSR. These RD's are described in detail in Section 5.5 Route Deviations.

Kilometre Postings (KPs) indicate the distance in kilometres from the Canadian Landfall at Nanticoke, Ontario (KP 0) to the US Landfall at Springfield Township, Pennsylvania. Measured from KP 0, the LEC Proposed Route length within Canadian waters is 46.911 km and the LEC Proposed Route length within American waters is 57.115 km. The total overall length of the LEC Proposed Route is 104.026 km.

Note: KP's and distances measured or stated in this report or presented on the Panel Map Sheets are horizontal distances and do not account for slope. Only the Route Position List (RPL) generated for Caldwell Marine International, LLC includes slope length calculations – see *Appendix VIII*. The RPL generated for this report is based on the LEC Proposed Route. Slope length calculated for the RPL is based on a 1 m x 1 m bathymetric grid of the lakebed and does not account for cable burial depth. The slope length includes depth deviations resulting from surficial boulders, scours and other features located on the lakebed along the LEC Proposed Route. The bathymetry used to calculate slope length are representative of the lakebed conditions at the time of the survey.

A routing boundary has been included on the Panel Maps Sheets to support the permitting process of the LEC Proposed Route. The routing boundary defines the maximum permissible deviation during design and construction. Over a majority of the route, the routing boundary is offset 50 metres to each side of the LEC Proposed Route, creating a 100 m corridor. At the Canadian Landfall, the routing boundary covers the entire arc of potential HDD end points. At the US Landfall, the routing boundary is offset 100 m to each side of the LEC Proposed Route, creating a 200 m corridor. The routing boundary is wider through this area to allow for possible route deviations related to the bedrock outcrops present in the US Landfall area.

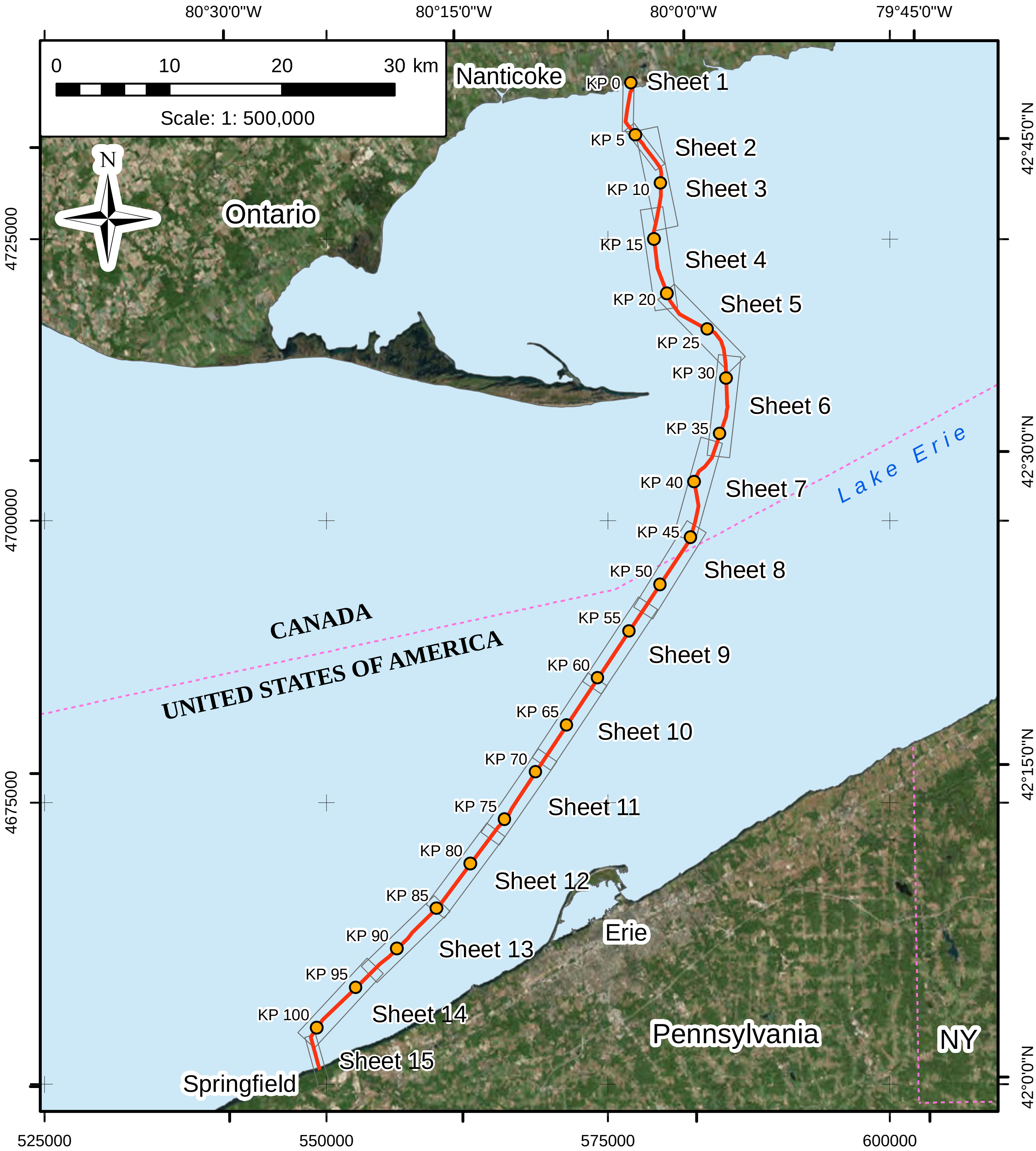


Figure 5.1 - Panel Map Sheet locations.

5.1 Bathymetry

The lakebed along the LEC Proposed Route is relatively flat with slopes generally less than 1%. Lakebed slopes of more than 1% occur in localized areas near the Canadian and United States Landfalls as well as over the Long Point Escarpment. The maximum water depth along the LEC Proposed Route is 62.3 m. The bathymetry of the lakebed is presented on the Panel Map Sheets and is summarized in Table 5.1.1.

Table 5.1.1 – LEC Proposed Route Bathymetry (5 m contour interval) Summary

Start KP	End KP	Water Depth (m)		Notes
		Start	End	
0.000	0.000			Nanticoke, Ontario, Canada 4738799.9 N / 577065.2 E 42°47'52.3" N / 80°03'27.4' W
0.273	0.537	1.1	5	CND data extents nearshore
0.537	2.724	5	10	
2.724	8.269	10	15	
8.269	10.538	15	20	
10.538	13.269	20	25	
13.269	16.004	25	30	
16.004	18.373	30	35	
18.373	21.230	35	40	
21.230	24.801	40	45	
24.801	27.673	45	50	
27.673	30.593	50	55	
30.593	34.412	55	60	
34.412	40.060	60	62	Max Depth 62.3 m
40.060	40.383	62	60	
40.383	40.535	60	55	
40.535	40.628	55	50	
40.628	41.573	50	45	
41.573	49.856	45	40	
49.856	54.055	40	35	
54.055	58.413	35	30	
58.413	62.308	30	25	
62.308	81.521	25	20	
81.521	87.100	20	15	
87.100	102.422	15	10	
102.422	103.381	10	5	
103.381	103.722	5	1.4	US data extents nearshore
104.026	104.026			Springfield Township, Erie County, Pennsylvania, USA 4651253.5 N / 549440.3 E 42°00'42.3" N / 80°24'10.5" W

5.2 GEOLOGY

Although Lake Erie is noted for shallow depths and gentle bottom relief, it is divided into the Eastern, Central and Western Basins by sand-covered ridges of glacial clay deposits known as terminal moraines. These features cross the lake between Long Point, Ontario and Erie, Pennsylvania, and Point Pelee, Ontario and Lorain, Ohio.

The Eastern Basin (the focus of this study) is best known for its deep water, its depositional environment and the potential for thicker fine grained sediments. Along the eastern Canadian shore, a thin veneer of glacial drift covers relatively resistant shale and forms a jagged coastline. Irregularities similar to that of the coast are observed lakeward as ridges and valleys. The Long Point Escarpment is one such feature that strikes in the same direction as the shoreline and is thought to delineate the boundary between a very resistant Upper Devonian limestone bed and a less resistant marine shale.

The lakebed in the basin is generally greater than 30 metres in depth and is covered with a soft, semi-fluid dark grey silty clay or clay. These muds are considered recent, post glacial deposits and resemble offshore facies of other deep-water lakes (Cameron, 1991). Glacio-lacustrine deposits, which are a product of glacial retreat, commonly underlie these deep-water muds.

The Long Point-Erie Ridge, which divides the Eastern Basin from the rest of the lake, has been interpreted as a terminal moraine formed during the last re-advance of glacial ice into the Eastern Erie Basin. The upper surface consists of glacial clay and is capped with sand and gravel. The sand deposit is believed to have originated as a beach deposit during lower lake levels. Long Point-Erie Ridge extends across the width of the lake and at low lake level, only allowed the Pennsylvania channel to balance water flow between the Eastern Basin and the Central Basin.

The glacial tills and glacio-lacustrine clays are remarkably similar in grain size. This reflects the overall homogenization achieved during glacial transport and the subsequent ineffective sub-marine sorting of these materials. They are both red or brownish grey, cohesive, uniform in appearance, and have abundant amounts of clay. These units are believed to have been sub-aerially exposed during lower lake levels and could therefore show erosional features such as ancient stream channels and ice scours. The glacial tills are not stratified, but the glacio-lacustrine sediments are laminated (only microscopically in places).

The southern shore of the Eastern Basin is much straighter than its northern counterpart and is nearly void of coves and inlets. The bedrock identified as outcropping on the southern shore consists of grey and black shales with minor thin units of siltstone and limestone. One prominent feature is Presque Isle, a sand spit that extends into the lake nearly 12 km. Presque Isle is located at Erie, Pennsylvania.

The surficial sediments and sub-bottom geology presented in this section were interpreted from the marine geophysical data acquired in 2014 and 2015. The interpretations of each are presented on the Panel Map Sheets 1-15. To support the interpretation of the geophysical data, ground truth information gathered from grab samples at the Canadian and United States Landfalls and field data from the geotechnical vibracore program have been correlated and incorporated into this report. Grab sample, Canadian vibracore and US vibracore field data are summarized within Tables 5.2.1 through 5.2.3 respectively. Vibracore field data was collected from the top of each geotechnical sample using a pocket penetrometer and field torvane to measure unconfined compressive strength (Kpa) and undrained shear strength (Kpa) respectively.

Table 5.2.1 – Grab Sample Sediment Descriptions

Sample	Sample Description
CANGS01	Olive gray fine sand with fine gravel
CANGS02	Olive gray fine sand with mussel shells
CANGS03	Mussels
CANGS04	Olive gray silt with trace fine sand, 10% organics
CANGS05	No sample recovered, rocky bottom
CANGS06	No sample recovered, rocky bottom
CANGS07	No sample recovered, rocky bottom
CANGS08	No sample recovered, rocky bottom
USAGS01	Light brown medium sand with shell fragments
USAGS02	Light brown medium sand with course sand and shell fragments, 10% organics
USAGS03	No sample recovered, rocky bottom
USAGS04	No sample recovered, rocky bottom

Table 5.2.2 – Canadian Vibracore Field Data

Vibracore	Vibracore Position						Vibracore Details				Unconfined Compressive Strength[1] (Kpa)						Undrained Shear Strengh[2] (Kpa)					
	Latitude	Longitude	Easting (m)	Northing (m)	KP (km)	VC offset (m)	Water Depth (m)	Penetration (m)	Recovered (m)	Time	Nose	GT1	GT2	GT3	GT4	GT5	Nose	GT1	GT2	GT3	GT4	GT5
VC1A	42.775673	-80.062443	576696.4	4736330.4	2.538	11.8	10.0	2.75	2.53	-	24.90	22.03	191.52	-	-	-	28.73	23.94	43.09	-	-	-
VC2	42.770185	-80.061903	576747.3	4735721.5	3.132	151.6	10.4	4.80	4.70	-	7.66	24.90	9.58	19.15	21.07	-	9.58	2.87	9.58	19.15	14.36	-
VC3	42.748827	-80.048252	577890.9	4733362.3	5.907	194.6	12.4	2.50	2.40	2m30s	57.46	28.73	-	-	-	-	38.30	28.73	-	-	-	-
VC4	42.736790	-80.033434	579118.9	4732039.4	7.715	6.9	13.9	4.70	3.70	-	-	2.87	2.87	2.87	-	-	-	3.83	2.87	1.92	-	-
VC5	42.725436	-80.026282	579718.9	4730785.4	9.144	3.9	17.7	2.20	2.14	-	430.92	2.87	-	-	-	-	191.52	3.83	-	-	-	-
VC6	42.715679	-80.026583	579706.8	4729701.6	10.227	8.1	19.8	1.70	1.45	-	95.76	2.87	-	-	-	-	57.46	6.70	-	-	-	-
VC7	42.702165	-80.028148	579595.8	4728199.5	11.735	3.5	20.9	3.20	3.00	1m25s	191.52	2.87	2.87	-	-	-	143.64	3.83	1.92	-	-	-
VC8A	42.681330	-80.033928	579148.9	4725880.5	14.098	5.7	27.3	4.70	4.00	1m	9.00	9.00	2.87	2.87	-	-	-	14.36	4.79	4.79	-	-
VC9	42.666122	-80.033368	579214.1	4724192.3	15.805	2.8	29.6	3.55	2.65	1m35s	-	2.97	2.97	2.97	-	-	-	7.18	0.96	0.96	-	-
VC10	42.649430	-80.030708	579453.4	4722341.2	17.677	13.6	34.1	4.70	3.20	-	-	2.97	2.97	2.97	-	-	-	2.39	1.44	0.96	-	-
VC11	42.632319	-80.022301	580164.4	4720449.1	19.698	28.5	38.1	4.70	3.88	1m50s	-	2.97	2.97	2.97	2.97	-	-	3.83	1.92	0.96	0.96	-
VC12	42.615045	-80.010012	581194.5	4718542.7	21.891	11.6	41.0	4.70	3.51	45s	-	2.97	2.97	2.97	2.97	-	-	4.79	2.87	1.92	0.96	-
VC13	42.605373	-79.989597	582881.7	4717488.5	23.909	14.5	43.5	4.70	3.64	45s	-	2.97	2.97	2.97	-	-	-	2.87	1.92	1.92	-	-
VC14	42.596254	-79.968397	584633.1	4716496.8	25.939	13.5	46.9	4.70	3.05	30s	-	2.97	2.97	2.97	-	-	-	3.83	2.87	1.92	-	-
VC15	42.579692	-79.959847	585357.1	4714666.3	27.944	4.2	50.6	4.60	3.65	30s	-	2.97	2.97	2.97	-	-	-	5.75	2.87	1.92	-	-
VC16	42.562162	-79.958389	585500.7	4712721.3	29.895	8.0	53.7	4.70	3.77	30s	-	2.97	2.97	-	-	-	-	2.87	1.92	-	-	-
VC17	42.543927	-79.957942	585562.3	4710696.8	31.920	17.6	56.7	4.70	3.75	30s	-	2.97	2.97	2.97	-	-	-	2.87	1.92	1.92	-	-
VC18	42.526820	-79.960242	585396.8	4708794.9	33.838	58.5	59.4	4.70	4.05	45s	-	2.97	2.97	2.97	-	-	-	2.87	1.92	0.96	-	-
VC19	42.509389	-79.968204	584766.3	4706851.5	35.880	107.4	59.2	4.70	3.95	1m20s	-	1.92	-	-	-	-	-	-	-	-	-	-
VC20	42.493328	-79.978980	583902.5	4705057.3	37.865	79.1	60.3	4.70	4.10	2m50s	-	1.92	-	-	-	-	-	-	-	-	-	-
VC21	42.479936	-79.994402	582652.9	4703555.1	39.859	17.9	62.0	4.70	3.90	30s	-	2.97	2.97	2.97	-	-	-	2.87	2.39	1.92	-	-
VC22	42.464004	-79.991390	582921.5	4701788.9	41.647	24.3	44.4	4.70	3.60	35s	-	2.97	2.97	2.97	2.97	-	-	3.83	1.92	1.92	0.96	-
VC23	42.444801	-79.994708	582673.9	4699653.4	43.834	4.8	44.1	4.70	3.51	35s	-	2.97	2.97	-	2.97	-	-	2.87	2.87	-	0.96	-
VC24	42.428412	-80.003733	581953.1	4697824.9	45.823	16.8	43.7	4.70	3.80	45s	-	2.97	2.97	2.97	2.97	-	-	3.83	2.87	1.92	0.96	-
VC44	42.675332	-80.035030	579066.3	4725213.4	14.775	6.9	27.6	3.75	3.15	53s	20.97	95.76	2.97	2.97	-	-	67.03	-	2.87	-	-	-
VC45	42.762126	-80.059430	576959.6	4734828.8	4.187	13.5	11.4	2.90	1.60	-	28.73	19.15	-	-	-	-	28.73	28.73	-	-	-	-
VC46	42.792389	-80.059789	576892.8	4738189.0	0.718	177.7	6.1	1.80	1.48	2m10s	-	11.97	13.50	-	-	-	-	23.94	23.94	-	-	-
VC47	42.791375	-80.058518	576998.0	4738077.6	0.771	34.2	6.5	2.95	2.77	2m15s	-	22.50	18.00	2.97	-	-	-	28.73	3.35	0.96	-	-
VC48	42.779306	-80.061172	576795.9	4736735.0	2.121	34.0	9.8	2.22	2.22	2m30s	-	20.97	23.94	2.97	-	-	-	28.73	43.09	0.96	-	-
VC49	42.706025	-80.027591	579636.6	4728628.7	11.305	17.7	20.7	2.40	2.15	1m30s	-	95.76	2.97	2.97	-	-	-	71.82	4.79	0.96	-	-
VC50	42.676205	-80.034458	579112.0	4725310.9	14.677	38.1	27.5	3.80	3.50	1m5s	-	6.03	2.97	2.97	2.97	-	-	4.79	1.92	0.96	0.96	-

[1] Pocket Penetrometer

[2] Field Torvane

Table 5.2.3 – United States Vibracore Field Data

Vibracore	Vibracore Position						Vibracore Details				Unconfined Compressive Strength[1] (Kpa)						Undrained Shear Strengh[2] (Kpa)					
	Latitude	Longitude	Easting (m)	Northing (m)	KP (km)	VC offset (m)	Water Depth (m)	Penetration (m)	Recovered (m)	Time	Nose	GT1	GT2	GT3	GT4	GT5	Nose	GT1	GT2	GT3	GT4	GT5
VC25	42.413094	-80.017133	580870.4	4696111.1	47.849	29.9	41.9	4.70	3.85	45s	-	2.97	2.97	2.97	-	-	-	3.83	1.92	0.96	-	-
VC26	42.398141	-80.030950	579752.5	4694437.7	49.863	24.8	39.7	4.70	3.97	45s	-	2.97	2.97	2.97	-	-	-	4.79	3.83	2.87	-	-
VC27	42.383823	-80.044516	578653.9	4692835.2	51.805	3.5	37.5	4.70	3.87	55s	-	2.97	2.97	2.97	2.97	-	-	4.79	4.79	2.87	0.96	-
VC28	42.368612	-80.058192	577546.8	4691133.7	53.834	16.0	35.4	4.70	4.20	1m10s	-	2.97	2.97	2.97	2.97	-	-	2.87	2.87	1.92	-	-
VC29	42.353738	-80.071664	576455.6	4689469.9	55.825	27.8	33.1	4.70	4.50	1m	-	2.97	2.97	2.97	2.97	-	-	3.83	2.87	3.83	3.83	-
VC30	42.339134	-80.085147	575362.6	4687836.3	57.790	21.5	30.7	4.70	4.33	45s	-	2.97	2.97	2.97	2.97	-	-	3.83	3.83	4.79	2.87	-
VC31	42.323956	-80.099214	574221.7	4686138.7	59.835	10.6	28.6	4.50	3.82	40s	-	2.97	2.97	2.97	-	-	-	4.79	3.83	1.92	-	-
VC32	42.309314	-80.112449	573148.1	4684501.4	61.793	22.4	25.8	4.70	4.40	1m30s	-	2.97	2.97	2.97	-	-	-	3.83	2.87	2.87	-	-
VC33	42.294471	-80.126238	572028.5	4682841.6	63.796	8.5	23.2	4.70	3.07	1m	-	2.97	2.97	2.97	2.97	-	-	3.83	3.83	2.87	2.87	-
VC34	42.279624	-80.139632	570941.0	4681181.7	65.780	21.3	23.2	4.00	2.70	1m	-	18.00	2.97	-	-	-	-	9.58	4.79	-	-	-
VC35	42.264582	-80.153484	569815.5	4679500.1	67.803	14.3	23.2	4.60	3.25	1m19s	-	2.97	2.97	-	-	-	-	9.58	7.18	-	-	-
VC36	42.250079	-80.166740	568737.9	4677879.0	69.749	13.9	24.0	4.70	4.40	1m17s	-	7.57	2.97	2.97	2.97	-	-	9.58	9.58	9.58	4.79	-
VC37	42.234590	-80.180908	567585.7	4676147.8	71.829	12.3	23.9	4.20	3.80	1m47s	335.16	2.97	2.97	2.97	-	-	52.67	9.58	14.36	4.79	-	-
VC38	42.219610	-80.194404	566487.8	4674473.9	73.831	24.1	23.2	4.25	4.15	30s	-	2.97	2.97	2.97	-	-	-	0.00	7.18	2.39	-	-
VC39	42.205241	-80.209309	565272.5	4672866.9	75.867	15.1	21.4	3.70	3.32	3m30s	-	23.94	23.94	2.97	-	-	-	28.73	28.73	14.36	-	-
VC40	42.190941	-80.223597	564107.5	4671268.3	77.844	17.5	19.9	2.20	1.49	4m	-	95.76	-	-	-	-	-	47.88	-	-	-	-
VC41	42.176647	-80.238420	562897.7	4669670.2	79.848	3.0	21.4	1.85	1.85	6m30s	-	26.91	-	-	-	-	-	47.88	-	-	-	-
VC42	42.162192	-80.253017	561706.2	4668054.6	81.856	10.6	19.7	4.70	4.30	3m10s	-	18.00	2.97	2.97	2.97	-	-	19.15	4.79	2.87	2.87	-
VC43	42.146978	-80.268253	560462.0	4666354.4	83.962	25.8	17.0	2.80	2.15	6m	-	26.91	0.96			-	-	4.79	4.79	-	-	-
VC67	42.131778	-80.288157	558831.5	4664652.8	86.323	19.7	15.5	3.00	2.03	5m	-	23.94	2.97			-	-	0.96	14.36	-	-	-
VC68	42.120897	-80.302542	557652.5	4663434.8	88.019	30.1	14.6	4.00	2.98	4m	-	47.88	47.88	20.97	-	-	-	47.88	6.70	2.87	-	-
VC69	42.108453	-80.320603	556170.5	4662041.1	90.057	89.6	13.7	4.70	3.22	1m14s	-	11.97	9.00	-	-	-	-	19.15	4.79	-	-	-
VC70	42.095971	-80.337752	554763.4	4660644.1	92.043	3.9	13.0	4.70	2.35	1m15s	-	18.00	26.91	-	-	-	-	9.58	4.79	-	-	-
VC70A	42.095895	-80.337744	554764.1	4660635.7	92.047	2.7	13.0	4.70	3.25	1m25s	-	20.97	6.03	-	-	-	-	9.58	1.92	-	-	-
VC71	42.083512	-80.354981	553349.1	4659249.9	94.028	2.5	13.4	4.70	1.93	1m45s	-	10.44	-	-	-	-	-	14.36		-	-	-
VC71A	42.083491	-80.354979	553349.3	4659247.6	94.030	4.3	13.4	4.70	2.74	1m15s	-	6.03	6.22	-	-	-	-	14.36	14.36	-	-	-
VC72	42.071067	-80.372658	551897.2	4657857.2	96.040	10.5	13.0	4.00	3.12	2m30s	-	18.00	47.88	-	-	-	-	23.94	14.36	-	-	-
VC73	42.058325	-80.389930	550478.5	4656432.1	98.051	31.4	13.1	4.70	4.49	3m30s	-	2.97	18.00	143.64	48.77	-	-	23.94	19.15	9.58	14.36	-
VC74	42.048101	-80.403077	549398.6	4655289.2	99.632	2.3	12.7	4.15	4.14	5m	-	287.28	287.28	143.64	-	-	-	57.46	57.46	19.15	-	-
VC75	42.040918	-80.409751	548851.8	4654487.9	100.603	9.9	12.3	4.60	4.18	4m	-	95.76	20.97	25.47	26.91	-	-	19.15	14.36	14.36	9.58	-
VC76	42.029523	-80.409610	548872.1	4653222.8	101.976	13.5	11.6	2.10	1.90	2m	430.92	47.88	-	-	-	-	60.33	14.36	-	-	-	-

[1] Pocket Penetrometer

[2] Field Torvane

5.2.1 Surficial Geology

The surficial sediments along the LEC Proposed Route corridor have been divided into six units. The surficial units are based upon their acoustic signature in geophysical records (sidescan sonar, seismic reflection and echosounder), along with verification from ground truthing (vibracore and grab samples). The distinguishable surficial units are described below and displayed on the Surficial Geology and Lakebed Features panel, see Panel Map Sheets accompanying this report. The surficial interpretations over the Canadian and United States Landfalls are displayed on Figures 5.2.1 and 5.2.2.

Post Glacial Clay / Silt

This unit occurs near the Canadian Landfall and is interpreted to be comprised of clay with silt due to its low reflectivity. The unit locally contains shallow gas accumulations.

Post Glacial Silt / Clay

Surficial sediments within this unit are interpreted to be mainly silt with clay and trace sand. This unit occurs extensively offshore within Canadian waters. Within American waters this unit occurs along the LEC Proposed Route north of the Pennsylvania Channel. Varying amounts of mussels gives this unit a mottled or speckled texture. Drag marks from fishing and/or other activity are noted within this unit. This unit also contains small, circular, low reflectivity patches that appear similar to gas escape features known as "pockmarks" (Fader, 1991; Hovland and Judd, 1988). These features are discussed further in Section 5.3. Other evidence including gas masking in seismic reflection profiles suggests that this unit has local areas of substantial amounts of near surface gas.

Post Glacial Sand / Silt

This unit is interpreted to be sand and silt and occurs throughout the Pennsylvania Channel and United States Landfall areas. This unit is interpreted to be of a different depositional origin than the post glacial sand unit described below. The unit contains local patches of mussels and occasional ripple marks.

Post Glacial Sand

This unit is interpreted to be comprised of sand with occasional veneer of silt/clay. The sand of this unit is interpreted to be a reworked relict beach deposit formed during a post glacial low lake level. Sections of this unit appear to be effected by NE-SW currents. This unit occurs throughout the Pennsylvania Channel United States Landfall areas.

Glacial Sediments

This unit is interpreted to be comprised of glacial till or glacial lacustrine sediments. The glacial sediments are a heterogeneous mixture of material mainly comprised of silt and clay, however sandy material as well as gravel, cobbles and boulders also occur. Cobbles and boulders are common and randomly scattered throughout the unit. The presence of mussels was also noted. This unit commonly occurs adjacent to areas of bedrock and is limited to the Canadian and United States Landfalls. Glacial till also occurs as a thin veneer over bedrock at the Canadian and US Landfalls in some areas. Occasional point source reflectors representing boulders are visible in the sidescan sonar data from areas dominated by glacial sediments.

Bedrock

This unit is found in the shallow portions of the landfall areas and is interpreted to be bedrock. A linear pattern, possibly related to jointing or bedding, is occasionally observed. Bedrock at the Canadian Landfall is mainly composed of limestone while at the United States Landfall the bedrock is mainly composed of shale. Fractures and possible faults are occasionally observed in the bedrock near the Canadian Landfall. Bedrock is locally covered by a thin (<0.5 m), intermittent veneer of till, sand, cobble, and/or silt/clay. Point source reflectors representing boulders are visible within the sidescan sonar data where the glacial till veneer is present.

Table 5.2.4 contains a description of the surficial and sub-surface geology along the LEC Proposed Route. Kilometre posts or KPs indicate the distance from the Canadian Landfall at Nanticoke.

Table 5.2.4 – LEC Proposed Route Surficial & Sub-Surface Geology Summary

Start KP	**End KP**	**Surficial Geology**	**Water Depth (m)**	**Interpreted Unconsolidated Sediment Thickness (m)**	**Notes**
0.000	0.000	Land			Nanticoke, Ontario, Canada 4738799.9 N / 577065.2 E 42°47'52.3" N / 80°03'27.4' W
0.273	0.505	Bedrock	0 - 5	Bedrock at surface	CND data extents nearshore
0.505	0.992	Clay/Silt	5 - 8	0-5	
0.992	1.615	Bedrock	8	Bedrock at surface	
1.615	1.808	Glacial Sediments	8 - 9	0-1.5	
1.808	5.000	Silt/Clay	9 - 12	1.5	
5.0000	10.000	Silt/Clay	12 - 19	6-32	
10.000	15.000	Silt/Clay	19 - 28	2.7-32	
15.000	20.000	Silt/Clay	28 - 38	4-40	
20.000	25.000	Silt/Clay	38 - 45	40-50	
25.000	30.000	Silt/Clay	45 - 54	45-60	
30.000	35.000	Silt/Clay	54 - 60	>10	-Near surface shallow gas
35.000	40.000	Silt/Clay	60 - 62	>10	-Near surface shallow gas
40.000	45.000	Silt/Clay	62 - 44	45-70	- 62.3 m maximum water depth - Zebra mussels present
45.000	50.000	Silt/Clay	44 - 40	55	- CAN/USA border at KP 46.911 - Zebra mussels present -Intermittent gas present
50.000	55.000	Silt/Clay	40 - 34	45-47	-Zebra mussels present - Sediment transport features present -Intermittent gas present
55.000	60.000	Silt/Clay	34 - 29	>10	- Sediment transport features present
60.000	65.000	Silt/Clay	34 - 23	>10	- Sediment transport features present
65.000	70.000	Silt/Clay	23 - 24	>10	- Sediment transport features present
70.000	75.000	Silt/Clay	24 - 22	>10	- Sediment transport features present
75.000	77.033	Silt/Clay	22 - 21	>10	- Sediment transport features present
77.033	80.555	Sand/Silt	21	>10	
80.555	85.000	Silt/Clay	21 - 16	>10	

Start KP	End KP	Surficial Geology	Water Depth (m)	Interpreted Unconsolidated Sediment Thickness (m)	Notes
85.000	86.010	Silt/Clay	16	>10	
86.010	90.000	Sand/Silt	16 - 13	>10	
90.000	95.000	Sand/Silt	13	>10	
95.000	100.000	Sand/Silt	13	>10	
100.000	102.015	Sand/Silt	13 - 11	1.5-11.3	
102.015	102.285	Sand	11 - 10	1.5-<0.5	-Local cobble and boulders
102.285	102.322	Bedrock	10	Bedrock at surface	
102.322	102.360	Sand	10	<0.5	-Local cobble and boulders
102.360	102.535	Bedrock	10 - 9	Bedrock at surface	
102.535	102.694	Sand	9 - 8	0-1	-Local cobble and boulders
102.694	102.703	Bedrock	8	Bedrock at surface	
102.703	102.726	Sand	8	<0.5	-Local cobble and boulders
102.726	103.722	Bedrock	8 - 0	Bedrock at surface	US data extents nearshore
104.137	104.026	Land			Springfield Township, Erie County, Pennsylvania, USA 4651253.5 N / 549440.3 E 42°00'42.3" N / 80°24'10.5" W

5.2.2 Sub-bottom Geology

The sub-bottom geology along the LEC Proposed Route has been divided into four main units based on their characteristics in seismic reflection profiles. Several other sub-bottom features such as significant reflectors, hyperbolic reflections and gas charged sediments are also included on the sub-bottom geology profiles. The sub-bottom geology is displayed on the LEC Proposed Route Profile and Sub-Bottom Geology panel, see Panel Map Sheets accompanying this report. Figure 5.2.3 illustrates a seismic reflection profile generated from chirp data showing all of the major sub-bottom units present in the Canadian Nearshore. Figure 5.2.4 illustrates a seismic reflection profile generated from chirp data that highlights the major sub-bottom units found through the US Nearshore and Landfall.

<u>Sub-bottom Unit 1 – Post Glacial Sediments</u>

This unit is characterized by weak to moderate, flat-lying, continuous reflectors with occasional hyperbolic reflections. It is interpreted to be interbedded silt and clay with occasional sand layers. This unit is commonly gas charged in deeper water and sporadically gas charged over the remainder of the LEC Proposed Route. This is the most common seismic sequence in the survey area and is interpreted to be post glacial sediments. Where present, Unit 1 is bounded at the top by the lakebed and at the bottom by Reflector 1 (R1).

R1 defines the boundary between post glacial and glacial sediments. R1 is an erosional unconformity in part, truncating underlying seismic reflectors in Units 2 and 3 in water depths less than approximately 31 m. In water depths greater than approximately 31 m, R1 is non-erosional and marked by a group of relatively strong coherent parallel reflectors. The point at which R1 changes from erosional to non-erosional corresponds to a previous low water stand in the lake.

Sub-bottom Unit 2 – Glacial Sediments
This is a homogeneous sediment type almost totally void of seismic reflectors. Rare, weak, discontinuous reflectors are visible in some areas on seismic refection profiles. This unit is interpreted to be composed of glacial sediments. Unit 2 is bounded at the top by R1 and at the bottom by Reflector 2 (R2).

Sub-bottom Unit 3A and 3B – Glacial Sediments
This unit (3A) is characterized by numerous internal continuous reflectors that have been interpreted as laminated beds of silt and clay. Many areas at the base of the unit display chaotic internal reflector pattern and an irregular upper surface (3B). This sediment package is interpreted as glacial lacustrine sediments (3A) or glacial till (3B). Although both units are glacial in origin, Unit 3A and 3B differ in the methods of deposition. Unit 3A is composed of glacial lacustrine sediments and is considered pro-glacial. Unit 3A was presumably deposited by sedimentary processes associated with a pro-glacial lake which coincided with the retreat of an ice sheet. This pro-glacial lake was formed either by the damming action of a moraine, an ice dam during a glacial retreat, or by meltwater trapped against an ice sheet due to isostatic depression. Unit 3B is composed of glacial till and was likely deposited through erosional processes and entrainment of material directly by the moving glacier. In some areas, in the lower portions of the sequence, glacial till dominates. The glacial till is defined by a distinct reflector, and is characterized by homogenous seismic stratigraphy.

Sub-bottom Unit 4 – Bedrock
The top of bedrock (acoustic basement) is characterized by a very strong continuous reflector. There are generally no visible internal reflectors in the bedrock due to decreased penetration of the seismic energy. This unit outcrops at the Canadian and United States Landfalls. Bedrock at the Canadian Landfall is mainly composed of limestone while at the United States Landfall the bedrock is mainly composed of siltstone and shale. Between KP 14.5 and KP 16.0 a reflector interpreted to be the top of bedrock is 3 to 5 metres below the lakebed. Apart from the Landfalls, this area presents the shallowest interpreted bedrock below the lakebed encountered along the LEC Proposed Route.

Undifferentiated Sediments
An area of undifferentiated sediments has been interpreted along the LEC Proposed Route between KP 0.5 and KP 1.0. This area is within the Canadian Landfall and located between the nearshore bedrock outcrop and bedrock shoal. These undifferentiated sediments are a mixture of both glacial and post glacial material and do not conform to the definitions of sub-bottom Units 1, 2 or 3A-3B. Seismic data collected in this area shows significant gas masking. VC 46 and VC 47 were collected from these sediments and the material was found to be a mixture of clay with fine sand and gravel combined with a high percentage of organic material in the form of shell fragments and wood pieces.

Gas Charged Sediments

Gas charged sediments prevent the penetration of the acoustic energy from the sub-bottom profiling systems thereby masking the signal in areas where shallow gas occurs, see Section 5.3.2 Sub-bottom Features.

Hyperbolic Reflections

Point source reflections within the shallow seismic data have been observed and are possibly caused by gas at surface, mussel beds, boulders or other features. All hyperbolic reflections mapped from the shallow seismic data are included on the Panel Map Sheets.

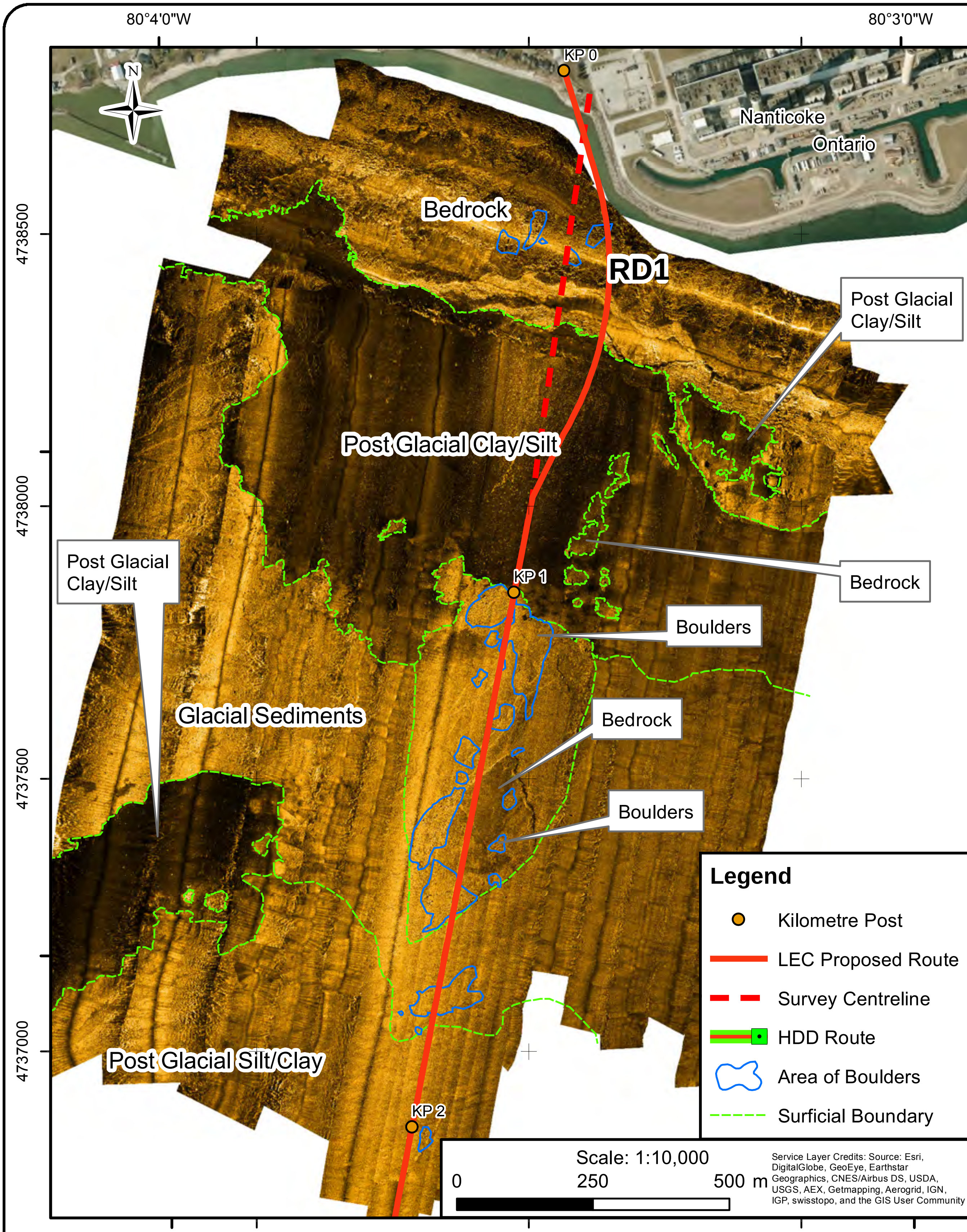


Figure 5.2.1 – Surficial interpretation along the Lake Erie Connector Proposed Route over the Canadian Landfall.

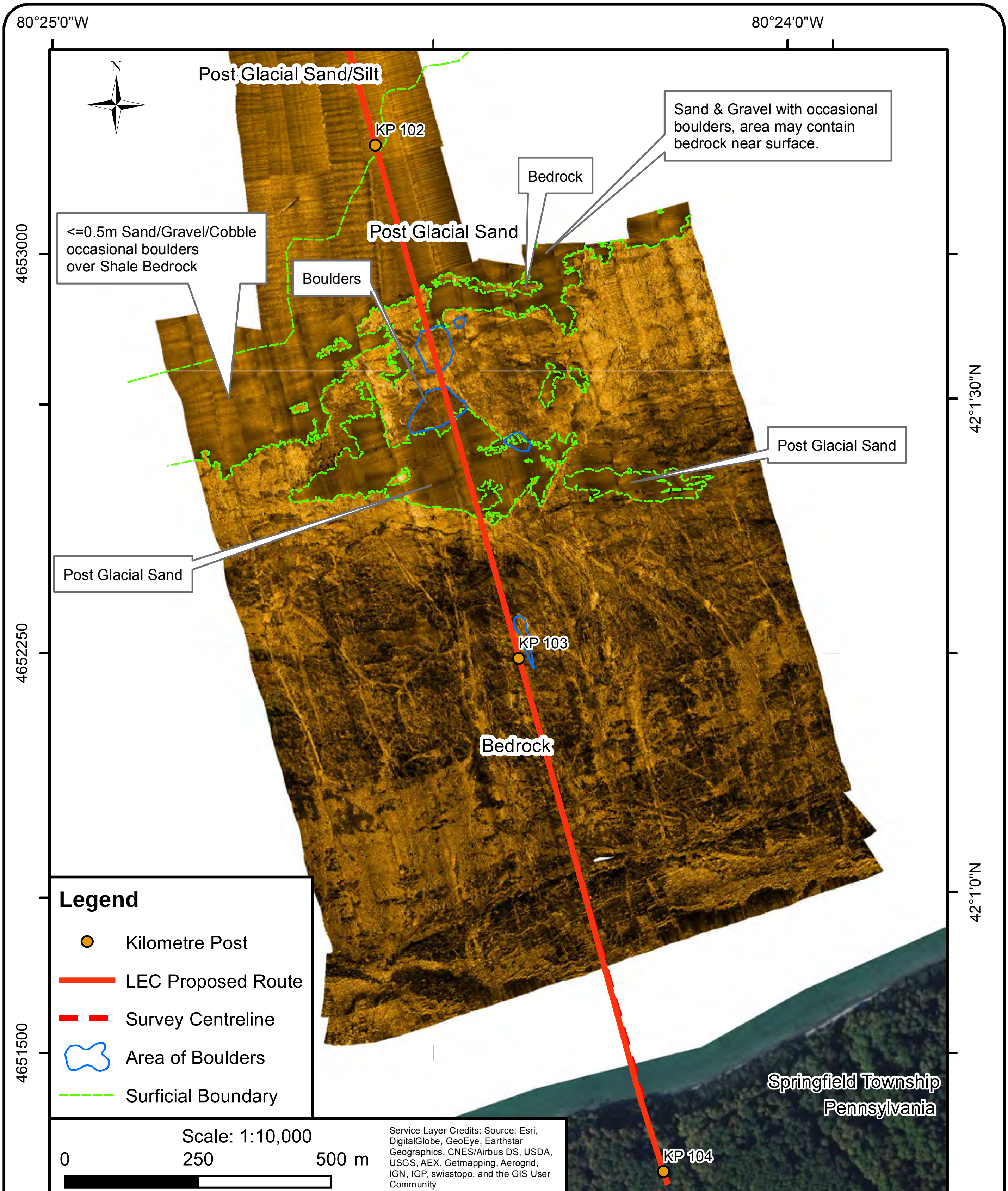


Figure 5.2.2 – Surficial interpretation along the Lake Erie Connector Proposed Route over the United States Landfall.

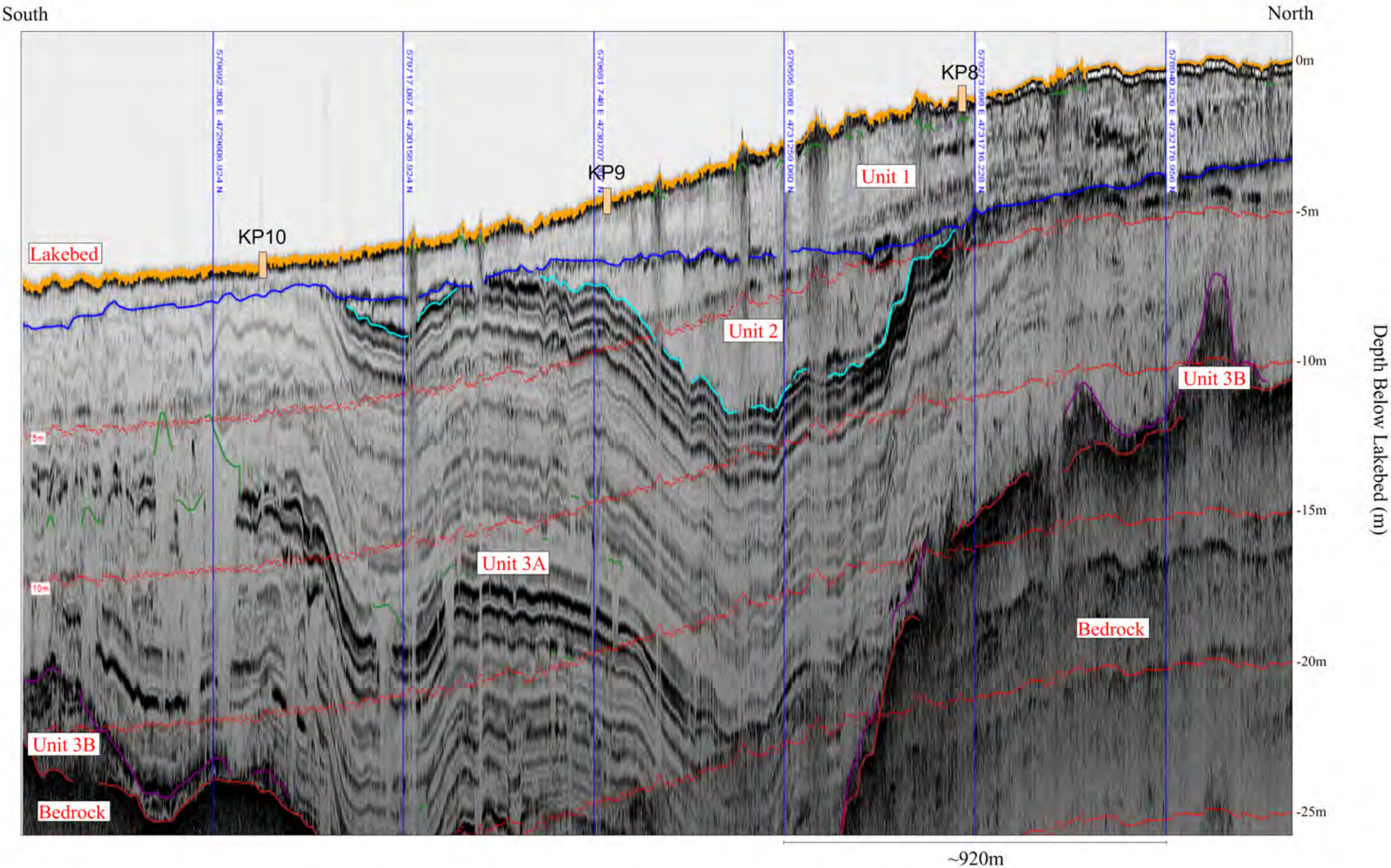


Figure 5.2.3 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route with all main sedimentary layers present, collected using the Klein 3000 Chirp Profiler.

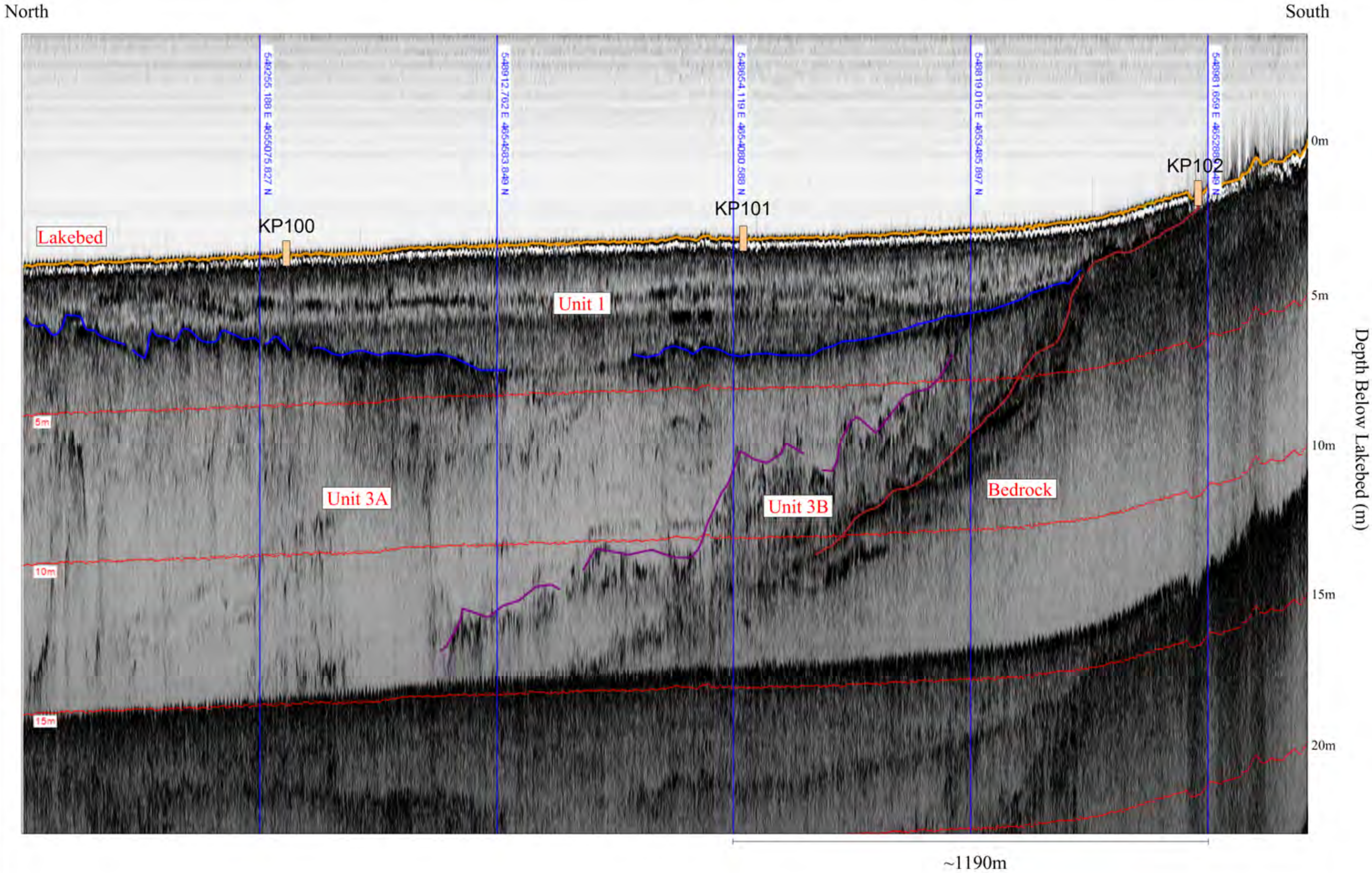


Figure 5.2.4 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route displaying the United States Nearshore area, collected using the Klein 3000 Chirp Profiler.

5.3 Surficial and Sub-bottom Features

This section provides a brief description of the surficial and sub-bottom features interpreted from the geophysical data acquired. A complete list of all surficial point source contacts identified in the sidescan data has been included in *Appendix III – Sidescan Sonar Point Source Contacts Table.* Examples of point source contacts mapped from the sidescan data include boulders, dredge spoils a shipwreck. All surficial point source contacts are plotted on Panel Map Sheets 1-15. Sonograms for each individual sidescan point source reflector contact have also been generated and included in *Appendix IV – Sidescan Sonar Sonograms.* Sonograms for 6 surficial targets identified by Archeological Services Inc. (ASI) have been included at the end of *Appendix IV*.

All sidescan point source contacts located within 50 m of the LEC Proposed Route are summarized in Table 5.3.1.

Surficial linear features have also been mapped from the sidescan data and plotted on the Panel Map Sheets 1-15. Examples of linear features include ice scours, drag marks, pipelines, possible cables and a trench. A complete list of all surficial linear features identified is included in *Appendix V – Sidescan Sonar Linear Features Table.*

Table 5.3.1 – Sidescan Sonar Contacts within 50 m of LEC Proposed Route

Sidescan Sonar Contacts within 50 m of LEC Proposed Route										
Label	**Latitude**	**Longitude**	**Easting (m)**	**Northing (m)**	**Offset (m)**	**Length (m)**	**Width (m)**	**Height (m)**	**Description**	**Mag Anomaly**
C2	42.7652180	-80.0617380	576767.0	4735170.0	43.195	5.6	1.9	1.1	Anthropogenic Contact	None
C3	42.7651281	-80.0617515	576766.0	4735160.0	36.283	2.1	1.5	1.2	Anthropogenic Contact	None
C9	42.7667188	-80.0638420	576593.0	4735334.7	3.462	4.3	3.1	0.5	Point Source Reflector (Probable Boulder)	None
C46	42.7665804	-80.0631596	576649.0	4735320.0	39.289	11.1	11.9	0.0	Circular Contact (Probable Dredge Spoil)	None
C47	42.7663103	-80.0631637	576649.0	4735290.0	21.235	8.1	8.0	0.4	Circular Contact (Probable Dredge Spoil)	None
C58	42.7882245	-80.0587439	576983.5	4737727.5	31.958	2.3	3.1	1.4	Point Source Reflector (Probable Boulder)	None
C67	42.7382425	-80.0341316	579060.0	4732200.0	43.576	42.8	13.5	1.0	Circular Contact (Probable Dredge Spoil)	None
C123	42.7417160	-80.0388656	578668.1	4732581.3	37.314	12.9	11.6	0.3	Circular Contact (Probable Dredge Spoil)	None
C124	42.7405707	-80.0378580	578752.0	4732455.1	46.995	20.6	19.1	0.4	Circular Contact (Probable Dredge Spoil)	None
C125	42.7394040	-80.0362996	578881.1	4732327.0	21.908	65.5	14.8	0.4	Circular Contact (Probable Dredge Spoil)	None
C127	42.7295640	-80.0267528	579675.1	4731243.2	13.789	67.0	16.5	1.5	Circular Contact (Probable Dredge Spoil)	None
C128	42.7259084	-80.0261211	579731.5	4730837.9	14.905	66.5	15.8	1.0	Circular Contact (Probable Dredge Spoil)	None
C144	42.6039298	-79.9873052	583071.6	4717330.4	32.978	3.1	1.7	0.6	Linear Contact	None
C173	42.1112318	-80.3145737	556666.6	4662353.6	34.437	18.6	24.8	0.2	Point Source Reflector (Probable Boulder)	None

5.3.1 Surficial Features

Sediment Transport Features
Patches of wave-formed sediment ripples occur in the southern portion of the survey grid (Figure 5.3.1.1) between KP 85.0 and KP 99.0. They are formed in shallow areas < 20 m depth where the bottom is sandy. The presence of ripples in the sand greatly increases the intensity of the acoustic signature on the sidescan sonar records. The sediment ripples measured within the LEC Proposed Route corridor are typically < 0.50 m in height and have wavelengths < 1.0 m.

Mussel Accumulation
The lakebed within the areas surveyed is locally heavily influenced by the presence of mussels. The mussels occur in beds or patches which are visible on sidescan sonar records as areas of higher reflectivity than the surrounding sediments. The mussel beds are also distinctly visible in the sub-bottom data and appear as highly reflective patches, no significant mussel accumulation is noted below lakebed. The types of mussels observed are likely zebra and quagga mussels. Based on the geophysical data interpretation and observations made during the vibracore program, mussel bed coverage and densities sampled along the LEC Proposed Route are not thought to be a constraint to cable installation.

Boulders
Boulders are present on the lakebed along the LEC Proposed Route. Sporadic boulders have been interpreted in both the Canadian and US Approaches and Nearshore areas. A higher frequency of interpreted boulders is seen in the both landfall areas. Most boulders are relatively small in size, generally less than 2 m in diameter (Figure 5.3.1.2). All boulders estimated to be larger than one metre in diameter have been mapped and included in both the *Appendix III - Sidescan Sonar Contacts Table* and plotted on the Panel Map Sheets. An 'Area of Boulders' surficial boundary has been added to the Panel Map Sheets where interpretation of the geophysical data indicated a higher frequency of near surface boulders.

Gas Escape Features (Pockmarks)
Low reflective patches in the sidescan sonar data, generally smaller than 15 metres in diameter, occur within sand / silt from KP 86.0 to KP 102.0. These low reflective patches are interpreted as gas escape features known as "pockmarks" (Fader, 1991; Hovland and Judd, 1988). Previous studies have also cited evidence of these pockmarks (also termed as "fluid vent features") in areas of post glacial sediment cover in eastern Lake Erie. These studies identify pockmarks appearing as a single feature or as linear arrays of vents (Blasco and Lewis, 2004).

The sub-bottom profiler records indicate the scattering of the acoustic signal over these areas. An example of an interpreted large pockmark found near KP 43.0 can be seen in Figure 5.3.1.3. This interpreted pockmark feature is approximately 60 m in diameter and 7 m deep (compared to the surrounding lakebed). It should be noted that the interpreted pockmark feature identified in Figure 5.3.1.3 is located approximately 250 m east of the

LEC Proposed Route so it is not a direct hazard to the route. Several other comparatively smaller pockmarks are illustrated in Figure 5.3.1.4. These features do not have a consistent shape and typically appear as patches or in some instances as a lineated pattern. The features are predominantly noticeable from KP 87.3 to KP 100.0. Among these, the bigger ones (<30 m in length) are concentrated from KP 98.0 to KP 100.5 and are within 50 m of the LEC Proposed Route. Smaller pockmarks (<10 m in diameter) are visible around KP 87.0.

Ice Scours

A number of ice scour related features have been identified within the route corridor. These features are discussed in detail in Section 5.3.3 Ice Scours.

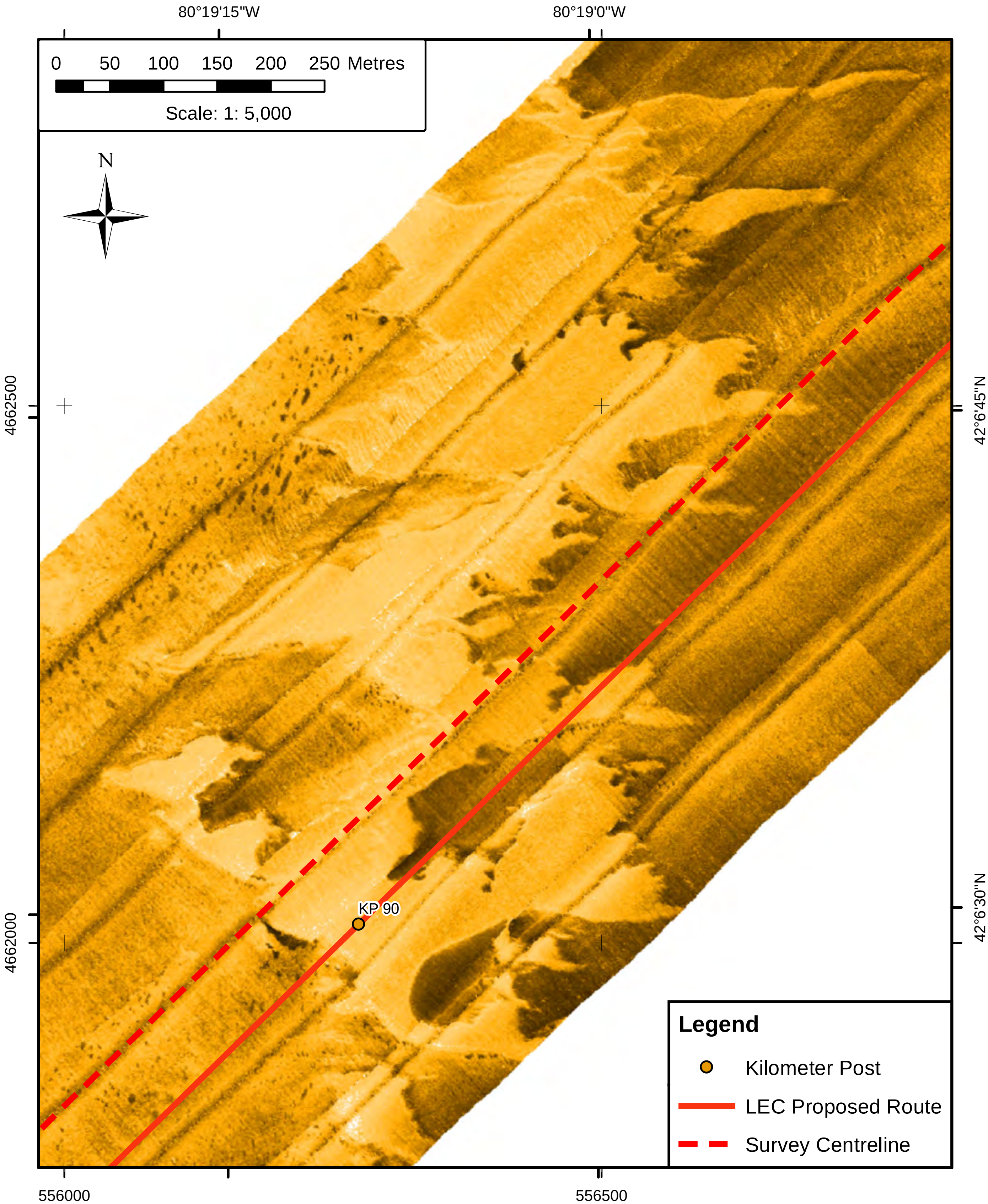


Figure 5.3.1.1 - Sidescan sonar mosaic of sediment transport features along the Lake Erie Connector Proposed Route.

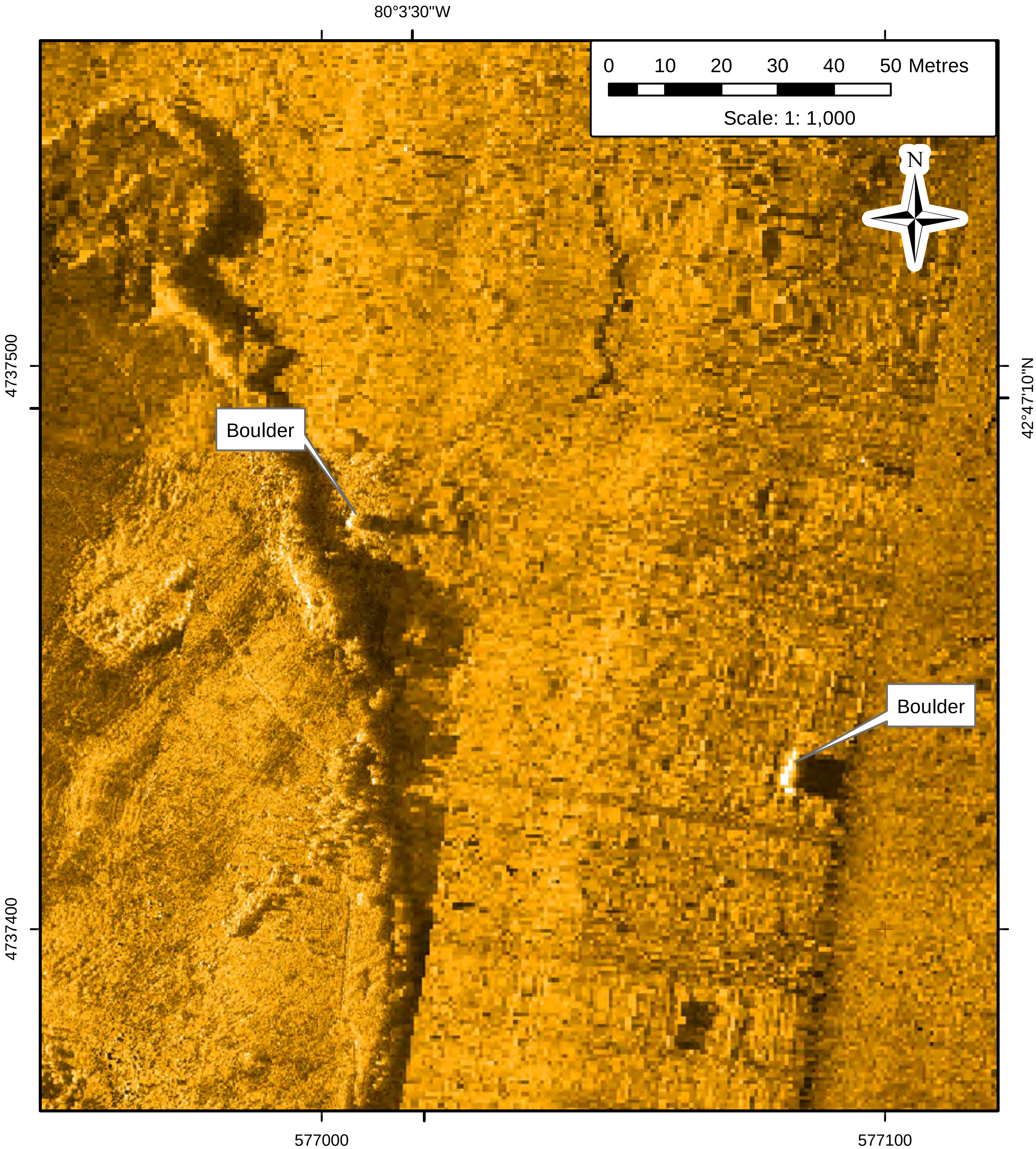


Figure 5.3.1.2 - Sidescan sonar mosaic of point source reflectors interpreted as boulders near the Canadian Landfall.

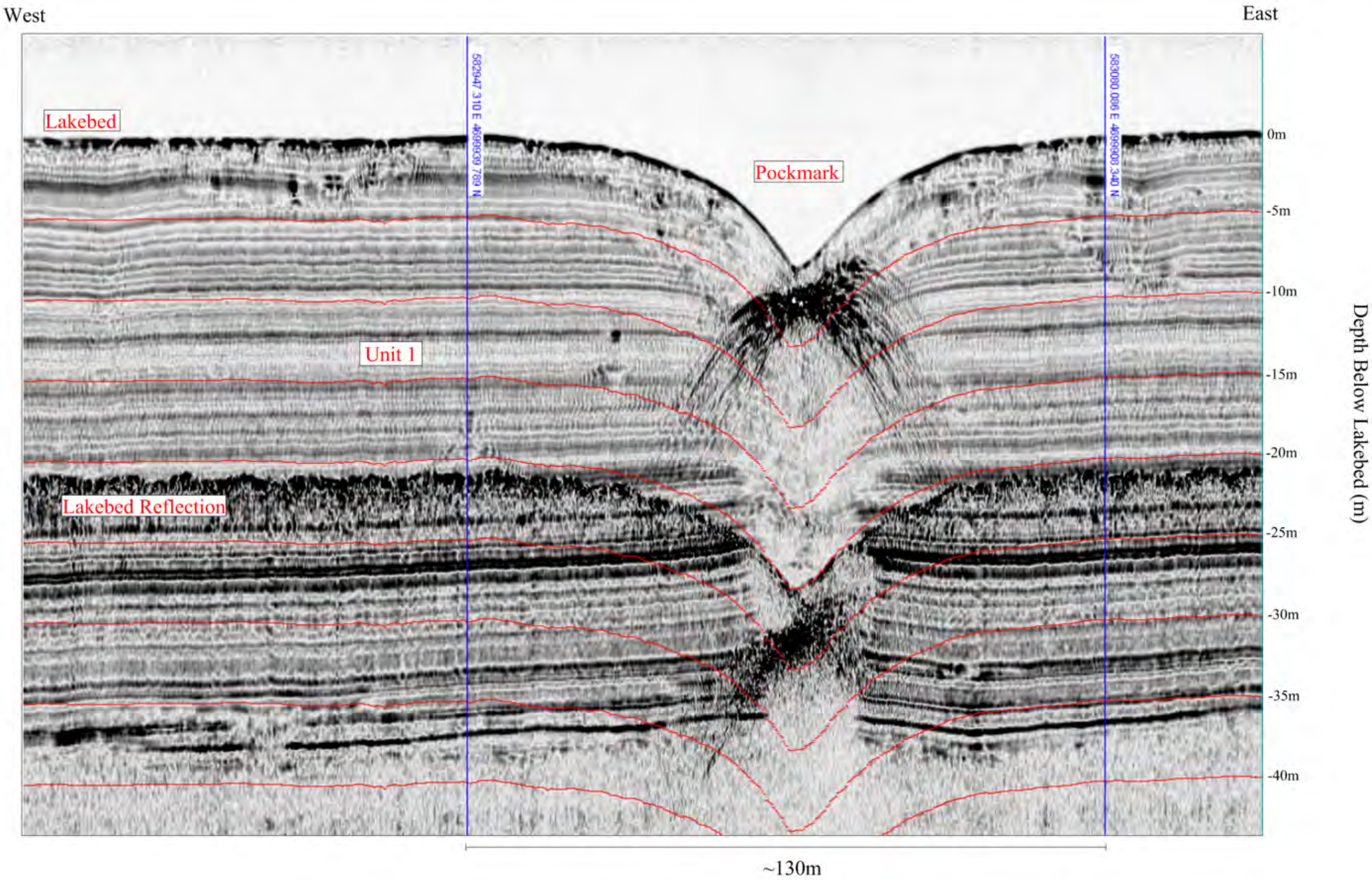


Figure 5.3.1.3 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route displaying a pockmark (gas escape feature) near KP 43, located 250m east of the route, collected using the Klein 3000 Chirp Profiler.

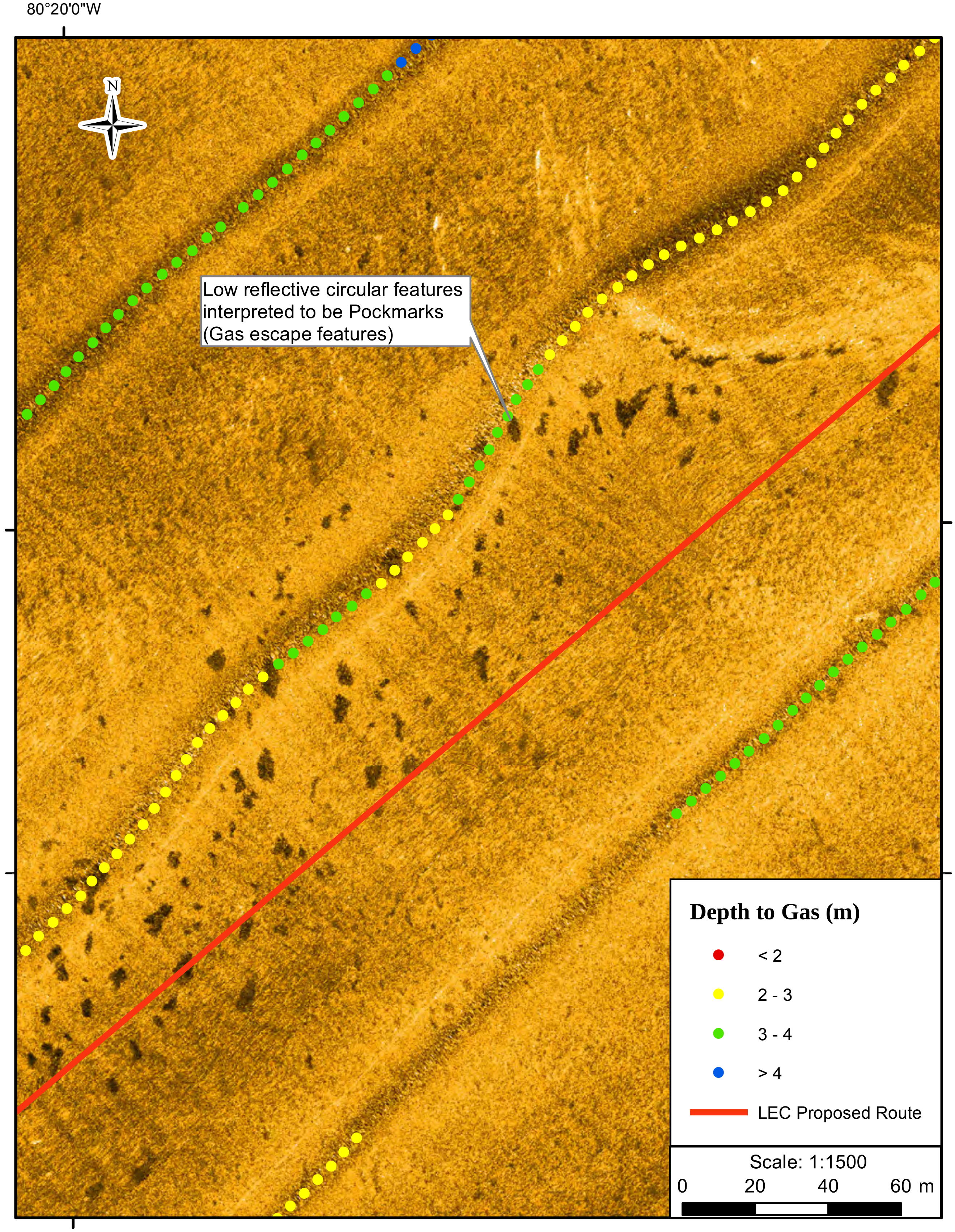


Figure 5.3.1.4 – Sidescan sonar record illustrating the presence of surficial features interpreted to be pockmarks (gas escape features) over the United States Offshore (approx. KP 91.5).

5.3.2 Sub-bottom Features

Shallow Gas Accumulation
The presence of gas charged sediments within the route corridor was interpreted from the chirp sub-bottom profiler and boomer shallow seismic data and later verified during the vibracore program. The presence of gas charged sediments can accentuate sub-bottom reflectors and cause “bright spots” but can also prevent the penetration of the acoustic energy from the seismic systems thereby masking the acoustic signal.

Interpreted areas of gas based on acoustic masking are displayed on the LEC Proposed Route Profile and Sub-Bottom Geology panel, see accompanying Panel Map Sheets. Examples of gas related acoustic masking can be seen in Figure 5.3.2.1, Figure 5.3.2.2 & Figure 5.3.2.3

The origin of the near surface gas in the survey area cannot be determined from the data collected from this survey. This gas could be originating from shallow decomposed organic material (biogenic) or from deep underlying bedrock formations (petrogenic). The area is underlain by significant deposits of natural gas within the bedrock which have been drilled extensively for hydrocarbons in the Canadian waters of Lake Erie. The biogenic source is also plausible since vegetation would have grown during a low lake level and then buried by transgression of the lake. This burial and subsequent decomposition could account for the significant amounts of sub-surface gas.

Shallow Gas Accumulation – Anchor Drag Survey
During the 2015 survey, a 3000 lb anchor was dragged along the lake bottom using the Nadro Marine tug *Ecosse*, which was mobilized for the vibracore program (see Section 3.5.7 Additional Survey Coverage). The objective of the anchor drag was to determine what would occur if the surficial sediments were disturbed with respect to the shallow gas accumulations below. The first 6 passes had roughly 90 m of anchor cable deployed, the next 5 passes had 215 m of cable deployed in 60 m of water. Upon retrieval of the anchor, approximately 60 m of cable was covered in grey silt / clay while the shank of the anchor was packed with clay.

Immediately after the anchor drag, sidescan sonar, multibeam and sub-bottom data was collected over the area. Examples of the sidescan sonar data and sub-bottom data are presented in Figure 5.3.2.4. The same geophysical lines were surveyed over the anchor drag site three days later to determine if any gas had leached out of the disturbed sediments over time. The geophysical survey track lines over the anchor drag site consisted of three main lines, oriented with the long axis of the anchor drag, spaced at 20-40 m. The tie lines were surveyed at 50 m intervals, perpendicular to the main lines. The results of this operation were inconclusive, the anchor did not leave deep scours in the lakebed, although it is believed that the anchor would have trenched into the lakebed 1-2 m based on the field vibracore results collected nearby. The fact that no significant scours were created from the drag is likely due to the soft nature of the sediments, combined with the high water content and gas presence in the material directly below the lakebed. The sediments in this area simply do not have the physical properties to be molded and thus infilled the trench created by the anchor almost immediately. Also, there did not appear to be any significant gas escape as a result of the anchor drags, any gas in the water column would have been visible in the chirp data. Based on the chirp sub-bottom profiler data, it is estimated that the anchor penetrated the lakebed a minimum of 0.8 m although this is also inconclusive due to the nature of seismic returns from the gas charged sediments.

Glacial Feature/Possible Diapir

Based on the geophysical data collected, subsequent data processing / analysis and consultation a GSC Geoscientist with extensive knowledge of Lake Erie geology (Gordon Cameron), it appears plausible that the geo-hazard located near KP 15.0, originally interpreted as a possible gas diapir is more likely remnants of glacial depositional processes. This does not infer that sub-surface gas is not present in the area, only that the origin of the geo-hazard is more likely glacial then gas related. The processes that created this geo-hazard were likely related to the formation of the Port Maitland Bank (glacial moraine) to the east. Based on the nature of the sediments and their negative effects on the sub-bottom acoustic data, is it difficult to decipher the internal characteristics of this geo-hazard. Therefore, the area is best avoided. The details of the route deviation around this geo-hazard to the east are outlined in Section 5.5.4 Glacial Feature/Possible Diapir Route Deviation.

Based on preliminary geotechnical data, there is medium / stiff clay with fine gravel located at the bottom of VC44 (the closest vibracore to this interpreted geo-hazard). This vibracore appears to have penetrated the same sedimentary layer that comprises the geo-hazard where it protrudes from the lakebed. The presence of gravel within the clay indicates glacial till. Figure 5.3.2.5 plots VC44 on the sub-bottom data and shows where the vibracore penetrated glacial till (Unit 3B) at a depth of approximately 3.0 m below the lakebed.

Long Point Escarpment Sediment Slumping

Successive slumping appears to have occurred along the LEC Proposed Route on the LPE slope from KP 40.45 to KP 40.64. However, it is difficult to predict the age of the slump events based on the data collected. The slumping appears rotational in nature as displayed in Figure 5.3.2.6. Rotational slumps occur when a block of unconsolidated sediments slides along a concave-upward slip surface with rotation about an axis parallel to the slope. Rotational movement causes the original surface of the block to become less steep while the top of the slump is rotated backward.

Faults/Fractures

A number of possible bedrock fractures or faults have been interpreted from seismic reflection data in the Canadian Nearshore & Approaches and Landfall. These features may be associated bedding planes within the limestone bedrock unit. These features typically have offsets of 1.0 meter or less. A prominent bedrock ridge 2.0 metres in height is observed at approximately KP 4.4, which may be the result of a bedrock fault (Figure 5.3.2.7).

The LEC Proposed Route is located in an area of mild potential for seismic activity

(ACNBC, 1980). The Lake Erie basin has had a history of low magnitude seismic events including: a 4.3 magnitude event in Welland, Ontario, in 1958 (Langley and Fitchko, 1981); a 5.0 event near Ashtabula, Ohio, in 1986 (Visnosky, 1998); a 5.4 event near the Pennsylvania/Ohio border in 1998 (Keung, 1998); and a 5.2 event north of Thunder Bay, Ontario, in 2000 (Laughren, 2000). It is not known if any of the possible faults / fractures in the survey area are active at present.

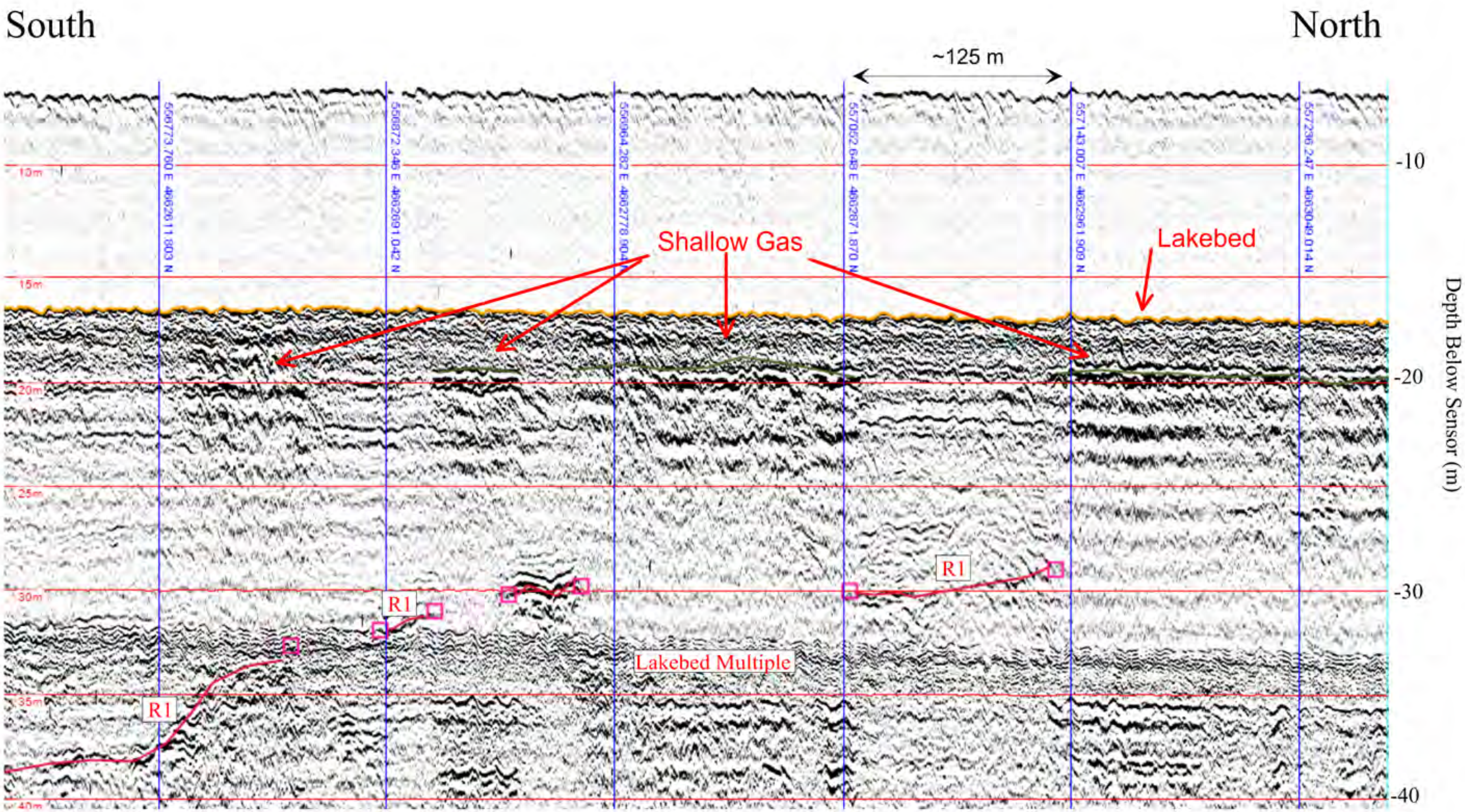


Figure 5.3.2.1 - Shallow seismic (sub-bottom) profile displaying shallow gas within the Pennsylvannia Channel over the LEC Proposed Route collected using CSR's EG&G boomer system.

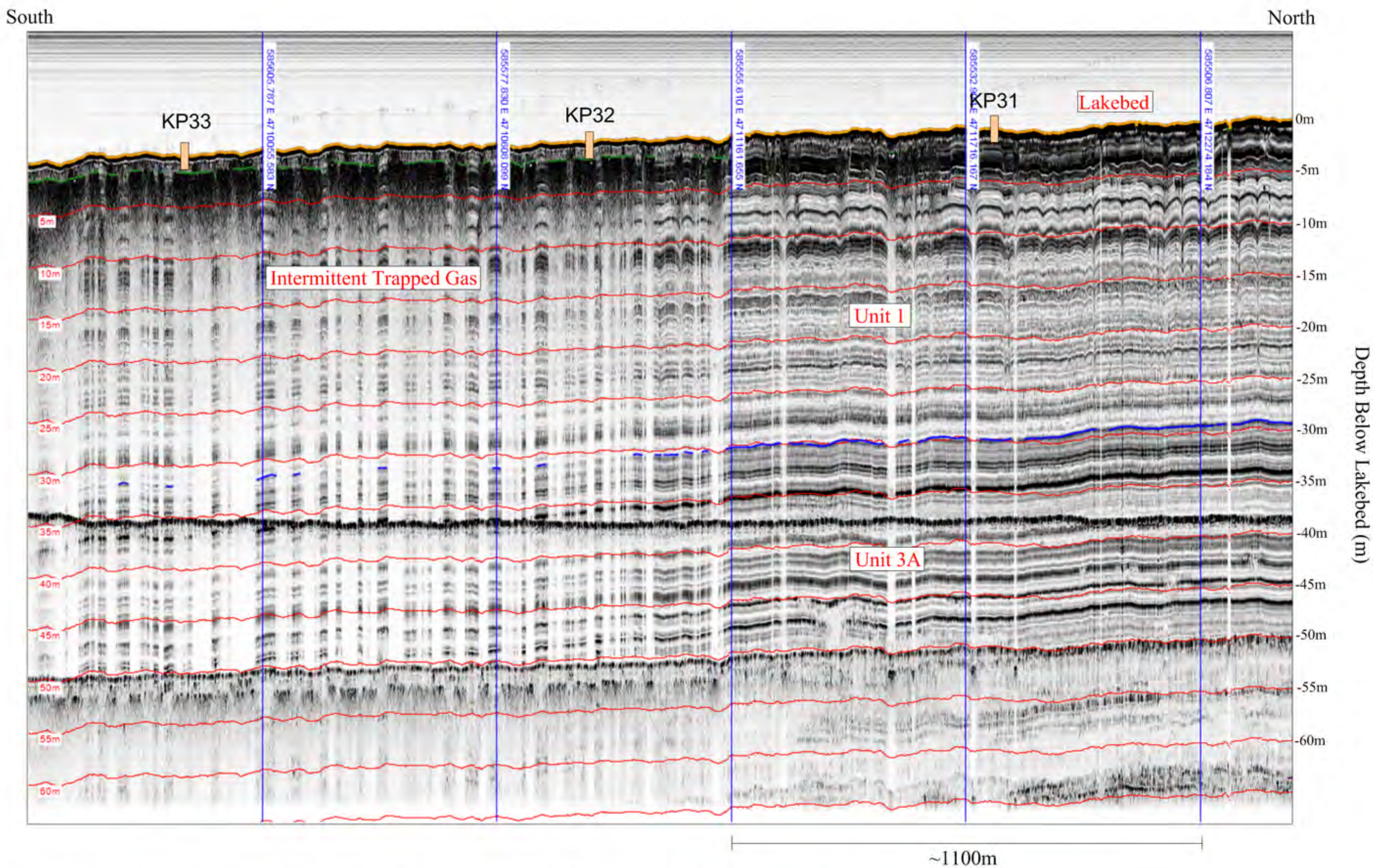


Figure 5.3.2.2 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route displaying intermittently trapped gas, collected with the Klein 3000 Chirp Profiler.

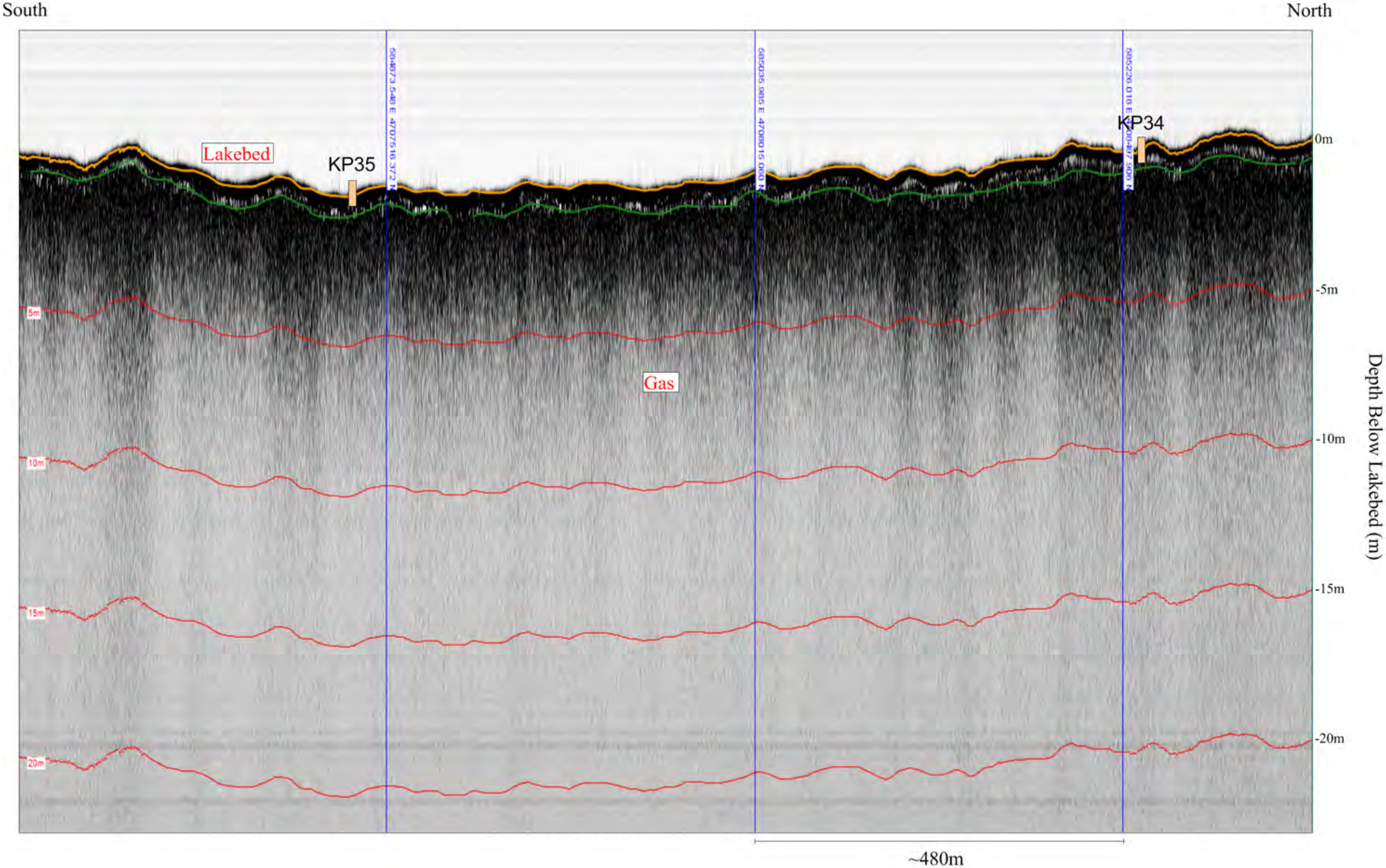
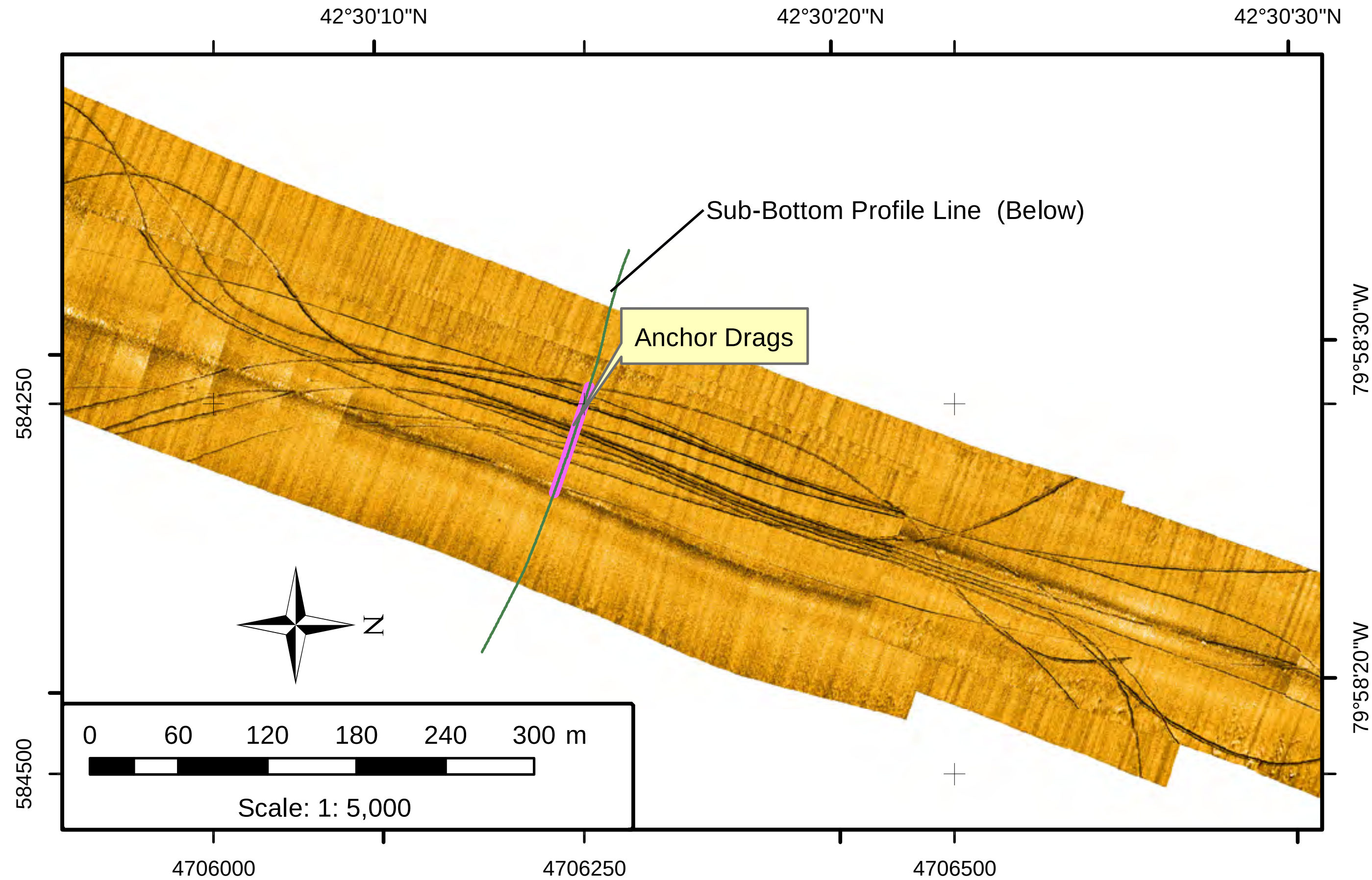


Figure 5.3.2.3 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route displaying trapped gas, collected using the Klein 3000 Chirp Profiler.



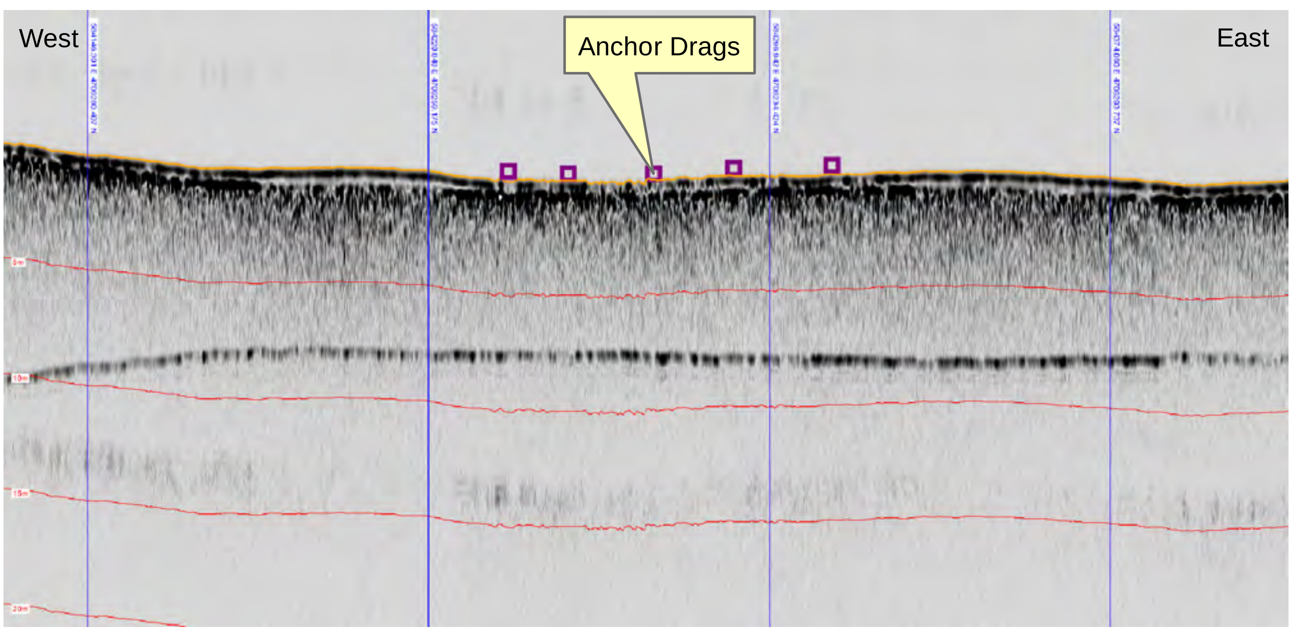


Figure 5.3.2.4 - Sidescan sonar mosaic of the anchor drag area post drag. The accompanying chirp figure shows that the significant gas masking in the area was unaffected by the drags.

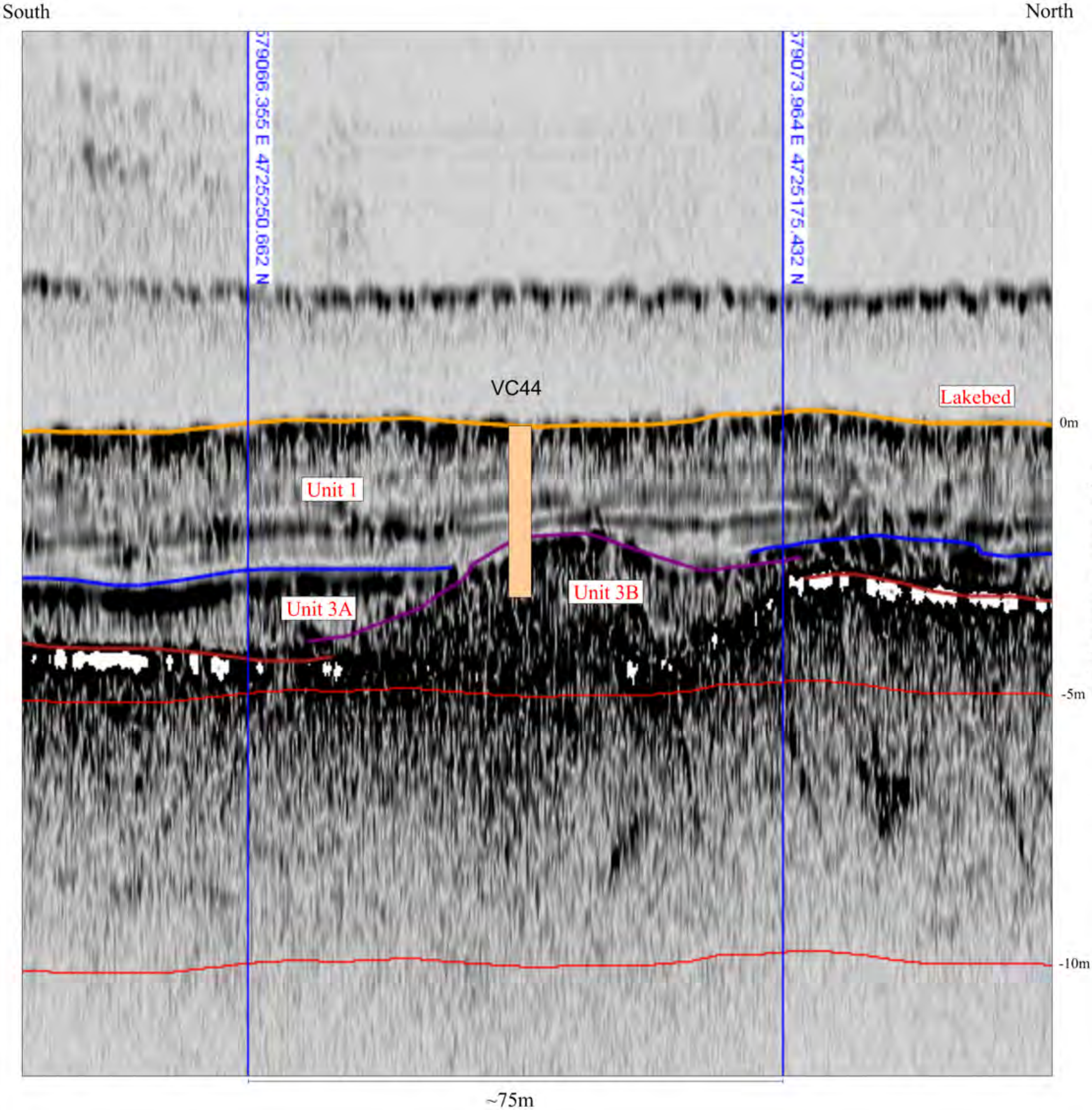


Figure 5.3.2.5 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route at VC44, collected using the Klein 3000 Chirp Profiler. This figure shows an accurate depth of recovered core into glacial till (Unit 3B), considered to be the same sedimentary unit comprising the glacial feature geo-hazard.

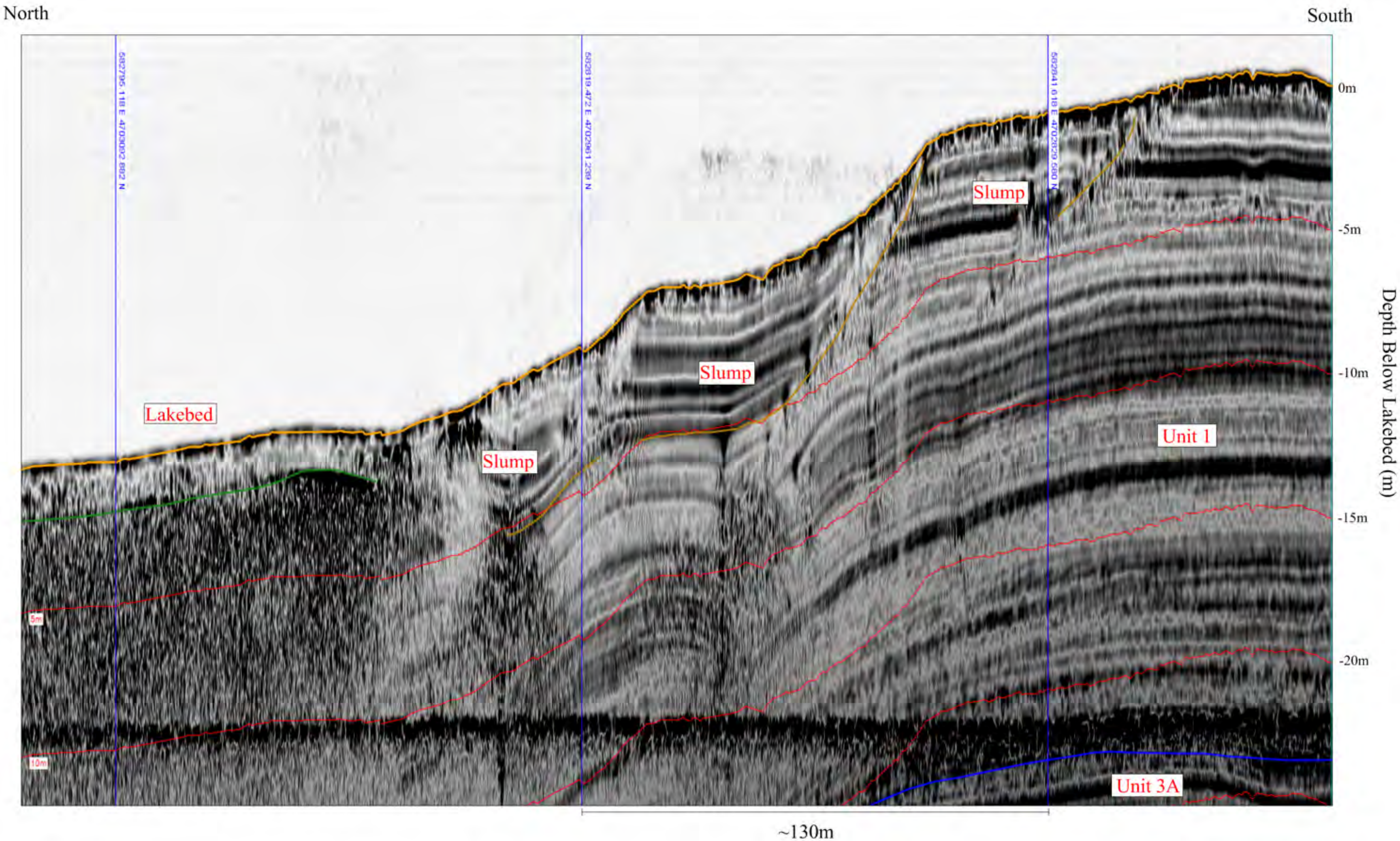


Figure 5.3.2.6 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route displaying slumping on the Long Point Escarpment, collected using the Klein 3000 Chirp Profiler.

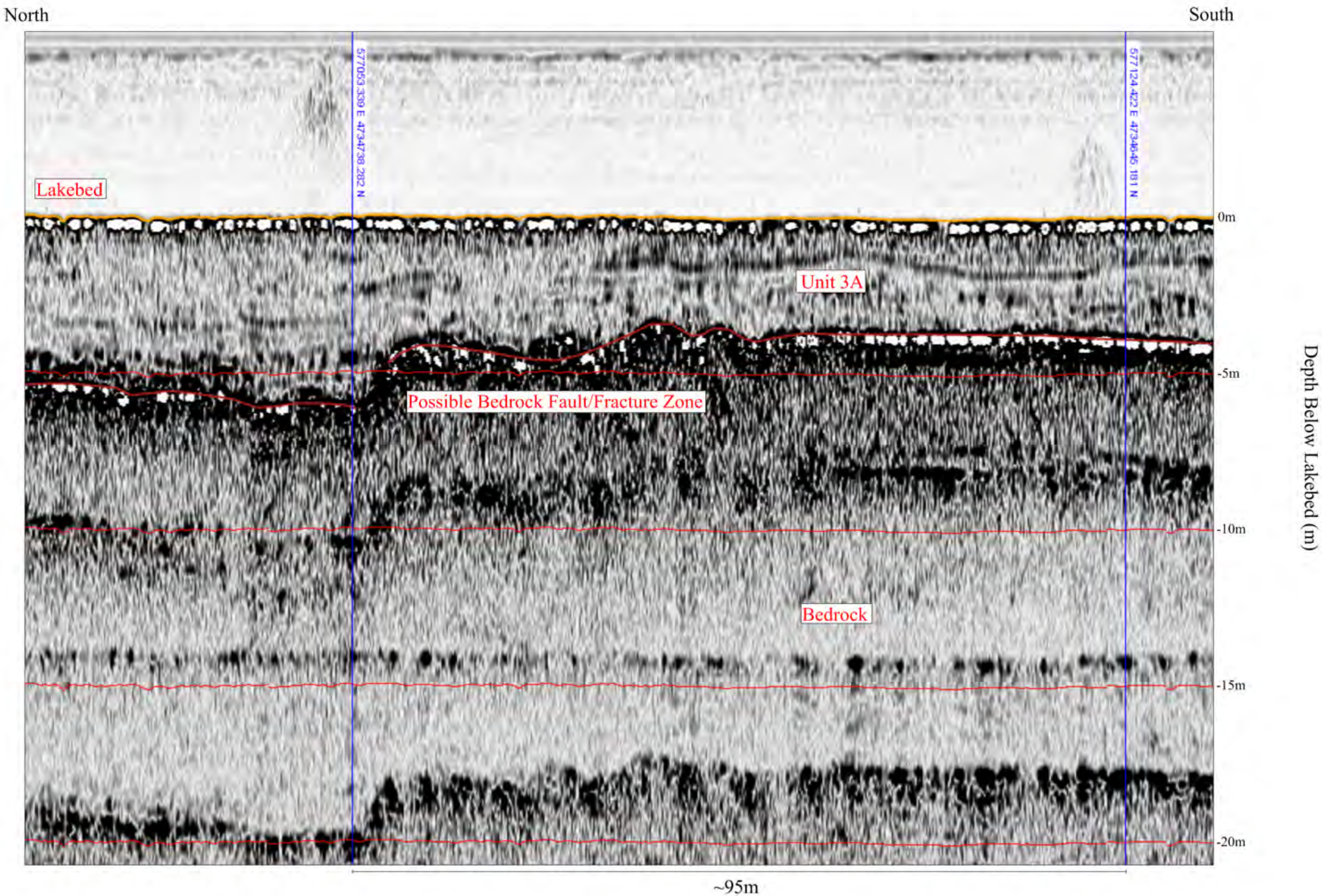


Figure 5.3.2.7 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route displaying a possible bedrock fault/fracture zone near KP 4.4, collected using the Klein 3000 Chirp Profiler.

5.3.3 Ice Scours

Ice scouring is the process whereby ice ridges or icebergs contact the seabed forming long, linear gouges in the seafloor sediments. This scouring process has long been recognised as a potential threat to submarine pipeline or cable installations and offshore structures such as drilling platforms and sub-sea installations.

The extent and thickness of Lake Erie ice is influenced by winter temperatures and greatly affected by the number, severity and duration of storms as well as wind direction (Foulds, 1985). The prevailing wind direction over Lake Erie is from the west- southwest quadrant. Strong winds can cause ice to fracture and pile up into ridges reaching 10 m in height. Ice ridges in Lake Erie are formed by compression or shear in the ice cover and are found in the shear zone between the landfast ice and the drift or pack ice. Subsequent movement of these ridges can cause their keels to scour the lakebed sediments. Scours up to 1.7 m deep, 100 m wide, and several kilometres long, in water depths up to 25 m have been observed. Ice scouring within Lake Erie is episodic, with high spatial and temporal variability of scour formation and infilling by sediments (Lever, 2000).

The scour depth parameter is perhaps the most important measurement in estimating the minimum trenching depths required for a sub-sea installation. Scour depth is a variant parameter, depending on a number of factors including: size of the scouring ice keel, scour age, amount of infill, bathymetry, physiographic location and the geotechnical soil conditions. The scour depth parameter represents a measurement that is derived from the acoustic data at some time after the passage of the ice keel. As a result, these values are considered minimum values. For example, upon scouring, some immediate sediment backfill may take place, especially in sandy or silty sediment. Subsequent to this, the scour may become infilled by hydrodynamic reworking, normal sedimentation, bioturbation or by additional scouring by other ice keels. Scours in clay and silt will typically infill or degrade slower than scours in areas of sand. Scours in cohesive clay and silt will also tend to maintain their shape while scours in sand will experience some infill immediately due to the lack of sediment cohesion. The degree of sediment transport within some areas of Lake Erie plays a major role in scour degradation and the amount of infill that occurs.

5.3.3.1 Ice Scour Mapping

During this study all ice scour features were identified through a detailed examination of sidescan sonar, multibeam echosounder, single beam echosounder & sub-bottom profiler data acquired during the 2014 and 2015 geophysical surveys. The centerline of each ice scour was digitized and databased within ArcGIS. The following is an overview of the key scour parameters while a complete list of fields, database codes and descriptions can be found in *Appendix VI*.

Bathymetry

Bathymetry was extracted from the processed sounding data at each ice scour location. The bathymetry values stored in the database represent the minimum and maximum water depth of the unscoured lakebed.

Scour Depth
Scour depth was measured from the unscoured lakebed datum to the deepest point observed. Accuracy of the scour depth measurement is dependent on the location of the interpreted unscoured lakebed datum and the quality of the data.

Scour depth was measured in metres manually by the interpreter for single beam echosounder and sub-bottom profiler data at the location where the geophysical profiler transects the ice scour. For scour depth measured from multibeam echosounder data it is possible to extract multiple depth measurements from the ice scour. The maximum depth extracted from the multibeam data along the track of each ice scour was stored in the database. In the case of infilled scours, depth measurements are made from the referenced datum to the top of the infill. Infill measurements are not possible from multibeam data.

Scour Length
Scour length was measured in metres and represents true length for scours where both endpoints were observed on the geophysical data, but is less than the true scour length for events which extend beyond the edge of sidescan sonogram or the swath of the multibeam. The latter is the case for the majority of length measurements. A length qualifier was included to describe the presence of end points observed and thus the quality of the length measurement.

Scour Width
Scour width was measured in metres from berm crest to berm crest, perpendicular to the long axis of the scour.

Orientation
Orientation is the bearing of the scour referenced to Grid North and expressed by convention between 0 and 179 degrees inclusive. Orientation does not imply scouring direction. Scour direction can only be determined if the termination is observed.

Scour Type
This field defines the scour type as single keel or multi-keel.

Scour Smoothness
Scour smoothness is a qualitative evaluation of the relative clarity and sharpness (edge or boundary definition) of the scour as it appears on the sidescan sonar record or multibeam echosounder data. Although this code is qualitative it can be used as a guide to the age of the scour.

Sediment Type
Surficial sediment type is interpreted from acoustic data sets and from sediment sampling.

Sediment Infill
The field records the thickness of sediment infill within the scour trough as measured from the available profiler data.

5.3.3.2 Ice Scour Analysis

Twenty-five ice scours were identified from the geophysical data acquired in 2014 and 2015 over the LEC Proposed Route corridor from sidescan sonar and multibeam echosounder data. Thirteen ice scours occur within Canadian waters and twelve within American waters. The locations of the scours are displayed on Figures 5.3.3.1 and 5.3.3.2 and summarized within Table 5.3.3.1. The Scour ID displayed on the figures corresponds to the ID included within the table.

Of the twenty-five ice scours observed, 14 are considered to have formed recently based on their acoustic signature and morphology. The remainder represents an older population of ice scours.

Table 5.3.3.1 – Summary of Ice Scours Observed

Scour Id	Location	Type	Interpreted Age	Bathymetry (m)	Orientation (degrees)	Width (m)	Length (m)	Depth (m)	Sediment Infill	Sediment Type
1	USA	SK	Recent	13-14	107	4.9	147.7	≤0.3	NM	Sand/Silt
2	USA	SK	Recent	15-16	66	3.1	366.6	≤0.2	NM	Sand/Silt
3	USA	MK	Recent	15-16	65	19.5	479.8	≤0.2	NM	Sand/Silt
4	USA	MK	Recent	15-16	70	17.9	418.9	≤0.2	NM	Sand/Silt
5	USA	MK	Recent	15-16	54	15.7	317.3	≤0.2	NM	Silt/Clay
6	USA	SK	Recent	13-14	98	6.5	201.9	≤0.2	NM	Sand/Silt
7	Canada	SK	Old	20-22	8	19.5	1348.4	0.60	0.6	Silt/Clay
8	Canada	SK	Old	21-22	96	25.4	697.4	0.70	0.5	Silt/Clay
9	Canada	SK	Old	20-21	53	14.1	688.1	0.20	1.2	Silt/Clay
10	Canada	SK	Old	14-15	65	9.2	708.4	≤0.2	NM	Silt/Clay
11	Canada	SK	Old	12-13	41	13.5	221.8	≤0.2	NM	Silt/Clay
12	Canada	SK	Old	12-13	6	26.6	266.3	≤0.2	NM	Silt/Clay
13	Canada	SK	Recent	6-7	29	13.5	156.2	≤0.2	NM	Clay/Silt
14	Canada	MK	Recent	6-7	29	28.0	170.2	≤0.2	NM	Clay/Silt
15	Canada	SK	Old	21-22	63	22.8	842.8	0.54	1.2	Silt/Clay
16	Canada	MK	Recent	9-10	28	6.2	144.7	≤0.2	NM	Silt/Clay
17	Canada	SK	Recent	9-10	31	2.5	190.0	≤0.2	NM	Silt/Clay
18	Canada	SK	Old	15-16	28	9.8	271.5	≤0.2	NM	Silt/Clay
19	USA	SK	Old	23-24	60	25.0	856.0	0.2	1.4	Silt/Clay
20	USA	SK	Old	20-21	78	11.9	420.0	≤0.2	NM	Silt/Clay
21	USA	MK	Recent	17-18	64	317.5	3477.9	1.36	NM	Silt/Clay
22	USA	SK	Recent	19-20	104	6.7	256.2	≤0.2	NM	Silt/Clay
23	USA	SK	Recent	12-13	68	12.7	286.4	≤0.2	NM	Sand/Silt
24	USA	SK	Recent	13-14	62	4.4	467.2	≤0.3	NM	Sand/Silt
25	Canada	SK	Old	30-31	36	8.0	557.6	0.2	0.9	Silt/Clay

NM – Not Measureable
SK – Single Keel Ice Scour
MK – Multi-keel Ice Scour

Within Canadian waters the majority of ice scours (69%) observed represents an older population. The ice scours observed within Canadian waters appear older due to their acoustic signature which indicates eroding berms and infilled troughs. The four scours interpreted to have formed recently occur in water depth 6 to 10 m and have scour depths ≤0.2 m. Figures 5.3.3.3 through 5.3.3.5 illustrate the morphology of three old ice scours (Scour Id 7, 8, & 15) located in water depth 20 to 22 m. The sidescan mosaic and multibeam surface displayed in Figure 5.3.3.3 illustrate their shape and cross cutting relationships. This figure includes the locations of scour centreline profiles extracted from the 2015 multibeam data and displayed in Figure 5.3.3.4. Chirp sub-bottom data acquired across the scours in 2015 indicate the berms are smoothed due to erosion and their troughs partially infilled with sediment; see Figure 5.3.3.5 (bottom).

Within American waters the majority of ice scours observed (83%) are interpreted to have formed recently. Two older scours occur in water depth 20 to 24 m. The 10 ice scours interpreted to have formed recently occur in water depths ranging from 13 to 20 m and have a maximum scour depth of 1.36 m. The majority of recent scours are narrow (4 to 20 m wide) and have scour depths ≤0.3 m. Ice scours formed in this area of Lake Erie are prone to rapid degradation due to sediment transport. Studies by Ontario Hydro in the 1980's illustrated new ice scours were formed within the Pennsylvania Channel annually. Typically, these news scours were obliterated, troughs were infilled and berms were completely eroded, within a one-year period.

The most significant recent ice scour is a 318 m wide multi-keel event (Scour id 21) identified in 17 to 18 m water depth approximately 8 kms offshore within the Pennsylvania Channel. This ice scour is interpreted to have formed during the winter of 2015. Figure 5.3.3.5 (bottom) includes chirp data acquired over the ice scour showing no visible sediment infill within the trough and rough berms unlike the older ice scour events.

NOAA satellite images displayed within Figure 5.3.3.6 illustrates the location of ice scour 21 and the dynamic ice conditions between February 13th and March 24th 2015. On February 13th a large ice floe the length of the ice scour is visible. On March 13th a lead in the ice which may represent the location of the landfast and pack ice is visible south of the ice scour location.

Additional survey work completed by CSR tracked the ice scour event for approximately 3.5 kms. A sidescan sonar mosaic and multibeam shaded relief image of the ice scour are presented in Figures 5.3.3.7 and 5.3.3.8 respectively. The large multi-keeled ice floe that formed the scour was moving in a southwest direction parallel to the bathymetry contours, see Figure 5.3.3.9. The scour termination indicates the ice keels grounded for a period of time before the ice moved offshore in a northeasterly direction as displayed in Figure 5.3.3.9.

In order to determine the maximum scour depth along the multi-keel event, an unscoured lakebed surface was generated by smoothing the lakebed multibeam data. The unscoured lakebed surface was subtracted from the multibeam lakebed surface, resulting in a scoured or difference surface, see Figure 5.3.3.10. This figure displays the spatial distribution of scour depth (-0.2 m to -1.36 m) and berm height (+0.2 m to +1.46 m) along the multi-keel event relative to the unscoured lakebed. Figure 5.3.3.10 also includes the location of the maximum scour depth (-1.36 m) extracted from the difference surface.

Centerline lakebed profiles were generated along 7 of the keels. The profile locations are displayed in Figure 5.3.3.9 and the profiles within Figures 5.3.3.11 and 5.3.3.12. The profiles include the scour centerline lakebed (blue) extended across the termination berm as well as the unscoured lakebed profile (grey).

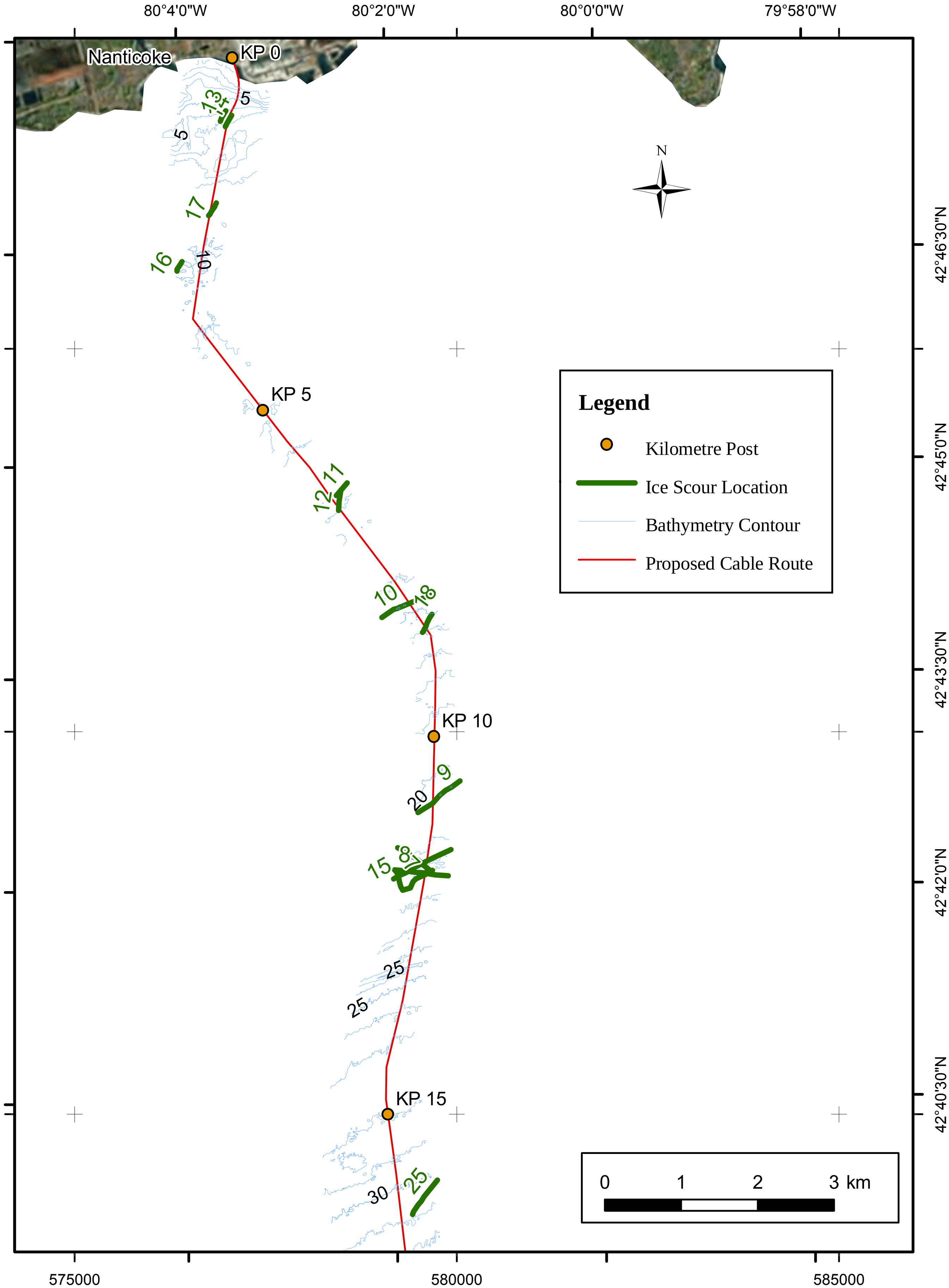


Figure 5.3.3.1 – Ice scour locations mapped within Canadian waters.

Canadian Seabed Research Ltd.

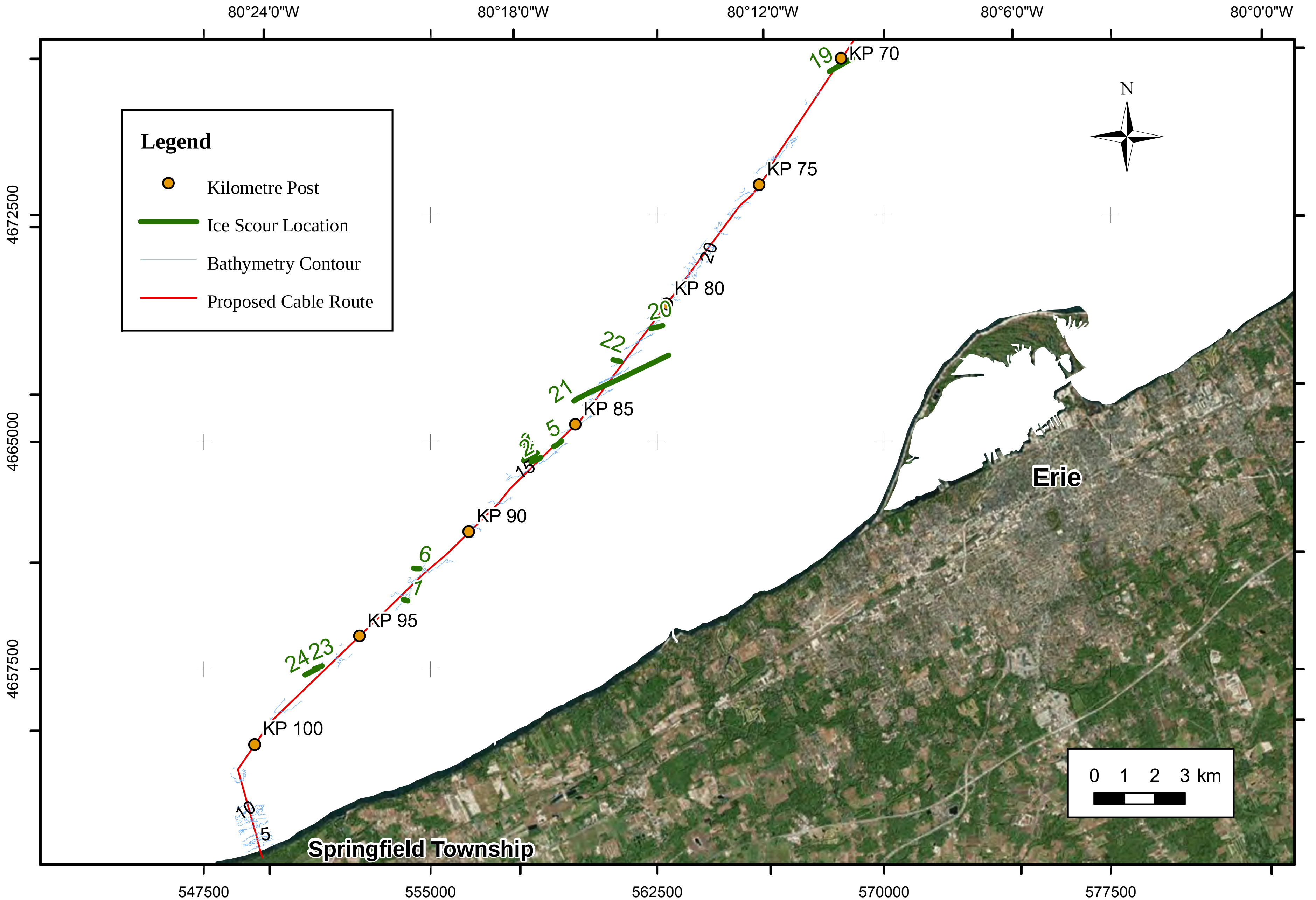


Figure 5.3.3.2 – Ice scour locations mapped within American waters.

Canadian Seabed Research Ltd.

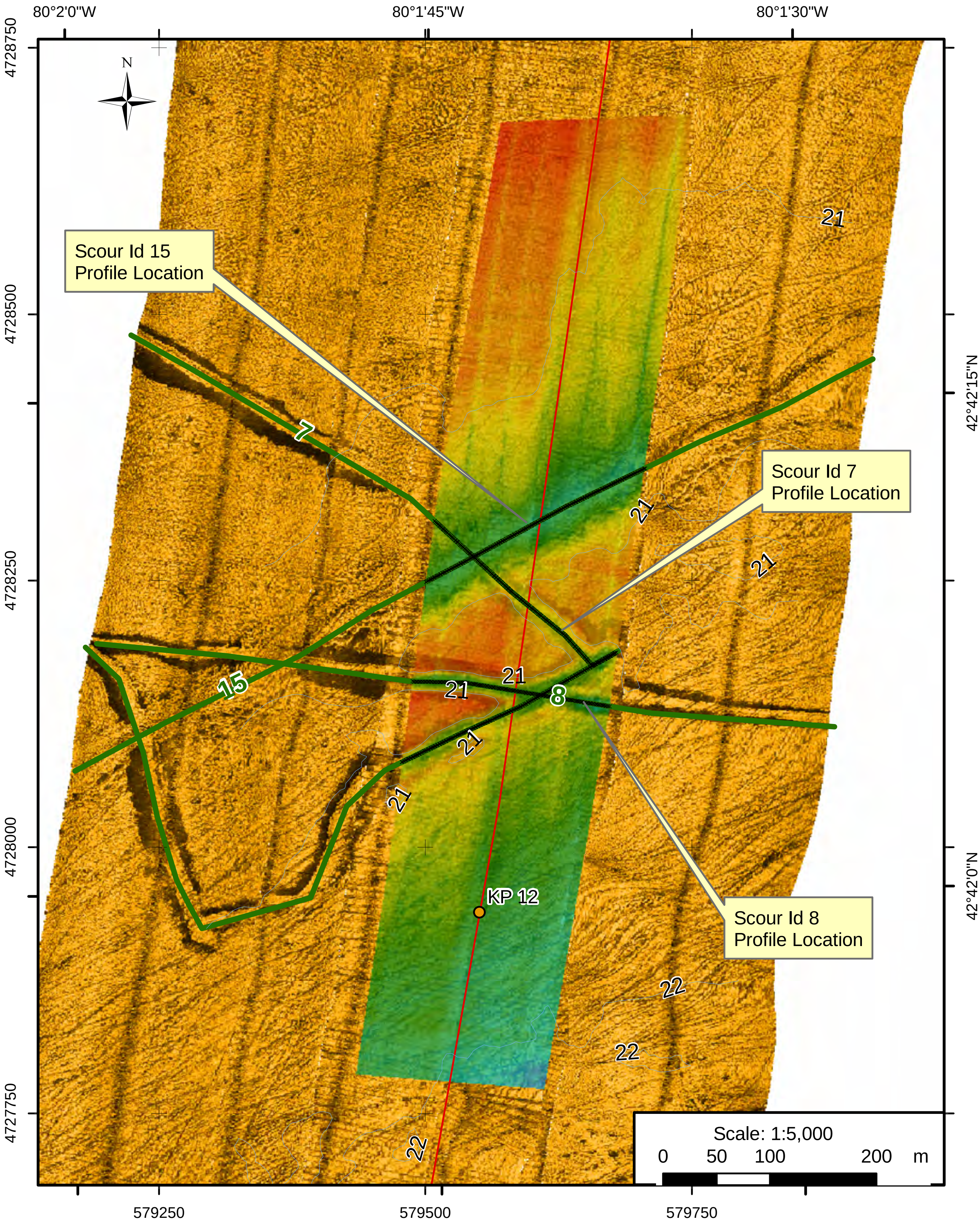


Figure 5.3.3.3 - Sidescan sonar mosaic with multibeam overlay of ice scours 7, 8, and 15 over the LEC route within Canadian waters. These ice scours are interpreted to represent an older population.

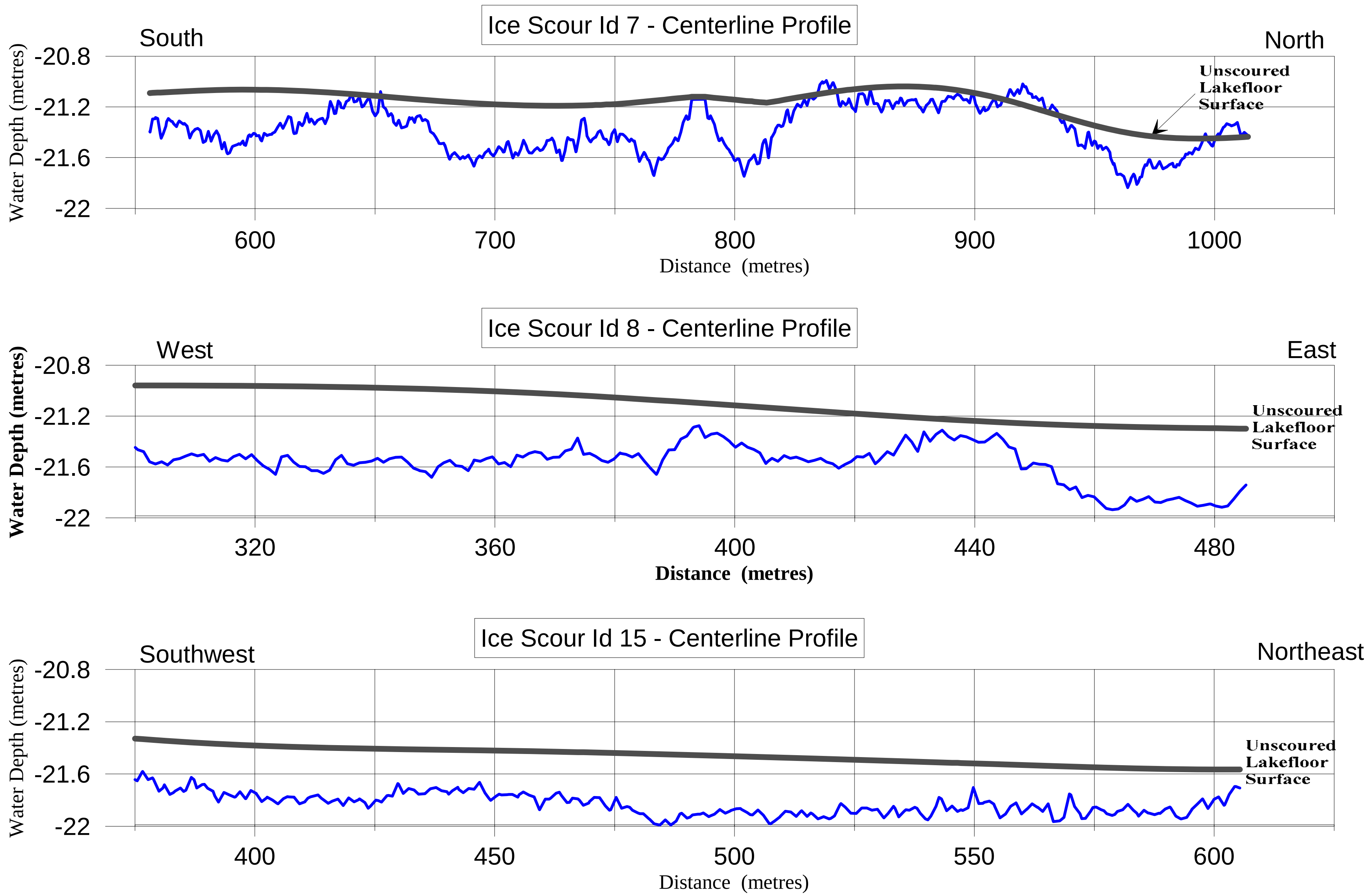
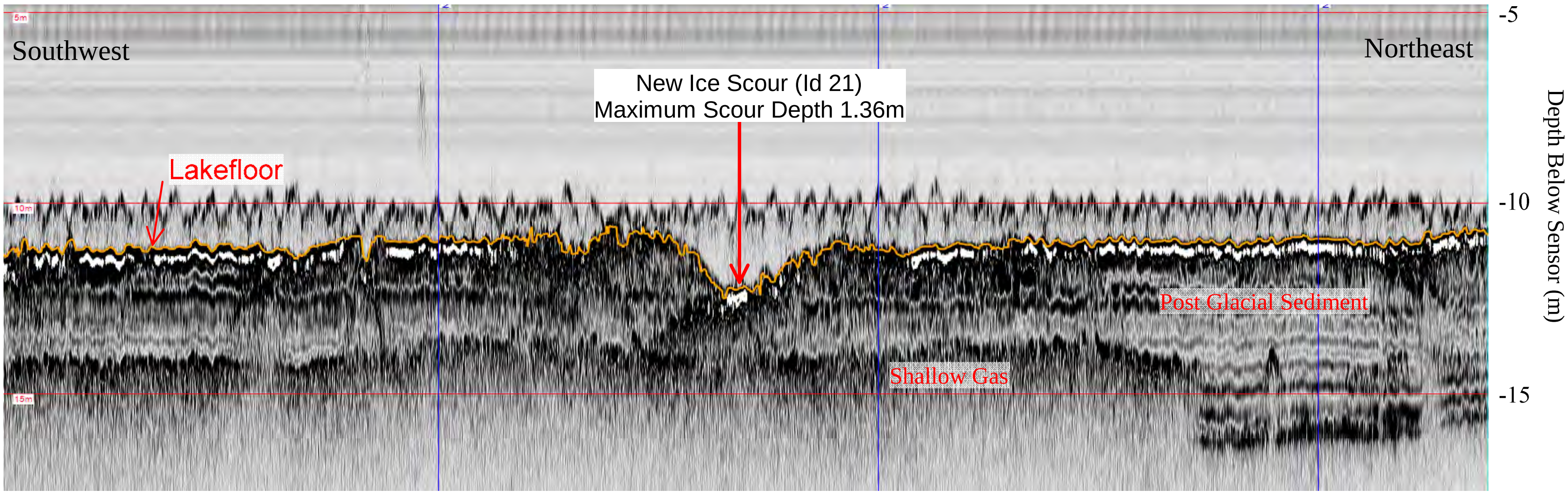


Figure 5.3.3.4 - Centerline lakefloor (blue) and unscoured lakefloor (grey) profiles along Scours 7, 8, and 15.

Canadian Seabed Research Ltd.



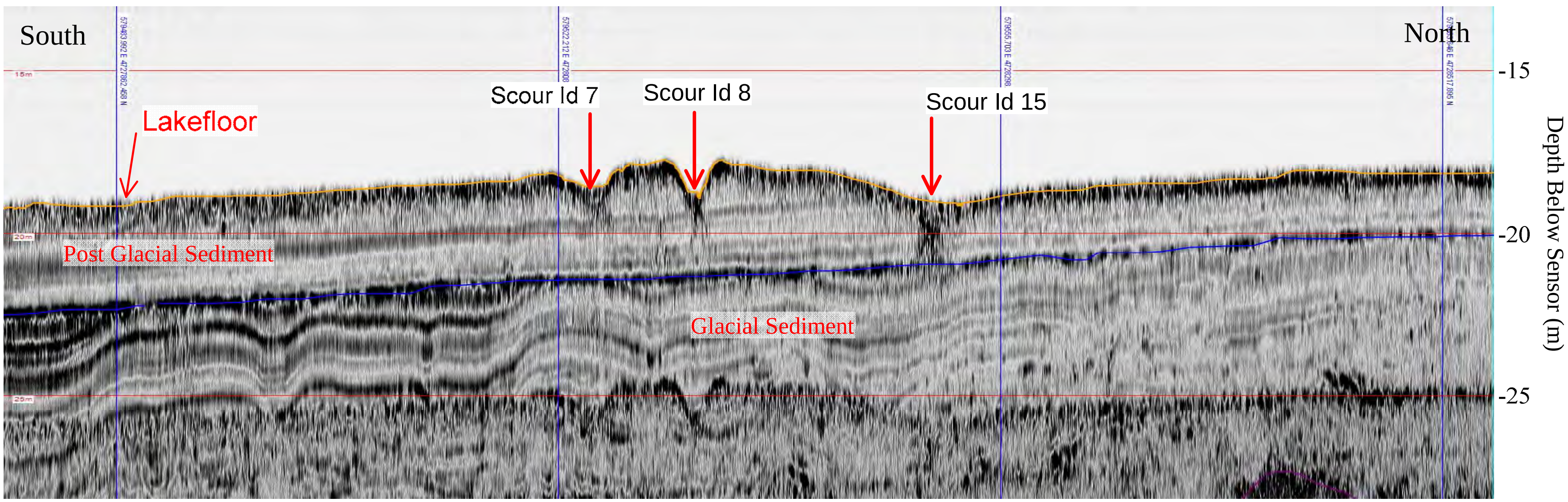


Figure 5.3.3.5 - Chirp (sub-bottom) profiler data illustrating morphology of new scour (top) within the Pennsylvania Channel and degraded / infilled old scours (bottom) within Canadian waters

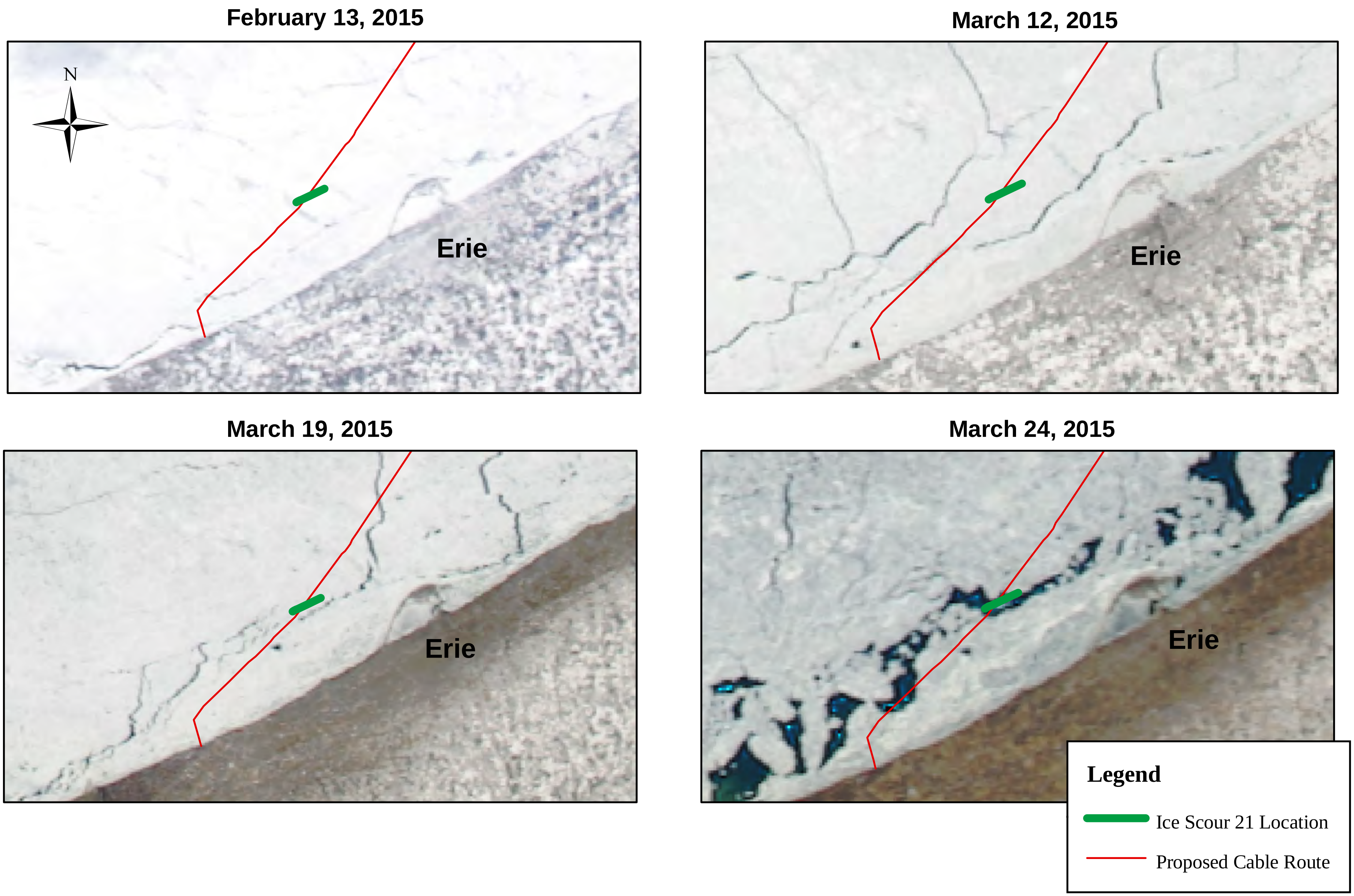


Figure 5.3.3.6 – NOAA satellite images illustrating ice conditions during the winter of 2015 over the location of Ice scour 21.

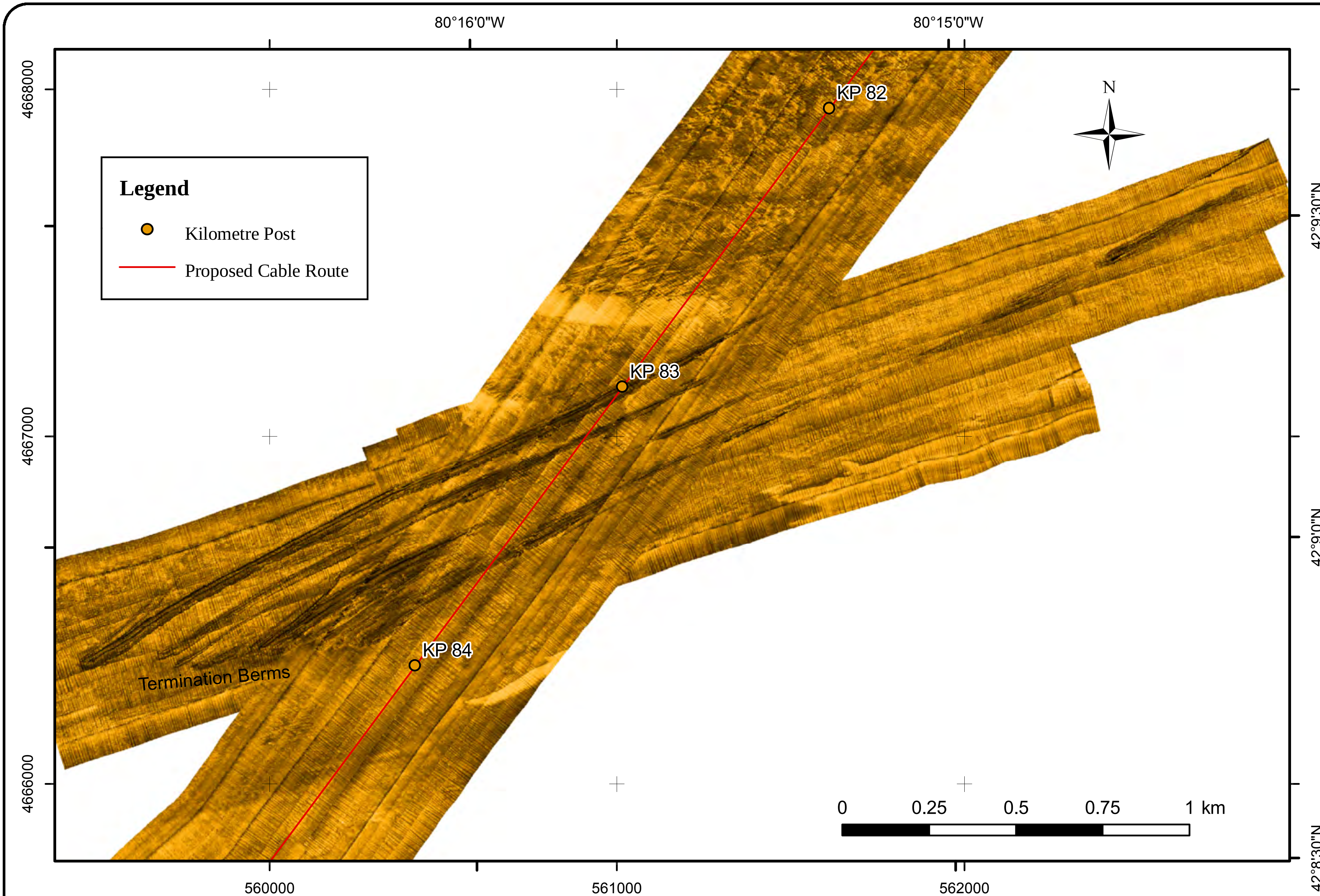


Figure 5.3.3.7 – Sidescan sonar mosaic of multi-keel ice scour 21 interpreted to have formed during the winter of 2015.

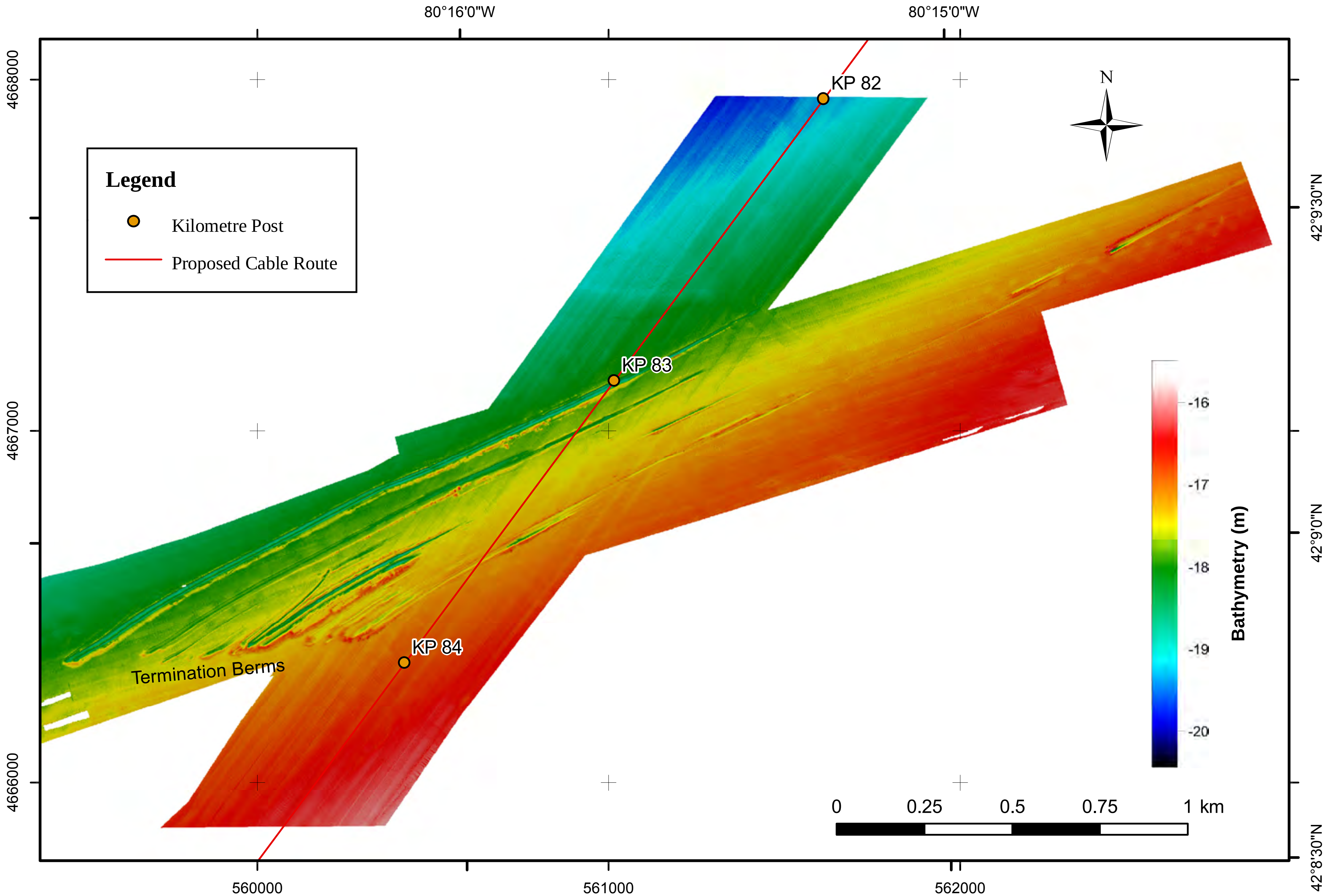


Figure 5.3.3.8 – Multibeam shaded relief image of multi-keel ice scour 21 interpreted to have formed during the winter of 2015.

Canadian Seabed Research Ltd.

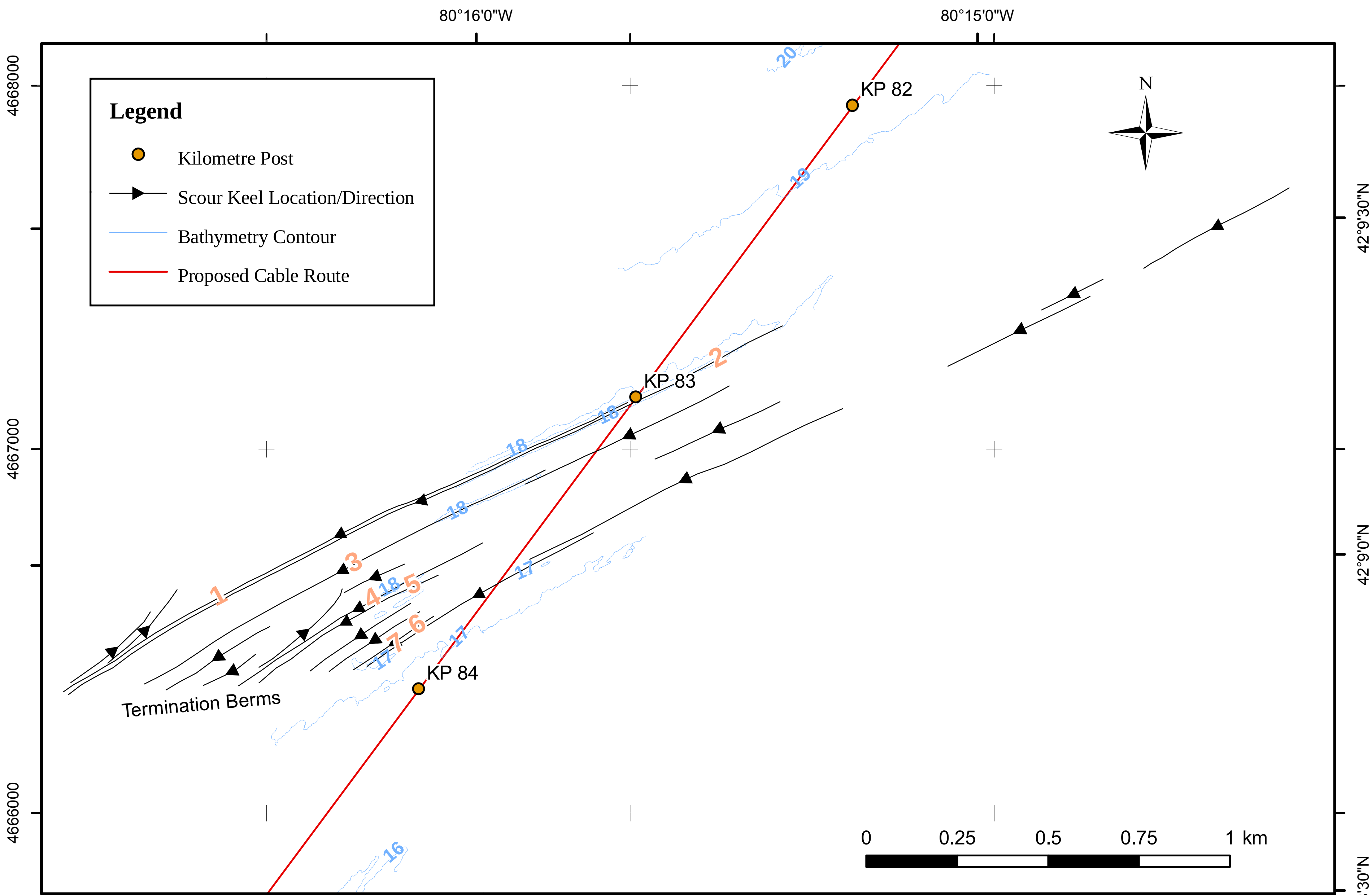


Figure 5.3.3.9 – Ice Scour 21 keel locations and scouring direction. Keel Profile numbers correspond to the centreline profiles displayed within Figures 5.3.3.11 and 5.3.3.12.

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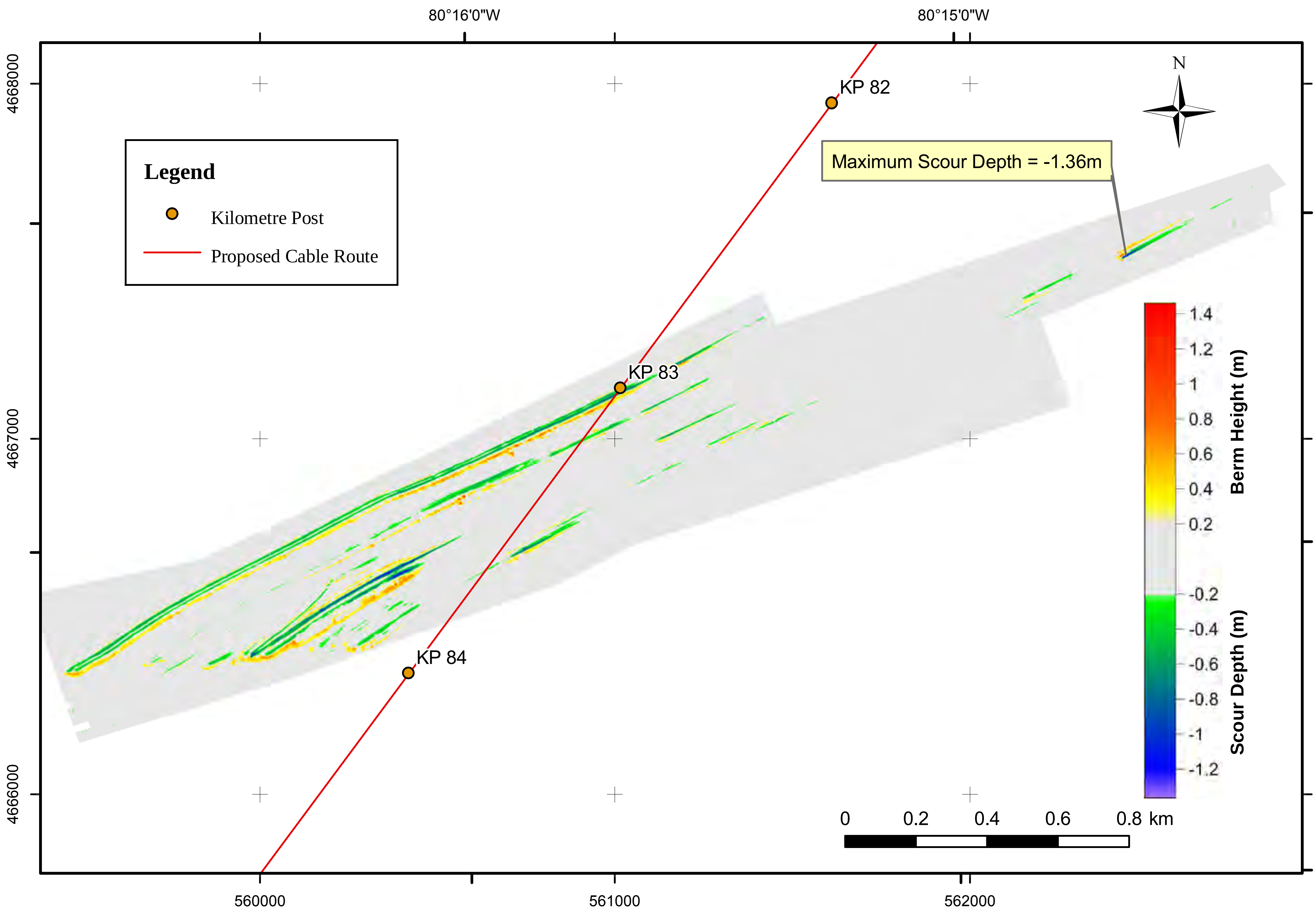

Figure 5.3.3.10 – Ice scour 21 scoured/difference surface illustrating the spatial distribution of scour depth and berm height referenced to the unscoured seafloor.

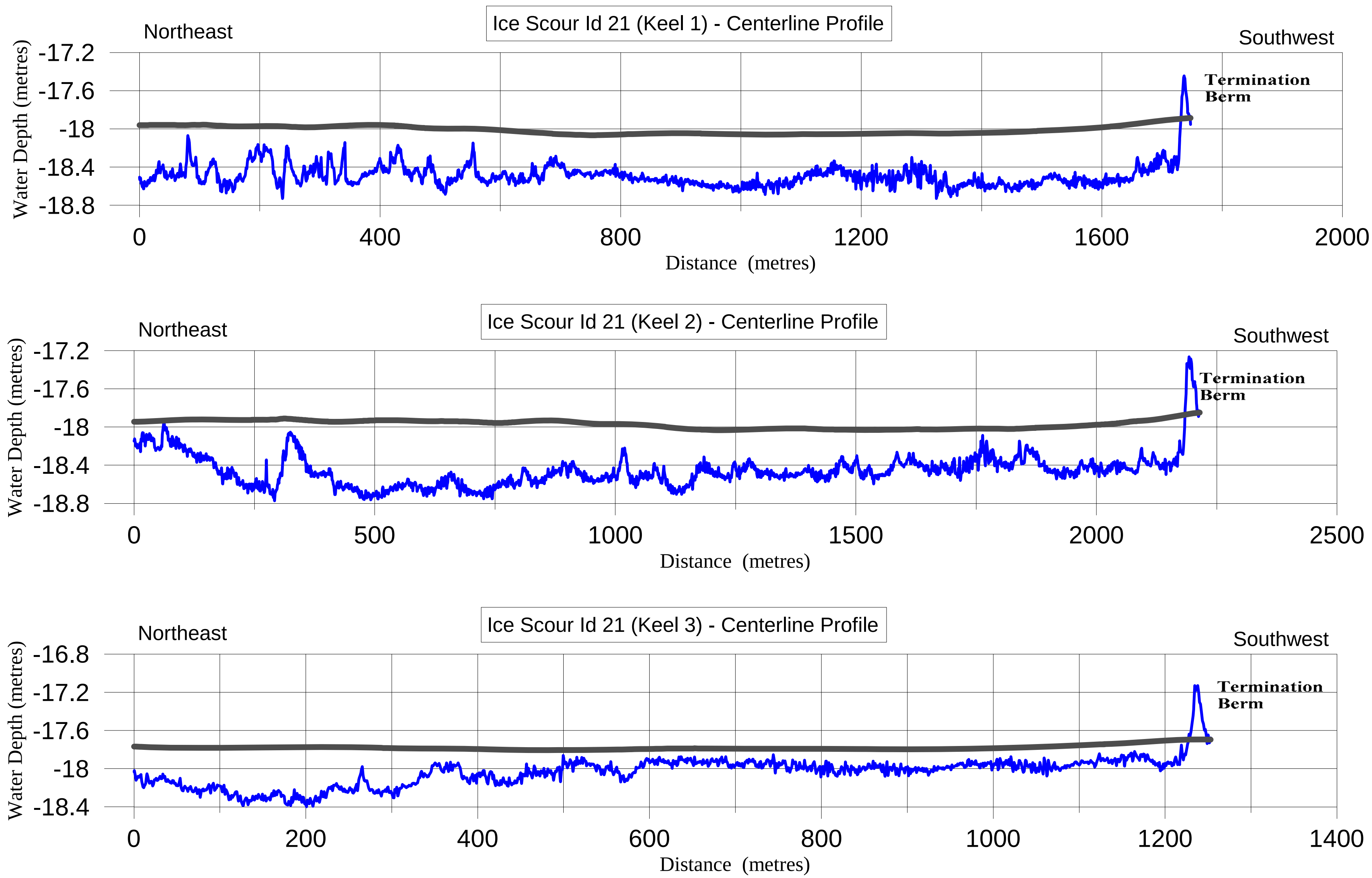

Figure 5.3.3.11 - Centerline lakefloor (blue) and unscoured lakefloor (grey) profiles along Scour 21 keels 1, 2 & 3.

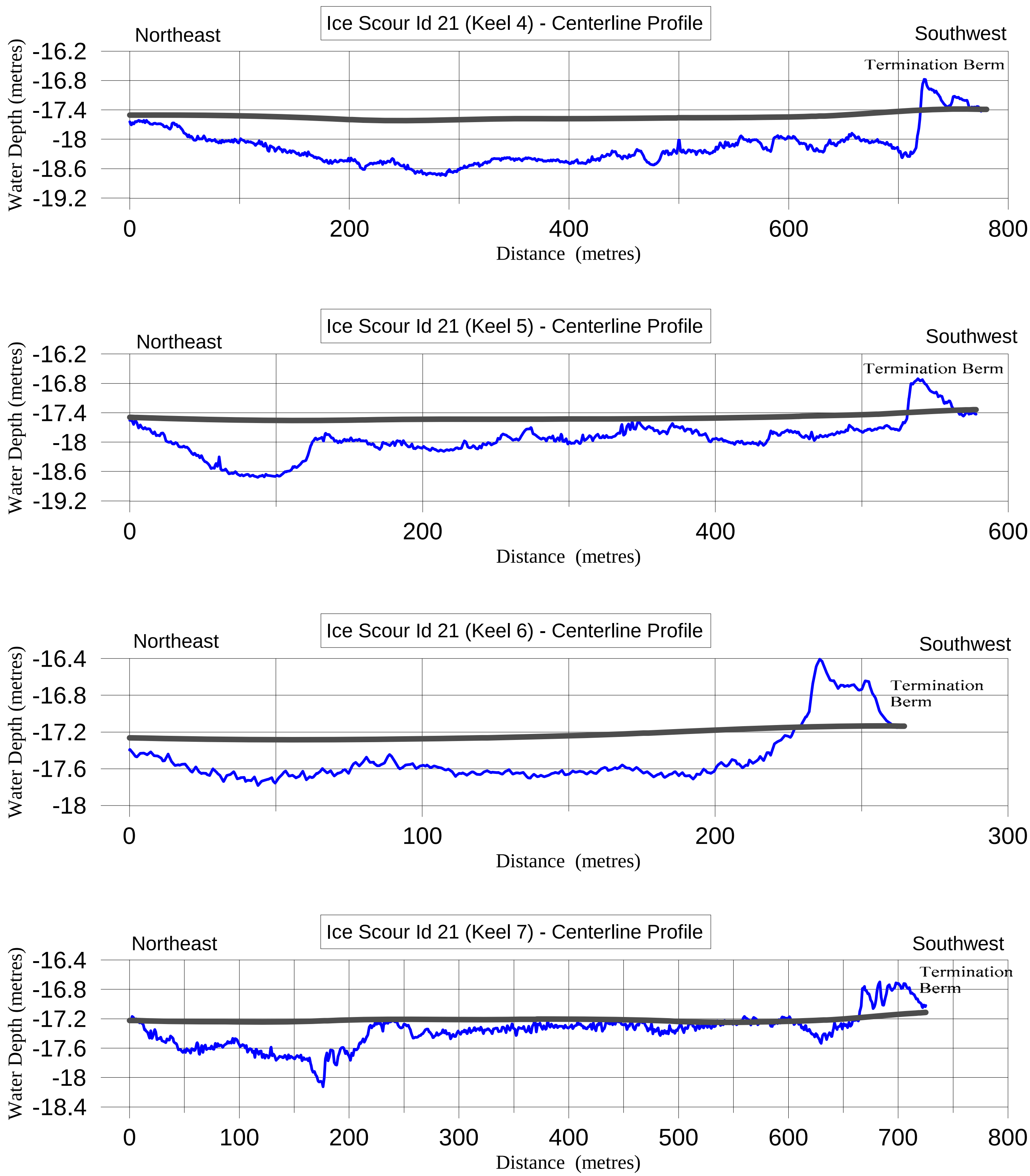

Figure 5.3.3.12 - Centerline lakefloor (blue) and unscoured lakefloor (grey) profiles along Scour 21 keels 4, 5, 6, & 7.

5.4 Commercial Operations and Obstructions

Pipelines

Dundee Energy operates a natural gas field within the Canadian Eastern and Central Lake Erie Basins. The natural gas is produced from sandstone and carbonates with main producing horizons within Grimsby, Whirlpool and Guelph formations. There are numerous pipelines present on the lakebed within Canadian waters. These pipelines carry gas from offshore wells to onshore collection/processing facilities. The positions of the pipelines displayed in Figure 5.4.1 have been obtained from Dundee Energy. Geophysical data acquired in 2014 and 2015 were analyzed to confirm the pipeline locations provided by Dundee and to identify other obstructions along the LEC Proposed Route. Table 5.4.1 includes the locations of the pipelines which cross the LEC Proposed Route based on information provided by Dundee while Table 5.4.2 includes the CSR surveyed locations of the pipelines.

The LEC Proposed Route will cross 4 pipelines ranging from 2” to 6” in diameter, two pipelines are natural gas and two are abandoned. One of the abandoned pipelines is also uncharted, see Table 5.4.1. The uncharted pipeline was identified from magnetometer data, and subsequently confirmed with Dundee Energy to be an abandoned 6” pipeline from 1984. All of the pipelines appear to be buried, except the 2” pipeline at KP 6.845. Magnetometer data has confirmed the locations of Dundee Energy’s charted pipelines. Magnetometer anomalies associated with two of the pipelines are displayed in Figure 5.4.2.

Table 5.4.1 – LEC Proposed Route Pipeline Crossing Summary (Dundee Energy)

Crossing Number	KP	Information Obtained from Dundee Energy Ltd. Drawings						
		Status	Size	Northing	Easting	Latitude (Degrees)	Longitude (Degrees)	Depth (m)
1	6.950	Natural Gas Pipeline	2"	4732651.0	578661.9	42.742344	-80.038931	13.4
2	10.700	Abandoned Pipeline	2"	4729242.3	579634.6	42.711551	-80.027529	20.1
4	26.360	Natural Gas Pipeline	6"	4716147.7	584869.6	42.593085	-79.965565	47.8

Table 5.4.2 – CSR Surveyed Pipeline Crossing Summary

Crossing Number	KP	CSR Surveyed Locations from Magnetometer Data								
		Status	**Size**	**Northing**	**Easting**	**Latitude (Degrees)**	**Longitude (Degrees)**	**Depth (m)**	**Corresponding Magnetic Anomalies**	**Corresponding Sidescan Contacts**
1	6.845	Natural Gas Pipeline	2”	4732719.4	578609.8	42.742966	-80.039558	13.4	M92, M93, M94, M97, M98, M99	L15 Pipeline
2	10.680	Abandoned Pipeline	2”	4729230.1	579688.2	42.711435	-80.026876	20.1	M104, M105	L36 Pipeline
3	23.310	Abandoned & Uncharted Pipeline	6”	4717763.1	582350.2	42.607903	-79.996036	42.9	M119, M120, M121, M122, M123, M124, M125, M126, M129, M130	None
4	26.210	Natural Gas Pipeline	6”	4716261.1	584787.4	42.594114	-79.966551	47.4	M137, M138, M140, M141, M142	L43 Pipeline

<u>Shoreline Infrastructure</u>

Two significant shoreline structures have been identified within the Canadian Landfall area. The first structure has been interpreted as a possible water intake pipe (L140). The interpretation of this pipe is based on six magnetometer anomalies (M25, M29, M38, M45, M46, M51) that occur along a line oriented NW-SE. The location and orientation of the magnetic anomalies also correlates with a linear feature on the sidescan data interpreted as a trench on the lakebed. The alignment of the interpreted pipe also coincides with the alignment of the road that meets the shoreline near KP 0. This interpreted intake pipe is significant because it occurs in the same location as the current HDD path from approximately KP 0 to KP 0.250.

The second structure identified within the Canadian Landfall area is crib work associated with the decommissioned coal plant east of the LEC Proposed Route landfall. This crib work is connected to the coal plant via a buried pipe beneath the lakebed. The crib work is not expected to be a constraint to the cable route as it is located > 200 m from the HDD path to the east. Due to the distance from the LEC Proposed Route, it does not appear within the extent of Panel Map Sheet 1.

<u>Fishing Related Drag Marks</u>

Areas of disturbed lakebed sediments are common within Canadian waters due to commercial fishing operations. Commercial trawling occurs throughout Canadian waters. Figure 5.4.3 shows an example of fishing related drag marks located on the LPE. Based on analysis of the sidescan data, the majority of fishing related trawl marks occur in water depths between 25 m and 50 m which approximately corresponds to KP 12.5 to KP 29.0. There is also evidence of sporadic trawl marks in water depths less than 25 m. The trawl marks observed on the lakebed in Canadian waters range from 0.5-2.0 m in width and based on analysis of multibeam and sub-bottom data, are no more than 50 cm deep.

Based on personal communication with Mike Waldie (Dundee Energy), the exposure risk to the cable in deeper water will be the trawling activity in the area south of exploration block 45/46. Mr. Waldie stated that trawling typically occurs in water depth > 30 m (100ft). He also stated that trawl doors are designed to slide across the bottom, but frequently will plow into soft lakebed sediments more than 4 feet (122 cm) if the net picks up debris. Divers have observed trawl marks deeper than 4 feet in soft sediments. It must be noted that CSR did not identify any trawl marks within the LEC Proposed Route corridor that were greater than 50 cm deep. Dundee Energy rarely experiences pipeline damage from trawling activity, but have frequently been affected by damage to exposed wellheads when the boats trawl too close.

Dredge Disposal Sites

According to CHS and NOAA charts dredge disposal sites are located to the east and west of the LEC Proposed Route within Canadian waters and offshore Erie within American waters.

Numerous circular mounds of sediment and / or rock interpreted to be dredge spoil were observed within the survey corridor and outside of the areas specified for dredge material. These mounds are 10 to 20 metres in diameter and appear to have low relief. The composition of the mounds is not known at this time. The locations of the probable dredge spoil are displayed on the Panel Map Sheets. Figure 5.4.4 depicts two suspected dredge spoil mounds located near the Canadian Landfall.

The origin of the spoils located in the Canadian Nearshore & Approaches area are likely related to past dredging activities in the Nanticoke Channel. Likewise, dredging is ongoing in the Erie Harbour entrance channel and is likely the major source of any dredge spoils in the vicinity of Erie, Pennsylvania.

Navigation Channels & Shipping Lanes

Designated shipping lanes are located in the Canadian Nearshore allowing ship traffic into the Nanticoke Generating Facility and the U.S. Steel Terminal. Shipping lanes also exist in Central Lake Erie near the international border. These shipping lanes are part of the main Great Lakes shipping route.

Based on information received from Frank Harrison of U.S. Steel, the navigation channel into the U.S. Steel Terminal has not been dredged in the last 20 years. Mr. Harrison claims that due to the frequent vessel traffic using the US Steel dock during a shipping season, there is little time for sediment to settle therefore hasn’t been a need for dredging of the shipping lane.

No information on the Nanticoke Channel was received from OPG for this report. According to Mike Waldie (Dundee) the Nanticoke Channel into the Nanticoke Generating Facility was initially dredged in the 1970’s to a depth of 30 ft. (9 m). He was unsure if maintenance dredging has occurred since then.

The following observations are based on interpretation of the geophysical data collected in 2014 and 2015 over the Nanticoke Channel. Sidescan sonar data indicates the lakebed is disturbed to the east of the LEC Proposed Route between KP 2.9 and KP 3.6, see Panel Map Sheet 1. The morphology of the disturbed lakebed east of the LEC Proposed Route is interpreted to be associated with dredging related activities. However, multibeam data acquired over the route corridor indicates the channel was not dredged at the LEC Proposed Route location. The interpreted edge of the dredged channel is visible on the sidescan sonar mosaic shown in Figure 5.4.5 and Panel Map Sheet 1. The dredged channel edge occurs between 250 m to 500 m east of the LEC Proposed Route.

Drag Marks

Some of the linear contacts observed on the lakebed are believed to be from the dragging of anchors, pipeline segments or other, possibly related to oil and gas activities. Several targets with strong acoustic signatures were identified from the sidescan sonar data. The features are long and linear and have been identified on the Panel Map Sheets.

To the south of the Long Point Escarpment, there is a series of linear features present, most predominantly between KP 42.0 and KP 43.0, identified in the sidescan sonar data. These features do not appear to have any specific trend or pattern. They do however appear to correlate with a two magnetic anomalies mapped in the area (M147 and M148). It appears possible, though unlikely, that these are submarine cables. A more likely explanation, which is based on local knowledge of the lake, is during the 1970’s and 1980’s it was common practice to drag unwanted pipeline segments out into this portion of the lake and dump them. This would explain the linear features evident on the lakebed. It would also explain why many of the drag scars do not have any magnetic anomalies associated with them but a select few do. Over time, the discarded pipes would have been buried by sedimentation processes and/or sunk into the very soft sediments at the lakebed. This could possibly explain the weak or non-existent magnetic signatures recorded over the drag marks. An example of a magnetic anomaly associated with one of these linear features is shown in Figure 5.4.6.

Possible Cables

Three linear features (L37, L41 and L44) identified from sidescan sonar data are interpreted as possible cables. These linear features occur within the route corridor between KP 19.5 and KP 29.4. Each of these linear features intersects the LEC Proposed Route (see Panel Map Sheets). L44 intersects the LEC Proposed Route line in two locations. The features are long narrow (< 0.5 m), and extend beyond the area surveyed. Extensive magnetometer data was collected over each of these linear features and no magnetic anomalies were observed that could be directly correlated with the features. As a result, these features could be related to pipeline segments being dragged across the lakebed, similar to those found over the LPE (discussed above). Although in some locations along the linear features, they appear to be ‘looped’ or ‘curled’ on the lakebed which would not be expected if they were created from the dragging of pipeline segments on the lakebed. The fact that no magnetic anomalies were mapped over these linear features points to the possibility that they could be long ropes laying on the lakebed, possibly discarded during fishing or oil and gas related activities. These linear features require further investigation using a remotely operated vehicle (ROV) or diver.

Shipwreck

One shipwreck was identified close to the LEC Proposed Route. This wreck was located at KP 40.5 and is approximately 350 m east of the route centerline. The wreck is displayed on Panel Map Sheet 7 and its sidescan sonar contact ID is C99. This shipwreck identified by CSR does not pose a hazard to the cable installation along the LEC Proposed Route.

There are however a number of unidentified magnetic anomalies (as discussed below) that could be related to uncharted wrecks or debris within the corridor. The Survey Centreline has been deviated to avoid any unidentified magnetic anomaly where deemed necessary – see Section 5.5 Route Deviations.

Magnetic Anomalies

A total of 189 magnetic anomalies were identified and mapped from the data acquired in 2014 and 2015. These anomalies are displayed on the Panel Map Sheets. Many of the anomalies have been correlated to known anthropogenic targets such as pipelines, lakebed debris, nearshore structures, etc. There are also a number of magnetic anomalies that could not be correlated with other geophysical data sets or hydrographic charts. The type of anomaly, magnitude of anomaly and the observations from the sidescan sonar in the area each anomaly were recorded. A complete list of all magnetic anomalies mapped during the 2014/2015 survey operations has been included in *Appendix VII – Magnetic Anomaly Table.*

A 50 m buffer was used to identify any magnetic anomalies identified close to the route line. Magnetic anomalies located within 50 m of the route line are summarized in Table 5.4.2. It should be noted that the position of a magnetic anomaly does not in some cases identify the precise location of the source of the anomaly.

Table 5.4.2 – Magnetic Anomalies within 50 m of LEC Proposed Route

Marine Magnetometer Anomalies within 50 m of LEC Proposed Route									
Label	**Latitude**	**Longitude**	**Easting (m)**	**Northing (m)**	**Route Offset (m)**	**Polarity**	**Amplitude (nT)**	**Corresponding Sidescan Sonar Linear Feature**	**Sidescan Sonar Contact Description**
M25	42.7945520	-80.0561476	577188.3	4738431.6	40.752	D	177.03	L140	Pipeline
M76	42.7845795	-80.0599516	576889.5	4737320.7	16.001	M	12.26	None	
M78	42.7838166	-80.0601498	576874.2	4737235.8	16.935	M	13.00	None	
M82	42.7702136	-80.0635660	576611.6	4735722.2	17.194	M	16.00	None	
M85	42.7502978	-80.0470718	577986.0	4733525.7	16.184	M	24.85	None	
M86	42.7502784	-80.0470558	577987.3	4733523.6	16.565	M	61.49	None	
M89	42.7495686	-80.0464732	578035.9	4733445.3	30.528	M	29.00	None	
M93	42.7432771	-80.0404679	578535.3	4732752.2	39.472	M	13.83	L15	Pipeline
M94	42.7430579	-80.0396916	578599.1	4732728.6	2.996	M	23.33	L15	Pipeline
M95	42.7430293	-80.0392393	578636.2	4732725.8	24.820	M	36.54	L15	Pipeline
M97	42.7428590	-80.0394401	578619.9	4732706.8	0.345	M	24.80	L15	Pipeline
M100	42.7422934	-80.0388990	578664.9	4732644.5	1.574	D	36.00	None	
M122	42.6079249	-79.9961582	582340.5	4717764.4	3.474	D	43.63	None	Abandoned & Uncharted Pipeline (from table 5.4.2)
M123	42.6078822	-79.9958630	582364.7	4717760.0	4.280	D	49.95	None	Abandoned & Uncharted Pipeline (from table 5.4.2)
M139	42.5942019	-79.9665113	584790.9	4716269.9	7.947	M	341.80	L43	Pipeline
M140	42.5941110	-79.9666521	584779.4	4716259.6	7.318	D	94.40	L43	Pipeline
M164	42.1804816	-80.2351157	563167.1	4670097.4	36.402	M	24.87	None	
M165	42.1544074	-80.2616855	560997.9	4667183.0	38.208	D	37.72	None	
M169	42.1160124	-80.3091202	557113.4	4662887.1	33.761	M	33.36	None	
M170	42.1040453	-80.3259578	555732.0	4661547.3	43.942	M	26.48	None	
M171	42.0995567	-80.3314452	555282.2	4661045.3	26.965	M	4.83	None	
M173	42.0699428	-80.3745349	551743.2	4657730.3	25.962	M	4.33	None	
M176	42.0269868	-80.4085395	548963.0	4652940.8	1.937	M	24.01	None	
M178	42.0237601	-80.4078646	549021.4	4652583.0	42.273	M	13.84	None	

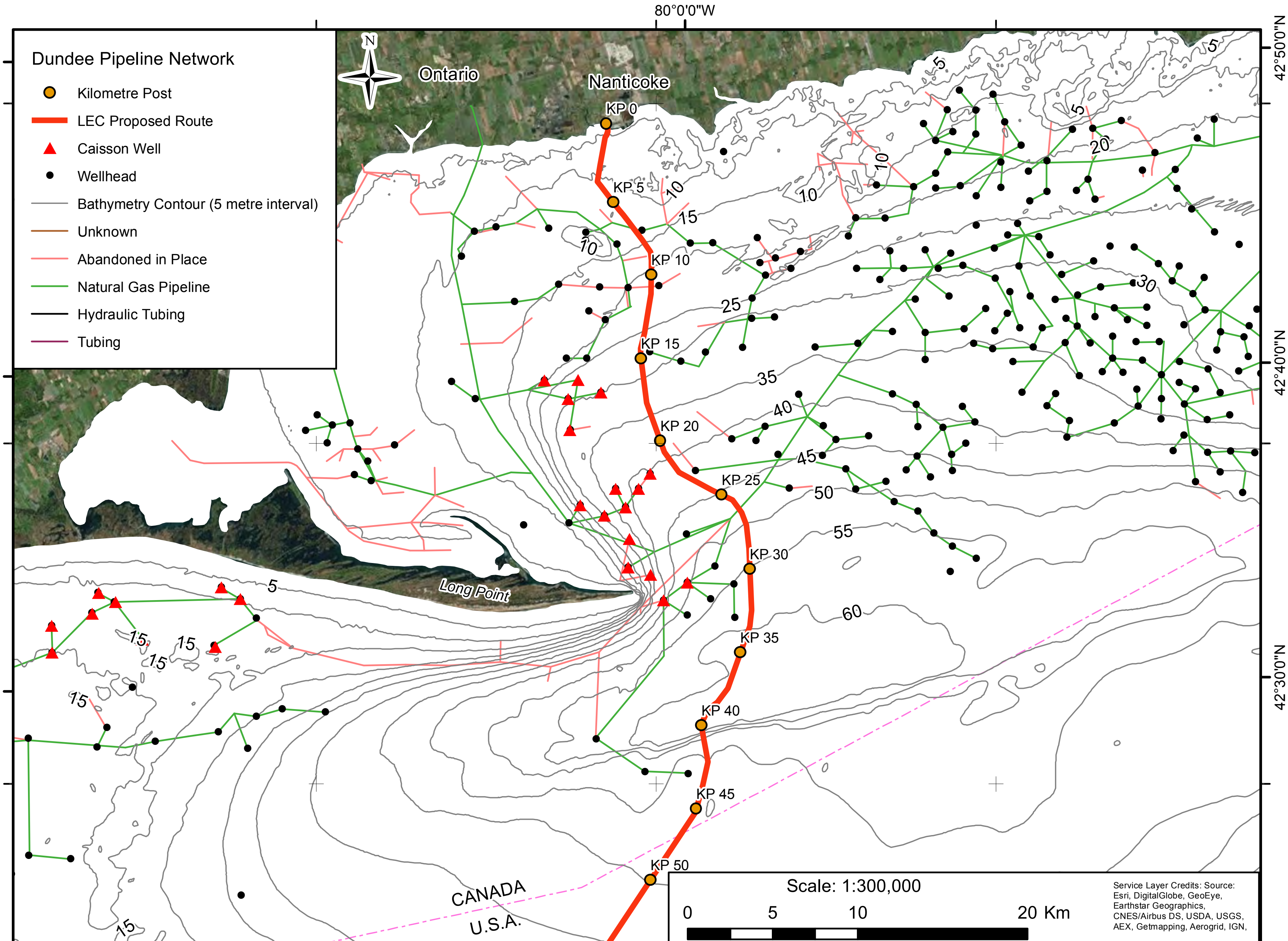

Figure 5.4.1 – Location of Dundee Energy natural gas pipeline network.

Canadian Seabed Research Ltd.

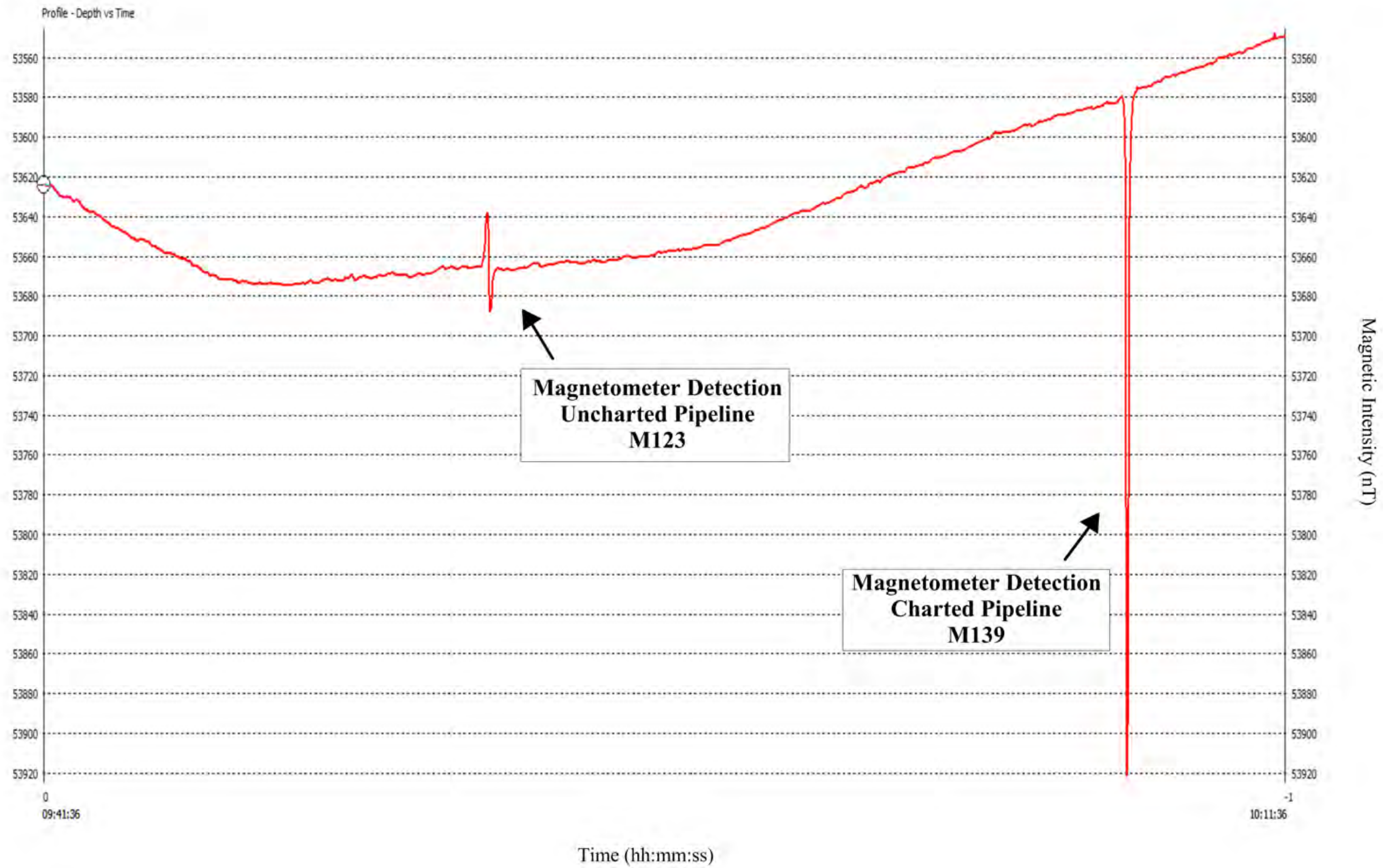

Figure 5.4.2 - Magnetometer anomaly detection of two pipelines, the uncharted pipeline at KP 23.31 and a charted pipeline at KP 26.21.

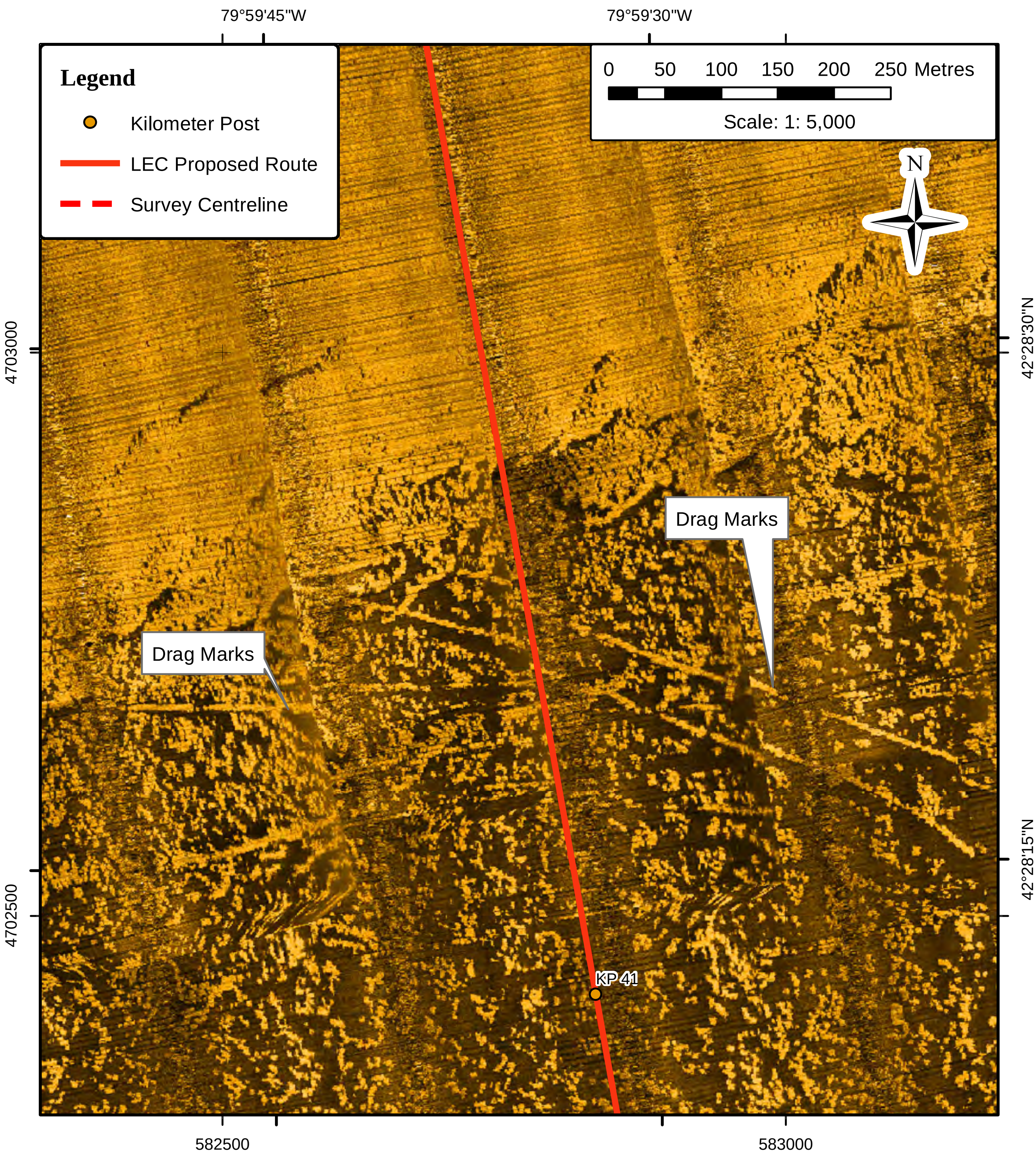

Figure 5.4.3 - Sidescan sonar mosaic of the top of the Long Point Escarpment along the Lake Erie Connector Proposed Route. Highly reflective areas are interpreted to be mussel beds disturbed by fishery related dragging. Numerous fishery related drag marks are visible on the lakefloor throughout Canadian waters.

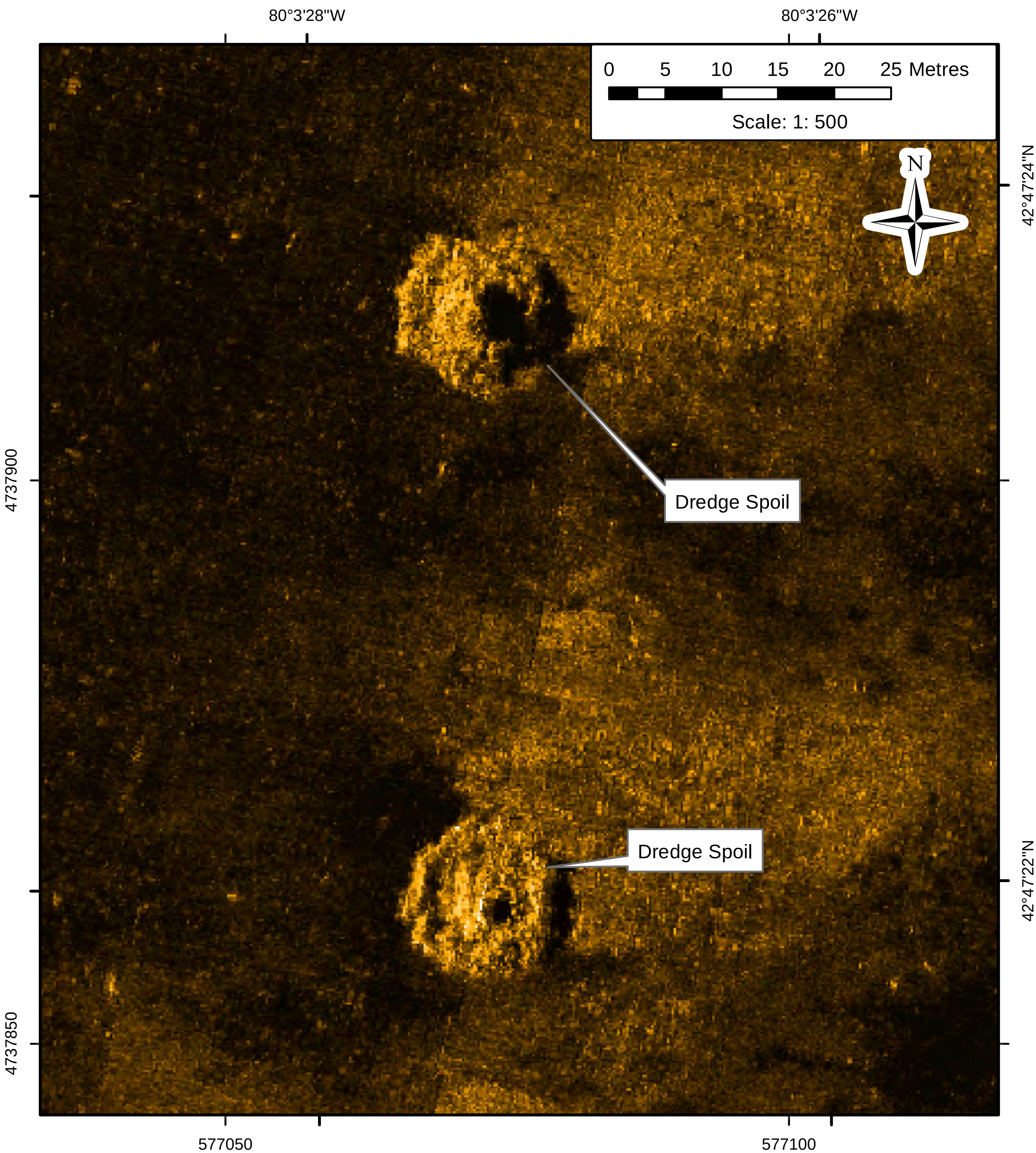

Figure 5.4.4 - Sidescan sonar mosaic of probable dredge spoils near the Canadian Landfall.

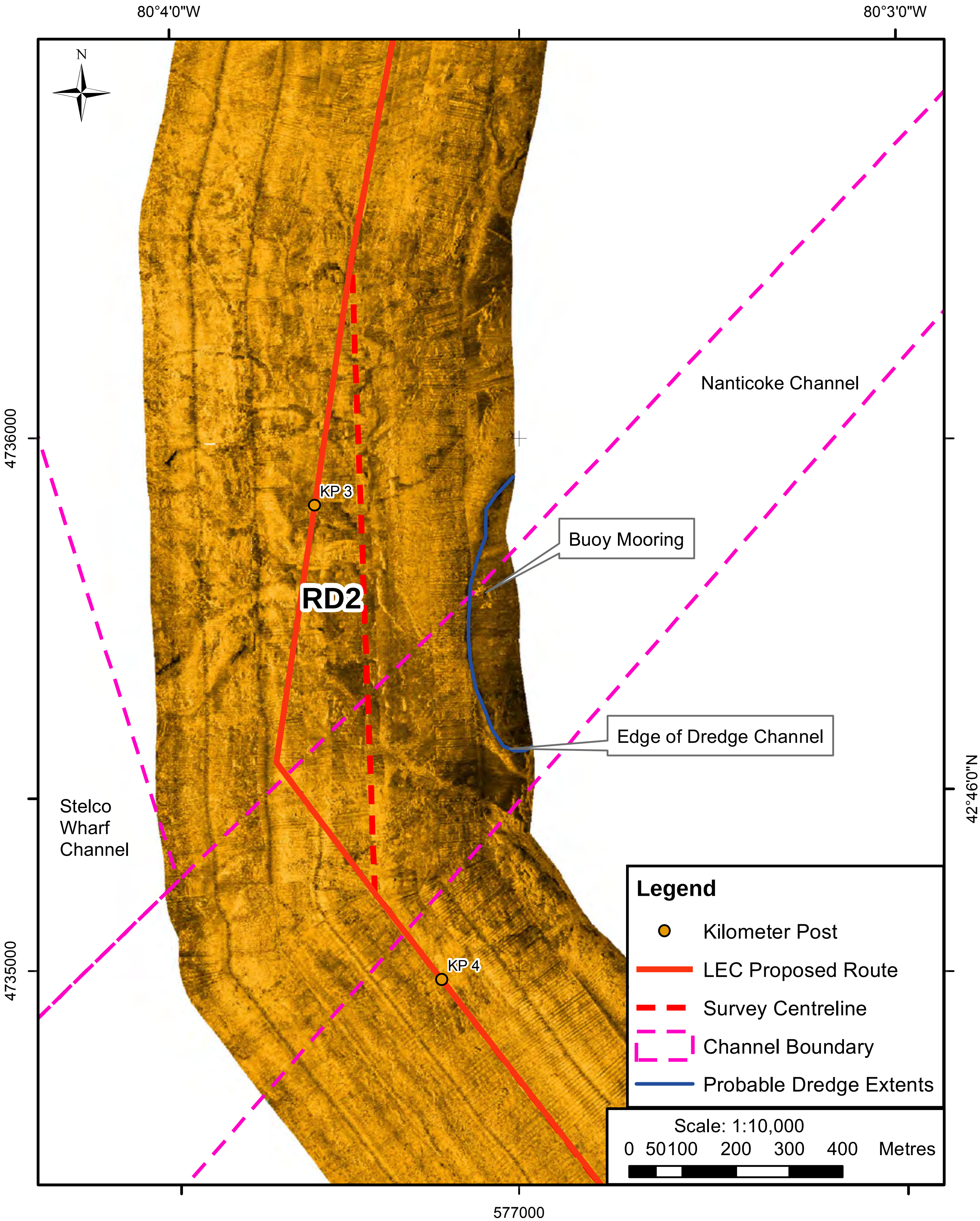

Figure 5.4.5 – Sidescan sonar mosaic of the Nanticoke Channel crossing showing the dredge extents.

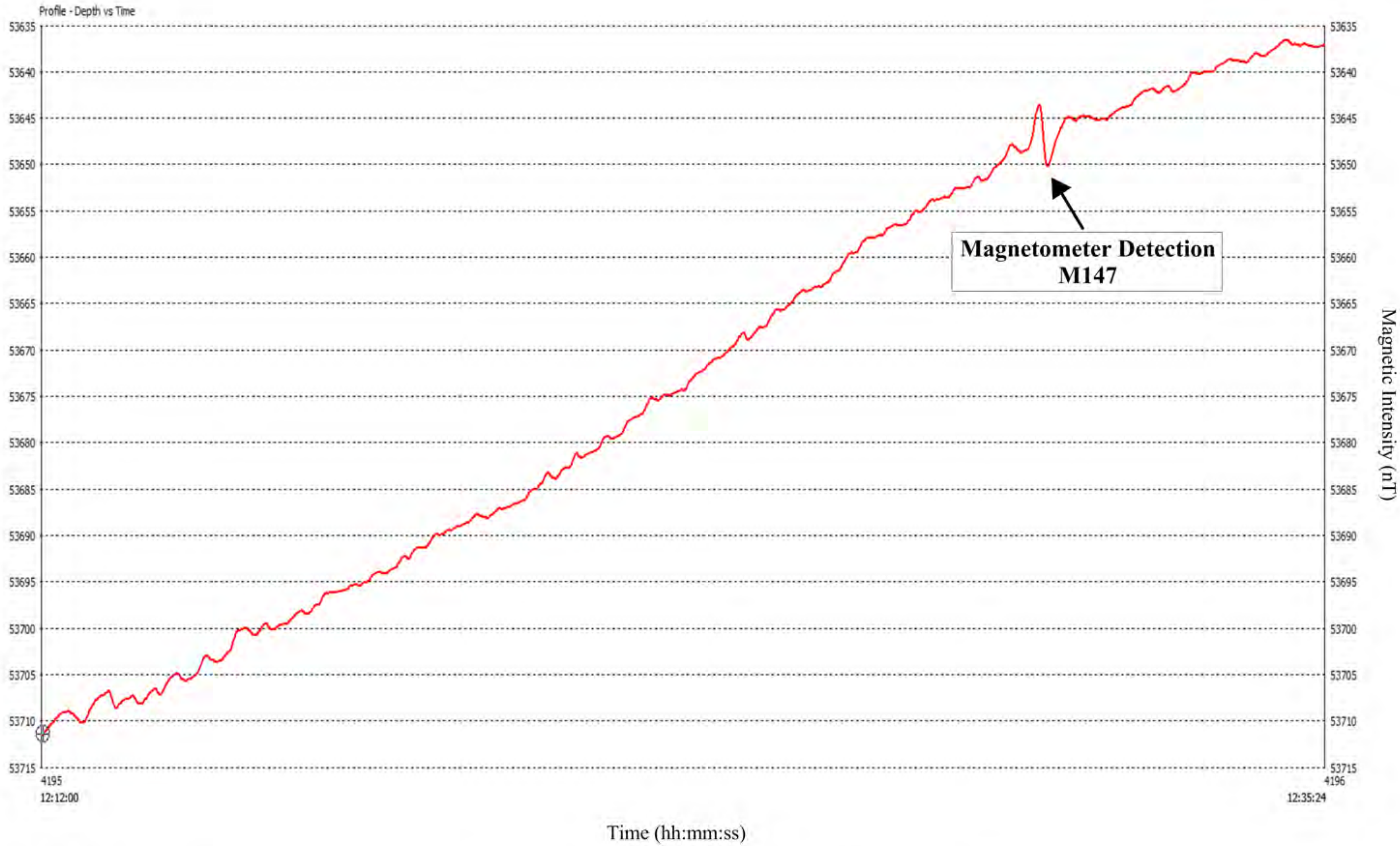

Figure 5.4.6 - Magnetometer anomaly detection on the linear features between KP 42 and KP 43

5.5 Route Deviations

Based on the geophysical data collected during 2014 and 2015 survey operations and subsequent discussions and meetings with ITC and B&V, there are 8 areas where deviation of the Survey Centreline appears beneficial and is recommended. This section details the reasoning for the route deviation (RD) recommendations and the specifics of the LEC Proposed Route deviations with respect to the Survey Centreline.

5.5.1 Canadian Horizontal Directional Drilling (HDD) Route Deviation

The Survey Centreline through the Canadian Landfall did not include the HDD path. Based on new information defining the HDD path and exit point, the Survey Centreline has been altered to align with the start of the HDD path at KP 0 (on land). The LEC Proposed Route deviation follows the HDD path and re-joins the Survey Centreline at KP 0.823. The specific information regarding this route deviation can be viewed in Table 5.5.1 and is labeled as Route Deviation (RD) 1 on the Panel Map Sheets. Also see Figure 5.5.1.

5.5.2 Nanticoke Channel Route Deviation

As a result of increased marine traffic through the Nanticoke Channel, it would be beneficial to minimize the distance that the route crosses the channel. This route deviation starts at KP 2.528 and extends for 0.96 km until it alters-course to the NE in order to cross the Nanticoke Channel at a perpendicular angle. This LEC Proposed Route deviation re-joins the Survey Centreline at KP 3.794 after it has passed the channel boundary to the south. The Survey Centreline route between KP 2.528 and KP 3.794 was 1195 m, the proposed RD is 1268 m. The specific information regarding this route deviation can be viewed in Table 5.5.2 and is labeled as Route Deviation (RD) 2 on the Panel Map Sheets. Also see Figure 5.5.1.

5.5.3 Canadian Nearshore & Approaches Route Deviations

Based on data collected over the Survey Centreline between KP 3.835 and KP 7.859, a route deviation is proposed in order to avoid magnetic anomalies detected on the Survey Centreline. The length of the Survey Centreline between KP 3.835 and KP 7.859 is 4024 m while the route deviation is 4026 m. RD3 deviates a maximum of 26 m to the east of the Survey Centreline route. The specific information regarding this route deviation can be viewed in Table 5.5.3 and is labeled as Route Deviation (RD) 3 on the Panel Map Sheets.

Based on data collected over the Survey Centreline between KP 9.138 and KP 11.134, it is necessary to deviate from the Survey Centreline in order to avoid a series of mapped obstructions. Along the Survey Centreline, a magnetic anomaly was detected and was further correlated with a probable dredge spoil and a rectangular feature. The Survey Centreline between KP 9.138 and 11.134 is 2004 m in length and the route deviation is 1996 m in length. RD4 deviates a maximum of 67 m west of the Survey Centreline. The specific information regarding this route deviation can be viewed in Table 5.5.4 and is labeled as Route Deviation (RD) 4 on the Panel Map Sheets.

5.5.4 Glacial Feature/Possible Diapir Route Deviation

Based on the data collected over the Survey Centreline between KP 14.378 and KP 17.62, it is necessary to deviate from the Survey Centreline to avoid an interpreted glacial feature and possible associated gas diapir. The area poses a geologic hazard which is best avoided due to the likely presence of hard glacial sediments and interpreted shallow gas pockets. The Survey Centreline route between KP 14.378 and KP 17.62 is 3318 m in length, while the route deviation is 3242 m in length. RD5 deviates a maximum of 315 m to the east of the Survey Centreline. The specific information regarding this route deviation can be viewed in Table 5.5.5 and is labeled as Route Deviation (RD) 5 on the Panel Map Sheets. Figure 5.5.2 presents chirp data depicting the glacial feature/possible diapir geohazard located on the Survey Centreline. Figure 5.5.2 also presents chirp data along the new proposed RD 5 route.

5.5.5 Canadian and United States Offshore Route Deviations

Based on data collected over the Survey Centreline between KP 32.444 and KP 38.248, it is necessary to deviate 75 m to the west of the Survey Centreline. This route deviation is designed to avoid two magnetic anomalies (M144 & M145). The Survey Centreline between KP 32.444 and KP 38.248 is 5861 m long, while the LEC Proposed Route deviation is 5804 m in length. The specific information regarding this route deviation can be viewed in Table 5.5.6 and is labeled as Route Deviation (RD) 6 on the Panel Map Sheets.

Based on data collected over the Survey Centreline between KP 73.903 and KP 75.922, it is necessary to deviate 100 m to the east of the Survey Centreline. This route deviation is designed to avoid a magnetic anomaly (M158). The Survey Centreline between KP 73.903 and KP 75.922 is 2000 m long, while the LEC Proposed Route deviation 2019 m in length. The specific information regarding this route deviation can be viewed in Table 5.5.7 and is labeled as Route Deviation (RD) 7 on the Panel Map Sheets.

5.5.6 United States Nearshore Anthropogenic Contact Route Deviation

Based on data collected over the Survey Centreline between KP 88.090 and KP 92.018, it is necessary to deviate to the south to avoid unidentifiable anthropogenic contacts (C100 & C101). The LEC Proposed Route was altered 75 m to the south at the maximum point of deviation. The Survey Centreline between KP 88.090 and KP 92.018 is 3921 m in length, while the LEC Proposed Route deviation is slightly longer at 3928 m. The specific information regarding this RD can be viewed in Table 5.5.8 and is labeled as Route Deviation (RD) 8 on the Panel Map Sheets.

Table 5.5.1 – Canadian Horizontal Directional Drilling Route Deviation (RD1)

Route Deviation 1					
KP	**Latitude**	**Longitude**	**Easting**	**Northing**	**Depth(m)**
0.000	42.7978722	-80.0575984	577065.2	4738799.9	-
0.100	42.7970079	-80.0572550	577094.3	4738704.2	-
0.200	42.7961434	-80.0569130	577123.4	4738608.5	-
0.300	42.7952603	-80.0566813	577143.4	4738510.7	1.40
0.400	42.7943612	-80.0566532	577146.8	4738410.8	1.91
0.500	42.7934709	-80.0568263	577133.8	4738311.8	4.61
0.600	42.7926144	-80.0571992	577104.4	4738216.4	5.39
0.700	42.7918121	-80.0577518	577060.2	4738126.8	6.08
0.823	42.7908230	-80.0584270	577006.1	4738016.2	6.65

Table 5.5.2 – Nanticoke Channel Route Deviation (RD2)

Route Deviation 2					
KP	**Latitude**	**Longitude**	**Easting**	**Northing**	**Depth(m)**
2.528	42.7760225	-80.0624990	576691.4	4736369.1	9.94
2.600	42.7751352	-80.0627059	576675.6	4736270.4	9.82
2.700	42.7742460	-80.0628988	576660.9	4736171.5	9.92
2.800	42.7733568	-80.0630917	576646.2	4736072.5	10.18
2.900	42.7724676	-80.0632846	576631.5	4735973.6	10.24
3.000	42.7715784	-80.0634775	576616.8	4735874.7	10.30
3.100	42.7706892	-80.0636703	576602.2	4735775.8	10.52
3.200	42.7698000	-80.0638632	576587.5	4735676.9	10.49
3.300	42.7689108	-80.0640561	576572.8	4735578.0	10.47
3.400	42.7680216	-80.0642489	576558.1	4735479.0	10.59
3.500	42.7671528	-80.0643279	576552.7	4735382.5	10.67
3.600	42.7664277	-80.0636032	576612.9	4735302.6	10.86
3.700	42.7657025	-80.0628786	576673.1	4735222.8	11.03
3.794	42.7650210	-80.0621970	576729.6	4735147.7	11.15

Table 5.5.3 – Canadian Nearshore & Approaches Route Deviation (RD3)

Route Deviation 3					
KP	**Latitude**	**Longitude**	**Easting**	**Northing**	**Depth(m)**
3.835	42.7647250	-80.0618940	576754.9	4735115.1	11.3
4.000	42.7635390	-80.0606760	576855.9	4734984.5	11.3
4.100	42.76312542	-80.06025041	576891.3	4734939.0	11.4
4.200	42.76240741	-80.05951288	576952.5	4734859.9	11.3
4.300	42.76168940	-80.05877537	577013.8	4734780.9	11.5
4.400	42.76097138	-80.05803787	577075.0	4734701.8	11.5
4.500	42.76025335	-80.05730039	577136.2	4734622.7	11.6
4.600	42.75953533	-80.05656293	577197.5	4734543.7	11.8
4.700	42.75881729	-80.05582548	577258.7	4734464.6	11.9
4.800	42.75809926	-80.05508805	577319.9	4734385.6	12.0
4.900	42.75738121	-80.05435064	577381.2	4734306.5	11.9
5.000	42.75666317	-80.05361324	577442.4	4734227.5	11.9
5.100	42.75594511	-80.05287587	577503.6	4734148.4	11.7
5.200	42.75522706	-80.05213851	577564.9	4734069.3	11.2
5.300	42.75450900	-80.05140116	577626.1	4733990.3	11.5
5.400	42.75379093	-80.05066383	577687.3	4733911.2	11.6
5.500	42.75307286	-80.04992652	577748.6	4733832.2	11.6
5.600	42.75236757	-80.04916741	577811.6	4733754.5	11.8
5.700	42.75167666	-80.04838380	577876.6	4733678.5	12.0
5.800	42.75098574	-80.04760020	577941.6	4733602.5	12.3
5.900	42.75029482	-80.04681663	578006.6	4733526.5	12.4
6.000	42.74960389	-80.04603306	578071.6	4733450.5	12.4
6.100	42.74886336	-80.04533812	578129.4	4733369.0	12.7
6.200	42.74812158	-80.04464543	578187.0	4733287.2	12.6
6.300	42.74737980	-80.04395276	578244.6	4733205.5	12.4
6.400	42.74663801	-80.04326011	578302.2	4733123.8	12.5
6.500	42.74591474	-80.04253234	578362.7	4733044.1	12.5
6.600	42.74519207	-80.04180343	578423.3	4732964.6	12.7
6.700	42.74446941	-80.04107454	578483.8	4732885.0	12.8
6.800	42.74374674	-80.04034567	578544.4	4732805.4	13.4
6.900	42.74302406	-80.03961681	578605.0	4732725.8	13.4
7.000	42.74230138	-80.03888797	578665.5	4732646.3	13.4
7.100	42.74157869	-80.03815914	578726.1	4732566.7	13.2
7.200	42.74085600	-80.03743034	578786.7	4732487.1	13.4
7.300	42.74013331	-80.03670155	578847.2	4732407.6	13.7
7.400	42.73941061	-80.03597277	578907.8	4732328.0	13.7
7.500	42.73868790	-80.03524402	578968.4	4732248.4	13.7
7.600	42.73796520	-80.03451528	579028.9	4732168.8	13.9
7.700	42.73724248	-80.03378655	579089.5	4732089.3	14.0
7.859	42.7357770	-80.0323460	579209.3	4731927.9	13.9

Table 5.5.4 – Canadian Nearshore & Approaches Route Deviation (RD4)

Route Deviation 4					
KP	**Latitude**	**Longitude**	**Easting**	**Northing**	**Depth(m)**
9.138	42.7254740	-80.0262310	579723.0	4730789.6	18.09
9.200	42.7249290	-80.0262580	579721.6	4730729.0	18.10
9.300	42.7240261	-80.0262993	579719.3	4730628.7	18.11
9.400	42.7231261	-80.0263405	579717.1	4730528.7	18.58
9.500	42.7222261	-80.0263817	579714.9	4730428.8	18.61
9.600	42.7213261	-80.0264230	579712.6	4730328.8	18.75
9.700	42.7204262	-80.0264642	579710.4	4730228.8	18.99
9.800	42.7195262	-80.0265054	579708.2	4730128.8	19.15
9.900	42.7186262	-80.0265467	579706.0	4730028.9	19.28
10.000	42.7177263	-80.0265879	579703.8	4729928.9	19.57
10.100	42.7168263	-80.0266291	579701.5	4729828.9	19.60
10.200	42.7159263	-80.0266704	579699.3	4729728.9	19.76
10.300	42.7150264	-80.0267116	579697.1	4729629.0	19.72
10.400	42.7141264	-80.0267528	579694.9	4729529.0	19.83
10.500	42.7132264	-80.0267940	579692.6	4729429.0	19.99
10.600	42.7123264	-80.0268353	579690.4	4729329.0	20.09
10.700	42.7114265	-80.0268765	579688.2	4729229.1	20.13
10.800	42.7105265	-80.0269177	579686.0	4729129.1	20.18
10.900	42.7096265	-80.0269589	579683.7	4729029.1	20.16
11.000	42.7087266	-80.0270001	579681.5	4728929.1	20.38
11.134	42.7075210	-80.0270560	579678.5	4728795.2	20.79

Table 5.5.5 – Glacial Geo-Hazard Route Deviation (RD5)

Route Deviation 5					
KP	**Latitude**	**Longitude**	**Easting**	**Northing**	**Depth(m)**
14.378	42.6787039	-80.0348614	579075.9	4725609.9	27.80
14.500	42.6778035	-80.0348840	579075.1	4725487.9	27.81
14.600	42.6769032	-80.0349066	579074.4	4725387.9	27.73
14.700	42.6760028	-80.0349292	579073.7	4725287.9	27.53
14.800	42.6751028	-80.0349446	579073.6	4725188.0	27.49
14.900	42.6742095	-80.0347910	579087.3	4725088.9	27.55
15.000	42.6733161	-80.0346373	579101.0	4724989.9	27.96
15.100	42.6724228	-80.0344837	579114.7	4724890.8	28.04
15.200	42.6715295	-80.0343301	579128.4	4724791.7	28.40
15.300	42.6706362	-80.0341765	579142.2	4724692.7	28.20
15.400	42.6697428	-80.0340228	579155.9	4724593.6	28.51
15.500	42.6688495	-80.0338692	579169.6	4724494.6	28.42
15.600	42.6679562	-80.0337156	579183.3	4724395.5	28.79
15.700	42.6670628	-80.0335620	579197.1	4724296.5	29.09
15.800	42.6661694	-80.0334099	579210.7	4724197.4	29.70
15.900	42.6652738	-80.0332827	579222.2	4724098.1	29.71
16.000	42.6643782	-80.0331554	579233.8	4723998.7	29.95
16.100	42.6634826	-80.0330282	579245.3	4723899.4	30.22
16.200	42.6625871	-80.0329009	579256.9	4723800.1	30.51
16.300	42.6616915	-80.0327737	579268.5	4723700.8	30.87
16.400	42.6607959	-80.0326464	579280.0	4723601.4	31.06
16.500	42.6599003	-80.0325192	579291.6	4723502.1	31.13
16.600	42.6590047	-80.0323920	579303.2	4723402.8	31.31
16.700	42.6581091	-80.0322647	579314.7	4723303.4	31.64
16.800	42.6572136	-80.0321375	579326.3	4723204.1	31.75
16.900	42.6563180	-80.0320103	579337.9	4723104.8	32.12
17.000	42.6554224	-80.0318831	579349.4	4723005.5	32.40
17.100	42.6545268	-80.0317558	579361.0	4722906.1	32.48
17.200	42.6536312	-80.0316286	579372.6	4722806.8	32.65
17.300	42.6527356	-80.0315014	579384.1	4722707.5	32.78
17.400	42.6518401	-80.0313742	579395.7	4722608.1	33.22
17.500	42.6509445	-80.0312470	579407.3	4722508.8	33.37
17.620	42.6498700	-80.0310950	579421.1	4722389.6	33.81

Table 5.5.6 – Canadian Offshore Route Deviation (RD6)

Route Deviation 6					
KP	**Latitude**	**Longitude**	**Easting**	**Northing**	**Depth(m)**
32.444	42.539220	-79.9575120	585604.0	4710174.6	57.05
32.600	42.5378261	-79.9577487	585586.5	4710019.6	57.21
32.700	42.5369326	-79.9579004	585575.3	4709920.2	57.42
32.800	42.5360391	-79.9580522	585564.1	4709820.8	57.49
32.900	42.5351456	-79.9582040	585552.8	4709721.5	58.17
33.000	42.5342522	-79.9583561	585541.5	4709622.1	58.01
33.100	42.5333587	-79.9585082	585530.3	4709522.7	58.05
33.200	42.5324653	-79.9586603	585519.0	4709423.4	58.06
33.300	42.5315718	-79.9588124	585507.7	4709324.0	58.49
33.400	42.5307002	-79.9590865	585486.4	4709227.0	58.49
33.500	42.5298543	-79.9595039	585453.3	4709132.6	58.29
33.600	42.5290084	-79.9599212	585420.1	4709038.2	58.78
33.700	42.5281624	-79.9603386	585387.0	4708943.9	58.71
33.800	42.5273165	-79.9607559	585353.9	4708849.5	59.06
33.900	42.5264705	-79.9611733	585320.8	4708755.2	59.43
34.000	42.5256246	-79.9615906	585287.7	4708660.8	58.77
34.100	42.5247786	-79.9620079	585254.5	4708566.5	59.45
34.200	42.5239327	-79.9624252	585221.4	4708472.1	59.45
34.300	42.5230867	-79.9628424	585188.3	4708377.8	59.95
34.400	42.5222408	-79.9632597	585155.2	4708283.4	59.87
34.500	42.5213948	-79.9636770	585122.0	4708189.1	60.45
34.600	42.5205489	-79.9640942	585088.9	4708094.7	60.54
34.700	42.5197029	-79.9645115	585055.8	4708000.3	60.56
34.800	42.5188569	-79.9649287	585022.7	4707906.0	60.19
34.900	42.5180110	-79.9653459	584989.5	4707811.6	60.13
35.000	42.5171650	-79.9657631	584956.4	4707717.3	59.87
35.100	42.5163191	-79.9661803	584923.3	4707622.9	59.86
35.200	42.5154731	-79.9665975	584890.2	4707528.6	59.79
35.300	42.5146271	-79.9670146	584857.0	4707434.2	59.87
35.400	42.5137811	-79.9674318	584823.9	4707339.9	59.77
35.500	42.5129352	-79.9678489	584790.8	4707245.5	59.36
35.600	42.5120892	-79.9682661	584757.7	4707151.2	59.32
35.700	42.5112432	-79.9686832	584724.5	4707056.8	59.40
35.800	42.5103972	-79.9691003	584691.4	4706962.4	59.27
35.900	42.5095513	-79.9695174	584658.3	4706868.1	59.07
36.000	42.5087053	-79.9699345	584625.2	4706773.7	58.72
36.100	42.5078593	-79.9703516	584592.0	4706679.4	59.12
36.200	42.5070133	-79.9707686	584558.9	4706585.0	59.12
36.300	42.5061673	-79.9711857	584525.8	4706490.7	58.97
36.400	42.5053213	-79.9716027	584492.7	4706396.3	58.76

Route Deviation 6					
KP	**Latitude**	**Longitude**	**Easting**	**Northing**	**Depth(m)**
36.500	42.5044753	-79.9720198	584459.5	4706302.0	59.17
36.600	42.5036294	-79.9724368	584426.4	4706207.6	59.39
36.700	42.5027834	-79.9728538	584393.3	4706113.3	59.82
36.800	42.5019374	-79.9732708	584360.2	4706018.9	59.45
36.900	42.5010914	-79.9736878	584327.0	4705924.5	60.07
37.000	42.5002454	-79.9741047	584293.9	4705830.2	59.79
37.100	42.4993994	-79.9745217	584260.8	4705735.8	59.65
37.200	42.4985534	-79.9749386	584227.7	4705641.5	59.97
37.300	42.4977751	-79.9755208	584180.9	4705554.5	59.76
37.400	42.4970647	-79.9762687	584120.4	4705474.9	59.91
37.500	42.4963543	-79.9770165	584059.9	4705395.2	60.40
37.600	42.4956439	-79.9777644	583999.4	4705315.6	59.98
37.700	42.4949335	-79.9785122	583938.9	4705236.0	59.89
37.800	42.4942231	-79.9792600	583878.4	4705156.4	60.08
37.900	42.4935127	-79.9800078	583817.9	4705076.7	59.98
38.000	42.4928023	-79.9807555	583757.4	4704997.1	60.48
38.100	42.4920919	-79.9815033	583696.9	4704917.5	60.70
38.248	42.4910400	-79.9826110	583607.3	4704799.6	60.77

Table 5.5.7 – United States Offshore Route Deviation (RD7)

Route Deviation 7					
KP	Latitude	Longitude	Easting	Northing	Depth(m)
73.903	42.2191970	-80.195136	566427.9	4674427.4	23.12
74.000	42.2184069	-80.1956418	566387.0	4674339.3	23.01
74.100	42.2175939	-80.1961628	566344.8	4674248.6	22.85
74.200	42.2167808	-80.1966838	566302.7	4674157.9	22.82
74.300	42.2159677	-80.1972047	566260.5	4674067.2	22.70
74.400	42.2151547	-80.1977257	566218.4	4673976.6	22.47
74.500	42.2143948	-80.1983642	566166.5	4673891.7	22.52
74.600	42.2136780	-80.1990975	566106.7	4673811.5	22.38
74.700	42.2129611	-80.1998307	566046.9	4673731.4	22.41
74.800	42.2122442	-80.2005640	565987.1	4673651.2	22.31
74.900	42.2115273	-80.2012972	565927.4	4673571.0	22.36
75.000	42.2108104	-80.2020304	565867.6	4673490.9	22.08
75.100	42.2100935	-80.2027636	565807.8	4673410.7	22.15
75.200	42.2093766	-80.2034968	565748.0	4673330.5	22.04
75.300	42.2086597	-80.2042299	565688.3	4673250.4	21.96
75.400	42.2079428	-80.2049631	565628.5	4673170.2	21.64
75.500	42.2073245	-80.2058385	565556.8	4673100.9	21.55
75.600	42.2067305	-80.2067491	565482.3	4673034.2	21.54
75.700	42.2061365	-80.2076596	565407.7	4672967.6	21.56
75.800	42.2055425	-80.2085701	565333.2	4672900.9	21.29
75.922	42.2048190	-80.2096830	565242.0	4672819.7	21.40

Table 5.5.8 – United States Nearshore Anthropogenic Contact Route Deviation (RD8)

Route Deviation 8					
KP	**Latitude**	**Longitude**	**Easting**	**Northing**	**Depth(m)**
88.090	42.1205960	-80.3033480	557586.2	4663400.9	14.47
88.200	42.1198228	-80.3041803	557518.0	4663314.4	14.40
88.300	42.1191203	-80.3049371	557456.1	4663235.9	14.39
88.400	42.1184177	-80.3056940	557394.2	4663157.4	14.27
88.500	42.1177152	-80.3064509	557332.3	4663078.9	14.11
88.600	42.1170126	-80.3072077	557270.3	4663000.3	14.04
88.700	42.1163582	-80.3080354	557202.5	4662927.1	13.91
88.800	42.1157330	-80.3089060	557131.1	4662857.1	13.93
88.900	42.1151078	-80.3097767	557059.7	4662787.1	13.77
89.000	42.1144825	-80.3106473	556988.2	4662717.1	13.71
89.100	42.1138573	-80.3115179	556916.8	4662647.1	13.62
89.200	42.1132321	-80.3123885	556845.4	4662577.1	13.49
89.300	42.1126068	-80.3132591	556774.0	4662507.1	13.46
89.400	42.1119816	-80.3141296	556702.6	4662437.1	13.40
89.500	42.1113563	-80.3150002	556631.2	4662367.1	13.33
89.600	42.1107311	-80.3158707	556559.8	4662297.1	13.31
89.700	42.1101058	-80.3167412	556488.4	4662227.1	13.11
89.800	42.1094805	-80.3176117	556416.9	4662157.1	12.98
89.900	42.1088552	-80.3184822	556345.5	4662087.1	12.69
90.000	42.1082300	-80.3193526	556274.1	4662017.1	13.32
90.100	42.1076047	-80.3202231	556202.7	4661947.1	13.74
90.200	42.1069794	-80.3210935	556131.3	4661877.1	13.71
90.300	42.1063541	-80.3219639	556059.9	4661807.1	13.59
90.400	42.1057287	-80.3228343	555988.5	4661737.1	13.40
90.500	42.1051034	-80.3237047	555917.0	4661667.1	13.45
90.600	42.1044781	-80.3245750	555845.6	4661597.1	13.33
90.700	42.1038527	-80.3254454	555774.2	4661527.1	13.22
90.800	42.1032274	-80.3263157	555702.8	4661457.1	13.16
90.900	42.1026021	-80.3271860	555631.4	4661387.1	13.10
91.000	42.1019767	-80.3280563	555560.0	4661317.1	13.10
91.100	42.1013965	-80.3289811	555484.0	4661252.1	13.06
91.200	42.1008190	-80.3299090	555407.8	4661187.4	13.06
91.300	42.1002414	-80.3308369	555331.6	4661122.6	13.22
91.400	42.0996638	-80.3317648	555255.3	4661057.9	13.20
91.500	42.0990862	-80.3326927	555179.1	4660993.2	13.19
91.600	42.0985086	-80.3336205	555102.9	4660928.4	13.16
91.700	42.0979310	-80.3345484	555026.7	4660863.7	13.07
91.800	42.0973534	-80.3354762	554950.4	4660799.0	13.03
91.900	42.0967758	-80.3364040	554874.2	4660734.3	13.04
92.018	42.0960940	-80.3374990	554784.2	4660657.9	12.92

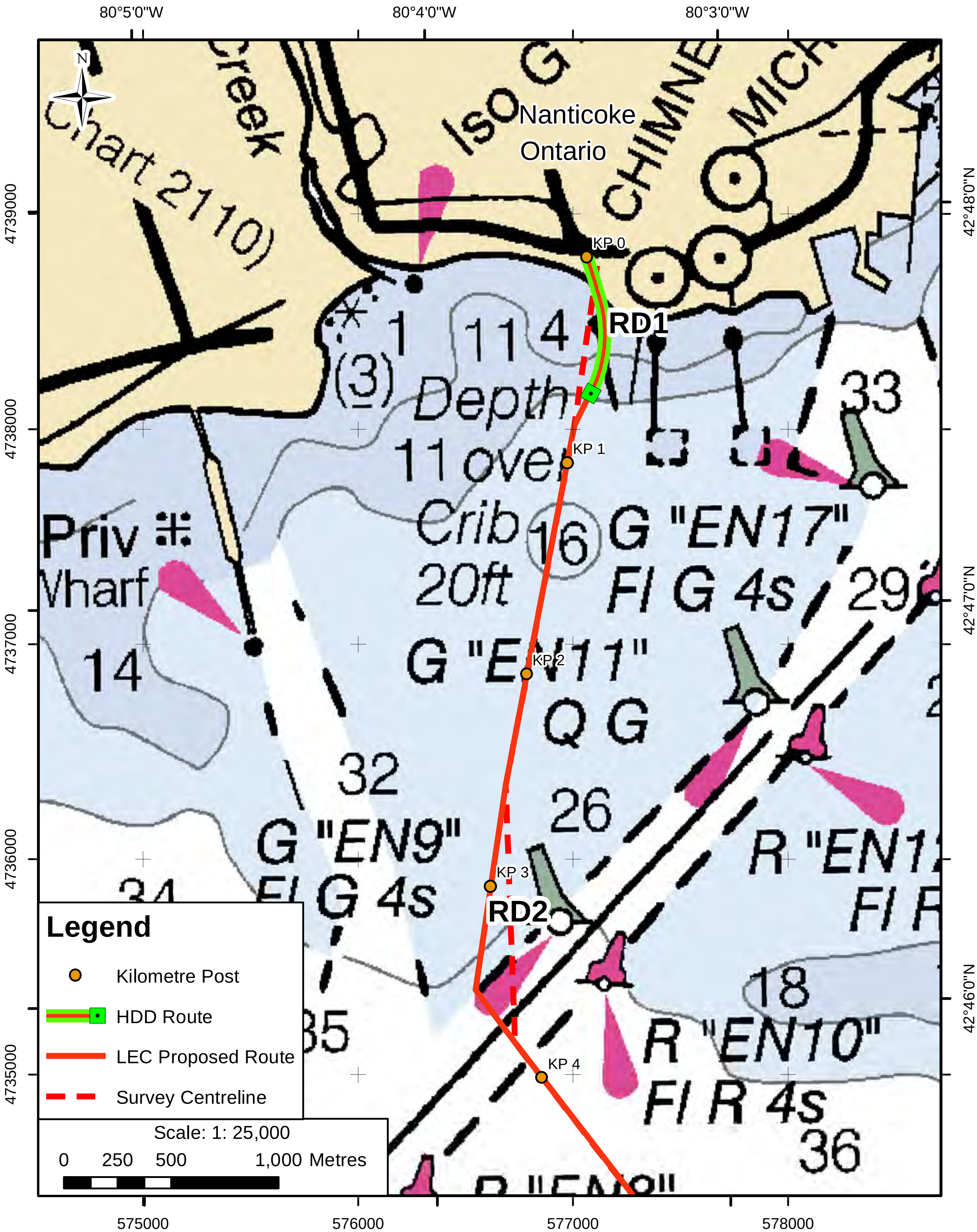

Figure 5.5.1 - Route Deviations at the Canadian Landfall (RD1) and over the Nanticoke Channel (RD2). NOAA chart 14838 pictured.

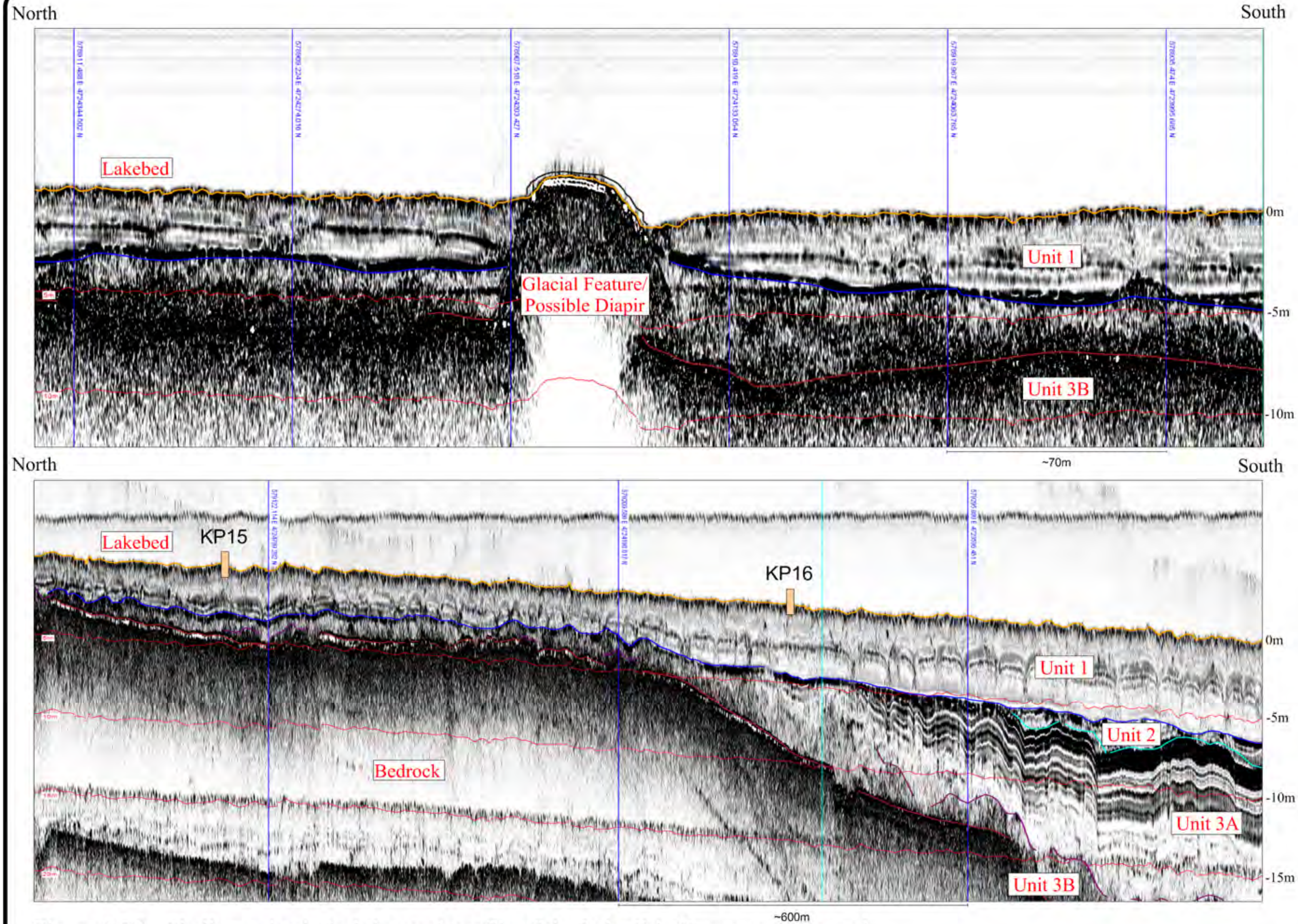

Figure 5.5.2 - Shallow seismic (sub-bottom) profile of the Lake Erie Connector Proposed Route collected using the Klein 3000 Chirp Profiler. Shown on the top is the original Survey Centreline over the glacial feature/possible diapir, shown on the bottom is the new proposed cable route around the glacial geo-hazard.

Canadian Seabed Research Ltd.

6.0 SUMMARY

Geophysical survey operations were conducted during the fall of 2014 and the spring/summer of 2015. The CSR survey vessel *Seabed* was used to survey the Canadian and United States Landfalls. Geophysical data over the majority of the route corridor was collected from the Nadro Marine vessel *VAC.* Survey equipment installed on the vessels for this survey included a sidescan sonar, marine magnetometer, single beam echosounder system, multibeam echo sounder system, boomer shallow seismic system and a chirp sub-bottom profiler. Several grab samples were taken in the Canadian and United States Landfall areas. A subsequent geotechnical survey was conducted in the late summer of 2015 using a Rossfelder P-3C Vibracorer from the Nadro Marine vessel *Ecosse.*

All the geophysical data was collected using NAD83 as the primary datum, with reference to UTM Zone 17 as the projection. The vertical datum used was Lake Erie Chart Datum (173.5 m above the International Great Lakes Datum 1985). The survey covered a 500 m corridor (minimum) over the marine portion of the LEC Proposed Route from Nanticoke, Ontario, Canada to Springfield Township, Pennsylvania, USA.

Bathymetric data was processed by CSR and was corrected to Lake Erie Chart Datum. Contours of the data was generated at one metre intervals along the LEC Proposed Route.

The lakebed along the LEC Proposed Route is relatively flat with slopes generally less than 1%. Lakebed slopes greater than 1% occur in localized areas near the Canadian and United States Landfalls and over the Long Point Escarpment. The maximum water depth along the route is 62.3 m (located at the toe of the LPE).

The sidescan sonar data was processed and a 0.2 m resolution mosaic was created. The processed data was interpreted visually to identify and map surficial geological boundaries and seabed features. The size, shape, homogeneity, apparent relief and acoustic character of specific return patterns were used to map surficial units and identify lakebed surficial features. Contacts and features mapped from the sidescan sonar data are summarized in Appendices III-V. All surficial boundaries and lakebed features mapped from the sidescan sonar data have been plotted on the Panel Map Sheets.

The magnetometer data was processed for layback and anomalies mapped based on nanotesla readings recorded by the sensor. The location, type and magnitude of each anomaly has been summarized in Appendix VII and positions for each magnetic anomaly have been plotted on the Panel Map Sheets. All magnetic anomalies were reviewed for correlations with the bathymetric data, sidescan data and nautical chart.

For the purpose of this study, the surficial geological units were divided into six units. Unit boundaries were based on the acoustic signatures interpreted from the sidescan sonar data. In order to verify the accuracy of the acoustic interpretations, grab sample and vibracore information was used.

Numerous surficial features were observed within the survey area. These features included ice-scours, ripple marks, mussel beds, pockmarks, boulders, dredge spoils, trench scars and different types of drag marks which appear to be related to human activity.

Twenty-five ice scours were identified from the geophysical over the LEC Proposed Route corridor. Of the twenty-five ice scours observed, 14 are considered to have formed recently based on their acoustic signature and morphology. The remainder represents an older population of ice scours. The majority of the older scours occur in Canadian waters while the majority of the recent scour population occurs in American waters. The most significant recent ice scour is a 318 m wide multi-keel event identified in 17 m to 18 m water depth approximately 8 km offshore within the Pennsylvania Channel. This ice scour is interpreted to have formed during the winter of 2015 and has a maximum scour depth of 1.36 m.

Near surface gas is abundant in the deep waters of the Canadian portion of the LEC Proposed Route. Areas of intermittent gas are present throughout the much of the route. Due to this gas presence, there are gas escape related features described as ‘pockmarks’ found in various locations on the lakebed within the route corridor.

All sub-bottom data was interpreted using established seismo-stratigraphic techniques. Seismo-stratigraphic analysis involves the identification of seismic sequences based on variations in acoustic character and correlation of bounding reflectors throughout the survey area. Identification of geological units was based on the internal characteristics of each sequence. The sub-bottom data was used to interpret and map the sub-bottom geological conditions and was further cross-referenced with the sidescan sonar data and vibracore information where possible. The sub-bottom data was also used to map the areas of shallow gas accumulation. The geological conditions encountered along the LEC Proposed Route have been interpreted to consist of four main units.

Four pipelines are crossed by the LEC Proposed Route. These pipelines are all located in Canadian waters and range in size from 2” to 6” in diameter. Three of the pipelines are charted and the approximate locations of these pipelines were known prior to the geophysical survey. One abandoned and uncharted pipeline was located during the geophysical survey. In addition to the natural gas pipelines encountered along the route, a suspected water intake pipe was also interpreted to extend out form the shoreline at the Canadian Landfall.

Based on the analysis of the geophysical data and the preliminary geotechnical data available from the survey area, CSR has selected and presented the best possible route for the proposed cable installation within the mapped corridor. This LEC Proposed Route includes 8 route deviations (RDs) which deviate from the Survey Centreline. The route deviations have been discussed in detail in Section 5.5 Route Deviations and have also been plotted on the Panel Map Sheets.

7.0 RECOMMENDATIONS

Remotely Operated Vehicle (ROV) Survey

There are a number of unidentified magnetic anomalies and sidescan sonar contacts that have been positioned within the route corridor. CSR recommends further investigation of each unidentified target that falls close to the route centerline using an inspection class ROV fitted with exploration tools including magnetometer and scanning sonar.

Based on the information collected, it is difficult for CSR to confidently identify a series of linear features to the south of the Long Point Escarpment. As discussed in Section 5.4 Drag Marks, these linear features are thought to be scars left by pipeline segments as they were dragged along the lakebed. Although no magnetic anomalies associated with these linear features were mapped close to the route centerline, it is likely that discarded pipes do exist in the vicinity of the route corridor. It is recommended that further investigation of these areas be undertaken using an ROV.

As discussed in Section 5.4, linear features interpreted as possible cables exist between KP 19.5 and KP 29.4. These features should be examined during the ROV survey.

In addition to the ROV survey of unidentified features and targets, the ROV could also be used to visually inspect and sample mussel beds along the LEC Proposed Route. From this inspection better estimates of coverage and density of the beds could be made.

Grapnel Survey

Another recommendation being made by CSR is to conduct a grapnel survey over linear features interpreted as possible hazards to the route. A grapnel survey would consist of tug dragging a grapnel or anchor through the upper lakebed sediments over selected transects. Transects would be designed to target unknown linear features with the intent to clear the targets as hazards to the route. Additional grapnel drags could also be conducted at other selected locations along the LEC Proposed Route where deemed beneficial. The grapnel survey should be conducted only after the ROV inspection of unidentified targets. As part of the project construction plan, a grapnel survey of the entire LEC Proposed Route is currently scheduled. The recommendations made by CSR above could be completed in conjunction with the pre-construction grapnel survey.

Clearance Survey

Prior to the installation of the submarine cable, a clearance survey should be conducted over the entire LEC Proposed Route. The width of the survey corridor for the clearance survey should be determined by the engineering design and requirements of the cable installation contractors. The clearance survey should include bathymetric and sidescan sonar data collected over 100 percent of the lakebed within the clearance corridor. Magnetometer data should be collected in conjunction with the sidescan sonar data at a minimum spacing of 20 m. Again, as part of the project construction plan, a clearance survey of the cable route is currently scheduled.

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Appendix I – Daily Field Log

CSR Daily Log – Marine Geophysical Survey– Lake Erie Connector - CSR project 1408	
Recorded by: Colin Toole	
Date: November 17, 2014– December 19, 2014	
Client: ITC	
Nov 17	Weather; snow and variable winds increasing in the evening
	Field crew and all equipment mobilized from office to Port Dover
	Recon at boat , discuss welding and electrical work with Boat crew
Nov 18	Weather; sunny, -15 degrees, winds 30knots
	Mobbing boat; welding, electrical work, Assembling CSR gear onboard
Nov 19	Weather; overcast, steady snow all day makes back deck mob a challenge, winds 30knots
	Continue Mobbing boat; welding, electrical work, Assembling CSR gear onboard
Nov 20	Weather; clear sunny, winds 20 knots
	Continue Mobbing boat; welding, electrical work, Assembling CSR gear onboard
Nov 21	Weather; clear sunny, temp -5c, winds 20 knots
	Continue Mobbing boat; welding, electrical work, Assembling CSR gear onboard
Nov 22	Weather; rain, temp 5c, winds 25-30 knots SW
	Continued mobbing boat; secured generator and other equipment, vessel offsets, hse review , hypack project
Nov 23	Weather; cloudy with rain showers, temp 10c, winds 10-20 knots S
	Tested equipment and collected data along Cnd landfall route; east option
	Mobilization complete
	Notified Justin that Wed Nov. 26 is next possible day for survey work
Nov 24	Weather; rain and strong winds, temp 5-10c, winds 30-45 knots S-SW
	Confirmed with Capt. Scott that he will issue a Notice to Mariners with Cnd CG
	Conducted hazard assessment on VAC tug and operations
	Reviewed data from test day
Nov 25	Weather; flurries, temp 0-5c, winds 25-40 knots S-SW
Nov 26	Weather; flurries, temp 0c, winds light-10 knots W-NW Seas 0.5-1.0m
	Collected data on Cnd landfall eastern route
Nov 27	Weather; mostly sunny, temp -2c, winds 10-15 knots W-NW Seas 0.5-1.5m
	Collected data on Cnd landfall eastern route
Nov 28	Weather; mostly sunny, temp -2c, winds 10-15 knots W-NW Seas 0.5-1.5m
	Collected data on Cnd landfall eastern route

Nov 29	Weather; partly cloudy, temp 0-5c, winds 20-25 knots SW Seas 1.5-2.0m
Nov 30	Weather; cloudy, temp 0-5c, winds 20-25 knots S-SW Seas 1.5-2.0m
Dec 1	Weather; partly cloudy, temp 0c, winds 10-15 knts NW Seas 0.5-1.0m
	Collected data on Cnd landfall eastern route; tie lines
Dec 2	Weather; cloudy with flurries, temp -5c, winds 10-20 knts NE Seas 0.5-1.5m
	Collected data on Cnd landfall eastern route; tie lines
Dec 3	Weather; overcast, temp 0c, winds 30-35 knts W Seas 1.5-2.0m
Dec 4	Weather; sunny, temp 2c, winds 0-5 knts W Seas 0-0.5m
	Collected data on Cnd landfall eastern route; nearshore
	Cnd landfall eastern route COMPLETE
Dec 5	Weather; overcast, temp 0c, winds 5-10 knts E Seas 0-1.0m
	Collected data on Long Point Escarpment; 200 m lines
Dec 6	Prepared for move to Erie, PA
Dec 7	Weather; mainly sunny, temp -5c, winds 10-20 knts N Seas 1.0-2.0m
	Boat, gear and 4 crew crossed to Erie
	CT drove to Erie
Dec 8	Weather; overcast, temp -2c, winds 10-15 knts SE Seas 0.5-1.5m
	Collected data on US landfall
Dec 9	Weather; overcast, temp 4c, winds 0-10 knts SW Seas 0-1.0m
	Collected data on US landfall
Dec 10	Weather; rain/snow, temp -2c, winds 20-25 knts N Seas 1.5-2.0m
Dec 11	Weather; snow, temp -2c, winds 25-30 knts N Seas 2.0-3.0m
Dec 12	Weather; cloudy, temp -2c, winds 20-25 knts NW Seas 1.5-2.0m
Dec 13	Weather; cloudy, temp 4c, winds 15-20 knts W-SW Seas 1.0-2.0m
	*attempted mag survey; sea conditions poor; ended survey early
Dec 14	Weather; overcast, temp 2c, winds 10-15 knts W-SW Seas 0.5-1.0m
	Collected data on US landfall
Dec 15	Weather; overcast and fog, temp 5c, winds 0-10 knts S Seas 0-0.5m
	Collected data on US landfall

Dec 16	Weather; periods of rain, temp 5c, winds 10-15 knts S Seas 0.5-1.0m
	Boat, crew and gear returned to Port Dover
	Started demob of boat
Dec 17	Weather; light rain, temp 0c, winds 10-20 knts S Seas 1.0-1.5m
	Demobbing equipment from boat
Dec 18	CT took flight from Toronto to Halifax
	NW, MK driving back to Halifax in cube truck with gear
Dec 19	NW, MK arrived in Halifax with cube truck and gear

CSR Daily Log – Marine Geophysical Survey– Lake Erie Connector - CSR project 1408	
Recorded by: Colin Toole, Matt Savelle, Pat Campbell	
Date: June 9th, 2015– August 25th, 2015	
Client: ITC	
June 9	Field crew and all equipment for nearshore survey in transit from office to Rivere De Loup, Que.
June 10	Field crew and all equipment for nearshore survey in transit from Rivere De Loup, Que. to Pembroke, Ont.
	Started mobbing nearshore survey vessel Seabed
	Reconed boat ramp in Pembroke, Ont.
June 11	Mobbing nearshore survey vessel Seabed
June 12	Mobbing nearshore survey vessel Seabed
June 13	Field crew and all equipment for nearshore survey in transit from Pembroke, Ont. To Nanticoke, Ont.
	Stopped in Hamilton, Ont. for supplies
	Dropped survey vessel Seabed at Hoovers Marina in Nanticoke, Ont.
June 14	Weather; overcast and fog in am, thunderstorms starting around noon, 24°C, winds 10-15 kts SW
	Launched boat at Hoovers Marina
	Testing equipment at dock
	Reconed spot for water level gauge (to act as back up for CCG/NOAA tides)
June 15	Weather; overcast and fog in am, clearing in afternoon, 28°C, winds 10-15 kts SW; seas 2ft
	Installed water level gauge at Hoovers Marina
	Mobbed generator on boat, built and installed tow-point extension mount
	Tested/fixed Yamaha kicker outboard
	Measured vessel offsets
	Initial boat mob complete
June 16	Weather; partly sunny, 28°C, winds 10-15 kts W-NW; seas 1-2ft
	Nearshore sidescan survey; 50 m range
	Field mosaic
June 17	Weather; overcast in am clearing later in day, winds 10-15 kts E; seas 2-3ft decreasing in pm
	Mobbed/tested magnetometer
	Finished nearshore sidescan survey; 75 m and 100 m range
	Bathymetry and sub-bottom survey; tie lines in shallow water

June 18	Weather; fog, clearing later in day, winds 5-10 kts SW increasing to 15 SW; seas 1-3ft
	Bathymetry, sub-bottom and mag survey; 25 m main lines
June 19	Weather; overcast and clearing in pm, winds 10-15 kts NE decreasing to 5-10 NE; seas 1-2ft
	Bathymetry, sub-bottom and mag survey; 25 m main lines
June 20	Weather; mostly sunny, winds 10 kts NE; seas 1-2ft
	Finished bathymetry, sub-bottom and mag survey; 25 m main lines and tie lines
	Collected grab samples
June 21	Weather; mostly sunny, winds 10-15 kts SW; seas 1-3ft
	Demobed SSS, mag, transducer
	Mobbed video
	Packed and prepped for transit to Erie, PA
	Reviewed data
	Prepped data, scanned logs to send to office
June 22	Weather; sunny, winds 5 kts S; seas flat to 1ft
	Sent data to office via courier
	Video transects
	Remobed SSS and ran 25 m range over mag targets close to route
	Canadian nearshore survey complete
	Pulled water level gauge at Hoovers Marina
	Pulled boat and prepped for transit to Erie, PA
June 23	Weather; mostly sunny, winds 15 kts SW
	Crew and gear transited from Port Dover, Ont. to Springfield, PA; crossed border at Peace Bridge in Buffalo
	Checked into Elk Creek Campground
	Reconed boat ramps at Elk Creek, Crooked Creek
June 24	Weather; sunny, winds 5 kts NW; seas flat to 1ft
	Bathymetry, sub-bottom and mag survey; 25 m main lines (US nearshore)
June 25	Weather; overcast, winds 5 kts S swinging to 5 kts NE; seas flat to 1ft
	Bathymetry, sub-bottom and mag survey; 25 m main lines and tie lines
	Sidescan survey; 75 m range
June 26	Weather; partly sunny, winds 15-20 kts NE; seas 3-5ft
	Reviewing and processing data
	Met with Port Authority in Erie, PA to discuss dockage for VAC & Ecosse
	Went to Staples to print customs docs

June 27	Weather; heavy rain most of day, winds 20-35 kts NE to SE; seas 5-8ft
	Reviewing and processing data
	Cleaned up boat
June 28	Weather; heavy rain most of day, winds 15-25 kts NE; seas 4-6ft
	Reviewing and processing data
June 29	Weather; mostly sunny, winds 5 kts S; seas flat to 1ft
	Finished bathymetry, sub-bottom and mag survey; 25 m main lines and tie lines
	Video transects
	Collected grab samples
	US nearshore survey complete
June 30	Weather; mostly sunny
	Prepped boat and gear for transit
	Field crew and all equipment for nearshore survey in transit from Erie, PA. to Port Dover, Ont.
	Started demobing nearshore survey vessel Seabed
July 1	Weather; mostly sunny
	Finished demob of Seabed
	Started mobbing VAC
July 2	Weather; mostly sunny
	Additional field crew arrived in Port Dover; brought winch, chirp and other gear
	MB and DMS arrived in Port Dover
	Continued mobilizing VAC
July 3	Weather; sunny, 28°C
	Winch on boat at tested
	MB mount in progress
	Chirp, mag put together (not tested)
	VS330 heading mount installed
	CPU's and monitors installed and tested in galley
	Generator mobilized on boat
July 4	Weather; sunny, 25°C
	Continued mobilizing VAC
	MB and mount, DMS05 mobilized
	Vessel offsets measured
	Chirp and mag tested

July 5	Weather; sunny, 25°C
	Continued mobilizing VAC
	Set up RTK GPS; shot vessel and sensor offsets, heading calibration
	Calibrated DMS05 motion sensor at dock
	Finished CPU setup in galley, configured Hypack project
	Added stabilizing cables to MB mount fore and aft
	Prepared for water testing scheduled for Monday
July 6	Weather; sunny, 25°C, winds 5 kts S; seas 1 ft
	Continued mobilizing VAC
	Conducted water tests of both multibeam and chirp/sss offshore Nanticoke
	Multibeam patch test
July 7	Weather: sun with afternoon showers, 25°C, winds 15 kts S-SW; seas 3-4 ft
	MS went home; Hamilton-Halifax flight
	Safety meeting with Nadro and CSR personnel in attendance
	Installed AC in galley
	Researched and made planned lines for MB patch test offshore over wreck (FHU)
	Reviewed patch test data from July 6
	Worked on Hypack project
July 8	Weather; sunny, 24°C, winds 10-15 kts NE decreasing to 5 kts NE in afternoon; seas 3ft decreasing to 1 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND main lines
July 9	Weather; rain, clearing late in day, 22°C, winds 5-10 kts NE; seas 1-3 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND main lines and tie lines
July 10	Weather; sunny, 25°C, winds light to 5 kts SW; seas flat to 1 ft
	MB patch test (over offshore wreck)
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND main lines and tie lines
July 11	Weather; sunny, 25°C, winds light to 5 kts SW; seas flat to 1 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND main lines

July 12	Weather; sunny, 28°C, winds light; seas flat
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND main lines
	Ran recon/tie lines through area of gas diapir, shallow bedrock; KP 14-17
July 13	Weather; sunny, 28°C, winds light to 5 kts NE; seas flat to 1 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND main lines
July 14	Weather; thunderstorms, heavy rain at times, 26°C, winds 15 kts with gusts to 45 kts SW. Strong Wind Warning issued by EC; seas 3-5 ft
	Uploading data to office through FTP
	Scanning logs
	Data review
July 15	Weather; mostly sunny, 21°C, winds 20-25 kts NE. Strong Wind Warning issued by EC; seas 3-5 ft
	Uploading data to office through FTP
	Working on paper work for customs clearance
	Data review
July 16	Weather; sunny, 30°C, winds light increasing 5-10 kts NE in pm; seas 1-2 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND main lines and tie lines
July 17	Weather; thunderstorms, heavy rain at times, 22°C, winds 20 kts SW. Strong Wind Warning issued by EC; seas 3-4 ft
	Uploading data to office through FTP
	Data processing
July 18	Weather; sunny, 29°C, winds 5-10 kts W-SW; seas 1-3 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND main lines
	Confirmed dockage in Erie, PA;

July 19	Weather; partly sunny with thunderstorms, 32°C, winds 5-10 kts increasing to 15 SW around noon; seas 2-5 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND tie lines
	Winds increased to 15 kts SW around noon; waves 3-5 ft; had to end data collection
	CT took flight from Toronto to Halifax at 8:00pm; MS returned on flight from Halifax to Hamilton at 7:00pm
July 20	Weather; sunny, 28°C, winds 5-10 kts SW; seas 1-3 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND tie lines
July 21	Weather; sunny, 28°C, winds 5-10 kts NW; seas 1-3 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND tie lines/main line
July 22	Weather; sunny, 25°C, winds 10-16 kts NW; seas >5 ft
	Scanning logs, copying data
	Organizing customs docs
	Prepared equipment list for VAC
July 23	Weather; sunny, 29°C, winds 5-10 kts W; seas 1-3 ft
	MB patch test
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND lines east of diapir area
	Confirmed dockage in Erie, PA; schedule is to move to US on Wed. July 22
July 24	Weather; sunny, 28°C, winds 5 kts S;
	Crew and gear transited from Port Dover, Ont. to Erie, PA;
	Checked into Hotel in Erie
July 25	Weather; sunny, 32°C, winds 5 kts SW;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	Called USCG (Notice to Mariners)
	Scanned logs

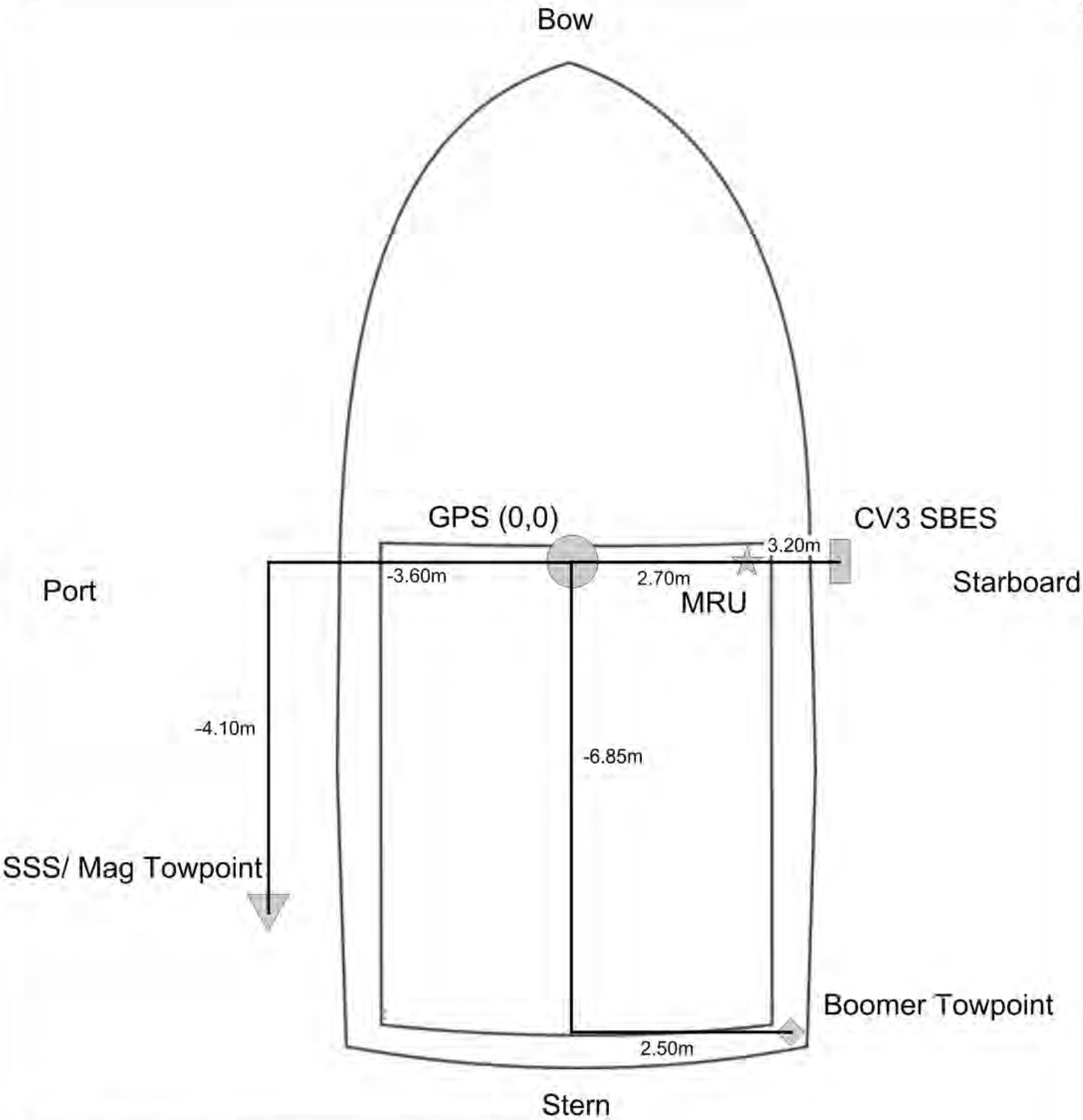
July 26	Weather; sunny, 32°C, winds 5 kts S;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	Recon new patch test area
	Relocated to new hotel
July 27	Weather; sunny, 34°C, winds <5 kts SW;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	MB patch test
July 28	Weather; sunny, 32°C, winds <5 kts S;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	MB patch test
July 29	Weather; sunny, 32°C, winds <5 kts S;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines and tie lines
	MB patch test
July 30	Weather; sunny, 28°C, winds 15 kts W; seas >5ft
	Scanning logs
	Uploading data to office through FTP
	Data processing
July 31	Weather; sunny, 26°C, winds 10 kts W, seas <5 ft in morning increased to 15 kts W in afternoon; seas >5ft
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	MB patch test
August 1	Weather; sunny, 25°C, winds 10 - 15 kts W; seas >5ft
	Scanning logs
	Uploading data to office through FTP
	Data processing
August 2	Weather; sunny, 25°C, winds 8-10kt SW; seas <5ft
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	MB patch test

August 3	Weather; sunny, 25°C, winds 10 - 15 kts W; seas >5ft
	Scanning logs
	Uploading data to office through FTP
	Data processing
August 4	Weather; sunny, 25°C, winds 8-13 kts SW; seas 3 - 5ft
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	MB patch test
August 5	Weather; sunny, 21°C, winds 5-10 kts W; seas <3ft
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	MB patch test
August 6	Weather; sunny, 22°C, winds 5-10 kts NE; seas <3ft
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	MB patch test
August 7	Weather; sunny, 25°C, winds 10-13 kts NE; seas 3-5ft
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines
	MB patch test
August 8	Weather; sunny, 20°C, winds 8-13 kts NE; seas 3-5ft
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US main lines and tie lines
	MB patch test
August 9	Weather; sunny, 20°C, winds 10-13 kts NE; seas 5ft
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US tie lines
	MB patch test
August 10	Weather; sunny, 26°C, winds 5 kts NW;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; US tie lines,
	MB patch test
	Contact ITC about running survey lines over ice scours
August 11	Weather; sunny, 26°C, winds 8-12 kts NW; seas 3-5ft
	Multibeam bathymetry, sidescan, chirp sub-bottom; US Scour,
	MB patch test

August 12	Weather; sunny, 24°C, winds 8-12kt NE; seas 3-5ft
	Multibeam bathymetry, sidescan, chirp sub-bottom; US Scour,
	MB patch test
August 13	Weather; sunny, 28°C, winds 10 kts SW; seas <3ft
	Crew and gear transited from Erie, PA to Port Dover, ON.
	Checked into Hotel
August 14	Weather; sunny, 28°C, winds >15 kts SW; seas >5ft
	Helping mob Ecosse
	Uploading data to office through FTP
	Data processing
	Scanning logs
August 15	Weather; sunny, 28°C, winds 5 kts SW;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; CND Nearshore lines
	MB patch test
August 16	Weather; sunny, 30°C, winds 5-10 kts SW;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; West of diapir
	MB patch test
August 17	Weather; sunny, 30°C, winds 10 kts SW;
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; Finished CND mainlines, continued tie lines
	MB patch test
August 18	Weather; sunny, 24°C, winds 10-12 kts SW; thunderstorms midday, clearing late afternoon
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; Collected additional sss/chirp and mag over center line and linear targets, anchor drag survey
	MB patch test
August 19	Weather; sunny, 32°C, winds 10-15 kts SW; decreasing in afternoon
	Multibeam bathymetry, sidescan, chirp sub-bottom and mag survey; Tie lines and abandoned pipeline survey
	MB patch test

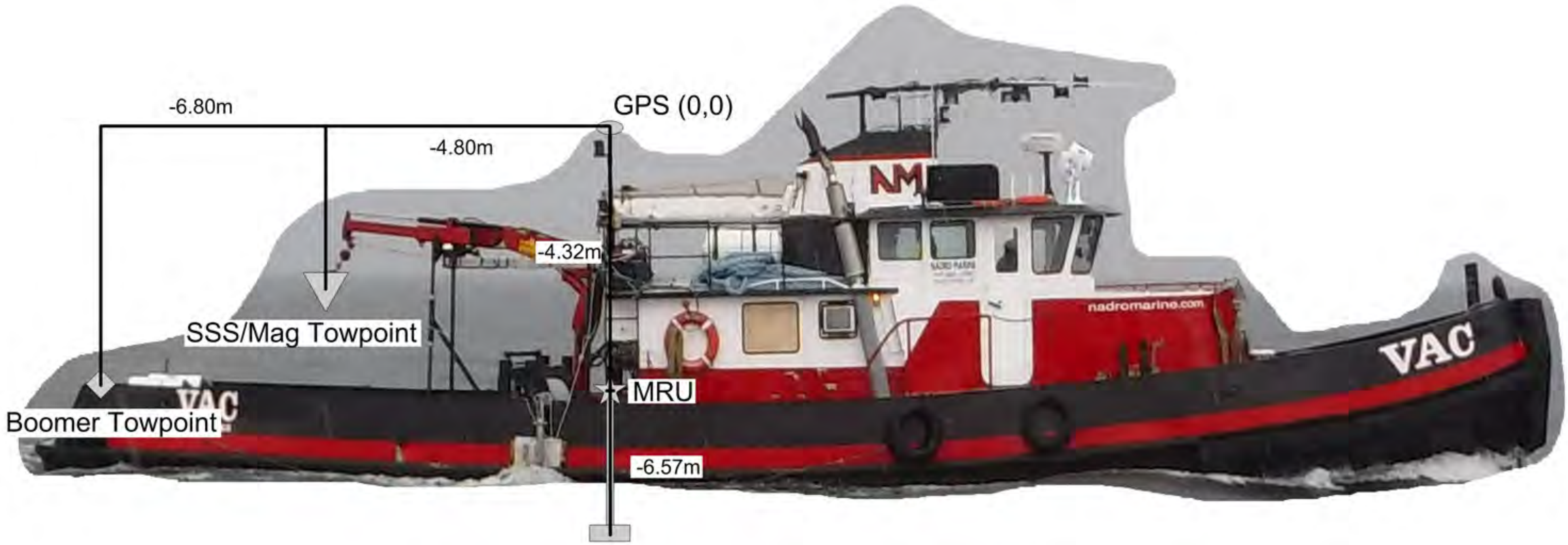
August 20	Weather; thunderstorms; clearing in pm, 28°C, winds 20-30 kts SW. Strong Wind Warning issued by EC; seas 4-6 ft
	NW took Hamilton flight to Halifax; took all data and logs up to Aug 19
	Remaining VAC crew worked on Ecosse (at dock)
	Geotherm (Deepak) arrived in Port Dover and did a mock mob of his equipment on Ecosse
August 21	Weather; sunny, 28°C, winds 10-15 kts W; seas 2-4 ft
	Sidescan, chirp sub-bottom and mag survey; Linear features additional survey
August 22	Weather; sunny, 30°C, winds <5 kts W; seas flat
	Sidescan, chirp sub-bottom and mag survey; Linear features additional survey, anchor drag survey 2
	Geophysics scope of work complete
	Started demobing the VAC
August 23	Weather; sunny, 28°C, winds 10 kts E; diminishing to 5 kts E; seas 2 ft-flat
	Demobing VAC
	Took chirp, sss, mag apart and loaded in box truck
	Took computers, sss tpu, ups, gps off boat and packed for shipping back to NS
	Loaded gear from storage space into box truck
August 24	Weather; sunny, 24°C, winds 15-20 kts W; seas 4-6 ft. Strong Wind Warning issued by EC
	Demobing
	Took winch, generator off VAC with crane
	Demobed boomer (back up) and crane crutch
	Finished loading box truck
August 25	Weather; cloudy, 22°C, winds 15-20 kts W; seas 3-5 ft
	Demob/travel: Last day of Operations

Appendix II – Vessel Offsets



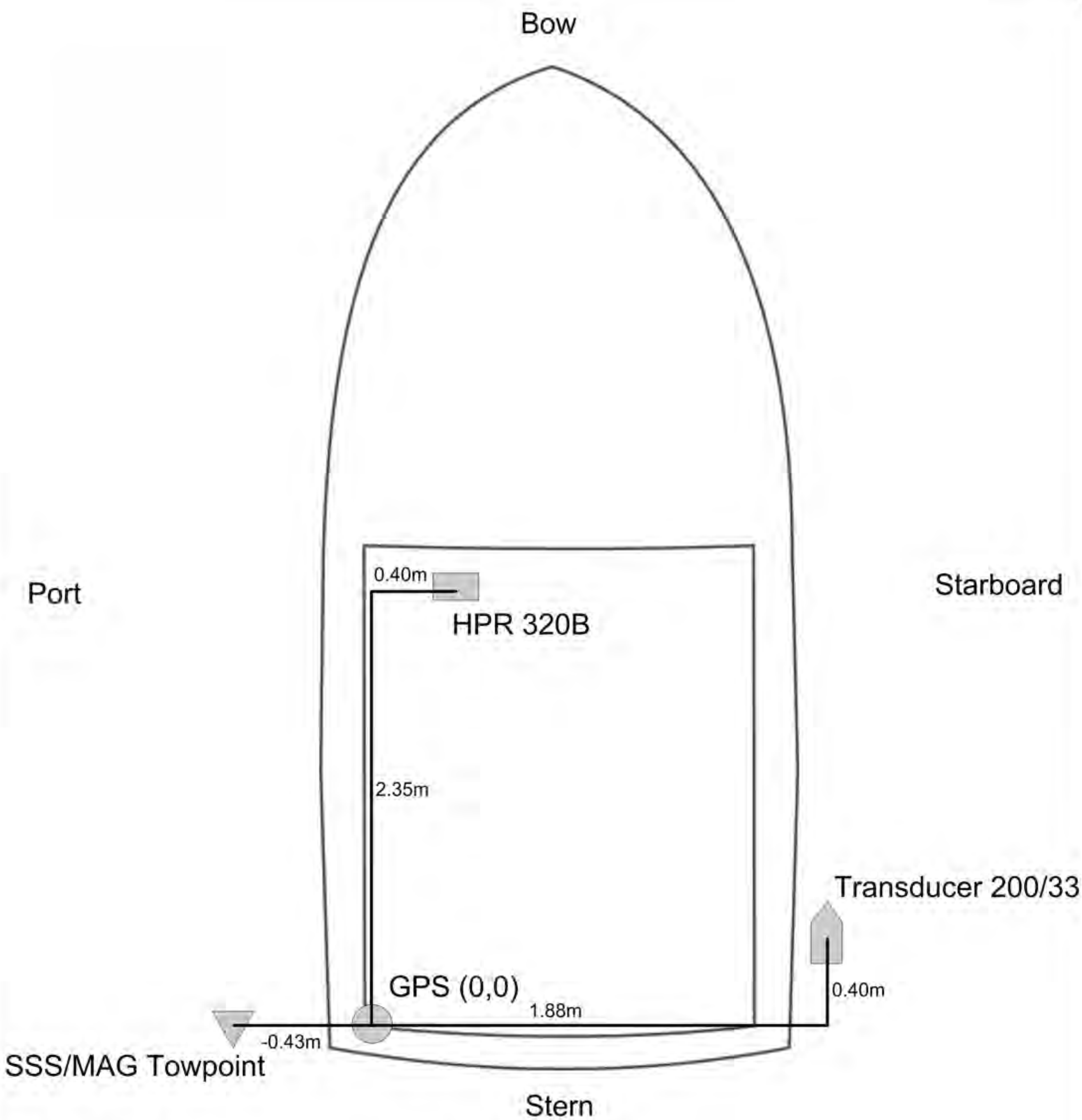
System Name	Offsets (m)		
	X	Y	Z
CV3	3.20	0.00	-6.57
MRU	3.20	0.00	-4.32
Boomer Towpoint	2.50	-6.85	
SSS/MAG Towpoint	-3.60	-4.10	

Appendix II. Plan view and vessel offsets of Nadro Marine tugboat *VAC,* during 2014 operations.



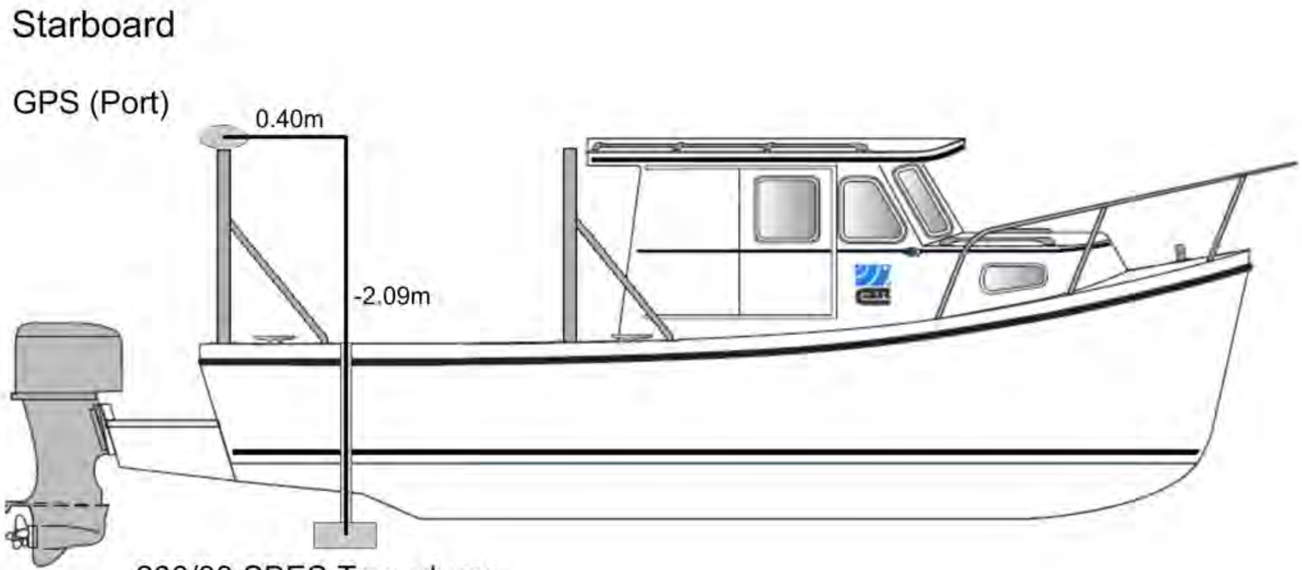
System Name	Offsets (m)		
	X	Y	Z
CV3	3.20	0.00	-6.57
MRU	3.20	0.00	-4.32
Boomer Towpoint	2.50	-6.85	
SSS/MAG Towpoint	-3.60	-4.10	

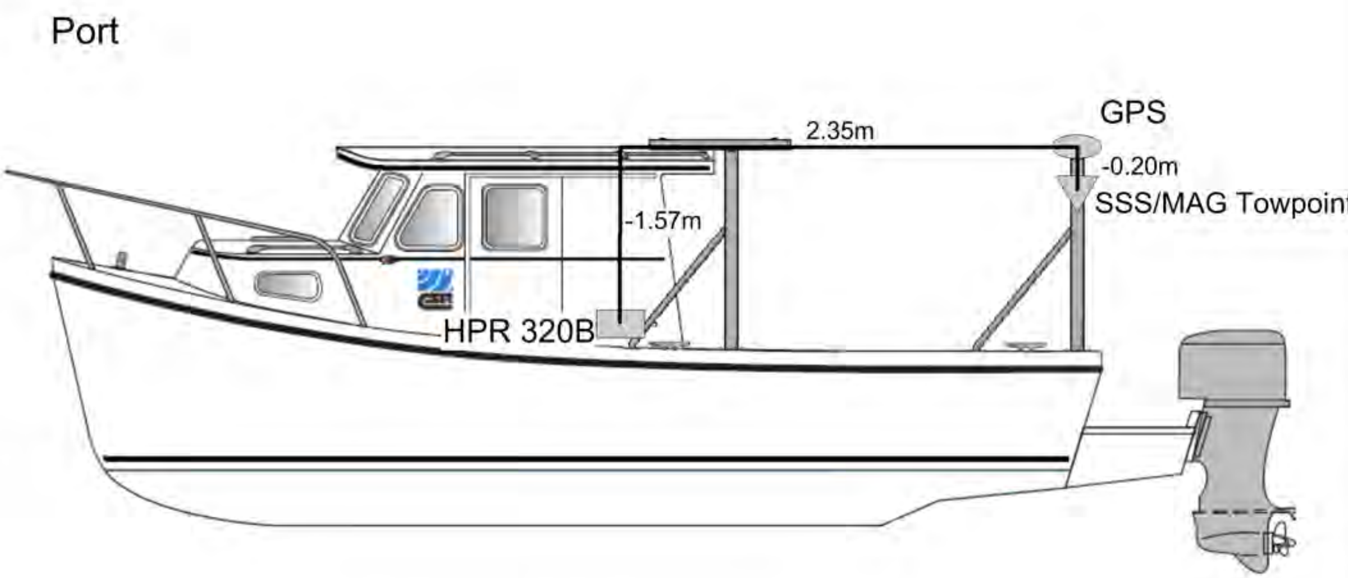
Appendix II. Profile view and vessel offsets of Nadro Marine tugboat *VAC*, during 2014 operations.



System Name	Offsets (m)		
	X	Y	Z
200/33 SBES	1.88	0.40	-2.09
HPR 320B	0.40	2.35	-1.57
SSS/MAG Towpoint	-0.34	0.00	-0.20

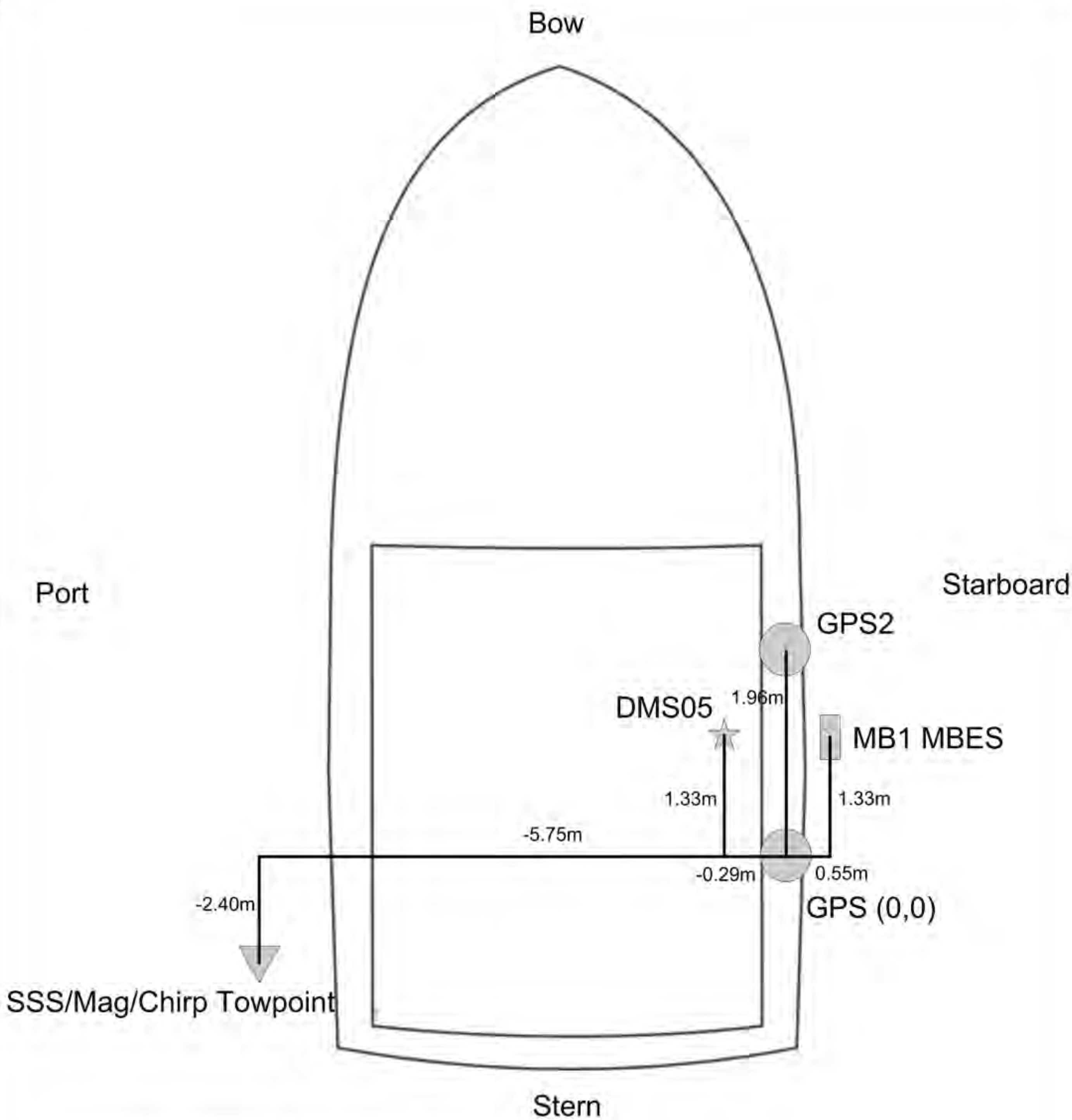
Appendix II. Plan view and vessel offset of CSR Survey vessel *Seabed*, during 2015 operations.





System Name	Offsets (m)		
	X	Y	Z
200/33 SBES	1.88	0.40	-2.09
HPR 320B	0.40	2.35	-1.57
SSS/MAG Towpoint	-0.34	0.00	-0.20

Appendix II. Profile views and vessel offsets of CSR Survey vessel *Seabed*, during 2015 operations.



System Name	Offsets (m)		
	X	Y	Z
DMS05	0.29	1.33	-1.86
MB1	0.55	1.33	-3.71
GPS2	0.00	1.96	0.00
Towpoint	-5.75	-2.40	-0.69

Appendix II. Plan view and vessel offsets of the Nadro Marine tugboat *VAC*, during 2015 operations.

System Name	Offsets (m)		
	X	Y	Z
DMS05	0.29	1.33	-1.86
MB1	0.55	1.33	-3.71
GPS2	0.00	1.96	0.00
Towpoint	-5.75	-2.40	-0.69

Appendix II. Profile view and vessel offsets of the Nadro Marine tugboat *VAC,* during 2015 operations.

Appendix III – Sidescan Sonar Contacts Table

Sidescan Sonar Contacts										
Label	Latitude	Longitude	Easting (m)	Northing (m)	Offset (m)	Length (m)	Width (m)	Height (m)	Description	Mag Anomaly
C1	42.7855537	-80.0575999	577080.3	4737432.0	182.573	3.5	2.8	1.9	Point Source Reflector (Probable Boulder)	None
C2	42.7652180	-80.0617380	576767.0	4735170.0	43.195	5.6	1.9	1.1	Anthropogenic Contact	None
C3	42.7651281	-80.0617515	576766.0	4735160.0	36.283	2.1	1.5	1.2	Anthropogenic Contact	None
C4	42.7588859	-80.0582894	577057.0	4734470.0	156.178	2.1	1.7	0.7	Point Source Reflector (Probable Boulder)	None
C6	42.7837355	-80.0620888	576715.4	4737226.0	137.197	0.7	0.9	0.4	Point Source Reflector (Probable Boulder)	None
C7	42.7819782	-80.0629886	576644.0	4737030.0	170.583	4.3	0.3	0.1	Linear Contact	None
C8	42.7753290	-80.0647880	576505.0	4736290.0	162.788	5.3	0.3	0.2	Linear Contact	None
C9	42.7667188	-80.0638420	576593.0	4735334.7	3.462	4.3	3.1	0.5	Point Source Reflector (Probable Boulder)	None
C11	42.7595211	-80.0588664	577009.0	4734540.0	151.263	6.7	3.6	0.7	Point Source Reflector (Probable Boulder)	None
C12	42.7593412	-80.0588936	577007.0	4734520.0	165.090	3.9	2.9	0.7	Point Source Reflector (Probable Boulder)	None
C13	42.7524377	-80.0516907	577605.0	4733760.0	157.701	4.2	3.2	0.7	Point Source Reflector (Probable Boulder)	None
C14	42.7753008	-80.0613413	576787.0	4736290.0	110.475	15.9	14.6	0.5	Circular Contact (Probable Dredge Spoil)	None
C15	42.7749386	-80.0611023	576807.0	4736250.0	139.735	15.6	14.9	0.3	Circular Contact (Probable Dredge Spoil)	None
C18	42.7767398	-80.0611239	576803.0	4736450.0	94.439	15.6	14.8	0.5	Circular Contact (Probable Dredge Spoil)	None
C20	42.7720590	-80.0613658	576789.0	4735930.0	201.333	1.2	1.2	0.8	Point Source Reflector (Probable Boulder)	None
C21	42.7486539	-80.0515041	577625.0	4733340.0	411.226	17.0	15.6	0.0	Circular Contact (Probable Dredge Spoil)	None
C22	42.7532639	-80.0535967	577448.0	4733850.0	226.712	17.2	15.1	0.0	Circular Contact (Probable Dredge Spoil)	None
C24	42.7560047	-80.0583453	577056.0	4734150.0	352.919	17.9	15.7	0.5	Circular Contact (Probable Dredge Spoil)	None
C25	42.7572671	-80.0585462	577038.0	4734290.0	281.421	17.8	16.9	0.0	Circular Contact (Probable Dredge Spoil)	None
C26	42.7578115	-80.0590390	576997.0	4734350.0	277.095	16.7	16.6	0.0	Circular Contact (Probable Dredge Spoil)	None
C27	42.7649311	-80.0659949	576419.1	4735134.3	256.131	3.7	0.6	0.4	Linear Contact	None
C29	42.7739045	-80.0668020	576342.0	4736130.0	281.217	2.1	2.3	1.3	Point Source Reflector (Probable Boulder)	None
C30	42.7861283	-80.0639286	576562.0	4737490.0	337.452	2.0	1.6	1.6	Point Source Reflector (Probable Boulder)	None
C31	42.7825394	-80.0655475	576434.0	4737090.0	388.111	2.5	1.9	0.7	Anthropogenic Contact	None
C32	42.7895780	-80.0568105	577139.9	4737879.6	157.088	13.2	15.7	0.4	Circular Contact (Probable Dredge Spoil)	None
C33	42.7893979	-80.0568132	577139.9	4737859.6	160.842	17.9	18.1	0.7	Circular Contact (Probable Dredge Spoil)	None
C34	42.7837153	-80.0585122	577008.0	4737227.0	149.984	8.2	0.8	0.4	Linear Contact	None
C35	42.7838082	-80.0595739	576921.0	4737236.3	62.826	1.8	1.5	1.1	Point Source Reflector (Probable Boulder)	None

Sidescan Sonar Contacts										
Label	Latitude	Longitude	Easting (m)	Northing (m)	Offset (m)	Length (m)	Width (m)	Height (m)	Description	Mag Anomaly
C36	42.7632095	-80.0584073	577042.0	4734950.0	125.891	12.5	14.6	0.4	Circular Contact (Probable Dredge Spoil)	None
C37	42.7674763	-80.0595584	576942.5	4735422.8	335.558	2.7	1.7	1.0	Point Source Reflector (Probable Boulder)	None
C38	42.7700640	-80.0596724	576930.0	4735710.0	392.304	1.1	0.8	0.0	Buoy Mooring	None
C39	42.7726373	-80.0593594	576952.4	4735996.0	343.379	11.9	10.1	0.3	Circular Contact (Probable Dredge Spoil)	None
C40	42.7727325	-80.0590415	576978.3	4736006.9	365.787	15.2	16.1	0.2	Circular Contact (Probable Dredge Spoil)	None
C41	42.7784408	-80.0599002	576901.0	4736640.0	155.042	16.1	15.1	0.0	Circular Contact (Probable Dredge Spoil)	None
C42	42.7885030	-80.0570092	577125.0	4737760.0	164.876	6.7	0.0	0.0	Linear Contact	None
C43	42.7846401	-80.0581437	577037.0	4737330.0	159.136	1.7	1.6	0.7	Point Source Reflector (Probable Boulder)	None
C44	42.7876941	-80.0572048	577110.0	4737670.0	167.032	1.5	1.4	1.3	Point Source Reflector (Probable Boulder)	None
C45	42.7800055	-80.0640208	576562.0	4736810.0	209.839	15.9	1.0	0.4	Linear Contact	None
C46	42.7665804	-80.0631596	576649.0	4735320.0	39.289	11.1	11.9	0.0	Circular Contact (Probable Dredge Spoil)	None
C47	42.7663103	-80.0631637	576649.0	4735290.0	21.235	8.1	8.0	0.4	Circular Contact (Probable Dredge Spoil)	None
C48	42.7750314	-80.0614431	576779.0	4736260.0	110.133	9.3	10.2	0.3	Circular Contact (Probable Dredge Spoil)	None
C49	42.7758320	-80.0602331	576877.0	4736350.0	185.890	42.7	0.0	0.0	Circular Contact (Probable Dredge Spoil)	None
C50	42.7835303	-80.0593753	576937.6	4737205.6	84.878	2.6	1.9	0.8	Point Source Reflector (Probable Boulder)	None
C51	42.7851840	-80.0585878	577000.0	4737390.0	111.533	1.8	1.5	1.1	Point Source Reflector (Probable Boulder)	None
C52	42.7857245	-80.0586041	576998.0	4737450.0	98.309	1.6	2.0	0.8	Point Source Reflector (Probable Boulder)	None
C53	42.7863538	-80.0584723	577008.0	4737520.0	94.994	1.8	1.6	0.9	Point Source Reflector (Probable Boulder)	None
C54	42.7899128	-80.0576171	577073.5	4737916.0	85.040	11.2	12.9	0.5	Circular Contact (Probable Dredge Spoil)	None
C55	42.7894260	-80.0576233	577073.6	4737861.9	95.286	16.3	14.2	0.5	Circular Contact (Probable Dredge Spoil)	None
C56	42.7890467	-80.0574166	577091.0	4737820.0	120.220	14.0	14.9	0.3	Circular Contact (Probable Dredge Spoil)	None
C57	42.7888700	-80.0578350	577057.0	4737800.0	90.577	8.6	0.2	0.1	Linear Contact	None
C58	42.7882245	-80.0587439	576983.5	4737727.5	31.958	2.3	3.1	1.4	Point Source Reflector (Probable Boulder)	None
C59	42.7859038	-80.0585035	577006.0	4737470.0	102.414	2.7	2.2	1.0	Point Source Reflector (Probable Boulder)	None
C60	42.7891988	-80.0640087	576551.7	4737830.9	411.580	2.7	2.1	1.4	Point Source Reflector (Probable Boulder)	None
C62	42.7875584	-80.0638675	576565.2	4737648.9	364.091	1.2	1.5	1.2	Point Source Reflector (Probable Boulder)	None
C63	42.7889987	-80.0625404	576672.0	4737810.0	289.460	11.1	3.0	0.0	Anthropogenic Contact	None
C66	42.7855036	-80.0609602	576805.6	4737423.3	85.706	2.4	2.7	1.0	Point Source Reflector (Probable Boulder)	None

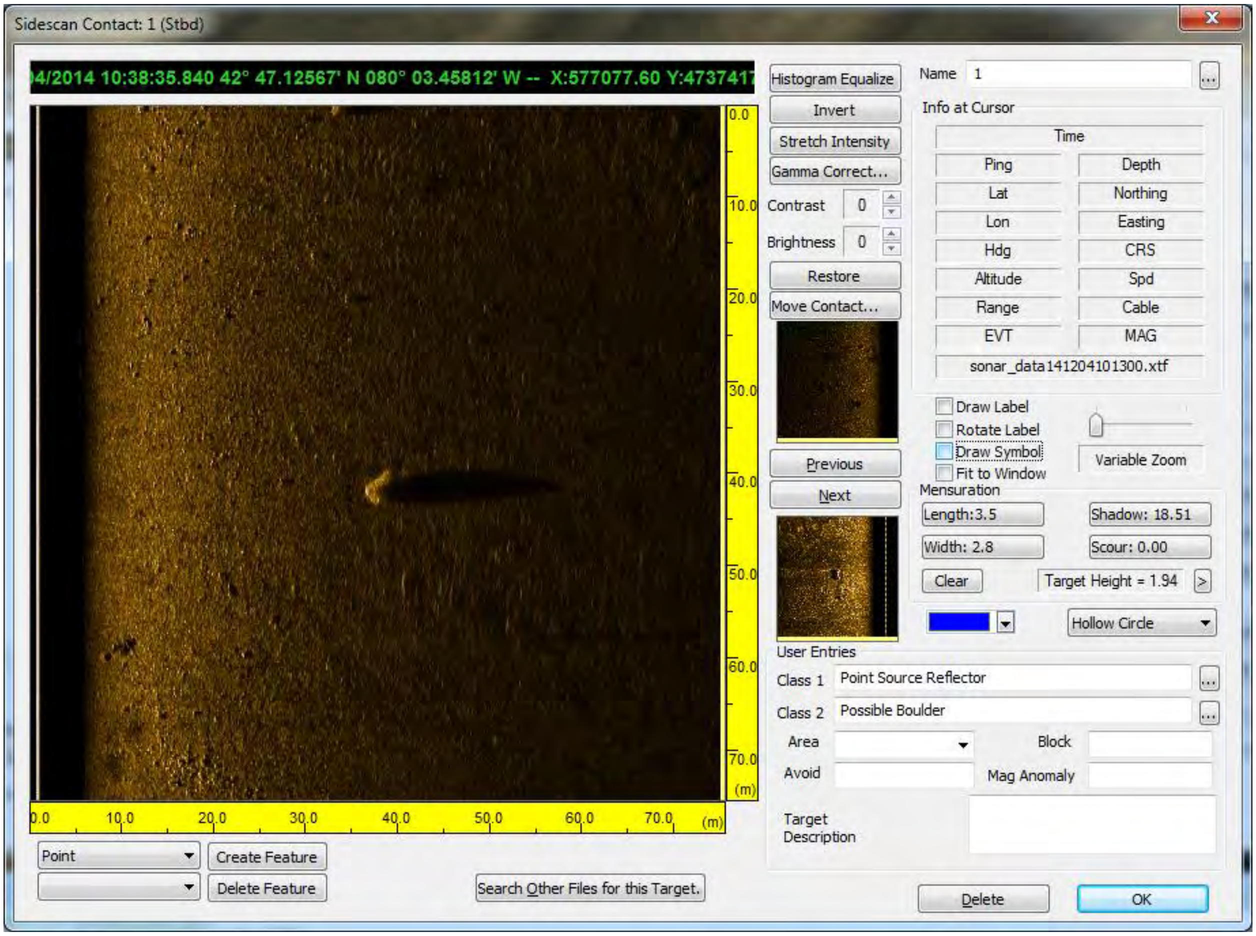
Sidescan Sonar Contacts										
Label	Latitude	Longitude	Easting (m)	Northing (m)	Offset (m)	Length (m)	Width (m)	Height (m)	Description	Mag Anomaly
C67	42.7382425	-80.0341316	579060.0	4732200.0	43.576	42.8	13.5	1.0	Circular Contact (Probable Dredge Spoil)	None
C68	42.7453506	-80.0441257	578233.0	4732980.0	142.045	43.6	13.0	0.0	Circular Contact (Probable Dredge Spoil)	None
C69	42.7612486	-80.0608813	576842.0	4734730.0	166.944	10.7	13.4	0.4	Circular Contact (Probable Dredge Spoil)	None
C70	42.7364542	-80.0356498	578938.0	4732000.0	174.637	20.6	20.1	0.0	Circular Contact (Probable Dredge Spoil)	None
C71	42.7247726	-80.0280015	579579.0	4730710.0	142.095	2.2	1.7	1.1	Point Source Reflector (Probable Boulder)	None
C72	42.7333016	-80.0355643	578949.0	4731650.0	371.241	21.1	18.8	0.3	Circular Contact (Probable Dredge Spoil)	None
C73	42.7569145	-80.0594802	576962.0	4734250.0	366.000	0.0	0.0	0.0	Circular Contact (Probable Dredge Spoil)	None
C75	42.7356642	-80.0380809	578740.0	4731910.0	386.698	21.6	17.6	0.3	Circular Contact (Probable Dredge Spoil)	None
C76	42.7453876	-80.0438923	578252.1	4732984.3	124.256	12.4	10.1	0.7	Circular Contact (Probable Dredge Spoil)	None
C77	42.7094772	-80.0296323	579465.0	4729010.0	218.258	19.9	17.7	0.0	Circular Contact (Probable Dredge Spoil)	None
C78	42.7080286	-80.0287268	579541.0	4728850.0	138.718	17.9	19.0	0.3	Circular Contact (Probable Dredge Spoil)	None
C79	42.6876492	-80.0361854	578956.0	4726580.0	348.502	3.0	1.5	0.9	Point Source Reflector (Probable Boulder)	None
C80	42.7184315	-80.0285157	579545.0	4730005.4	160.415	22.4	23.5	0.0	Circular Contact (Probable Dredge Spoil)	None
C81	42.7184339	-80.0287966	579522.0	4730005.4	183.410	18.1	17.2	0.0	Circular Contact (Probable Dredge Spoil)	None
C82	42.7314850	-80.0337235	579102.0	4731450.0	356.221	18.0	18.5	0.0	Circular Contact (Probable Dredge Spoil)	None
C83	42.7317573	-80.0339758	579081.0	4731480.0	356.858	19.1	18.9	0.0	Circular Contact (Probable Dredge Spoil)	None
C84	42.7312167	-80.0339475	579084.0	4731420.0	387.919	32.6	17.3	0.0	Circular Contact (Probable Dredge Spoil)	None
C85	42.7313987	-80.0341646	579066.0	4731440.0	391.659	16.5	17.2	0.0	Circular Contact (Probable Dredge Spoil)	None
C86	42.7321442	-80.0264938	579693.0	4731530.0	178.492	10.9	13.2	0.0	Circular Contact (Probable Dredge Spoil)	None
C87	42.7133197	-80.0258300	579771.5	4729440.3	78.555	18.6	17.3	0.0	Circular Contact (Probable Dredge Spoil)	None
C88	42.7353270	-80.0301333	579391.0	4731880.0	123.812	17.6	14.7	0.8	Circular Contact (Probable Dredge Spoil)	None
C89	42.7359640	-80.0309175	579326.0	4731950.0	109.062	13.5	14.7	0.0	Circular Contact (Probable Dredge Spoil)	None
C90	42.7364142	-80.0309104	579326.0	4732000.0	137.020	16.4	19.0	0.0	Circular Contact (Probable Dredge Spoil)	None
C91	42.7365056	-80.0310678	579313.0	4732010.0	131.832	16.3	16.4	0.0	Circular Contact (Probable Dredge Spoil)	None
C92	42.7366881	-80.0313460	579290.0	4732030.0	123.948	21.2	20.1	0.3	Circular Contact (Probable Dredge Spoil)	None
C93	42.7368696	-80.0315142	579276.0	4732050.0	124.597	17.3	19.3	0.0	Circular Contact (Probable Dredge Spoil)	None
C94	42.7363234	-80.0308263	579333.0	4731990.0	137.231	14.1	16.6	0.0	Circular Contact (Probable Dredge Spoil)	None
C95	42.7369620	-80.0317937	579253.0	4732060.0	112.353	14.7	15.5	0.0	Circular Contact (Probable Dredge Spoil)	None

Sidescan Sonar Contacts										
Label	Latitude	Longitude	Easting (m)	Northing (m)	Offset (m)	Length (m)	Width (m)	Height (m)	Description	Mag Anomaly
C96	42.7267283	-80.0250028	579822.0	4730930.0	117.016	16.6	16.7	0.0	Circular Contact (Probable Dredge Spoil)	None
C97	42.7267233	-80.0244166	579870.0	4730930.0	164.576	16.1	17.5	0.0	Circular Contact (Probable Dredge Spoil)	None
C98	42.7269962	-80.0247421	579843.0	4730960.0	141.877	18.4	17.4	0.0	Circular Contact (Probable Dredge Spoil)	None
C99	42.4749737	-79.9842818	583491.3	4703014.0	752.316	25.3	5.9	0.0	Shipwreck	None
C100	42.1046049	-80.3264075	555694.0	4661610.0	115.341	7.9	0.0	0.0	Anthropogenic Contact	None
C101	42.1156479	-80.3111123	556948.8	4662846.2	119.821	20.1	4.3	0.0	Anthropogenic Contact	None
C102	42.1401600	-80.2808635	559426.5	4665588.4	274.762	13.9	3.1	1.1	Point Source Reflector (Probable Boulder)	None
C103	42.1387761	-80.2844150	559134.3	4665432.3	366.818	12.7	0.8	0.0	Linear Contact	None
C104	42.1382679	-80.2846573	559114.7	4665375.7	339.922	4.7	1.3	0.0	Linear Contact	None
C108	42.0802641	-80.3644222	552571.0	4658883.3	280.134	7.2	4.8	0.8	Point Source Reflector (Probable Boulder)	None
C109	42.0568044	-80.3973095	549869.1	4656258.9	266.603	15.6	0.2	0.2	Linear Contact	None
C110	42.7172680	-80.0255239	579791.5	4729879.0	88.798	30.4	17.1	0.0	Rectangular Feature	None
C111	42.0283608	-80.4112983	548733.3	4653092.7	86.361	39.2	1.9	0.0	Linear Contact	None
C115	42.7450026	-80.0405382	578527.1	4732944.7	70.558	101.5	29.2	0.7	Circular Contact (Probable Dredge Spoil)	None
C116	42.7363032	-80.0336745	579099.9	4731985.1	54.863	51.0	29.5	0.7	Circular Contact (Probable Dredge Spoil)	None
C117	42.7424941	-80.0377803	578756.0	4732668.7	85.538	39.8	27.3	0.5	Circular Contact (Probable Dredge Spoil)	None
C118	42.7428601	-80.0383407	578709.6	4732708.8	72.967	23.7	30.4	0.7	Circular Contact (Probable Dredge Spoil)	None
C119	42.7421715	-80.0373321	578793.1	4732633.3	93.606	16.1	15.5	0.5	Circular Contact (Probable Dredge Spoil)	None
C120	42.7419397	-80.0368598	578832.0	4732608.0	109.275	30.6	24.0	0.5	Circular Contact (Probable Dredge Spoil)	None
C121	42.7416711	-80.0365547	578857.3	4732578.5	111.526	33.5	23.8	0.4	Circular Contact (Probable Dredge Spoil)	None
C122	42.7356957	-80.0304767	579362.4	4731920.6	122.830	14.3	16.8	0.4	Circular Contact (Probable Dredge Spoil)	None
C123	42.7417160	-80.0388656	578668.1	4732581.3	37.314	12.9	11.6	0.3	Circular Contact (Probable Dredge Spoil)	None
C124	42.7405707	-80.0378580	578752.0	4732455.1	46.995	20.6	19.1	0.4	Circular Contact (Probable Dredge Spoil)	None
C125	42.7394040	-80.0362996	578881.1	4732327.0	21.908	65.5	14.8	0.4	Circular Contact (Probable Dredge Spoil)	None
C126	42.7367763	-80.0320467	579232.5	4732039.1	83.426	28.8	18.0	0.9	Circular Contact (Probable Dredge Spoil)	None
C127	42.7295640	-80.0267528	579675.1	4731243.2	13.789	67.0	16.5	1.5	Circular Contact (Probable Dredge Spoil)	None
C128	42.7259084	-80.0261211	579731.5	4730837.9	14.905	66.5	15.8	1.0	Circular Contact (Probable Dredge Spoil)	None
C130	42.7250234	-80.0251625	579811.1	4730740.5	89.284	17.4	17.6	0.6	Circular Contact (Probable Dredge Spoil)	None

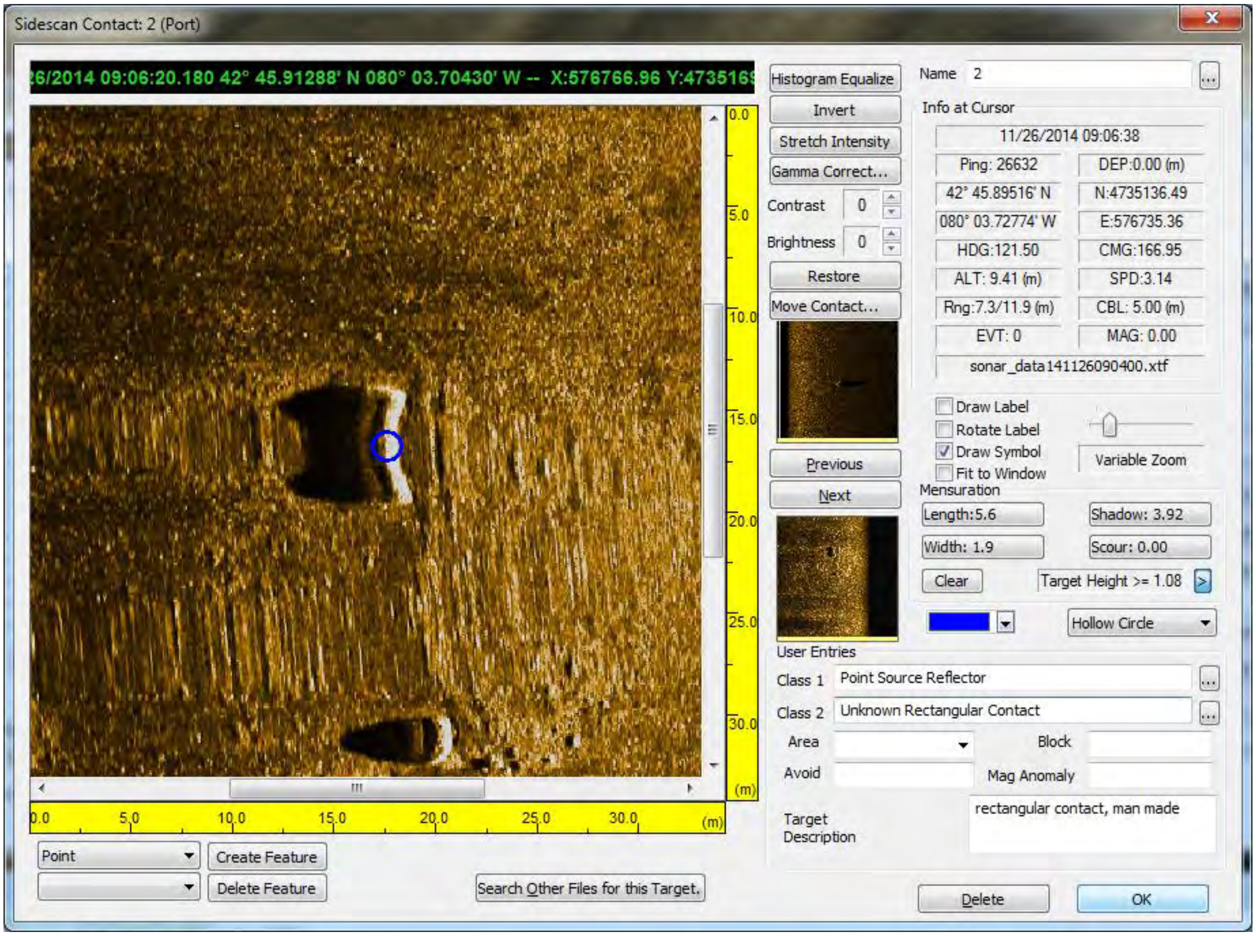
Sidescan Sonar Contacts										
Label	Latitude	Longitude	Easting (m)	Northing (m)	Offset (m)	Length (m)	Width (m)	Height (m)	Description	Mag Anomaly
C131	42.7244455	-80.0246800	579851.4	4730676.8	130.935	16.1	17.6	0.8	Circular Contact (Probable Dredge Spoil)	None
C134	42.7182316	-80.0249047	579840.9	4729986.6	135.854	8.0	9.3	0.2	Circular Contact (Probable Dredge Spoil)	None
C138	42.6014048	-79.9737642	584185.8	4717063.4	220.131	5.5	3.2	0.4	Point Source Reflector (Probable Boulder)	None
C139	42.6005392	-79.9711819	584398.8	4716969.8	228.250	5.0	6.6	0.6	Point Source Reflector (Probable Boulder)	None
C144	42.6039298	-79.9873052	583071.6	4717330.4	32.978	3.1	1.7	0.6	Linear Contact	None
C171	42.0319110	-80.4093881	548888.7	4653488.0	128.277	7.9	0.2	0.4	Linear Contact	None
C173	42.1112318	-80.3145737	556666.6	4662353.6	34.437	18.6	24.8	0.2	Point Source Reflector (Probable Boulder)	None
C174	42.1187878	-80.3037508	557554.5	4663199.8	99.604	9.8	7.0	0.2	Circular Contact (Probable Dredge Spoil)	None
C177	42.1397734	-80.2745321	559950.0	4665549.9	118.152	3.4	3.3	0.3	Point Source Reflector (Probable Boulder)	None
C179	42.1471096	-80.2657660	560667.4	4666370.7	180.935	3.8	2.0	1.2	Point Source Reflector (Probable Boulder)	None
C180	42.7916917	-80.0550525	577281.1	4738115.9	258.744	2.8	5.2	1.4	Rectangular Contact (Probable Water Intake)	M62
C181	42.7910459	-80.0530430	577446.2	4738046.0	431.780	17.1	12.2	2.9	Crib (Probable Water Intake)	None
C182	42.7913546	-80.0545764	577320.4	4738078.9	333.430	7.7	5.3	1.6	Point Source Reflector (Probable Boulder)	None
C183	42.7909923	-80.0542564	577347.0	4738038.9	336.060	8.5	9.0	1.3	Point Source Reflector (Probable Boulder)	None
C185	42.7928769	-80.0543038	577340.8	4738248.2	297.920	5.8	3.1	1.5	Point Source Reflector (Probable Boulder)	None
C186	42.7910445	-80.0635368	576588.0	4738036.3	415.450	10.3	0.4	0.6	Linear Contact	None
C187	42.7911060	-80.0642392	576530.5	4738042.5	472.270	2.5	2.5	1.0	Point Source Reflector (Probable Boulder)	None
C188	42.7912873	-80.0546221	577316.8	4738071.4	301.310	5.0	0.7	0.5	Linear Contact	None
C189	42.7964161	-80.0630642	576620.0	4738633.2	473.190	2.6	2.3	1.1	Point Source Reflector (Possible old Channel Marker)	M10, M9, M8
C190	42.7964620	-80.0631928	576609.4	4738638.2	486.010	3.0	2.2	0.8	Point Source Reflector (Possible old Channel Marker)	M10, M9, M8
C191	42.7952956	-80.0596908	576897.3	4738511.8	179.650	3.0	2.0	1.0	Point Source Reflector (Probable Boulder)	None
C192	42.7951007	-80.0588873	576963.2	4738490.9	110.740	2.5	2.5	1.2	Point Source Reflector (Probable Boulder)	None
C193	42.7949542	-80.0613383	576763.0	4738472.4	304.960	4.1	1.5	0.8	Point Source Reflector (Probable Boulder)	None
C194	42.7952706	-80.0623859	576676.9	4738506.6	396.820	5.8	1.9	0.8	Point Source Reflector (Probable Boulder)	None
C195	42.7935710	-80.0583030	577012.9	4738321.6	35.360	4.4	0.6	0.4	Linear Feature - Metal Debris	M33
C196	42.7935620	-80.0584200	577003.4	4738320.5	44.600	4.3	0.8	0.4	Linear Feature - Metal Debris	M36

Appendix IV – Sidescan Sonar Sonograms

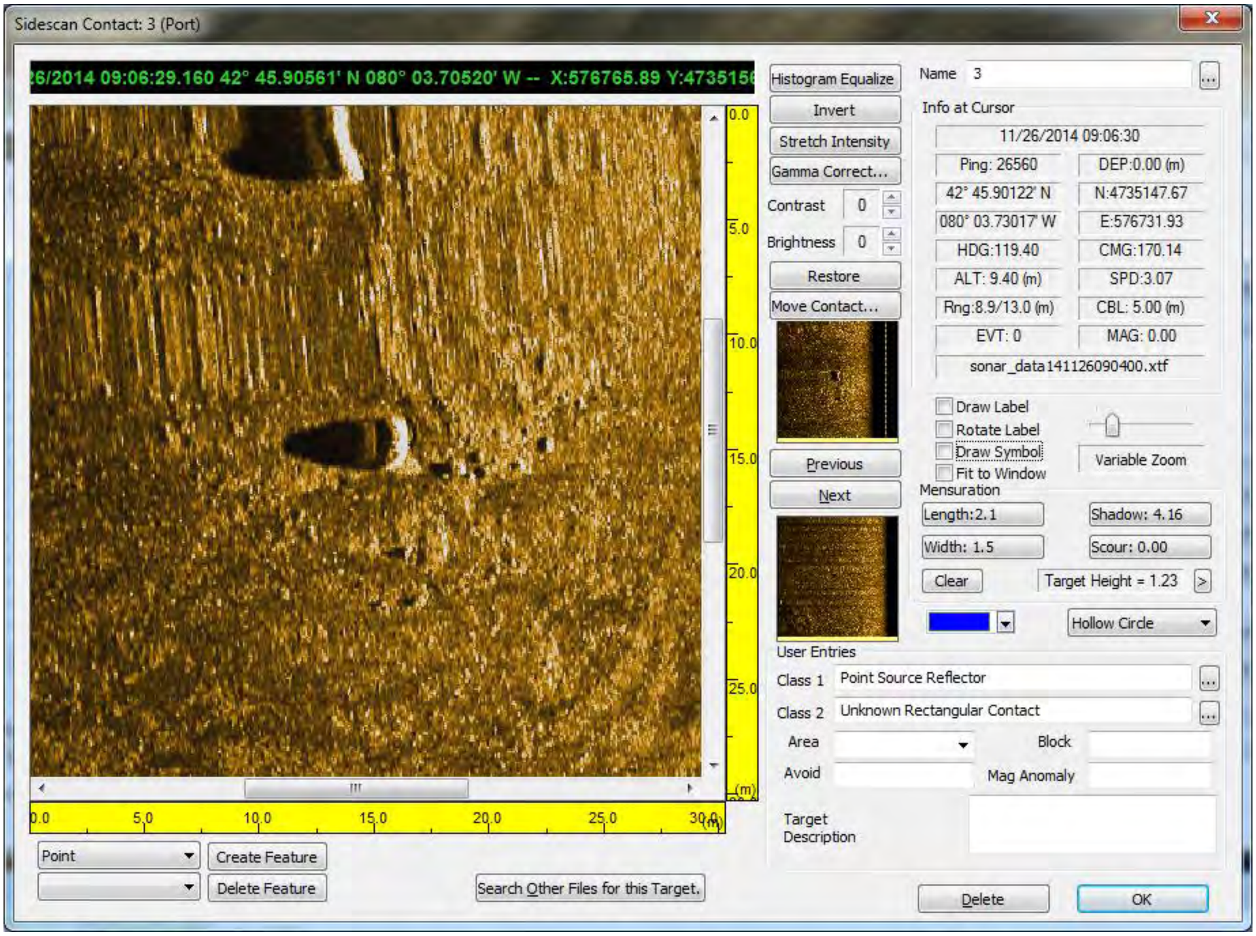
C1- Point Source Reflector (Probable Boulder)



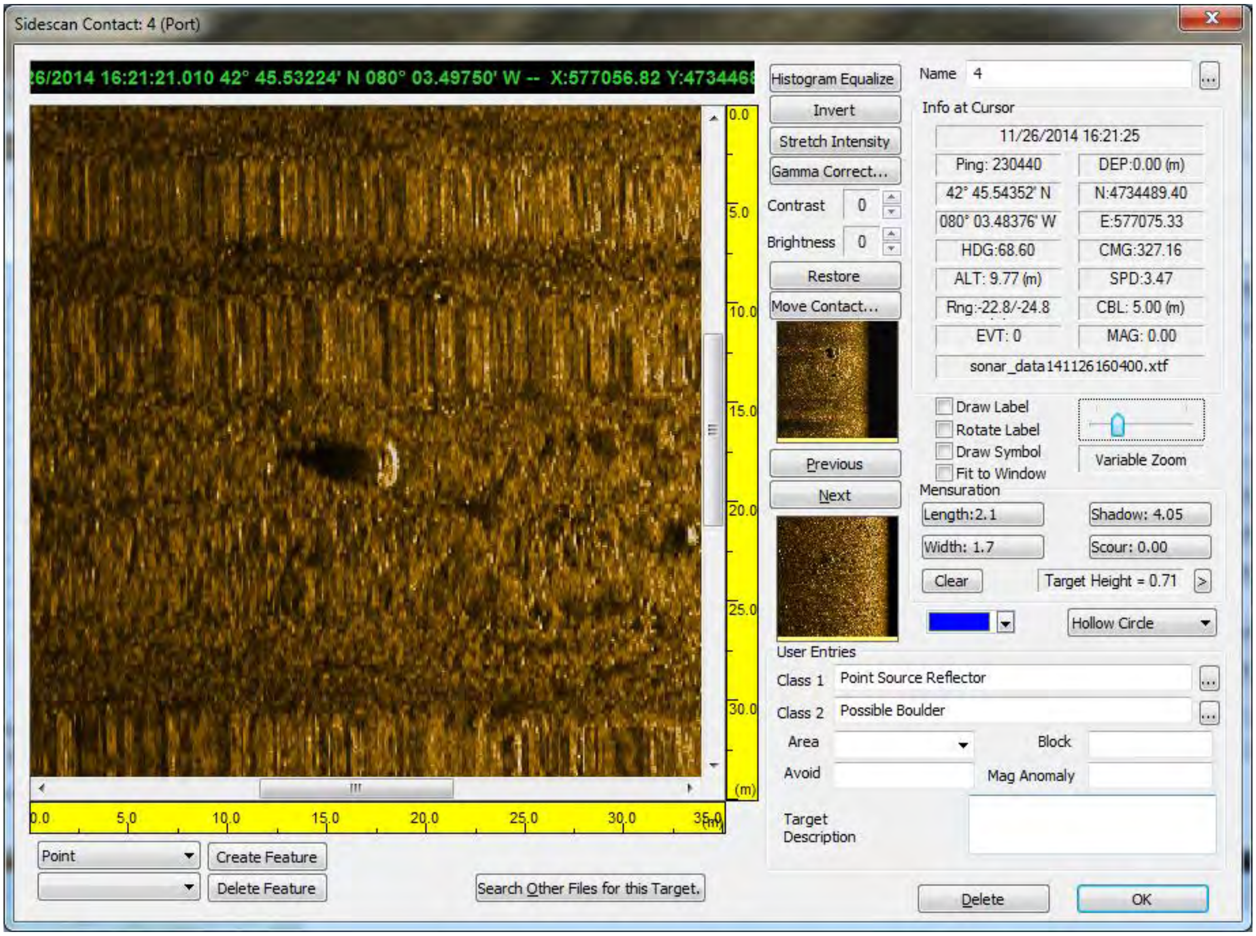
C2- Anthropogenic Contact



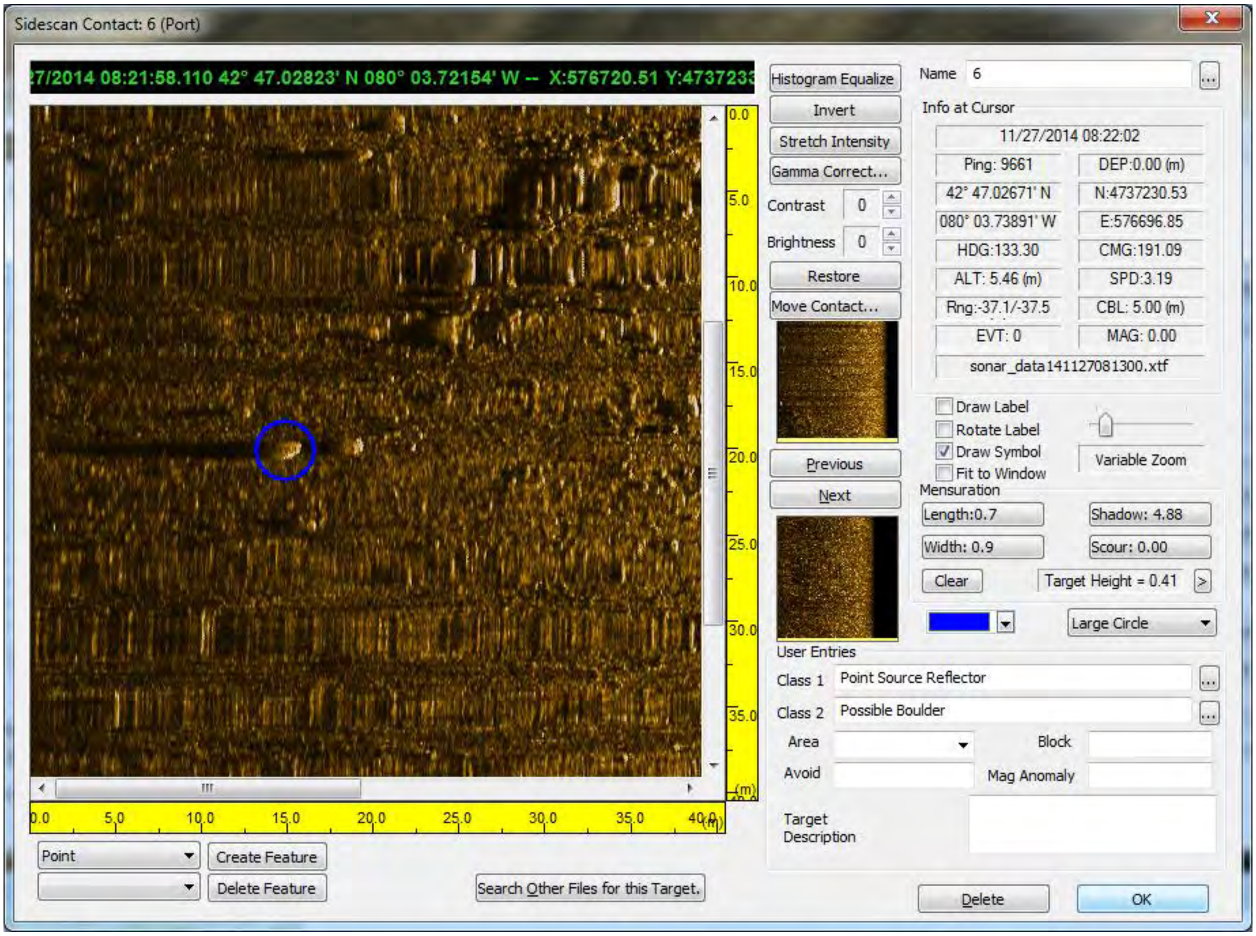
C3- Anthropogenic Contact



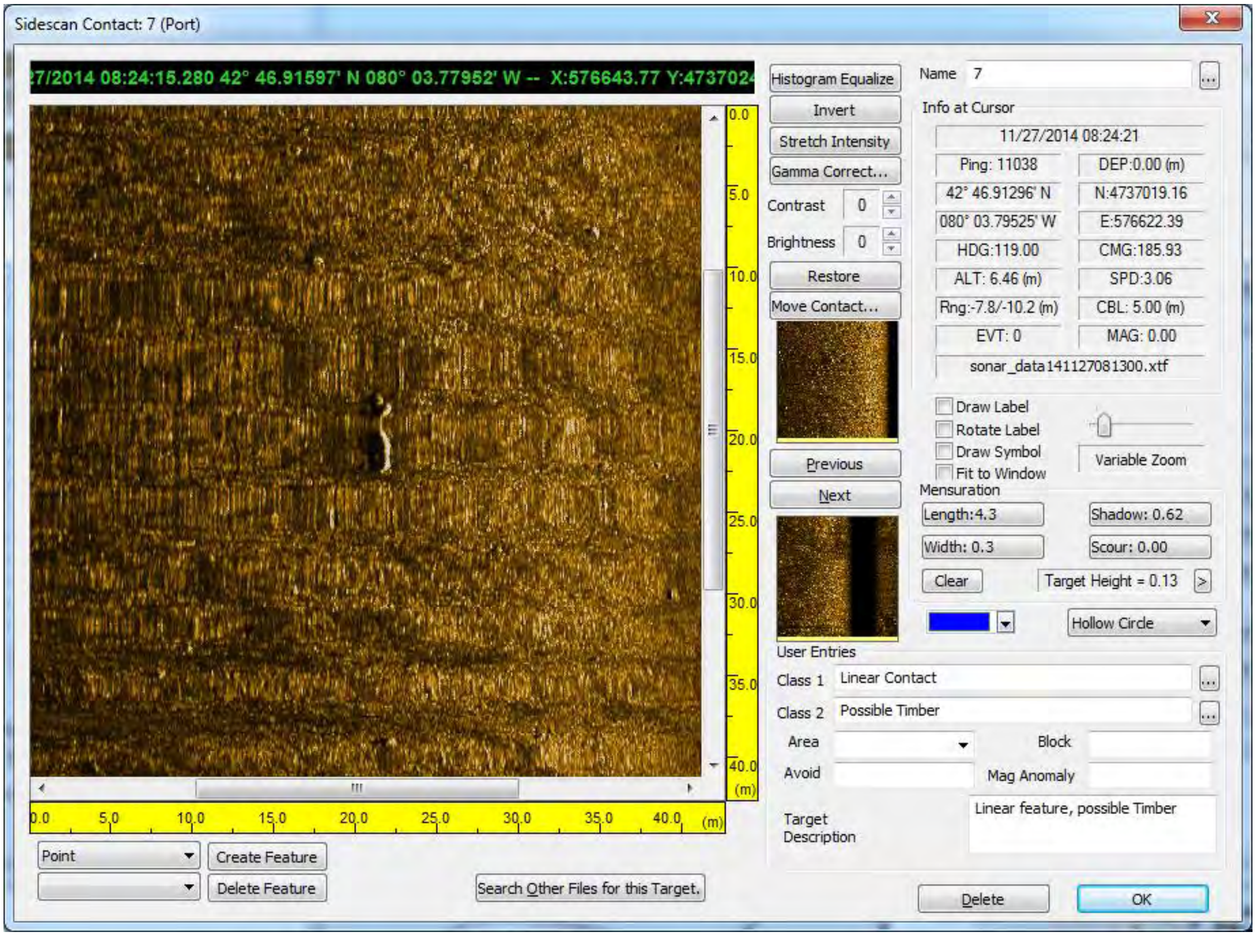
C4- Point Source Reflector (Probable Boulder)



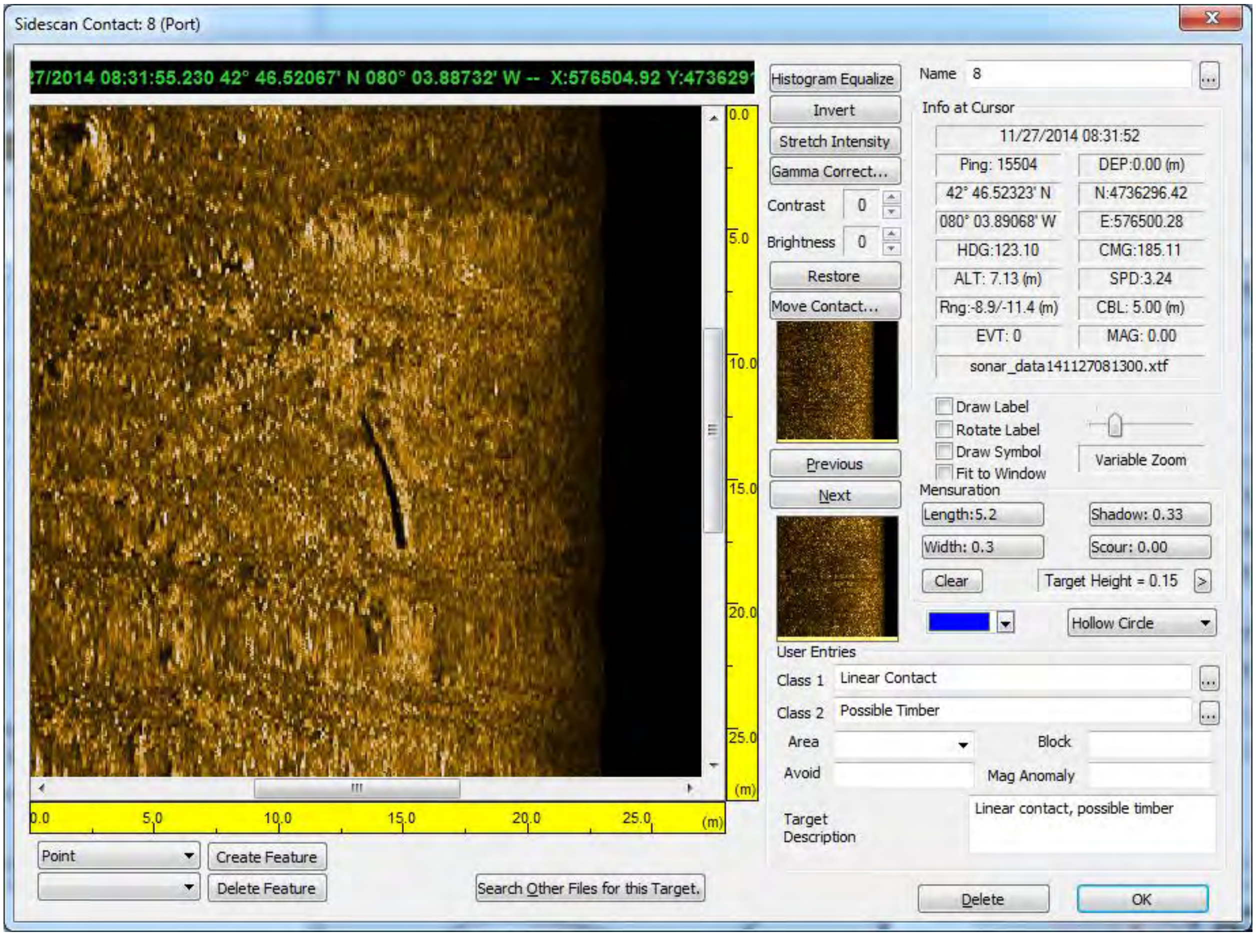
C6- Point Source Reflector (Probable Boulder)



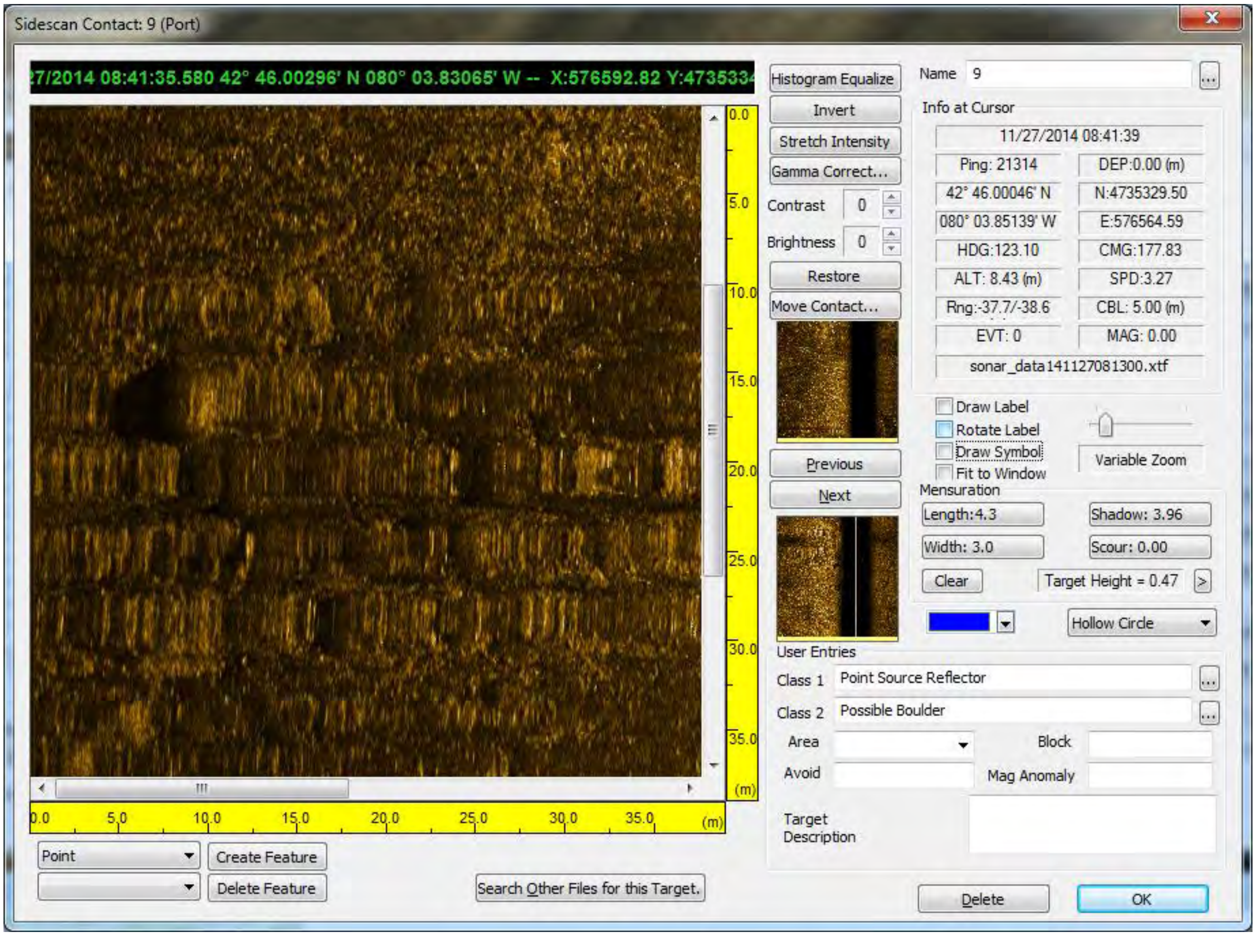
C7- Linear Contact



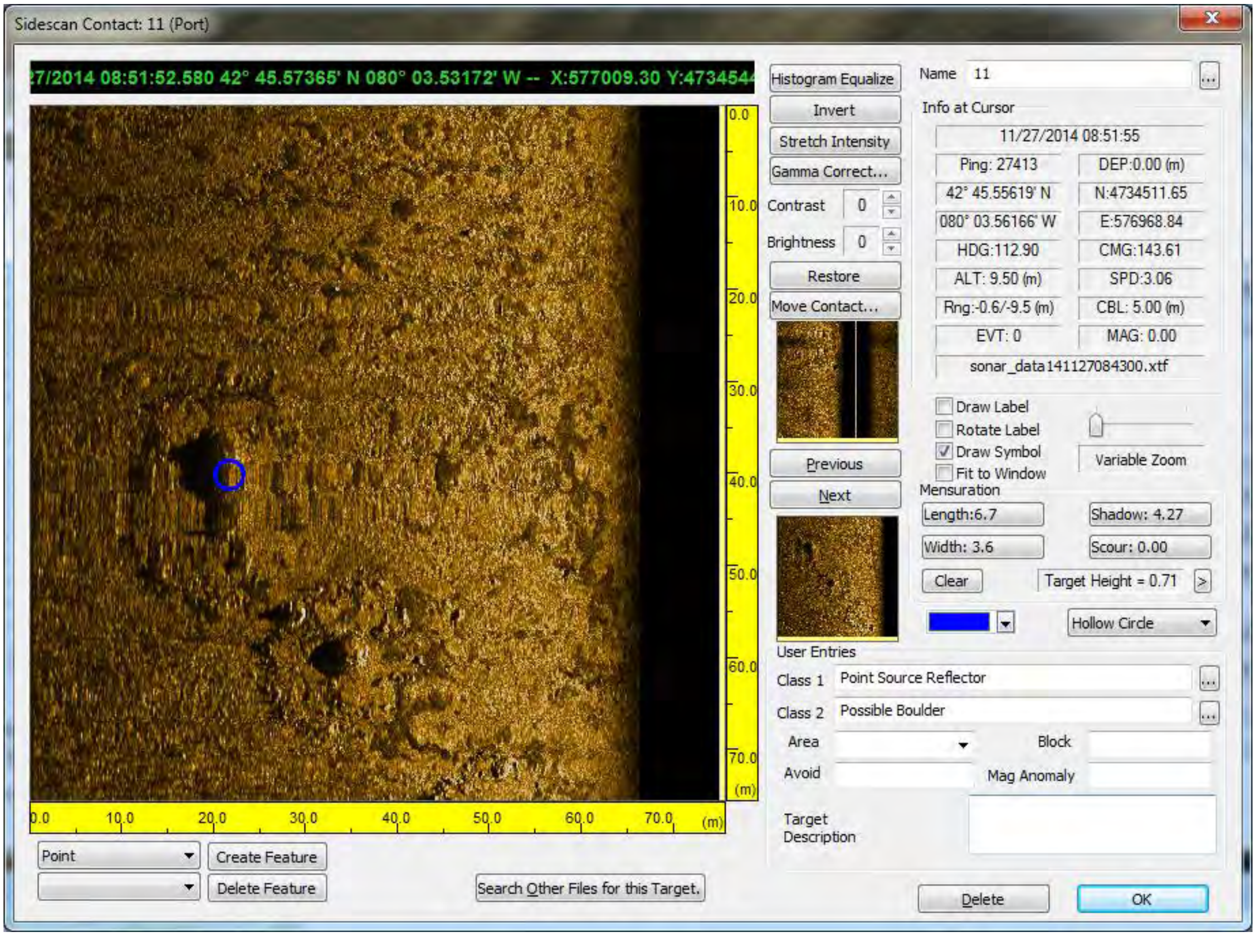
C8- Linear Contact



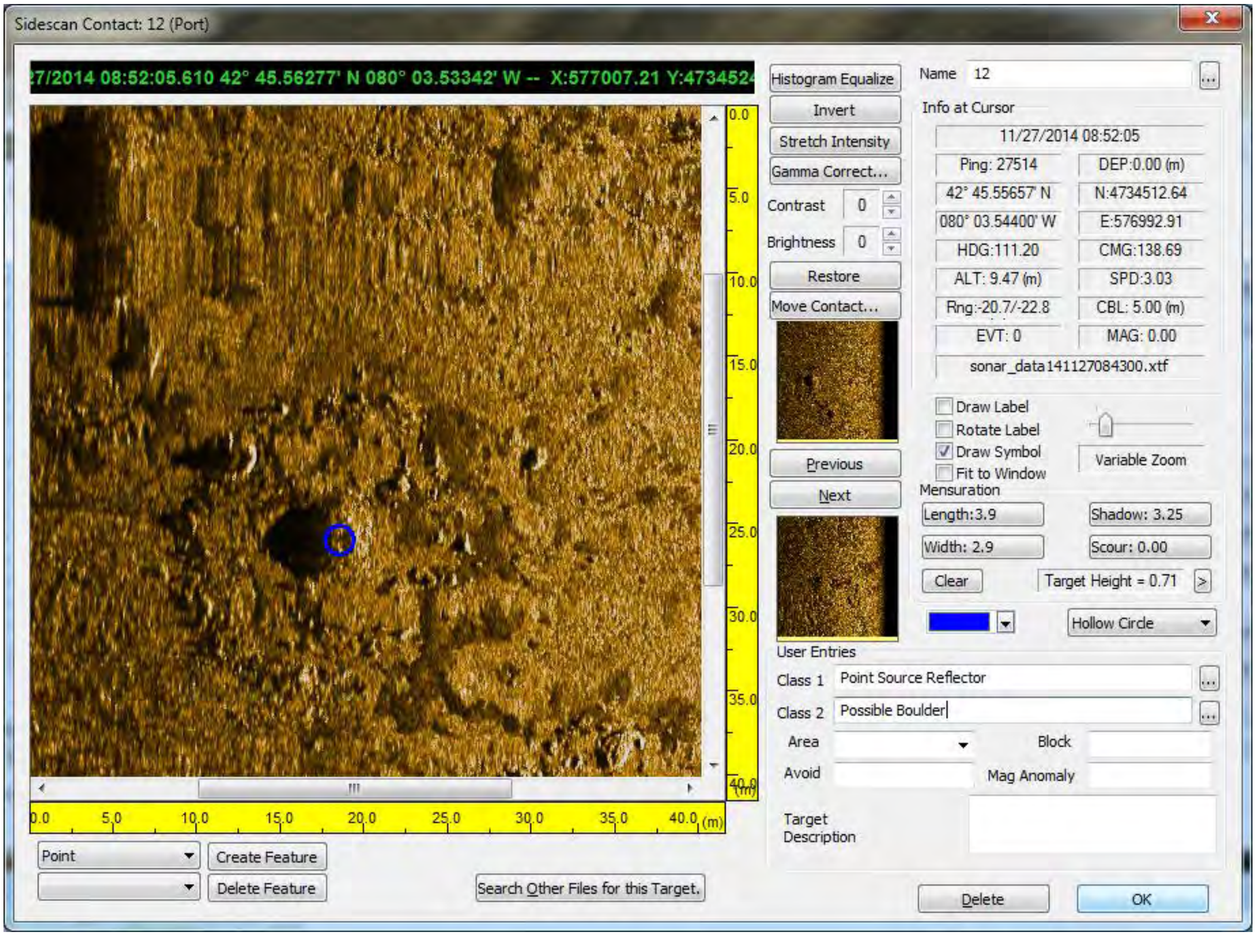
C9- Point Source Reflector (Probable Boulder)



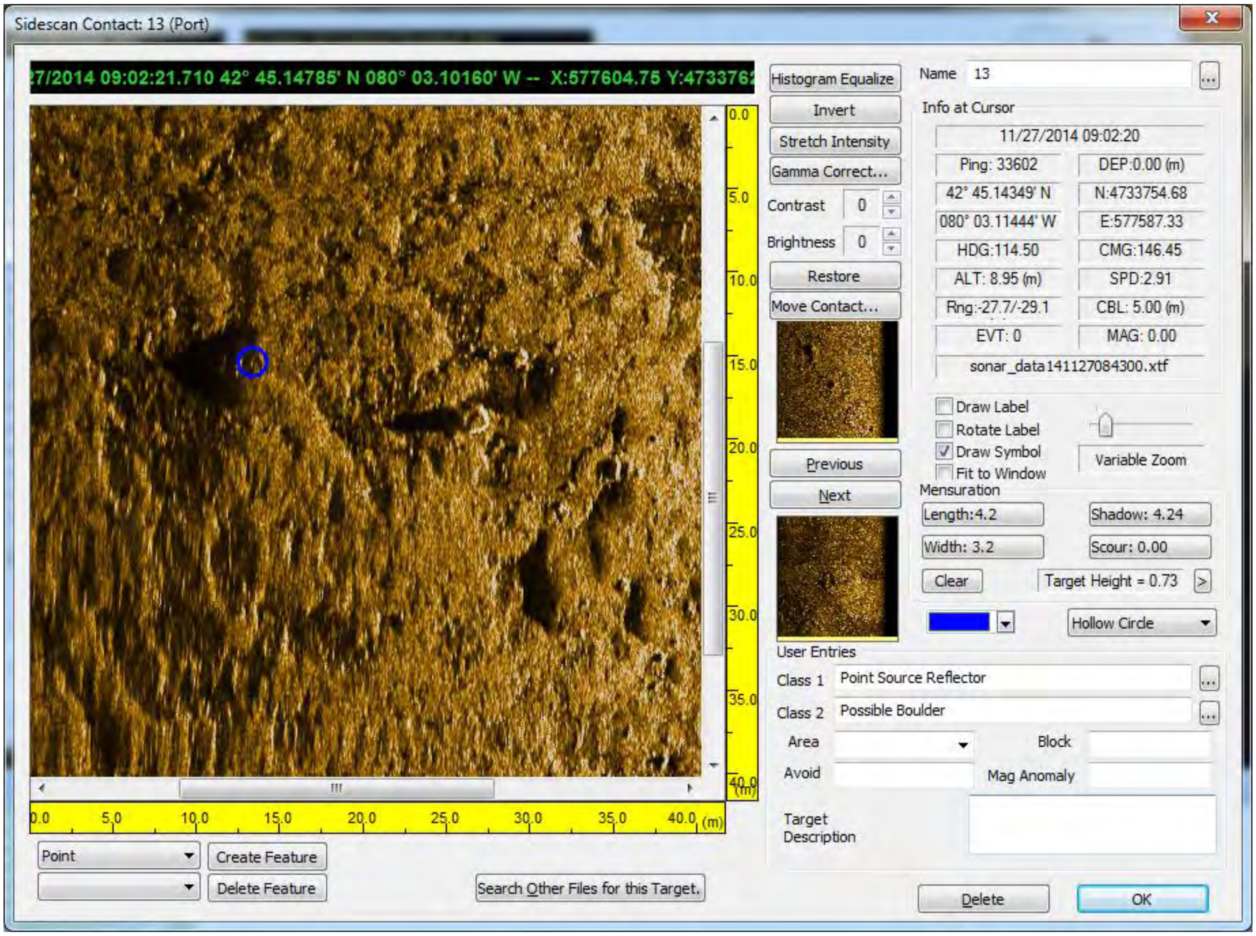
C11- Point Source Reflector (Probable Boulder)



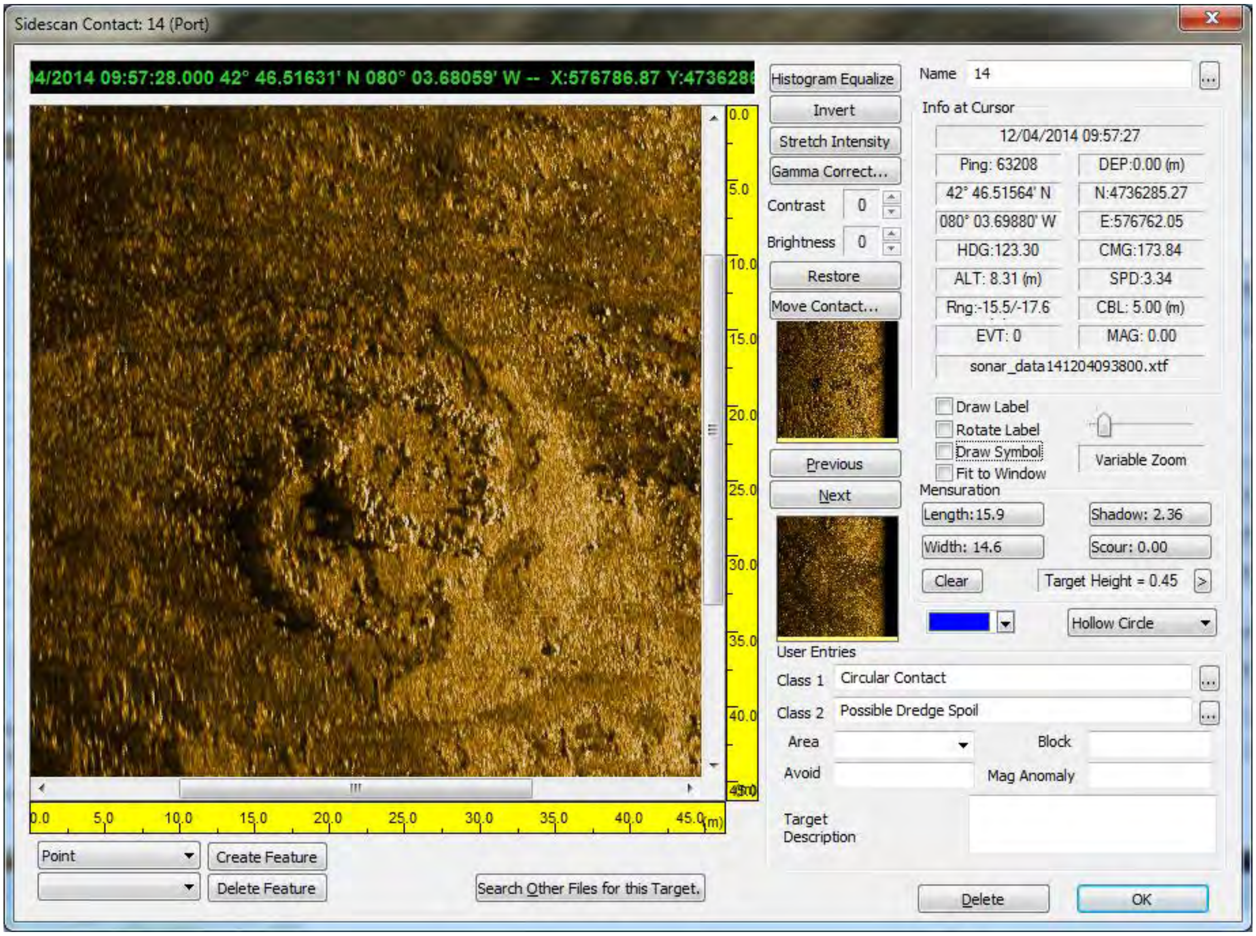
C12- Point Source Reflector (Probable Boulder)



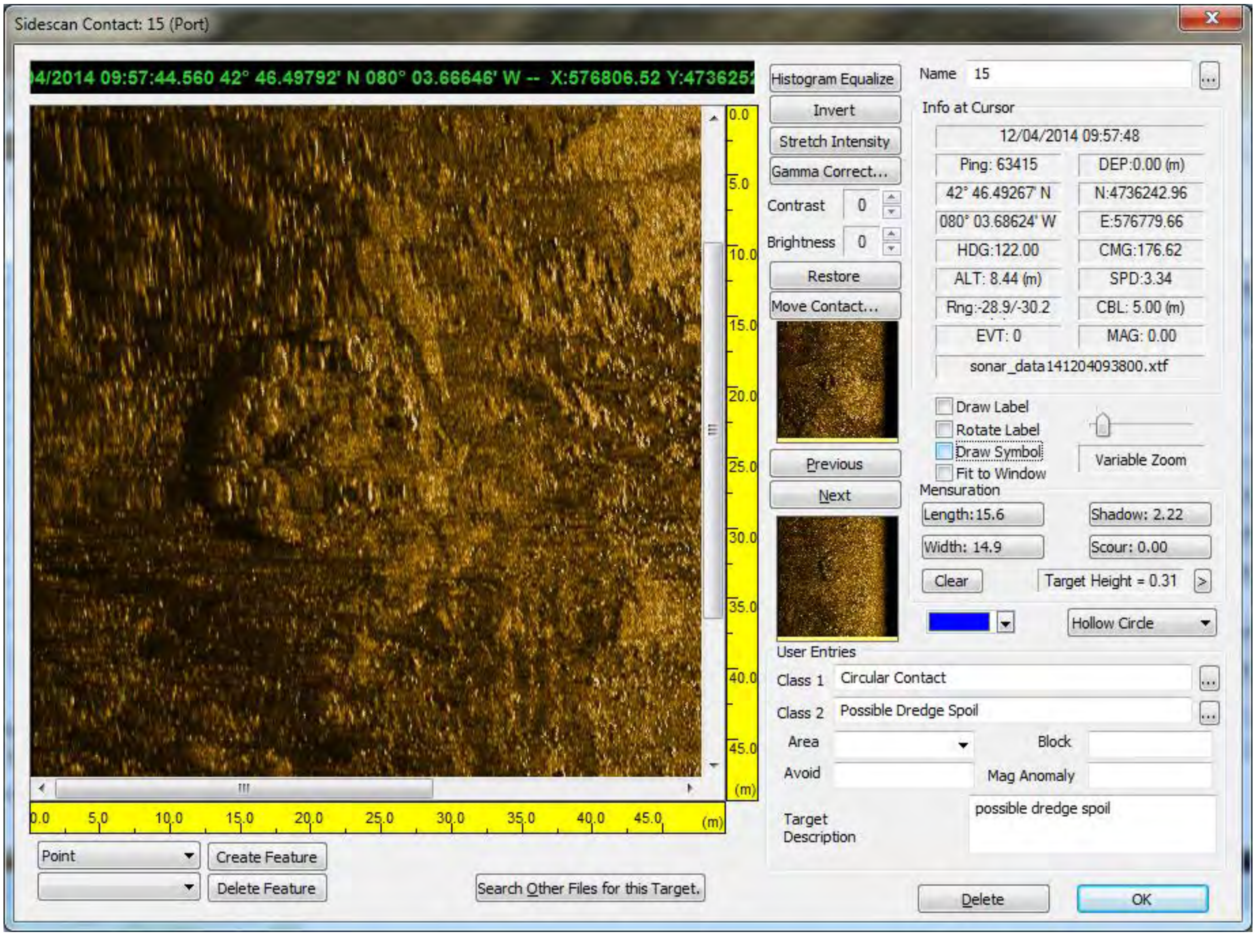
C13- Point Source Reflector (Probable Boulder)



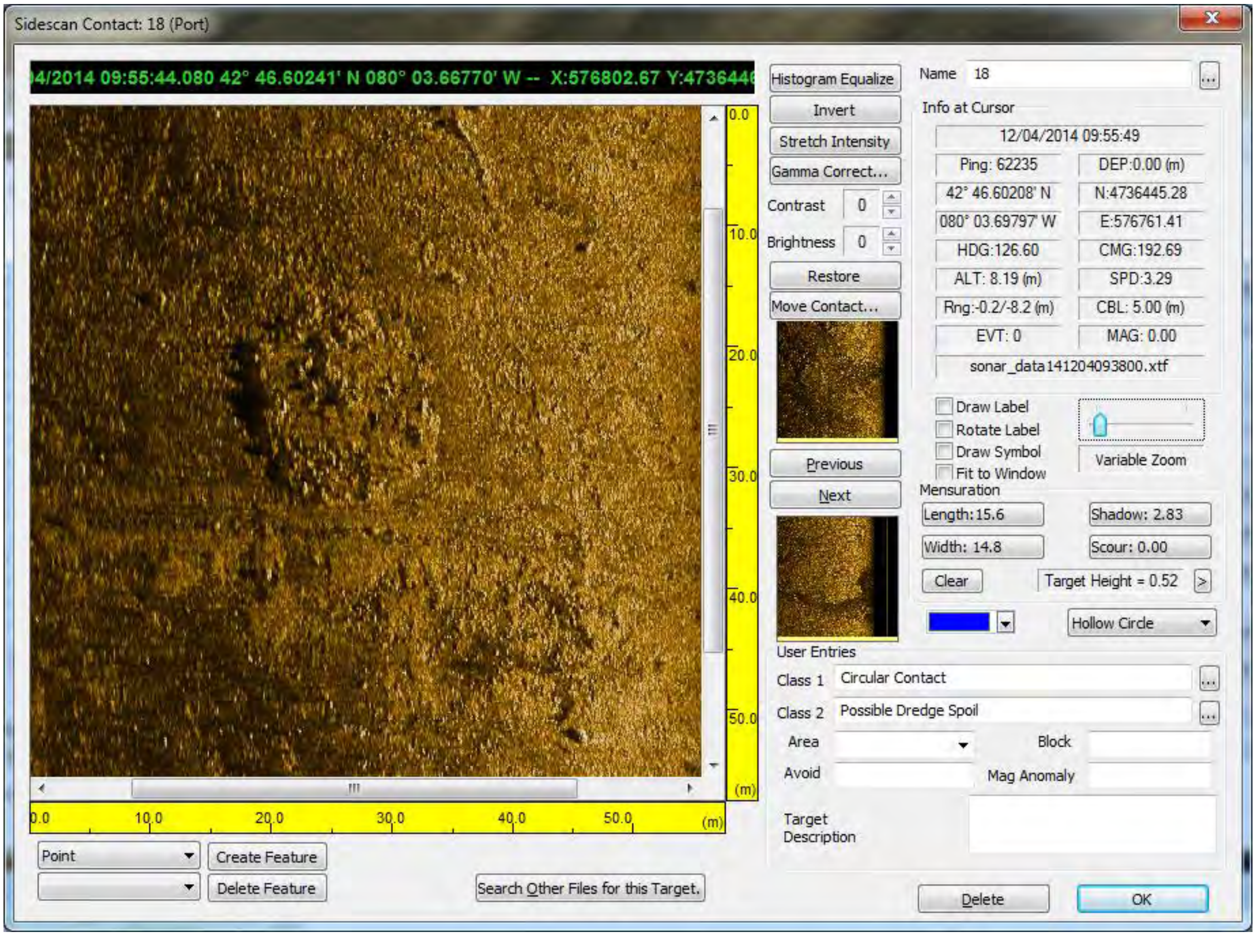
C14- Circular Contact (Probable Dredge Spoil)



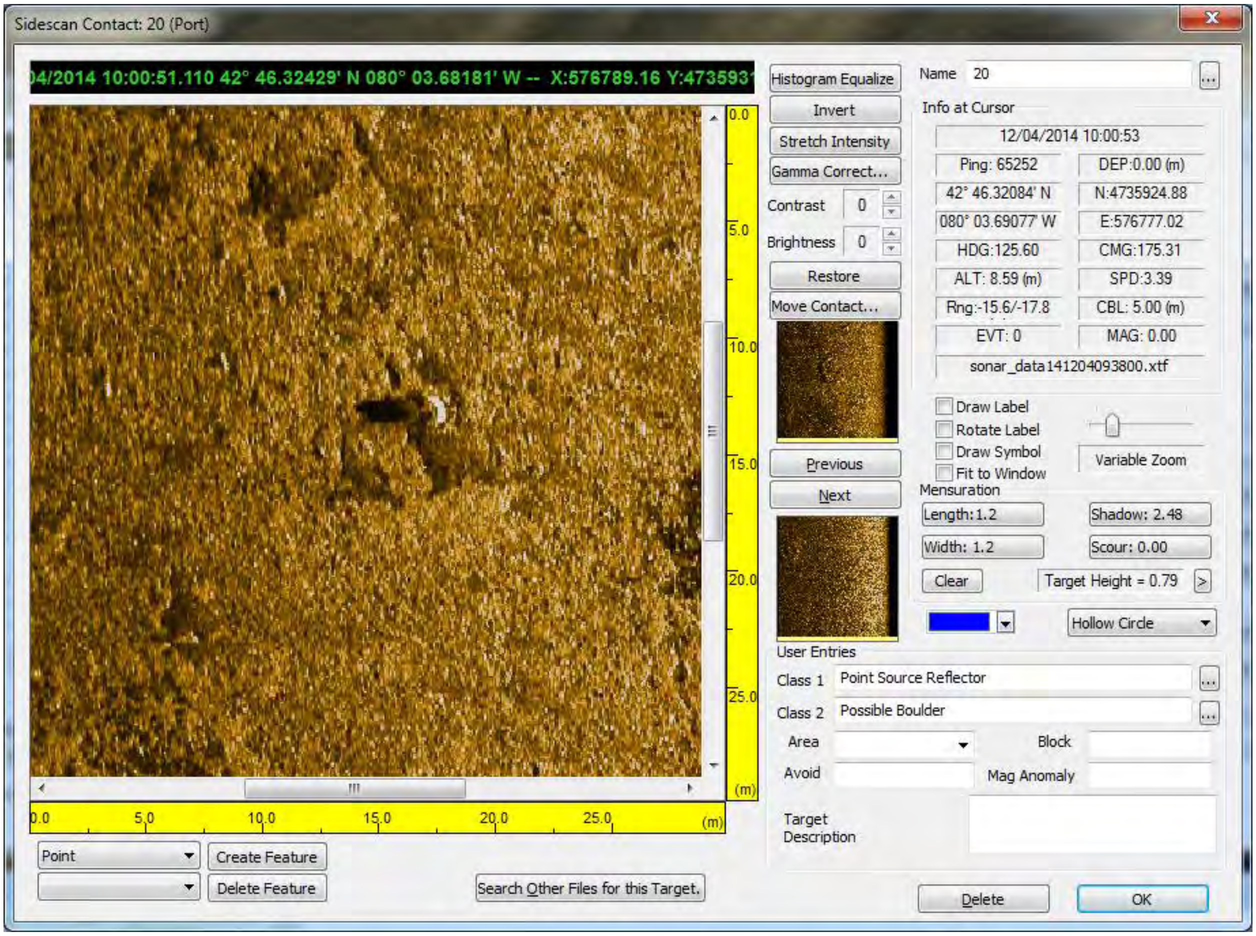
C15- Circular Contact (Probable Dredge Spoil)



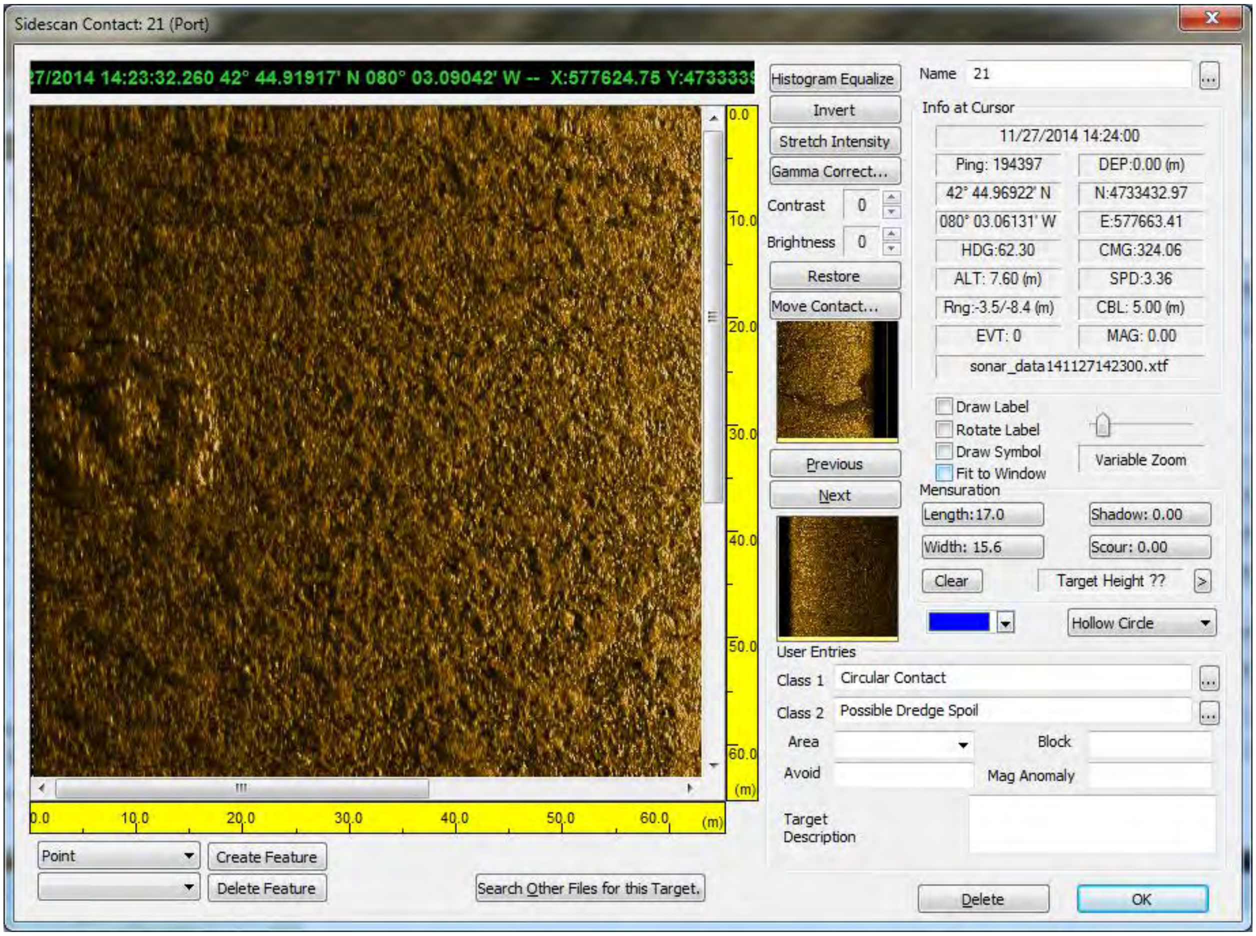
C18- Circular Contact (Probable Dredge Spoil)



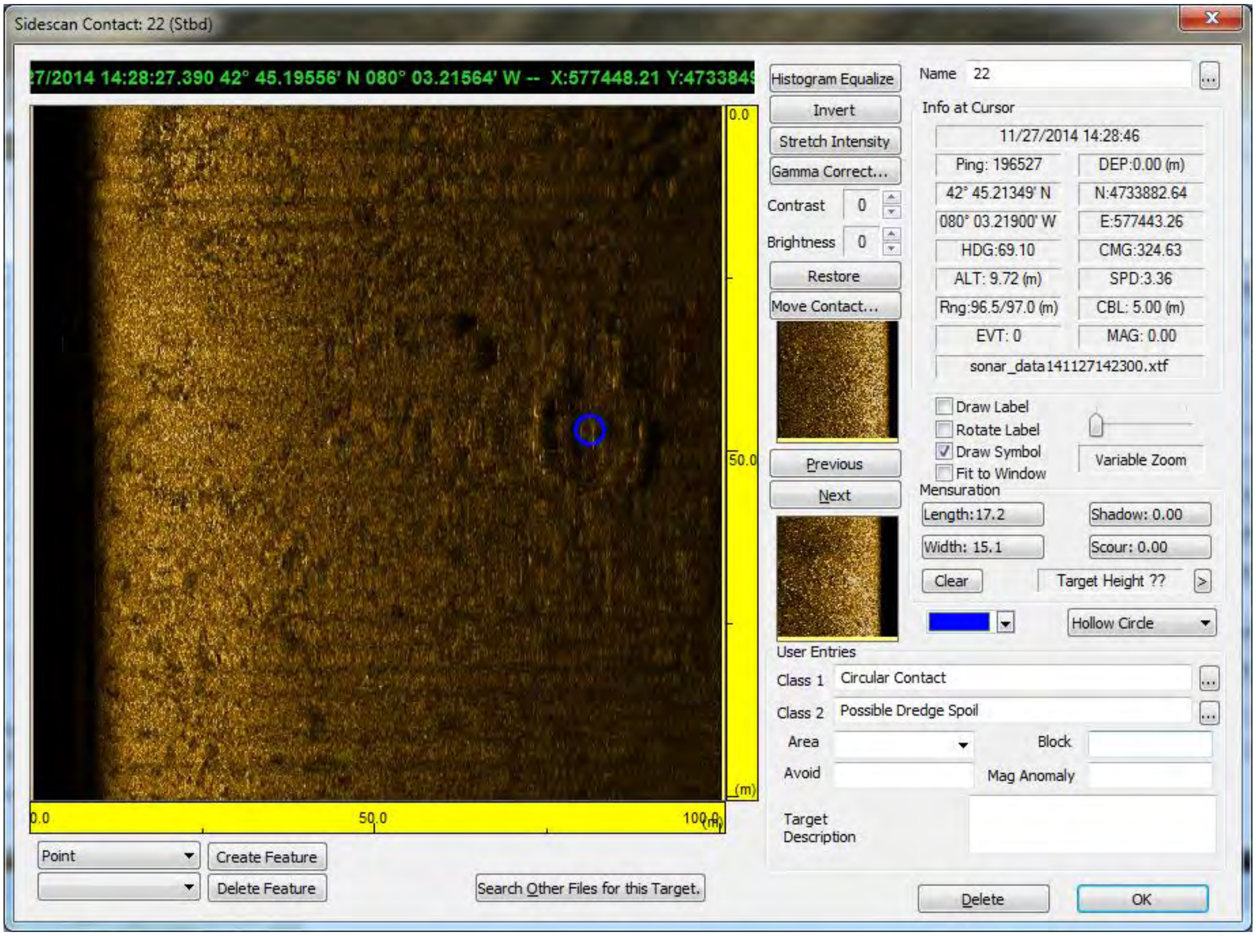
C20- Point Source Reflector (Probable Boulder)



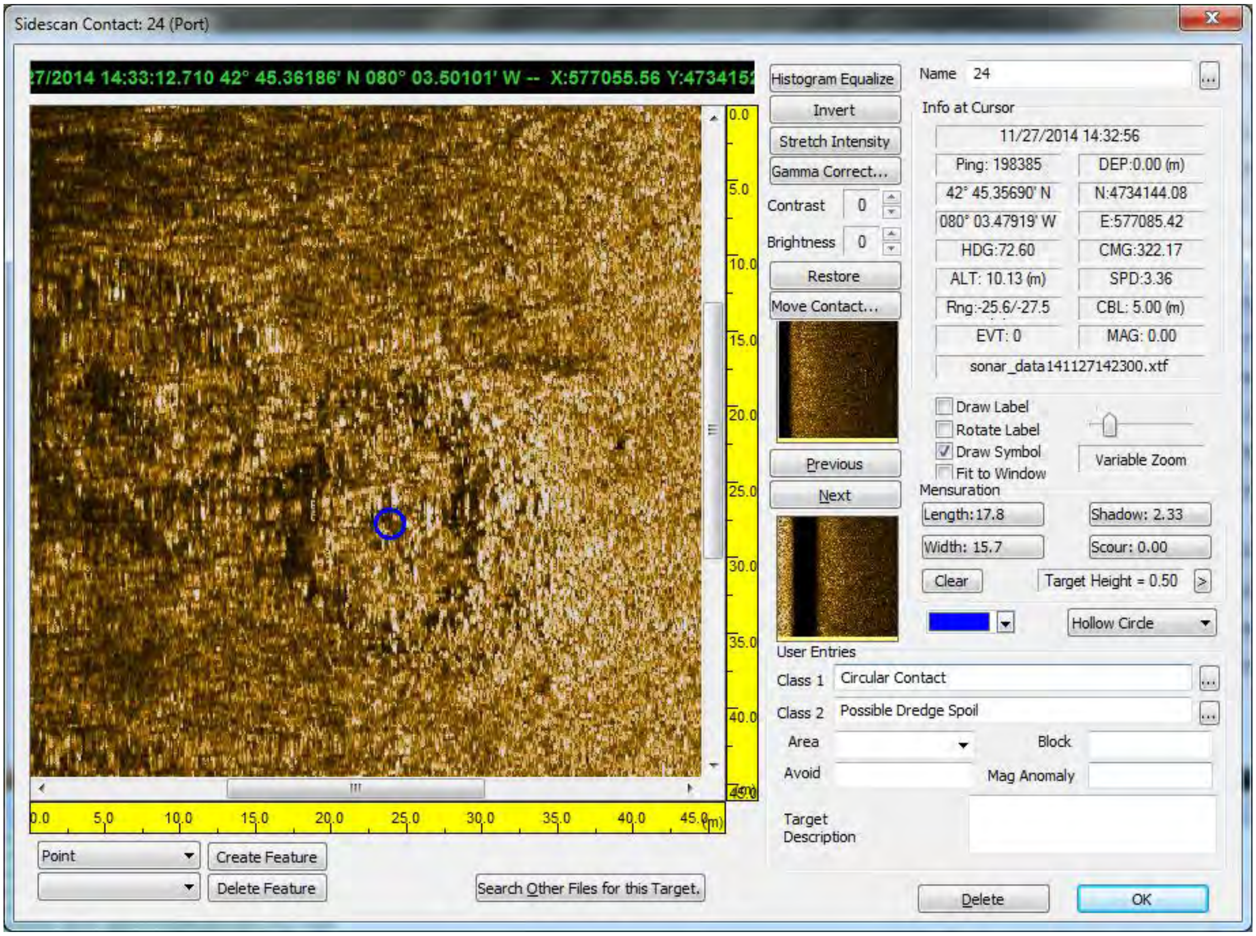
C21- Circular Contact (Probable Dredge Spoil)



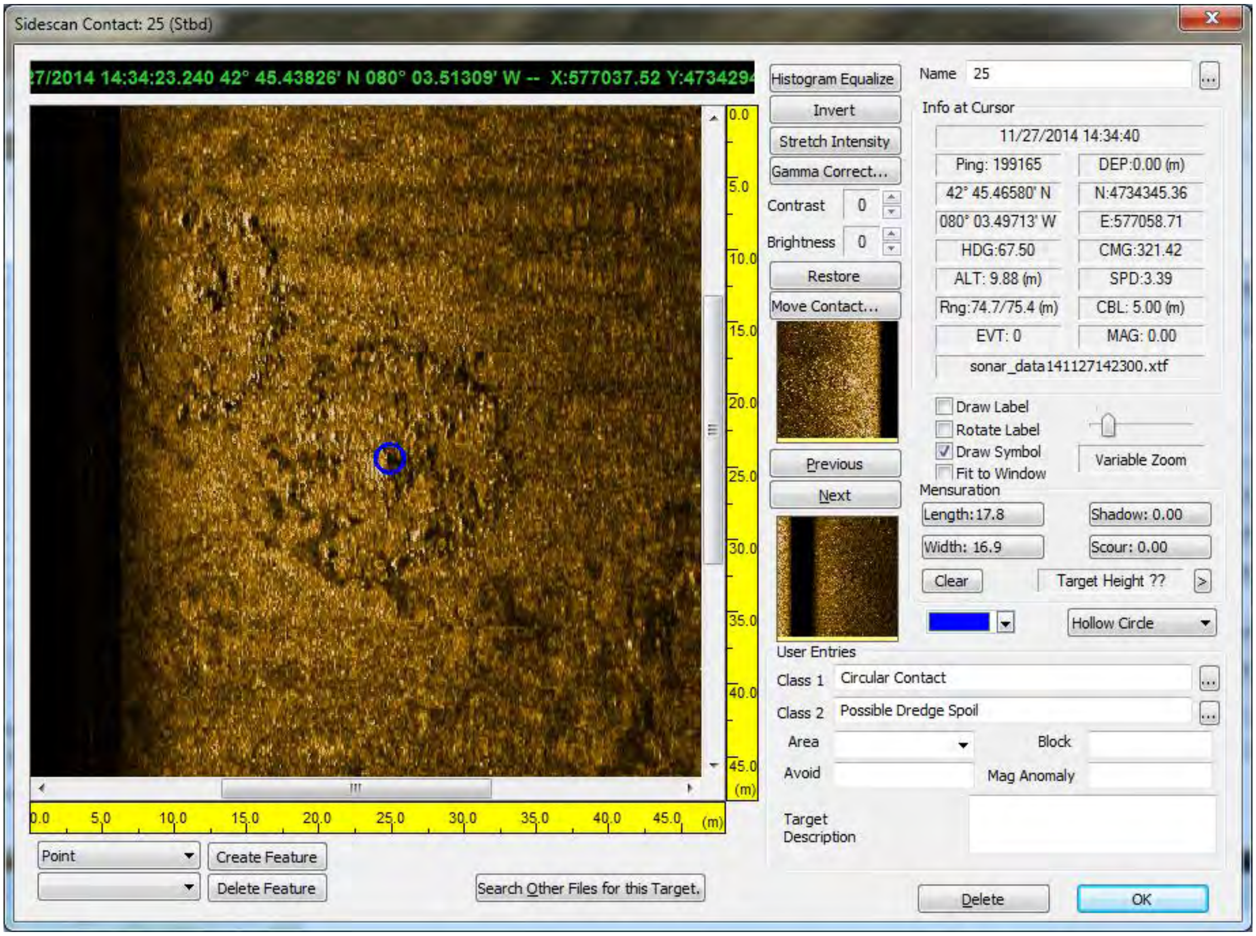
C22- Circular Contact (Probable Dredge Spoil)



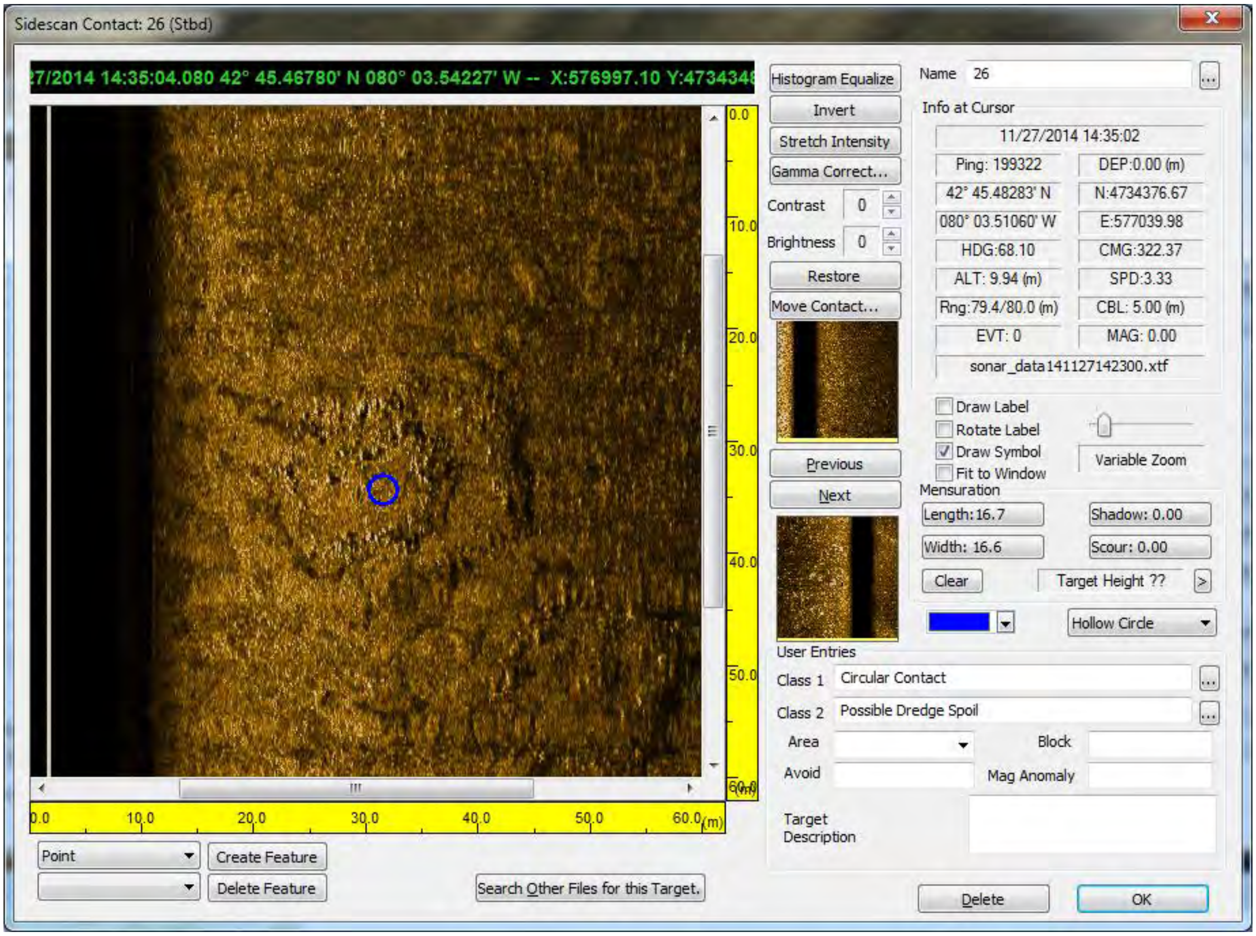
C24- Circular Contact (Probable Dredge Spoil)



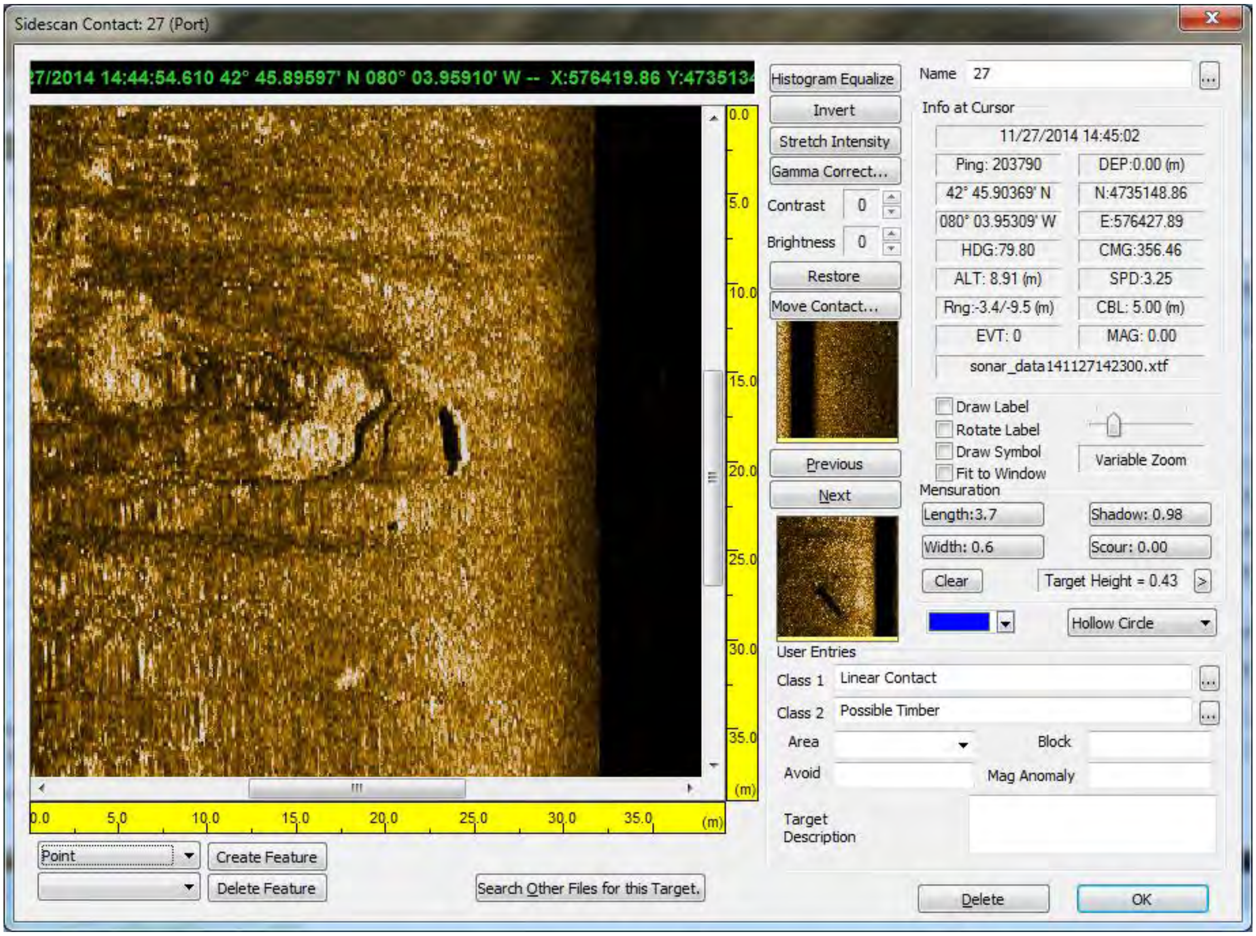
C25- Circular Contact (Probable Dredge Spoil)



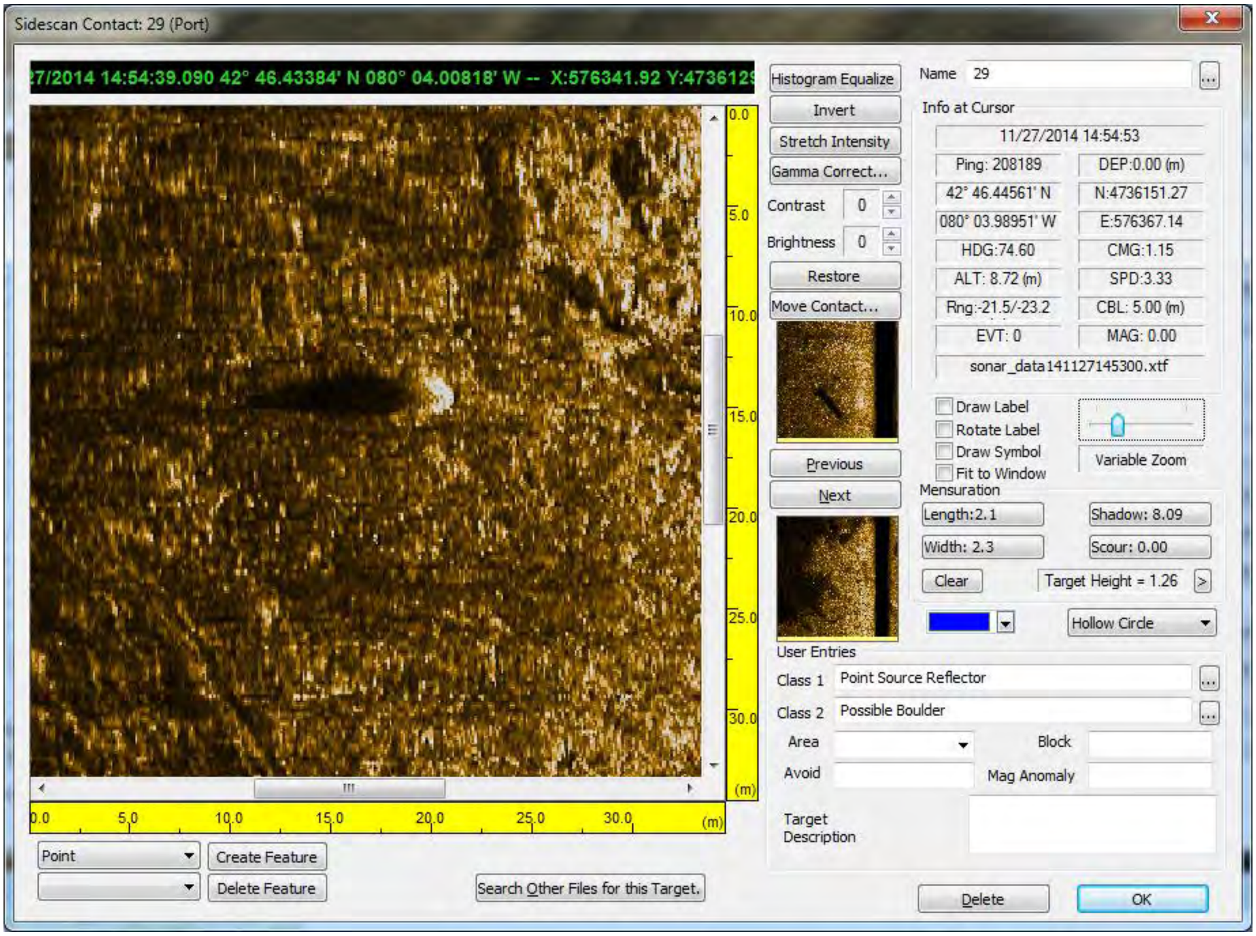
C26- Circular Contact (Probable Dredge Spoil)



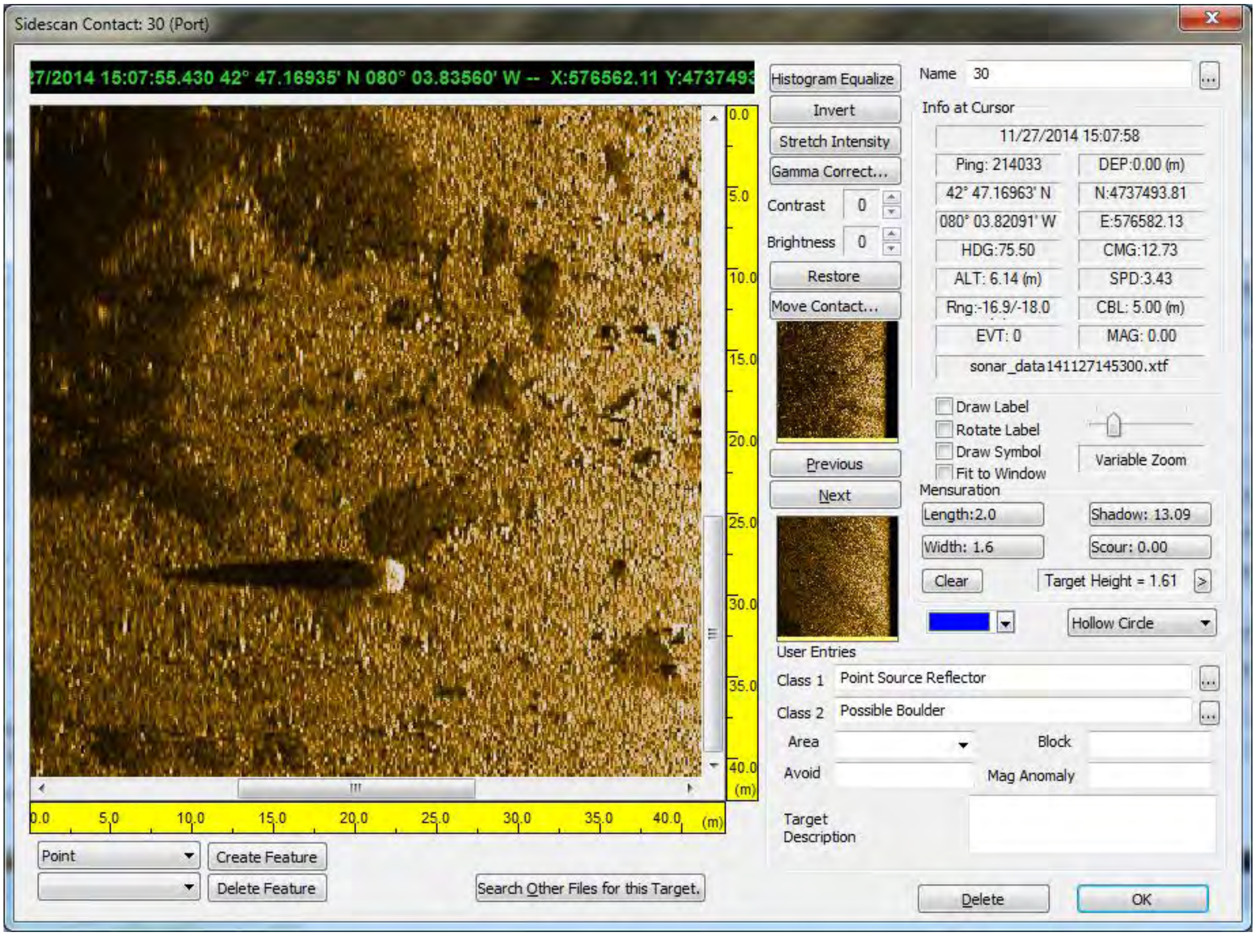
C27- Linear Contact



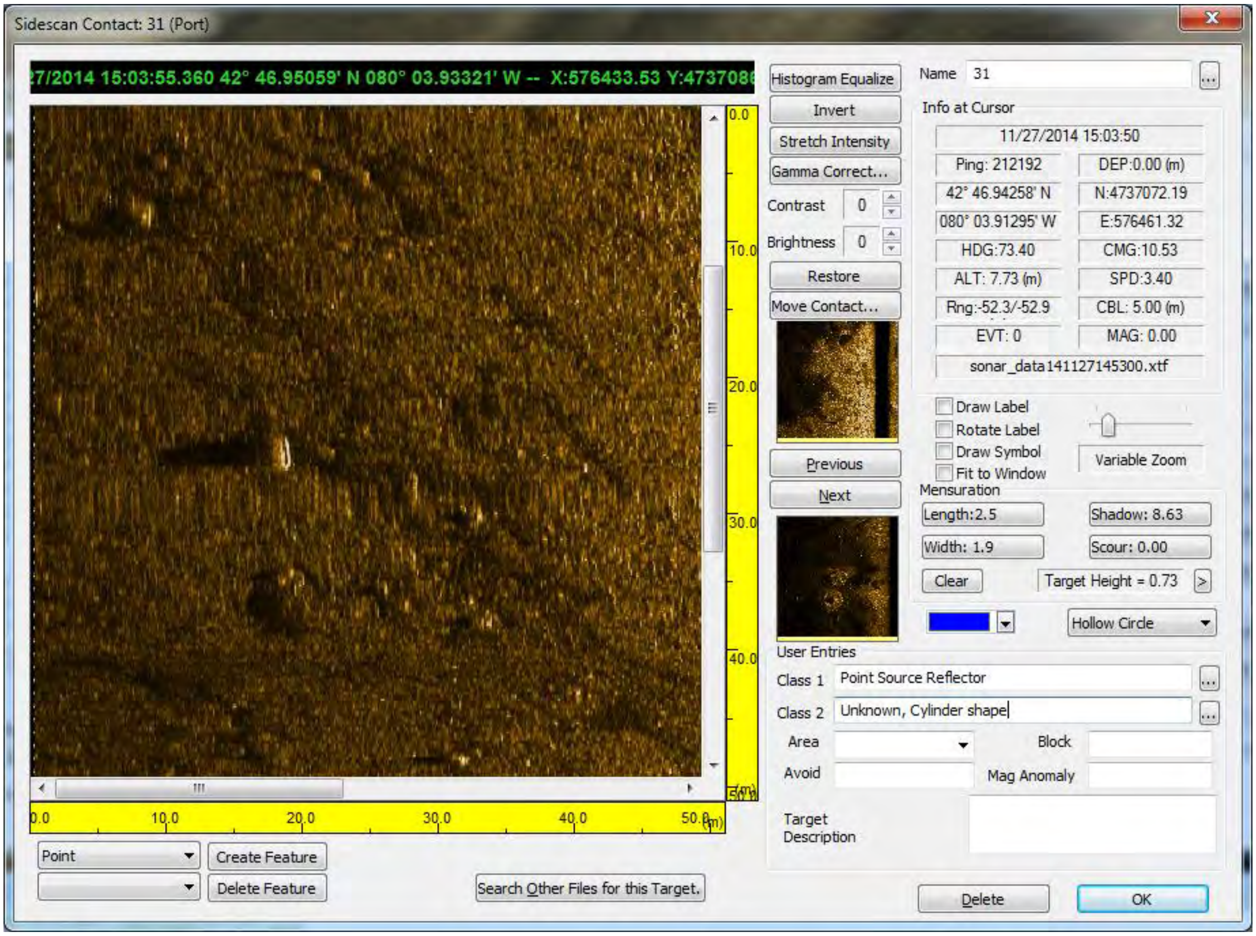
C29- Point Source Reflector (Probable Boulder)



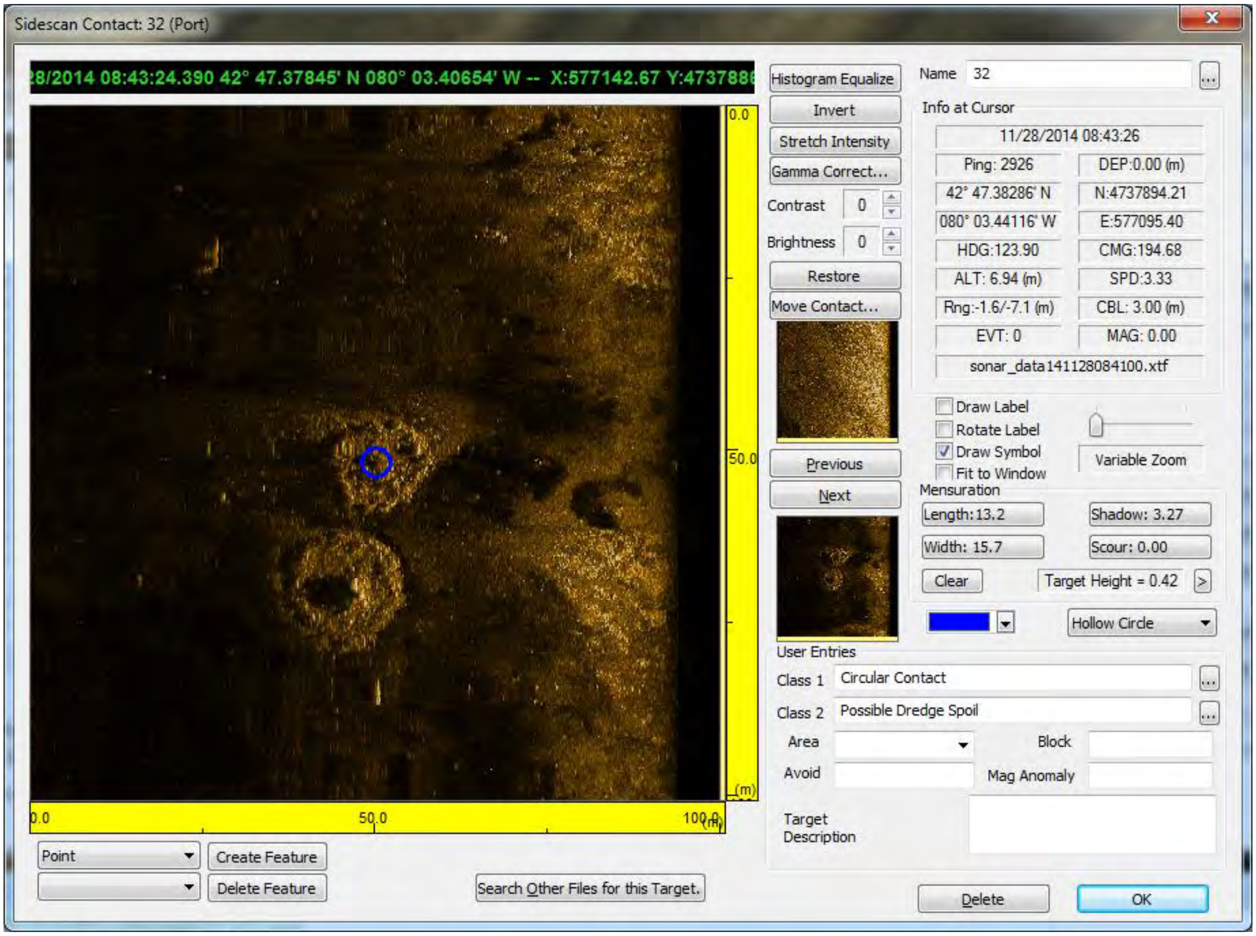
C30- Point Source Reflector (Probable Boulder)



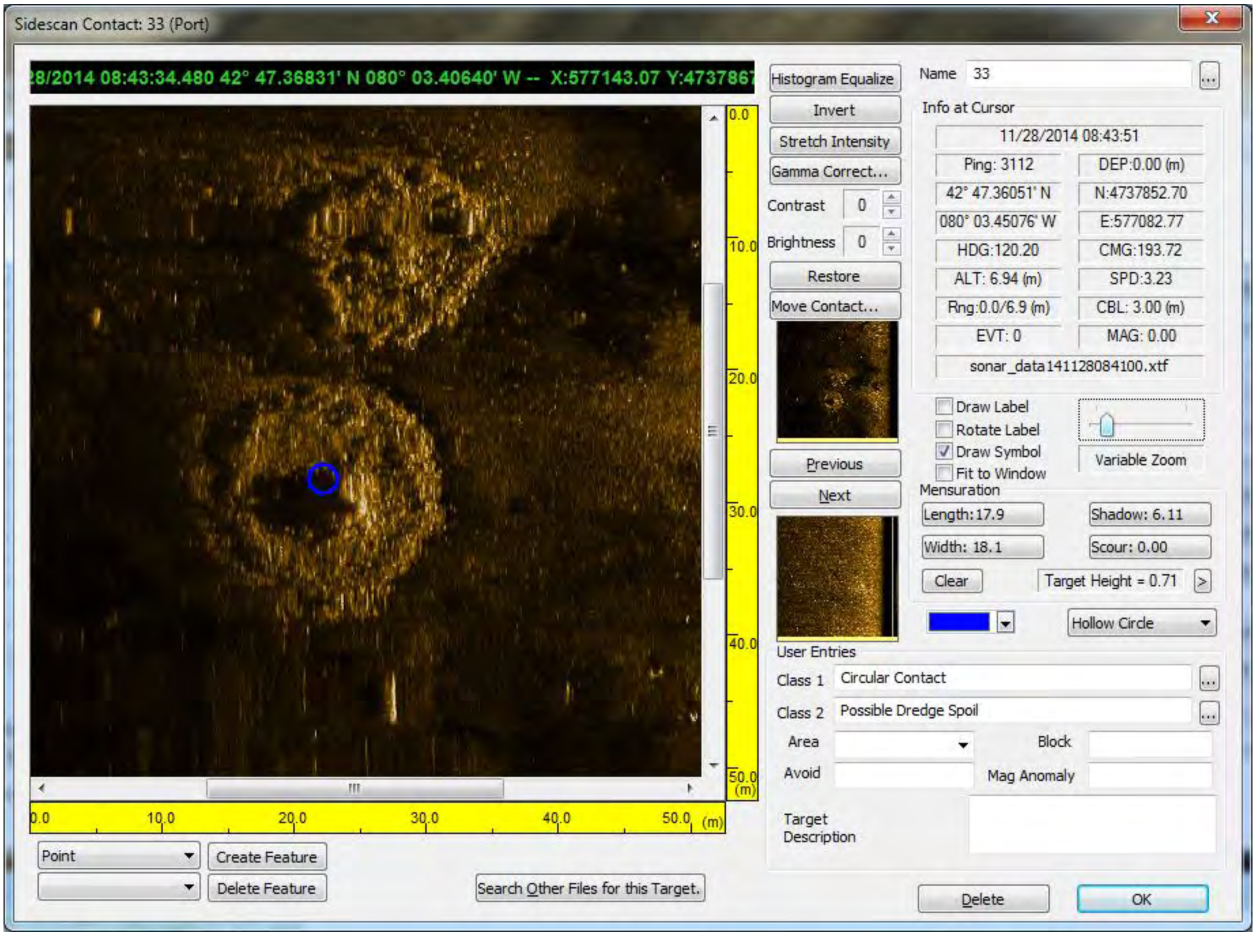
C31- Anthropogenic Contact



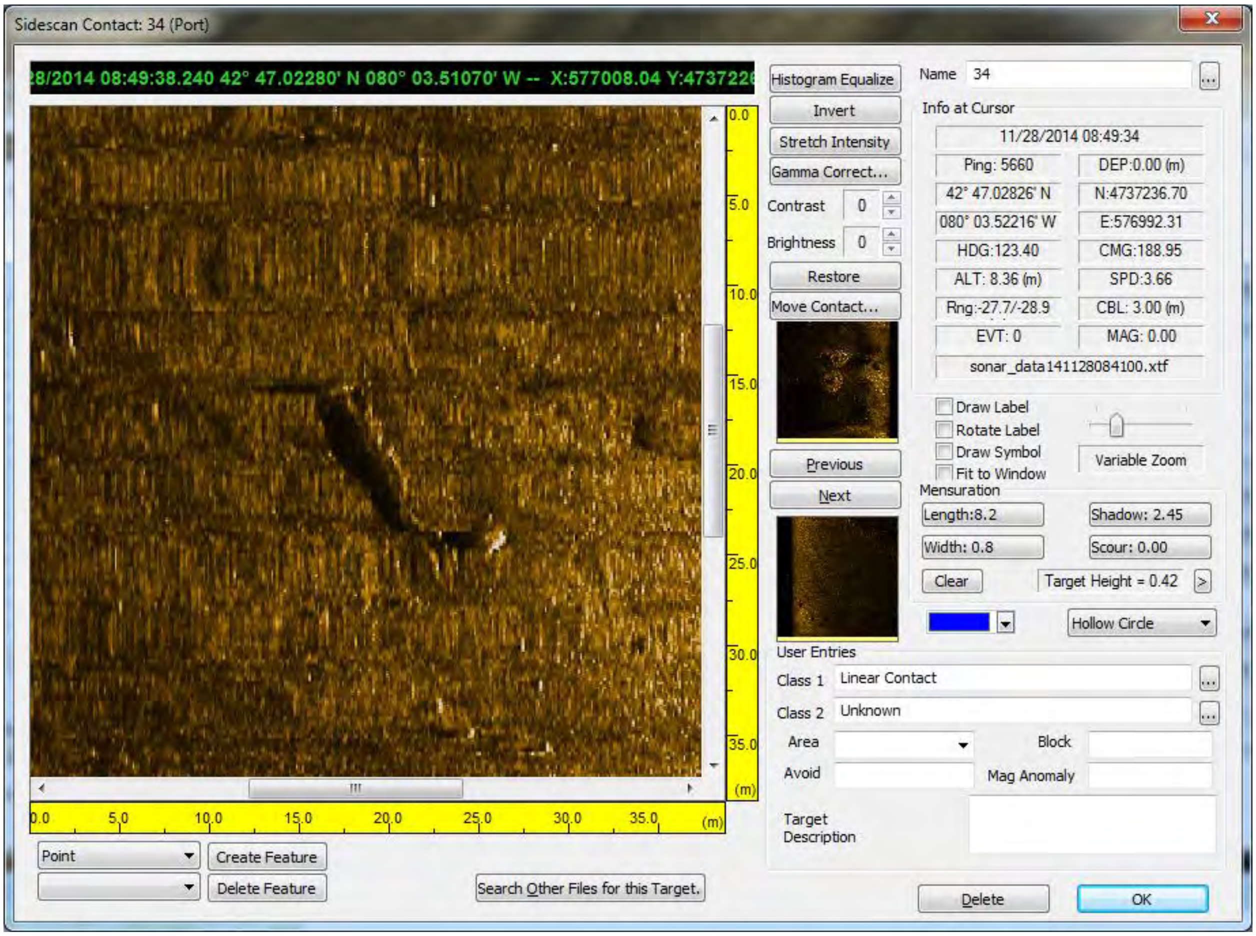
C32- Circular Contact (Probable Dredge Spoil)



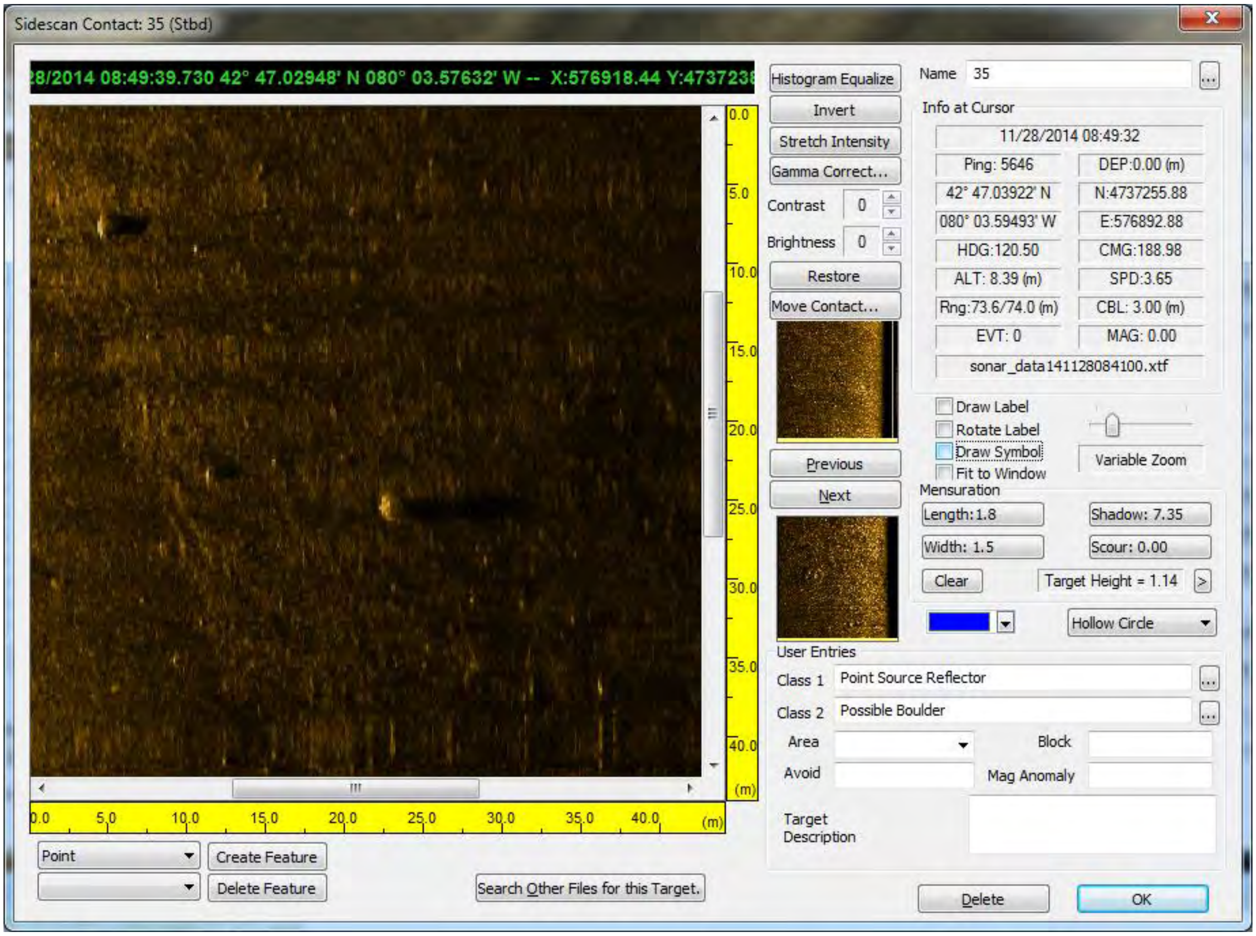
C33- Circular Contact (Probable Dredge Spoil)



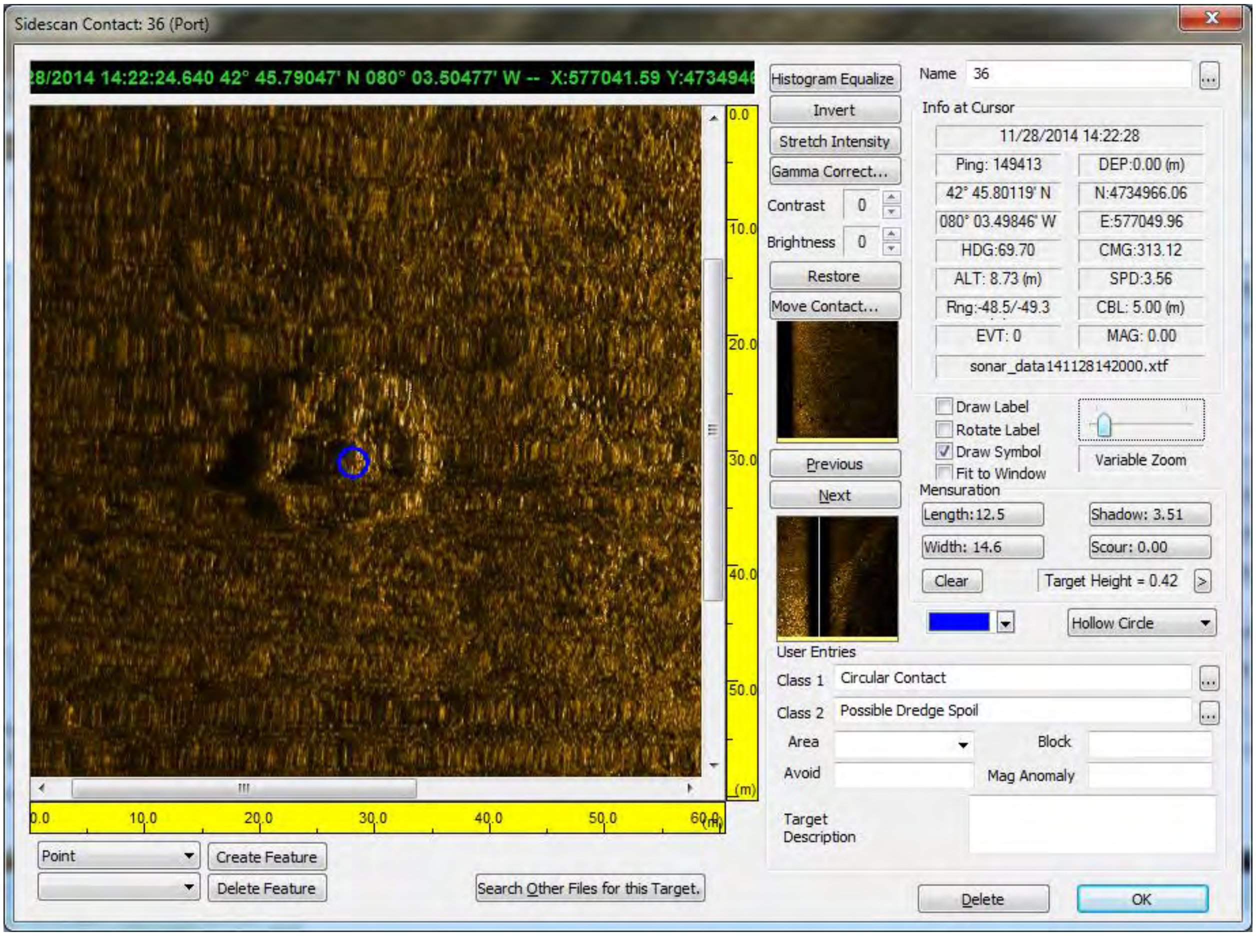
C34- Linear Contact



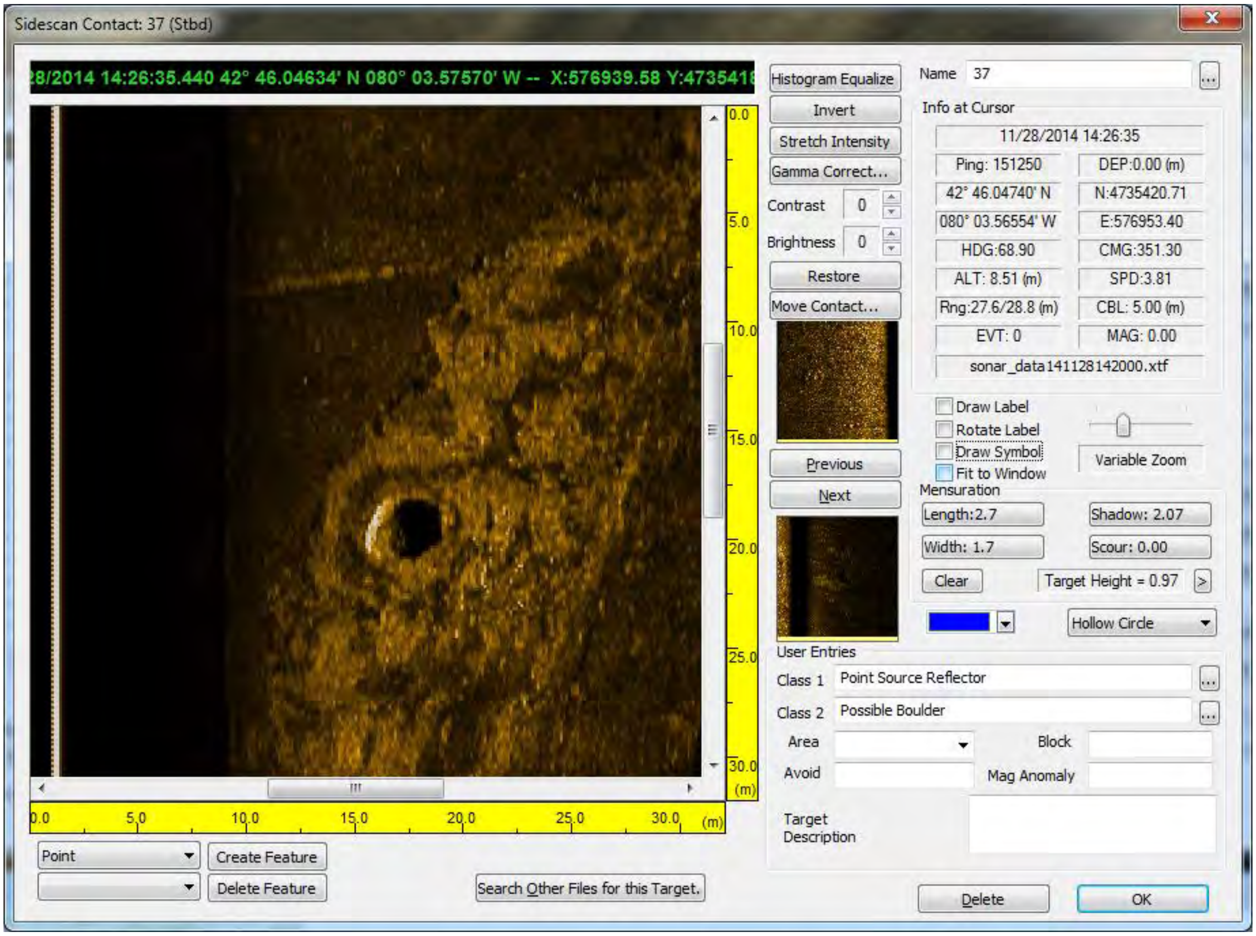
C35- Point Source Reflector (Probable Boulder)



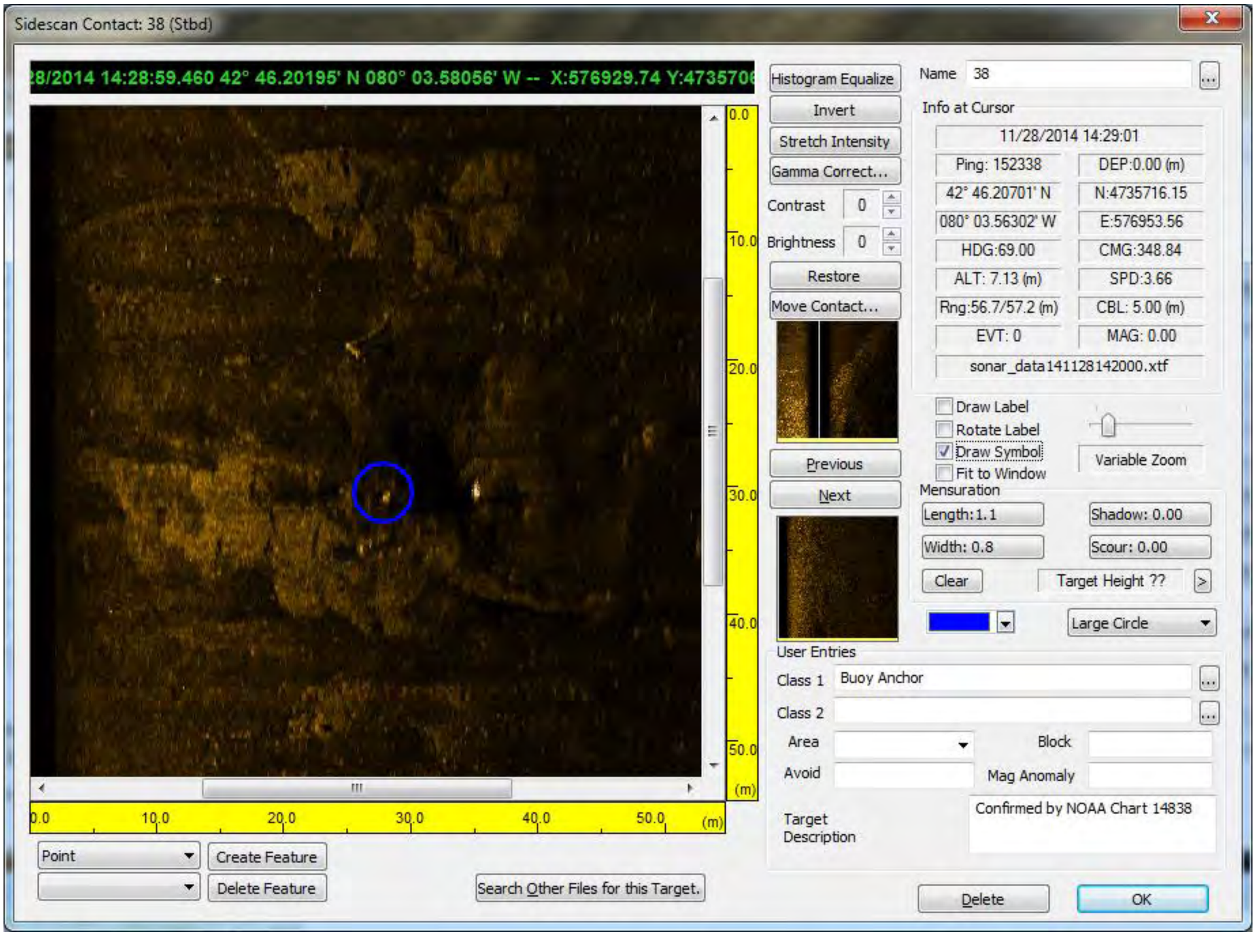
C36- Circular Contact (Probable Dredge Spoil)



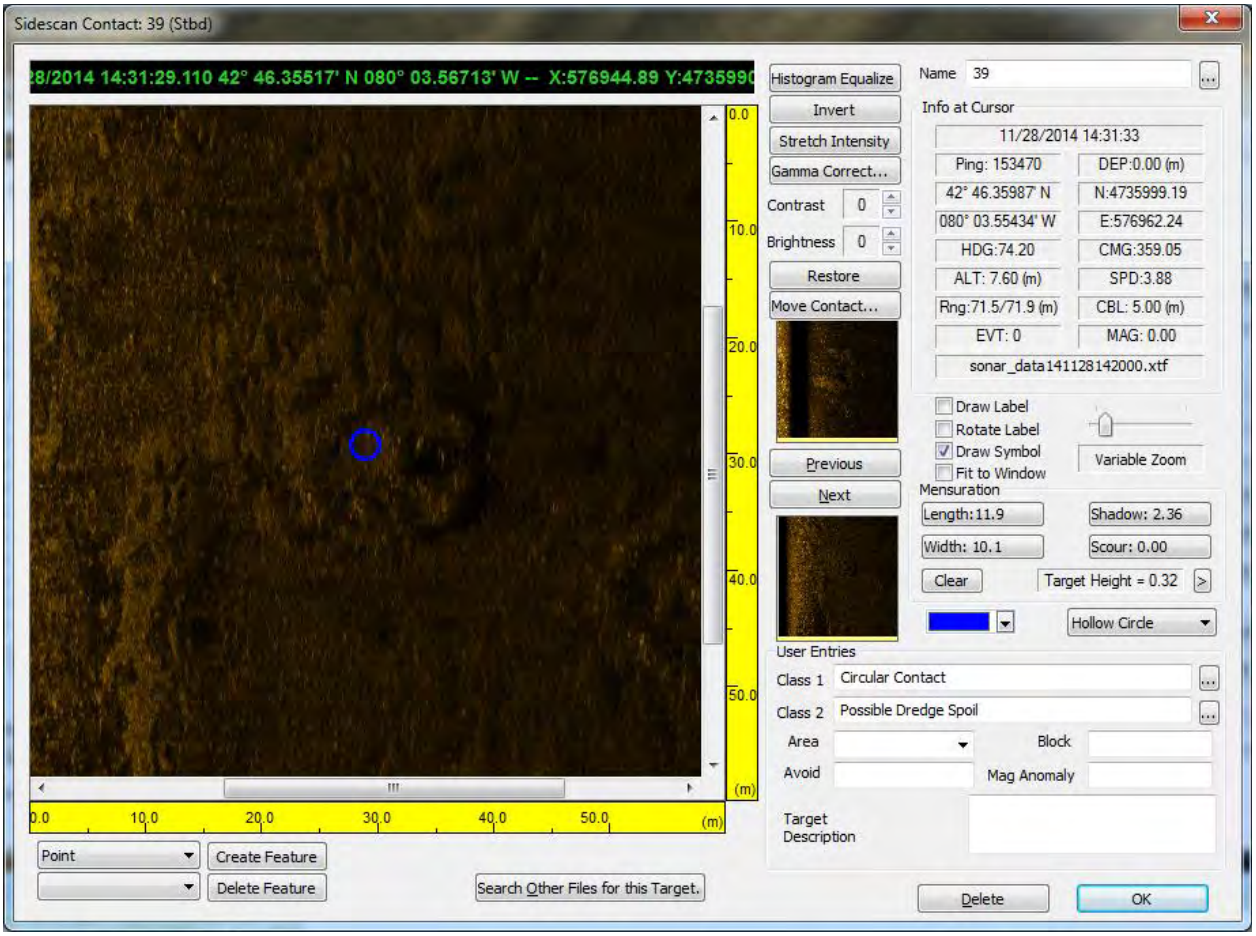
C37- Point Source Reflector (Probable Boulder)



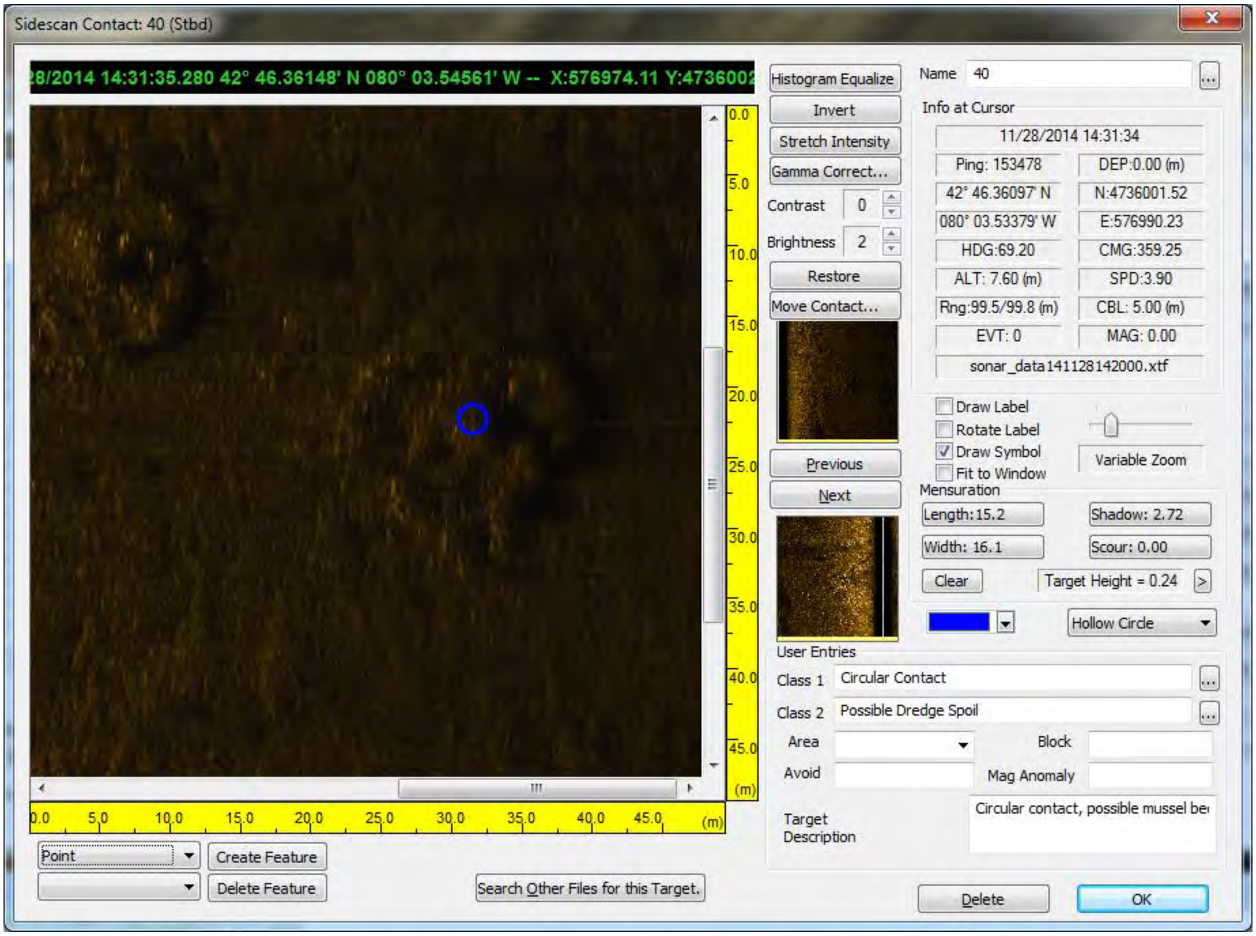
C38- Buoy Mooring



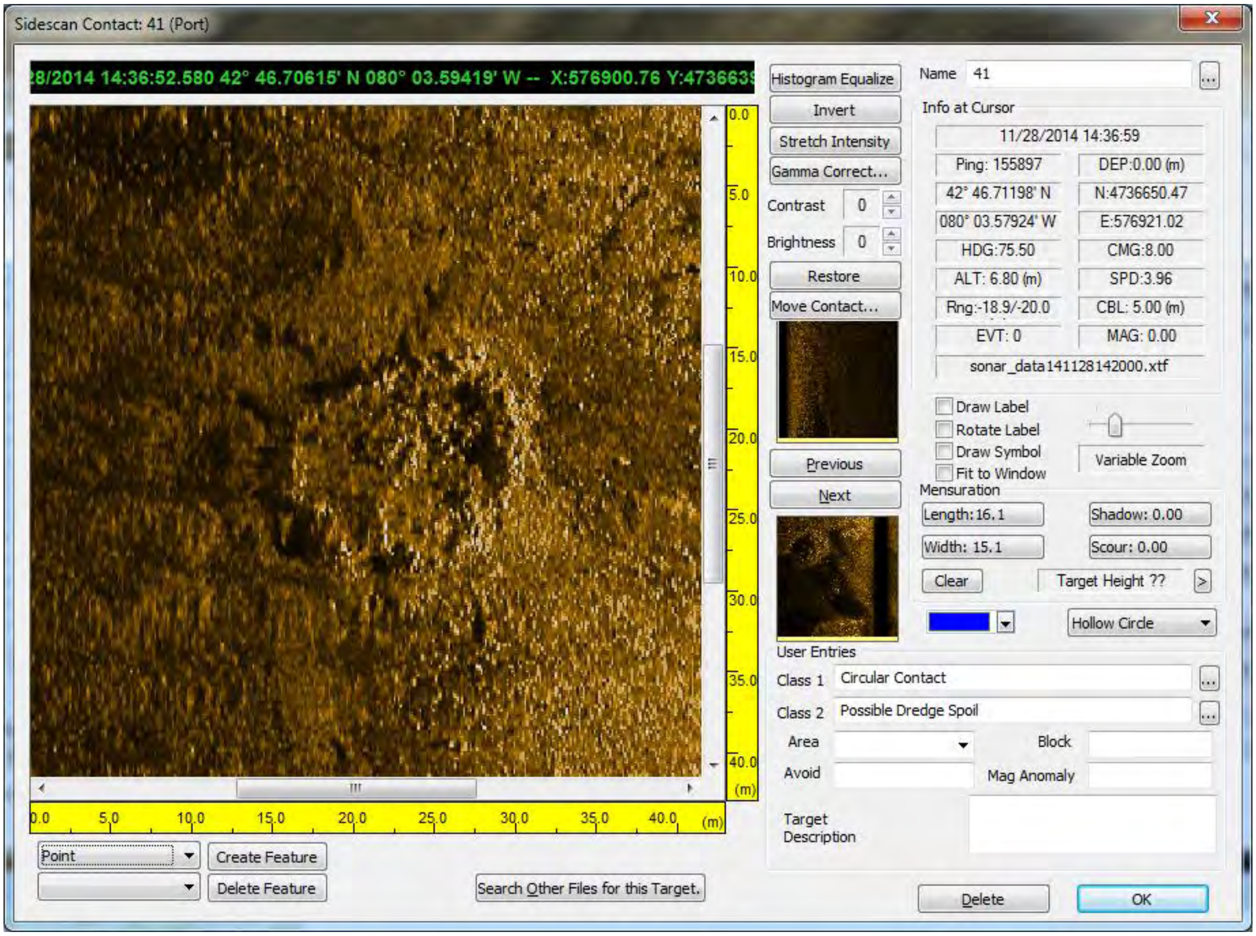
C39- Circular Contact (Probable Dredge Spoil)



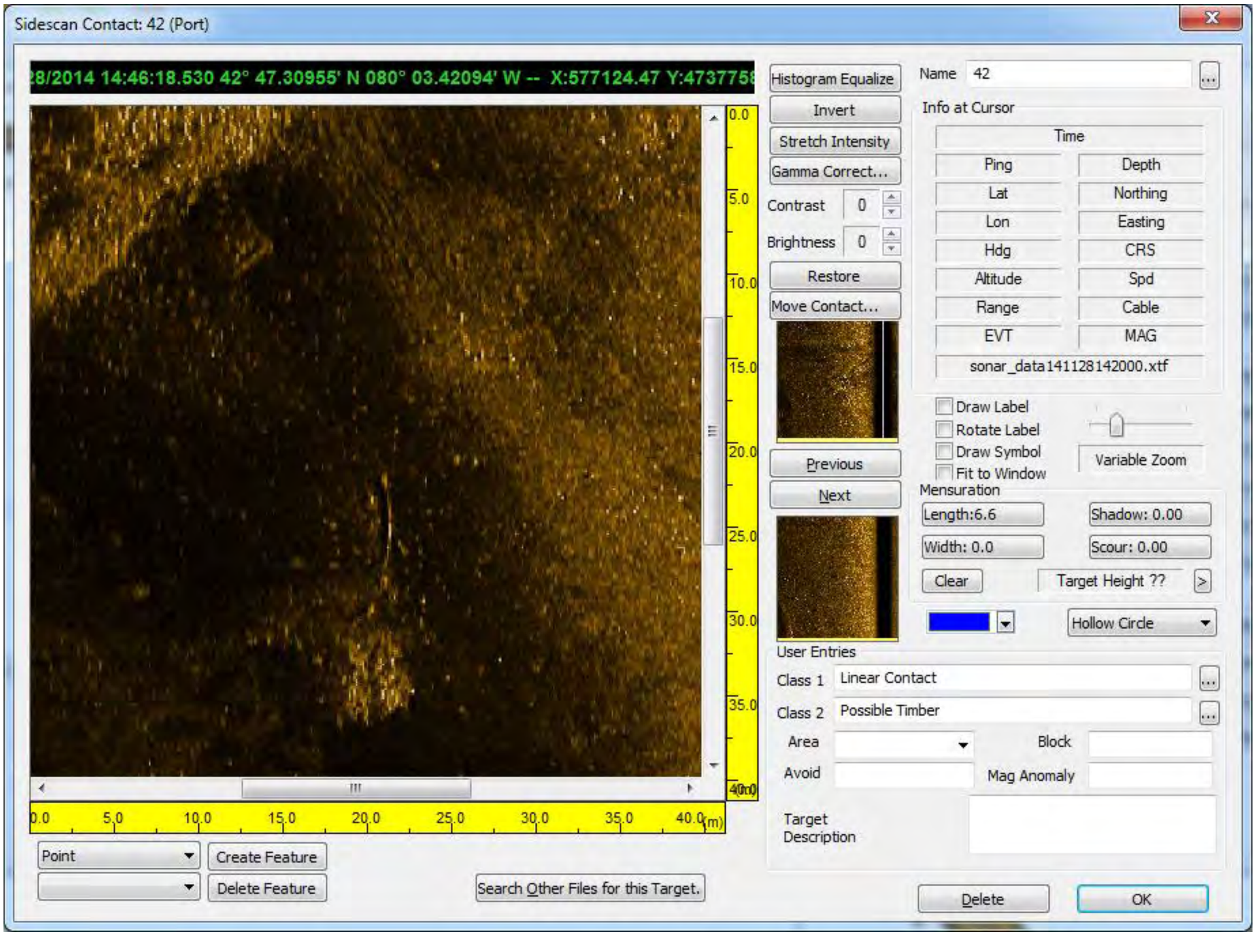
C40- Circular Contact (Probable Dredge Spoil)



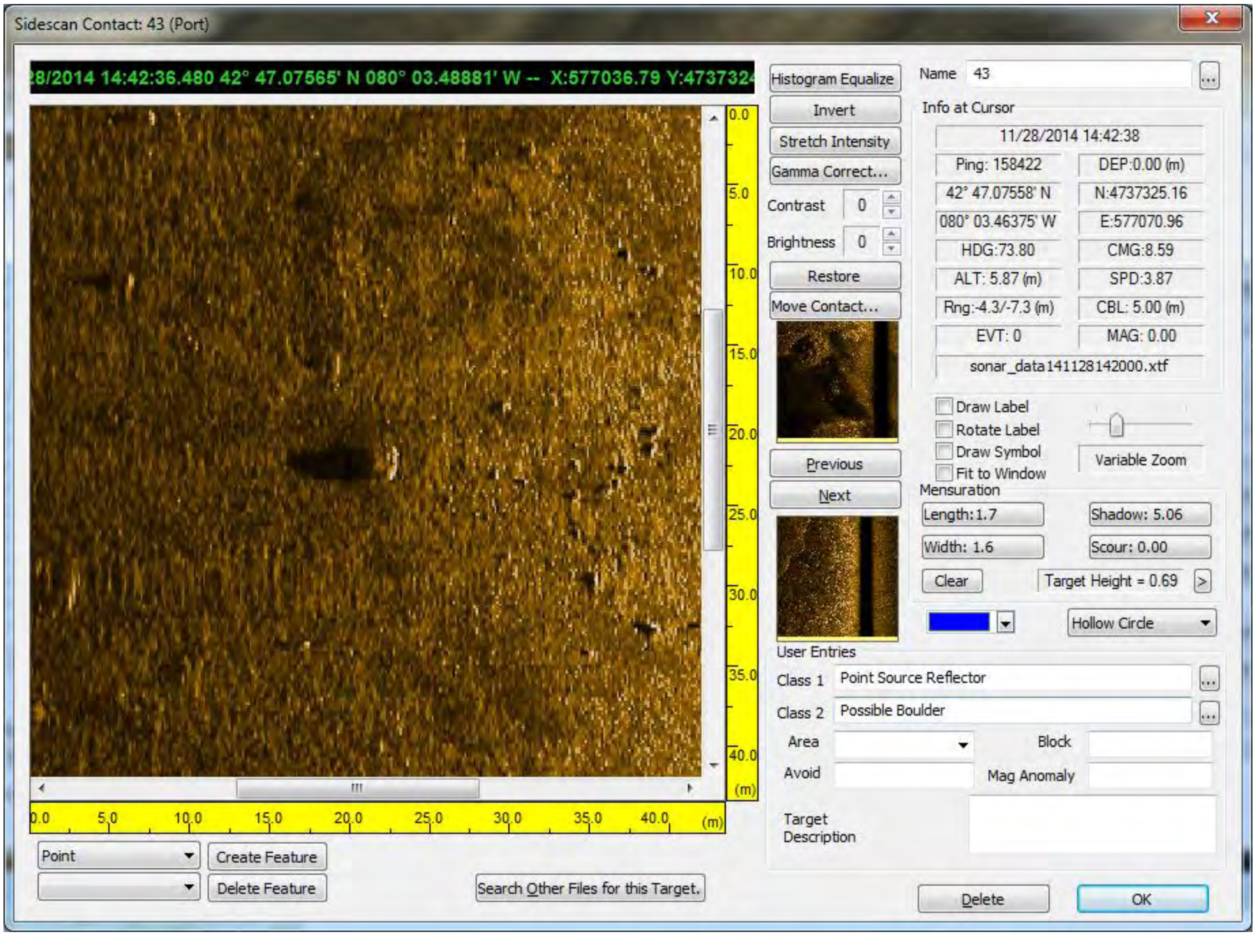
C41- Circular Contact (Probable Dredge Spoil)



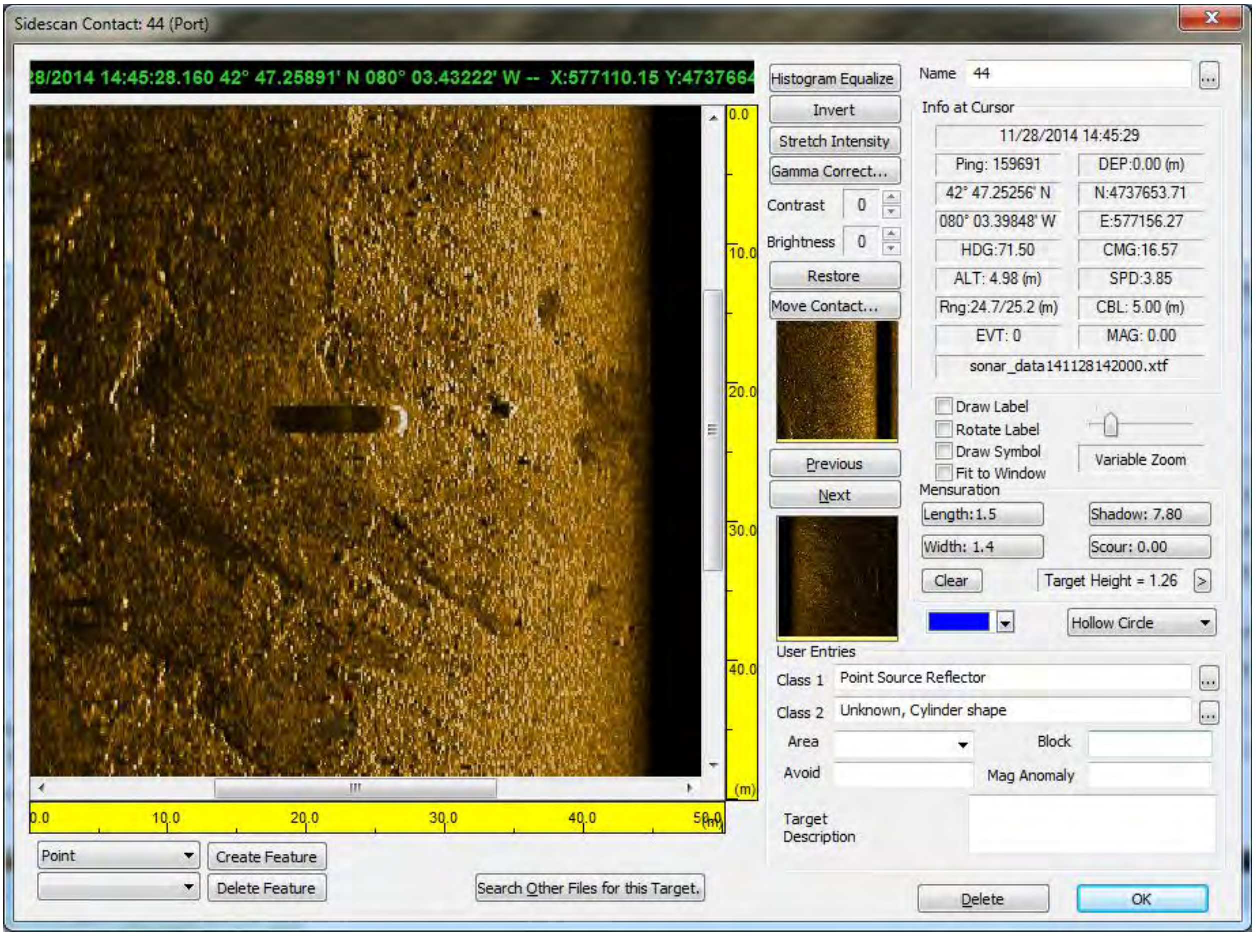
C42- Linear Contact



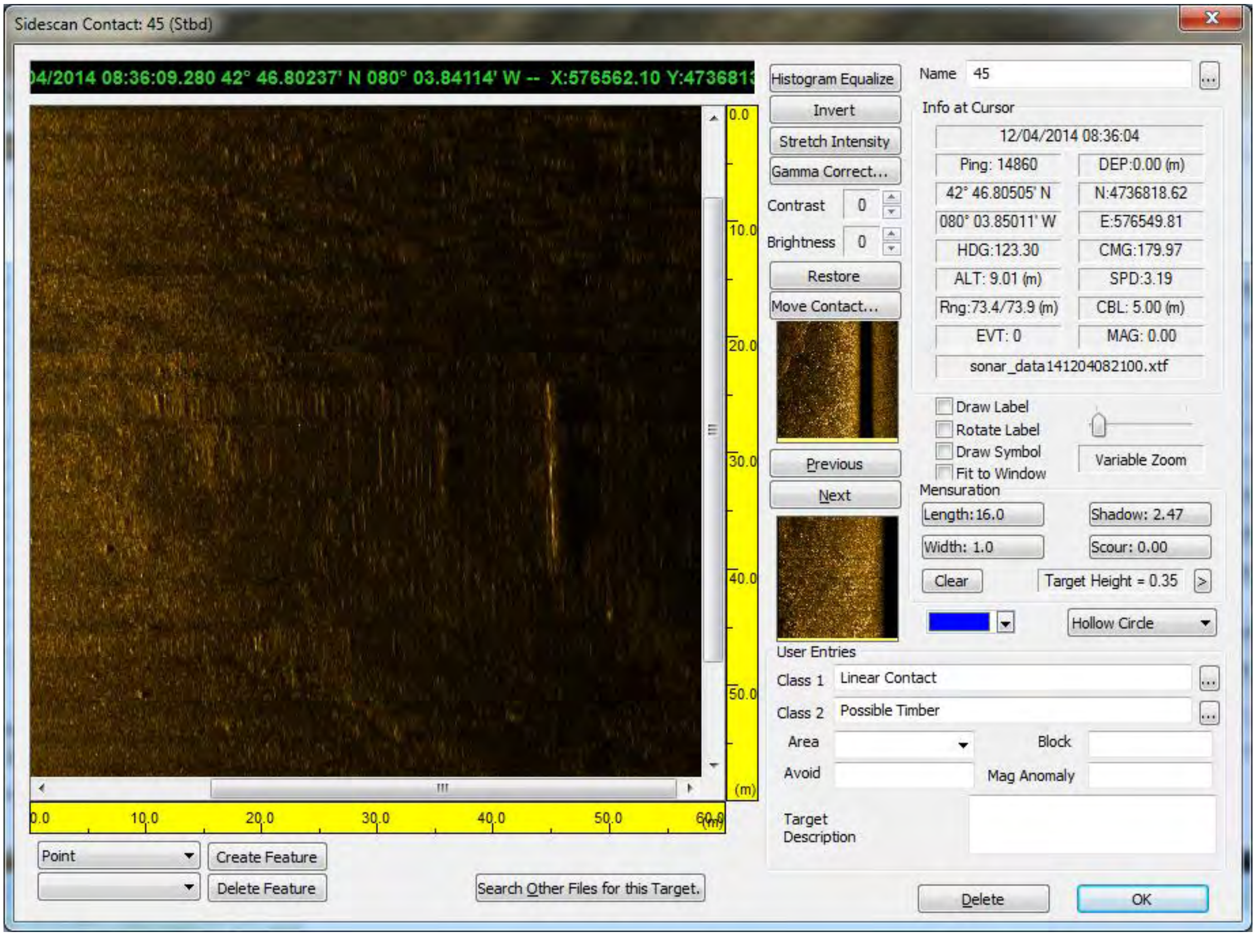
C43- Point Source Reflector (Probable Boulder)



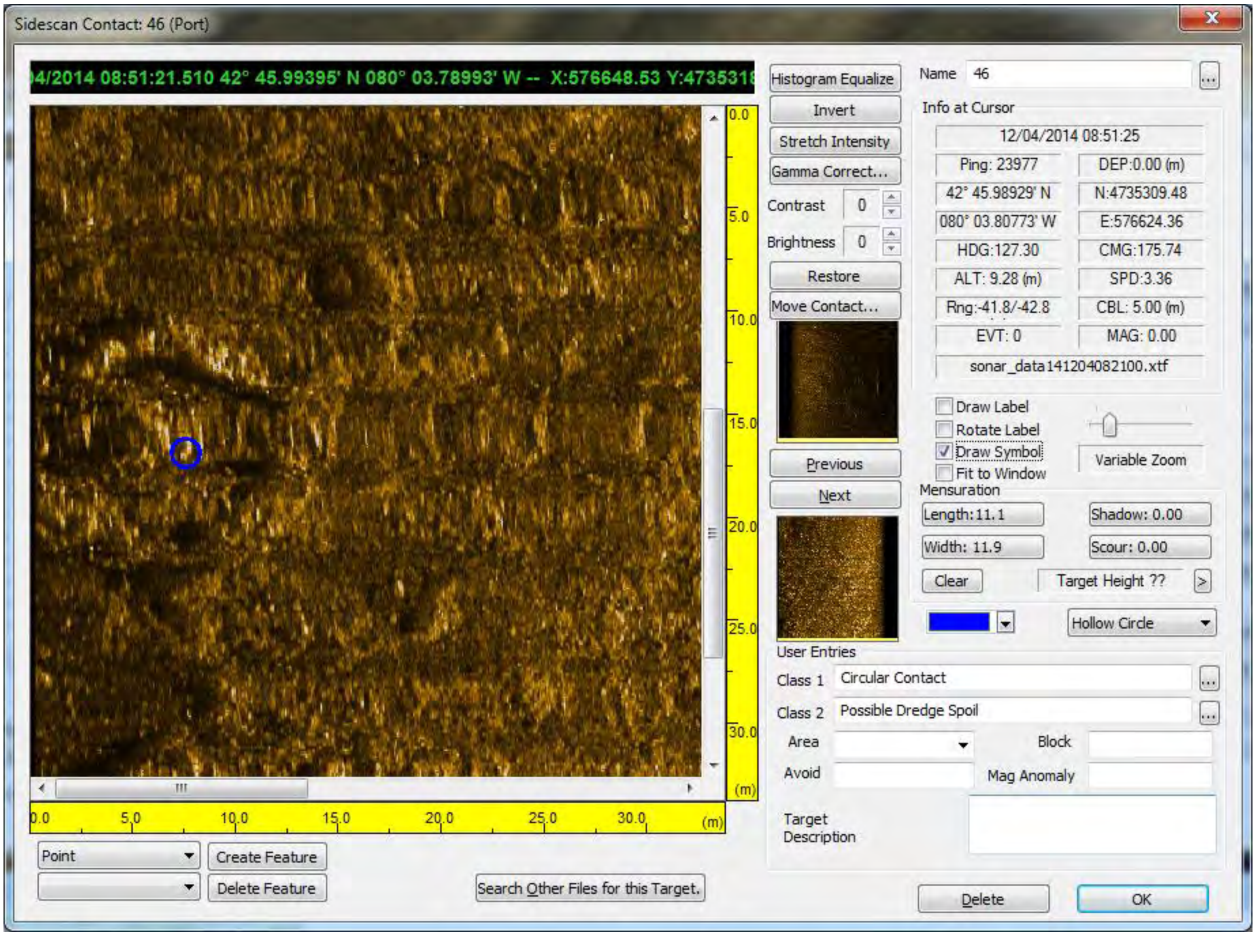
C44- Point Source Reflector (Probable Boulder)



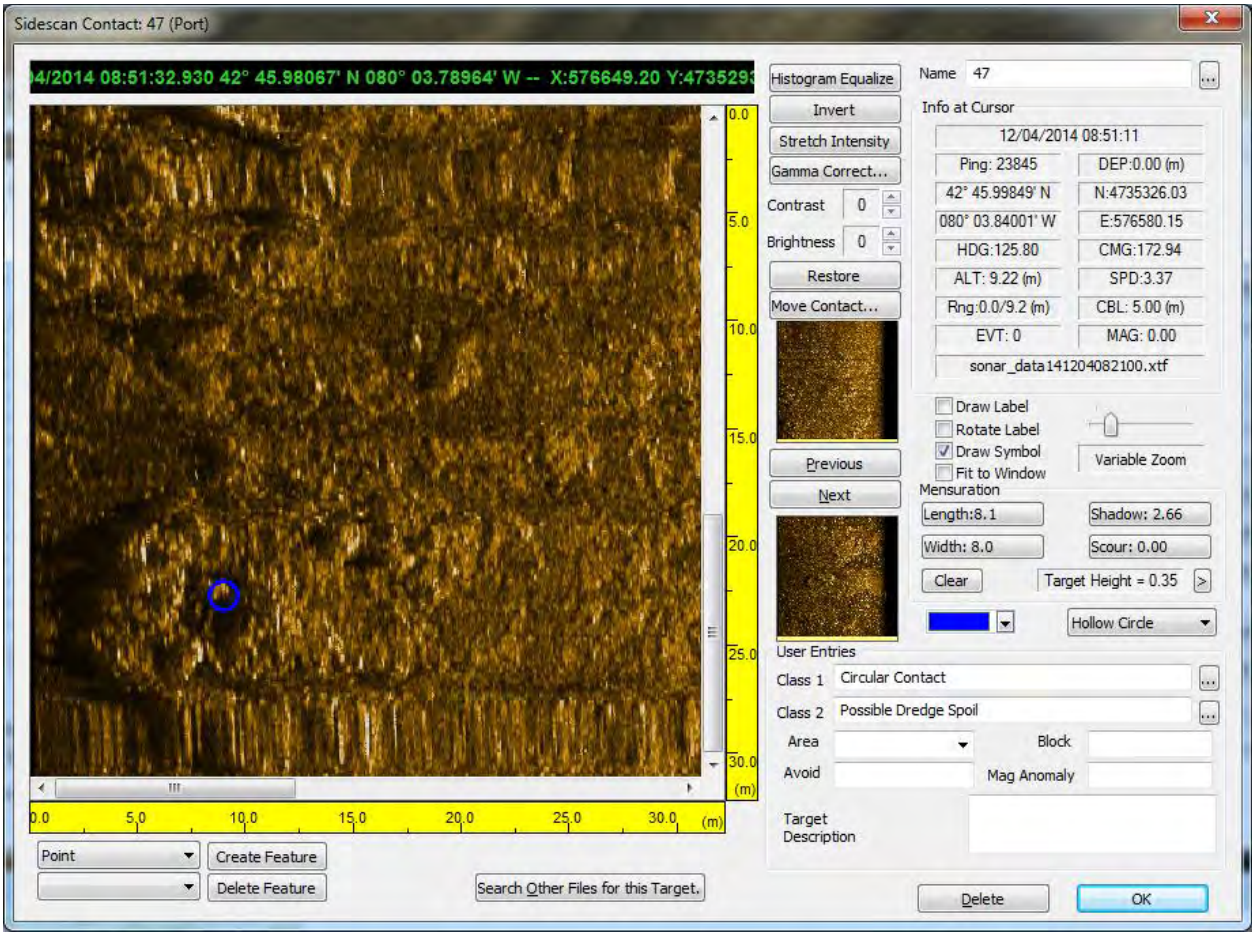
C45- Linear Contact



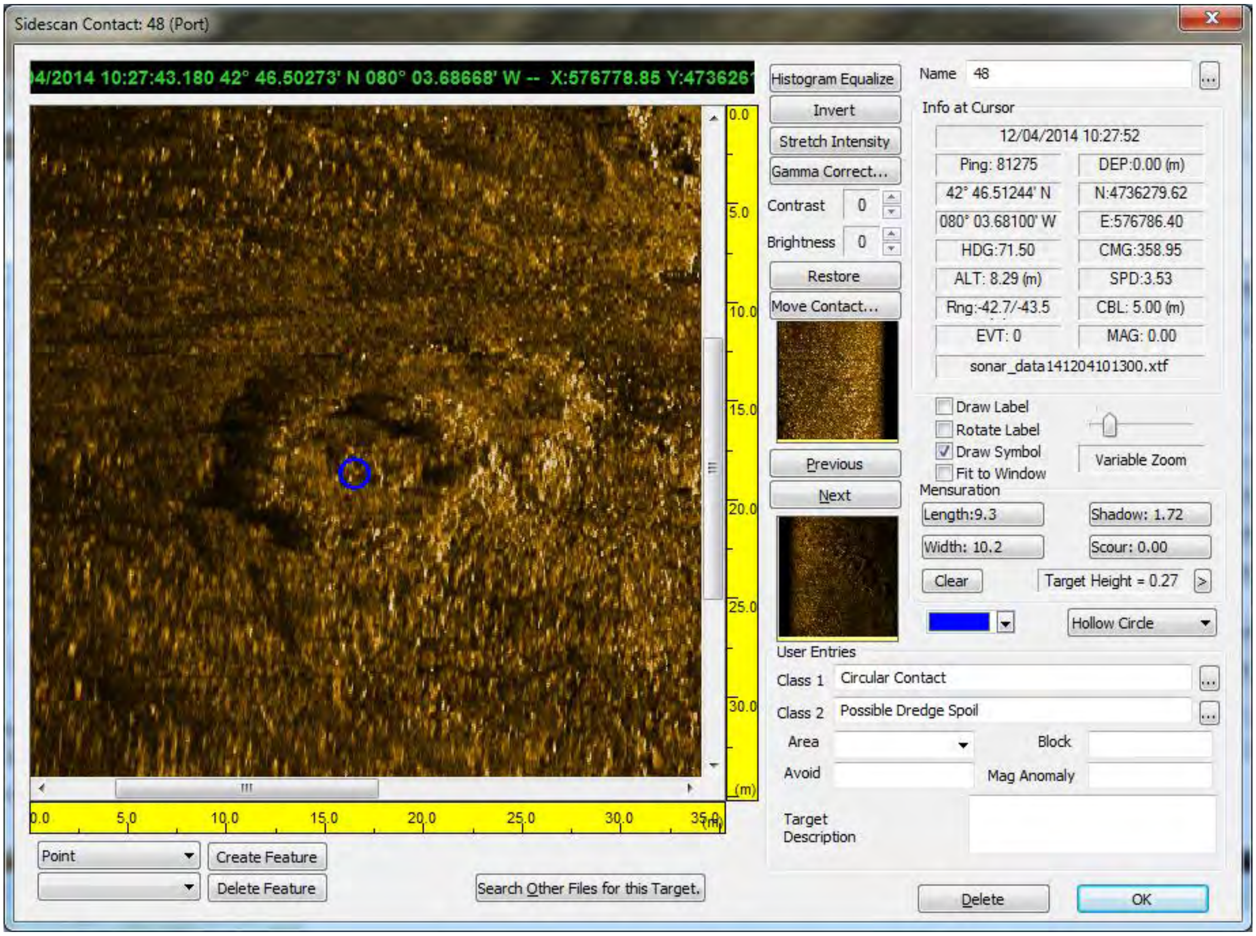
C46- Circular Contact (Probable Dredge Spoil)



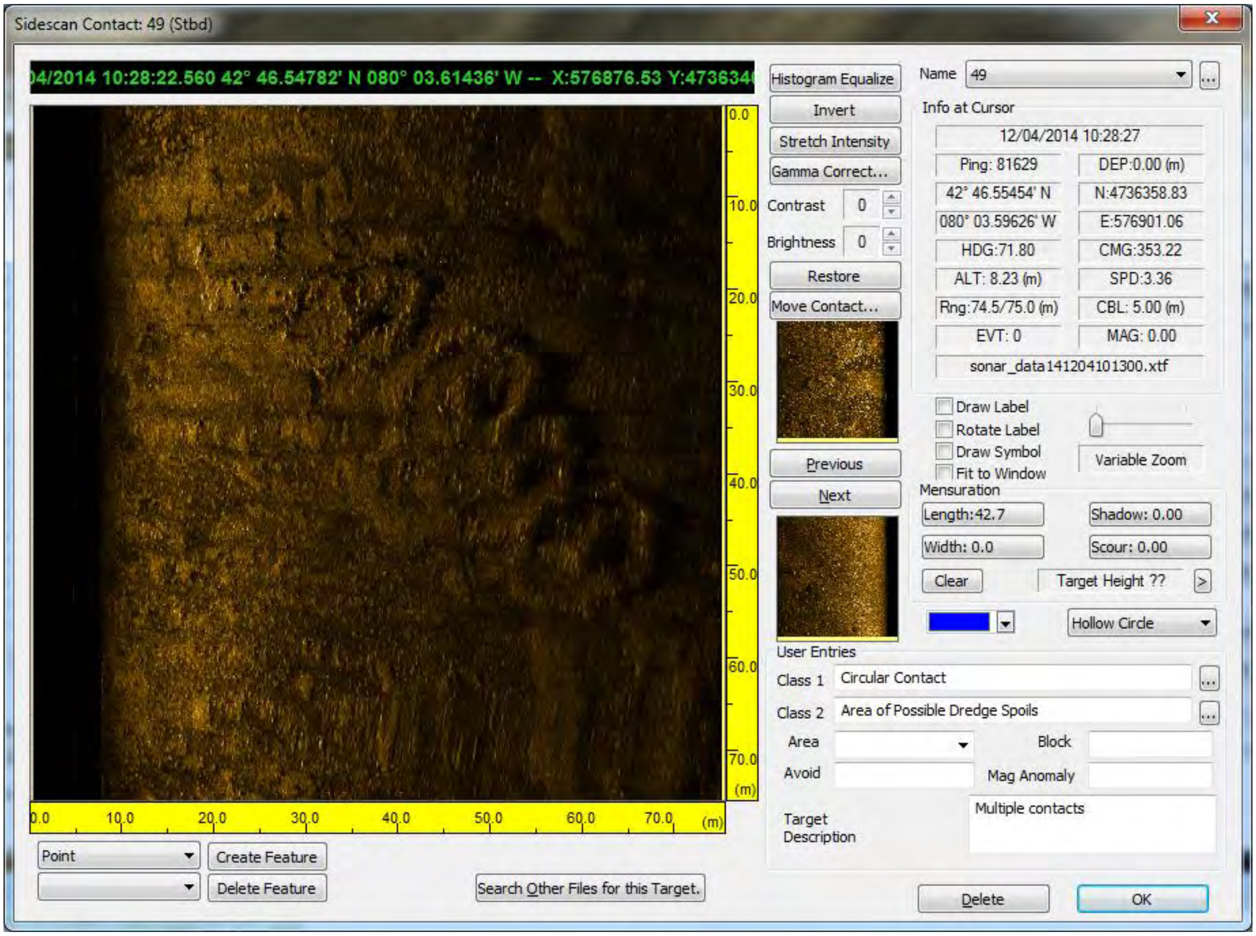
C47- Circular Contact (Probable Dredge Spoil)



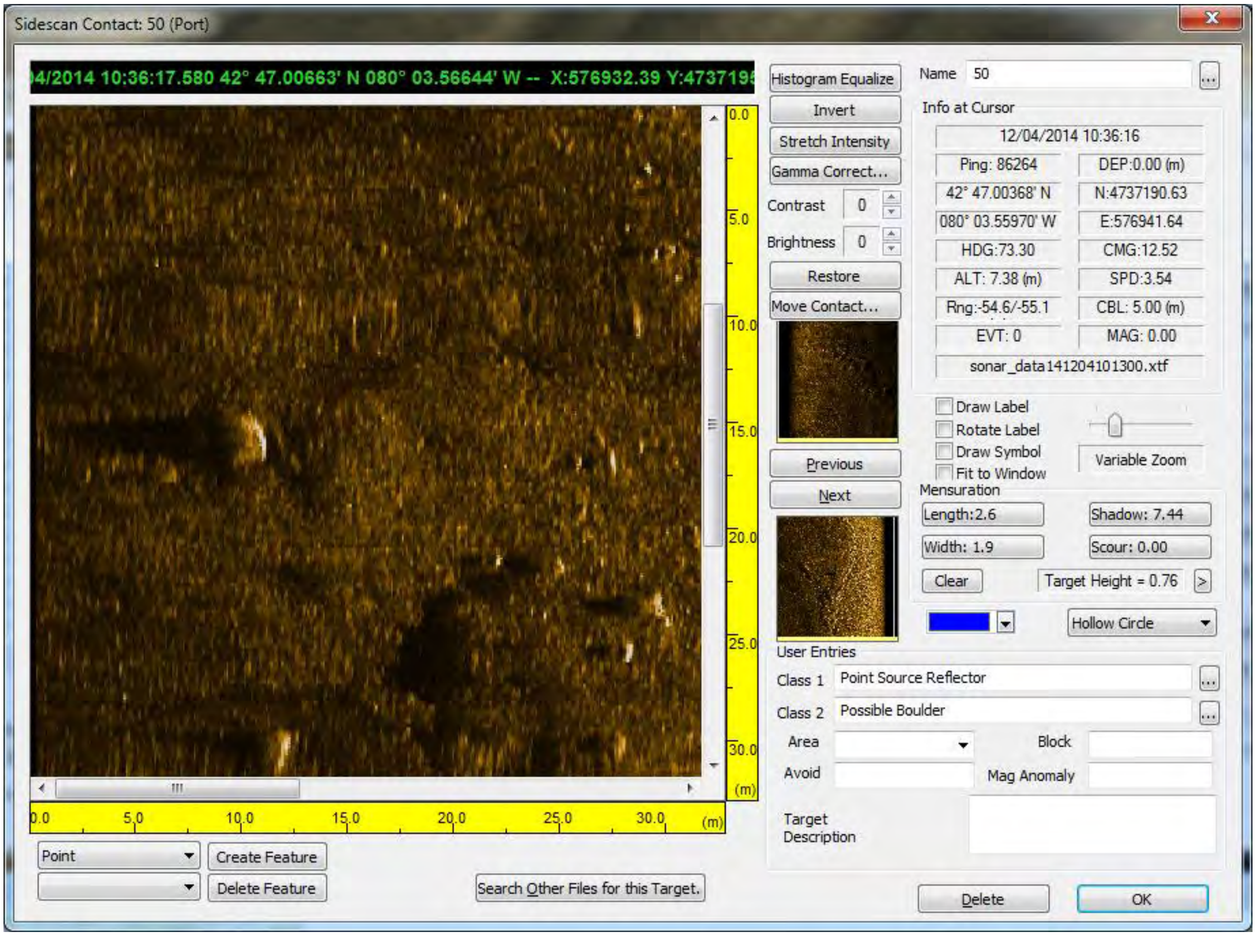
C48- Circular Contact (Probable Dredge Spoil)



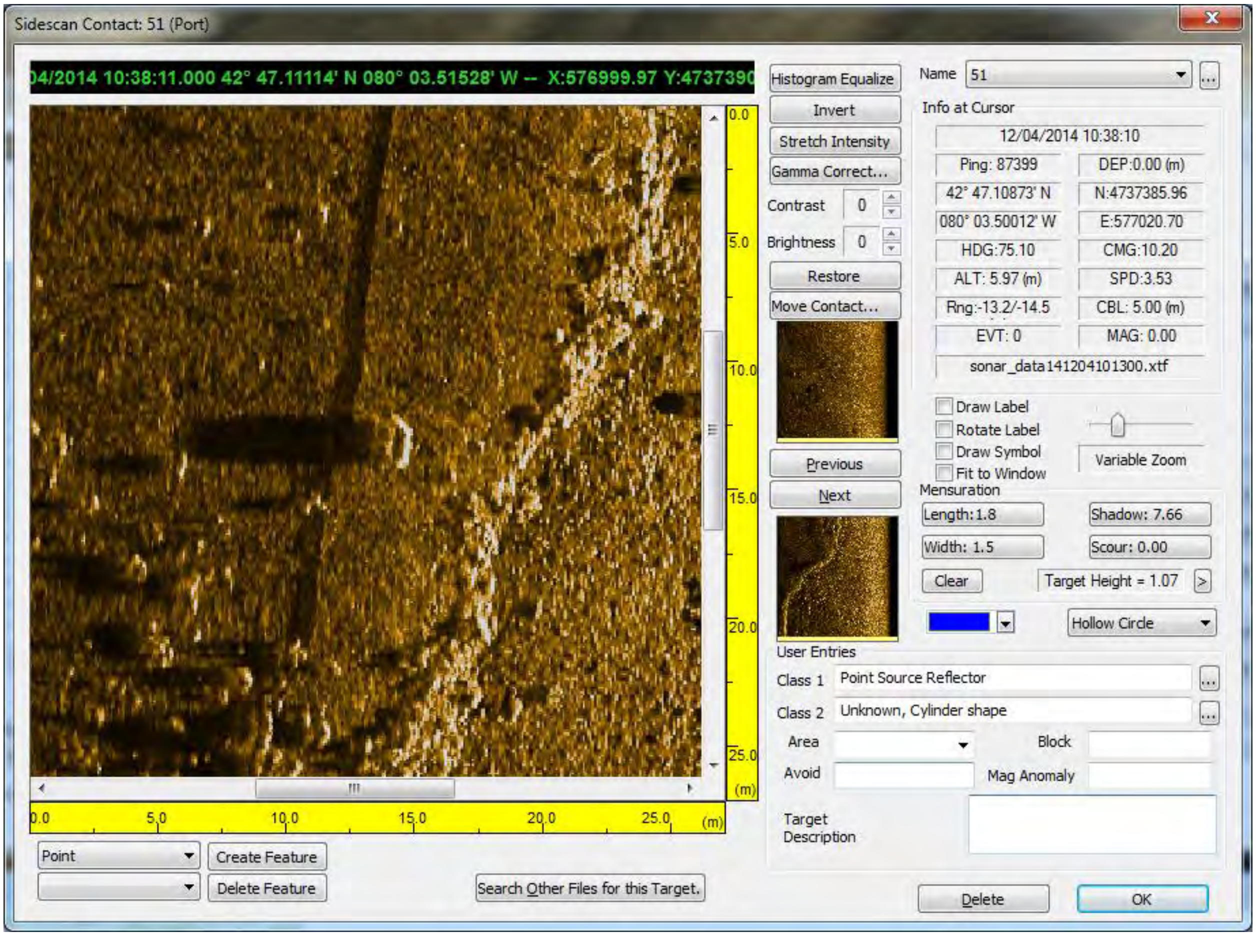
C49- Circular Contact (Probable Dredge Spoil)



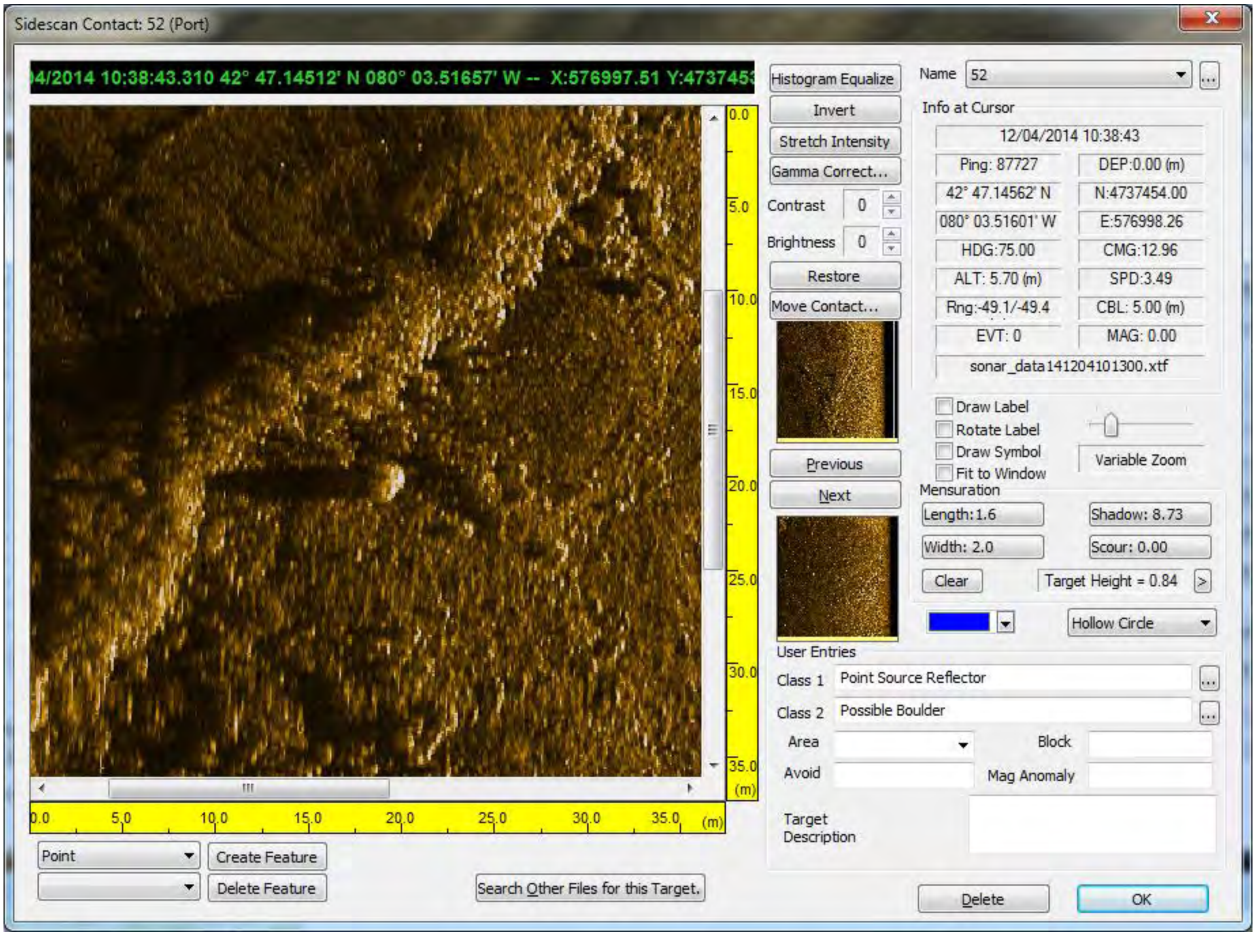
C50- Point Source Reflector (Probable Boulder)



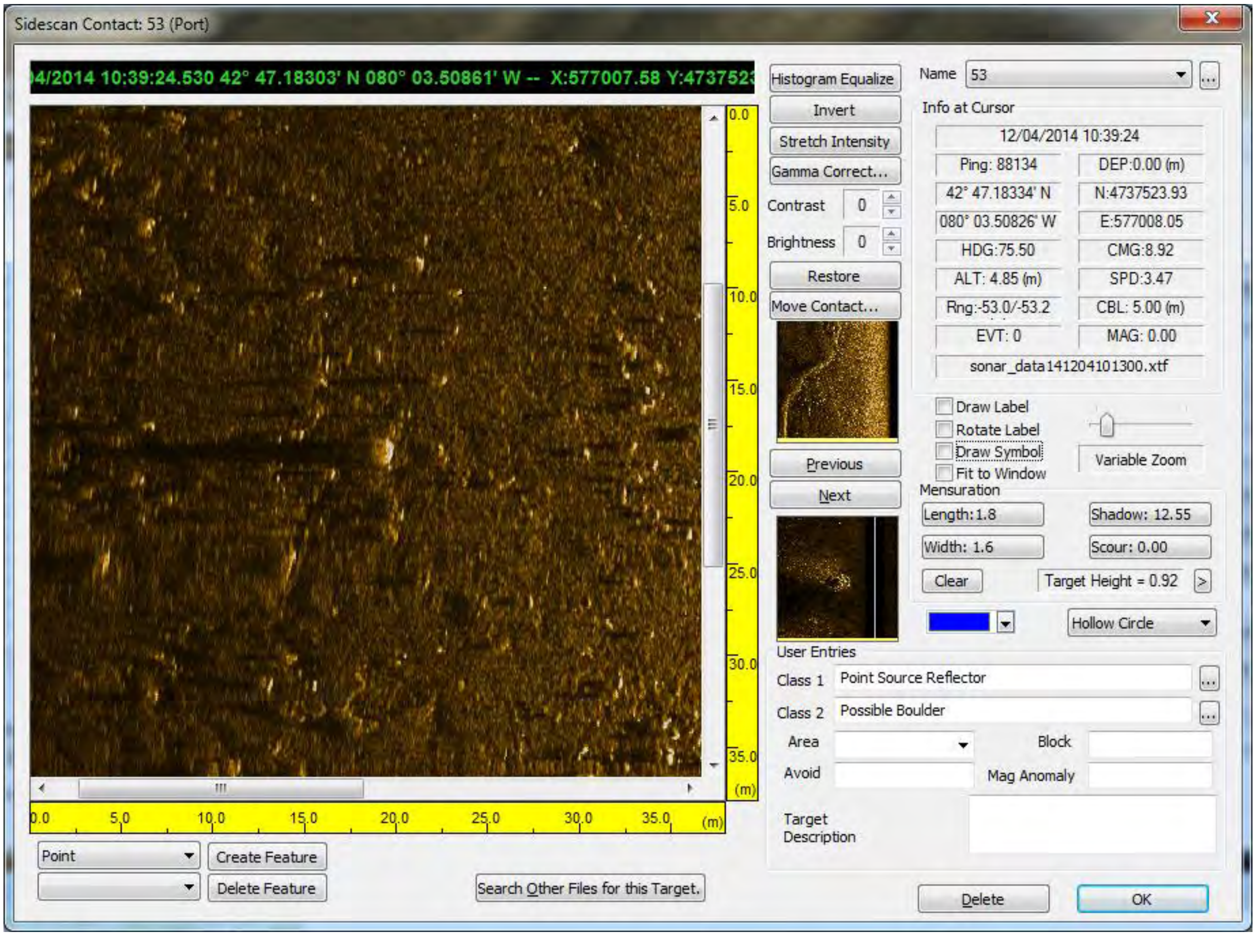
C51- Point Source Reflector (Probable Boulder)



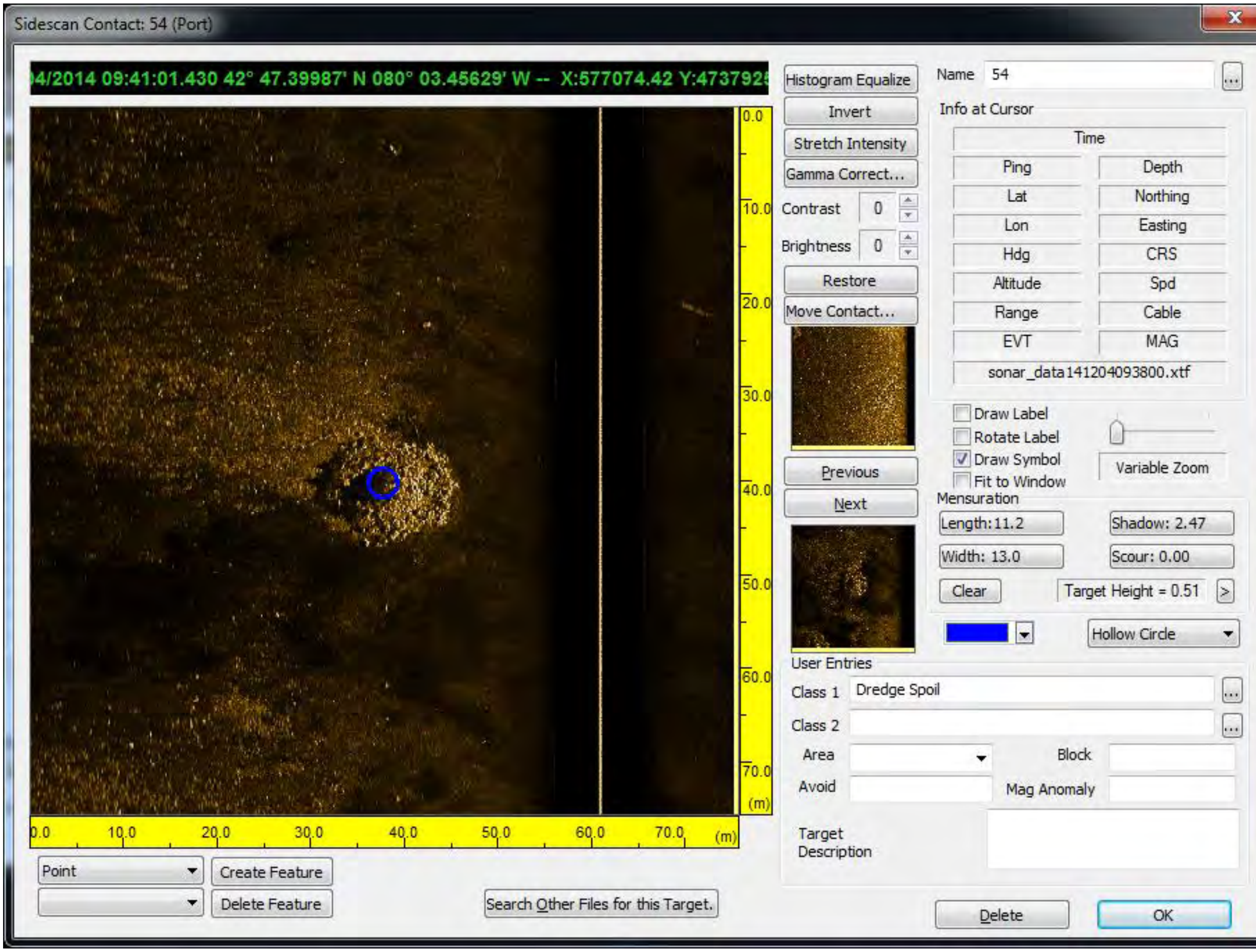
C52- Point Source Reflector (Probable Boulder)



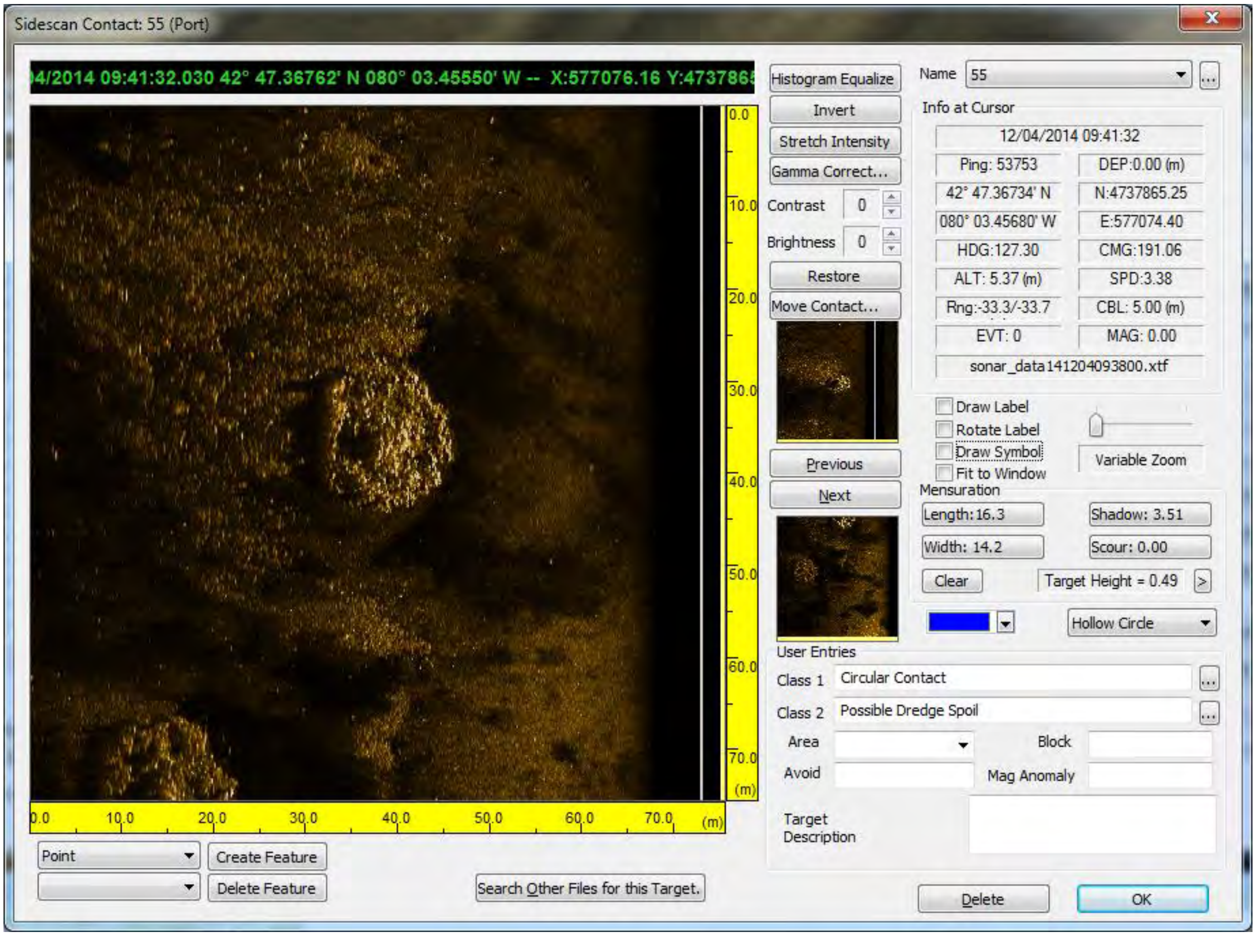
C53- Point Source Reflector (Probable Boulder)



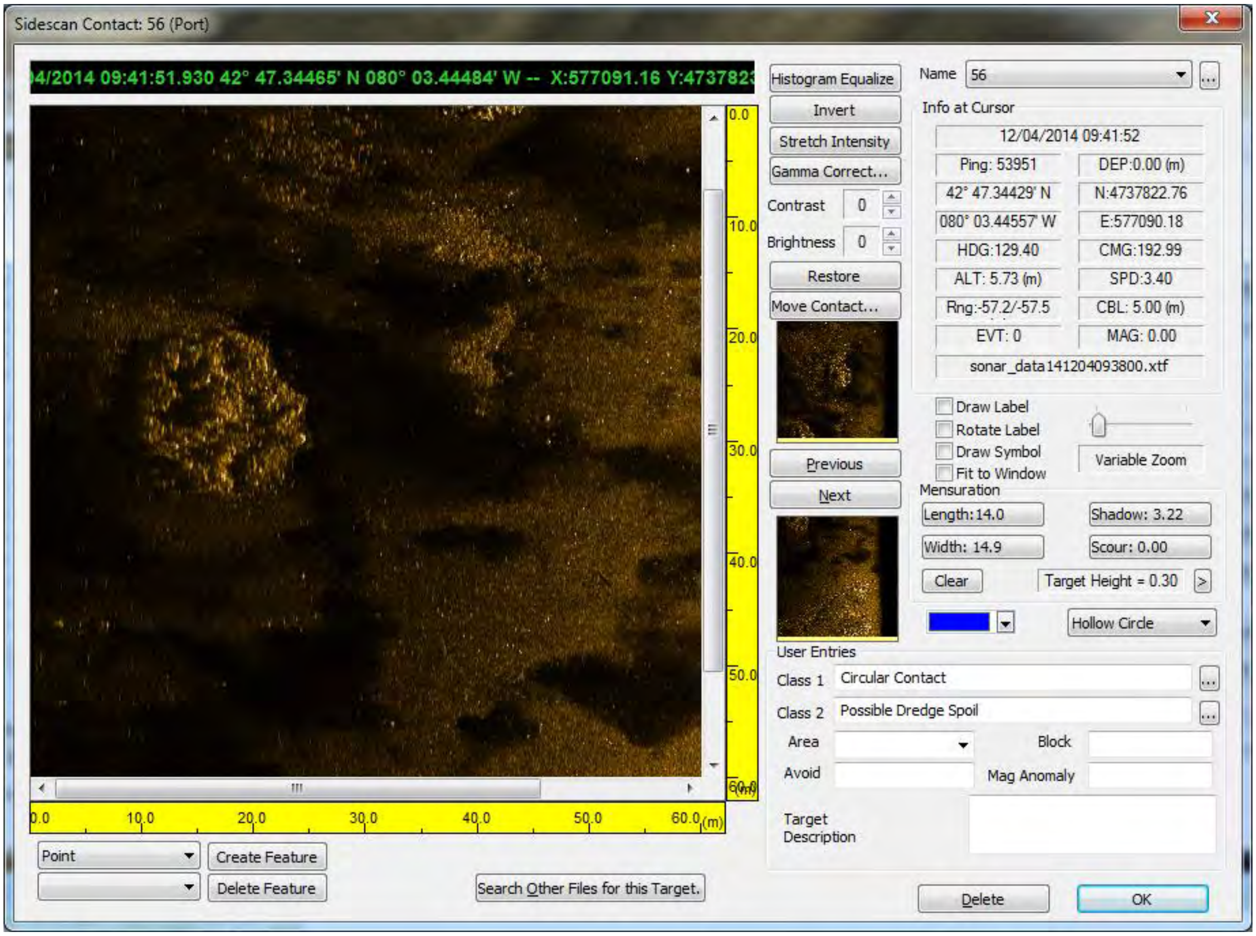
C54- Circular Contact (Probable Dredge Spoil)



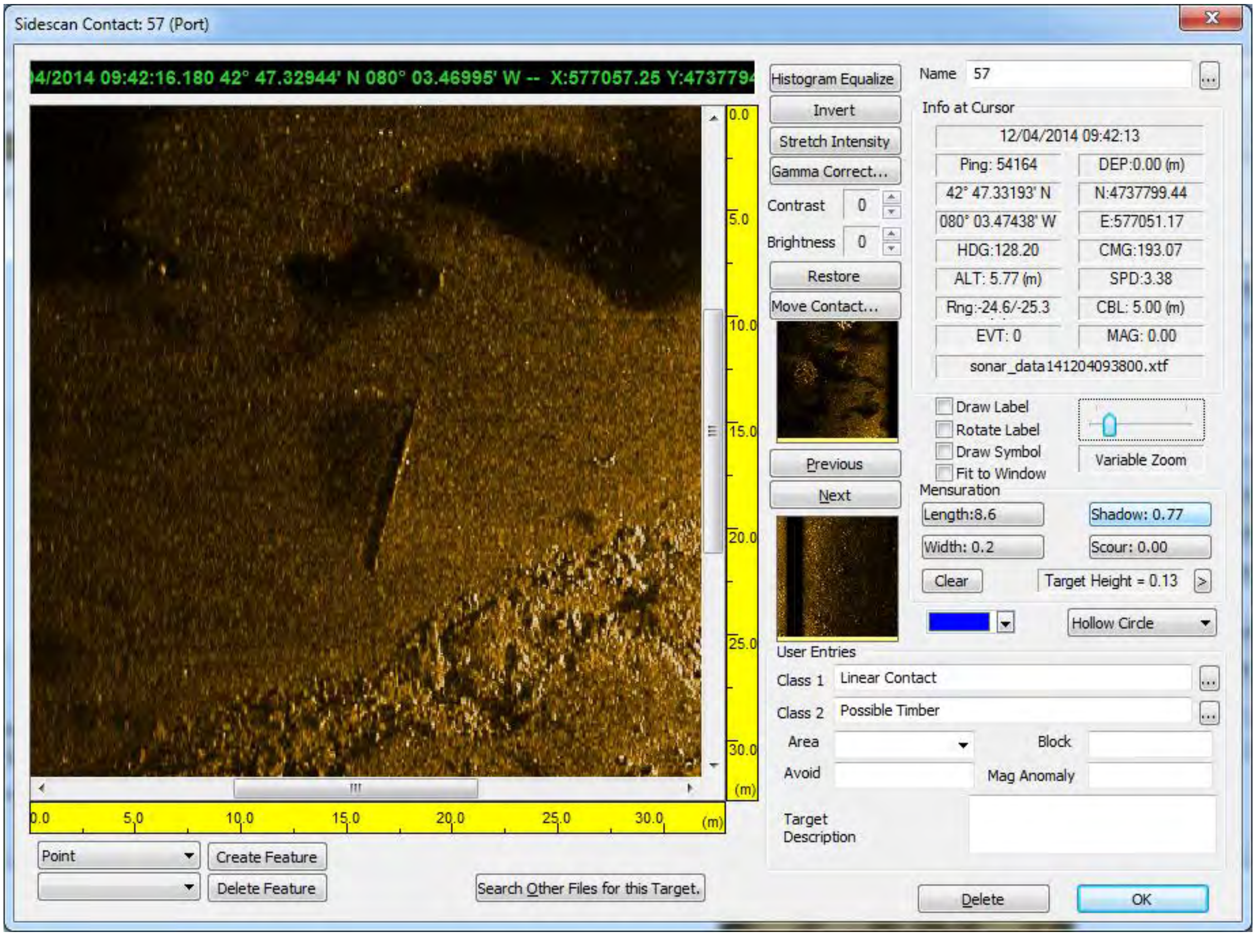
C55- Circular Contact (Probable Dredge Spoil)



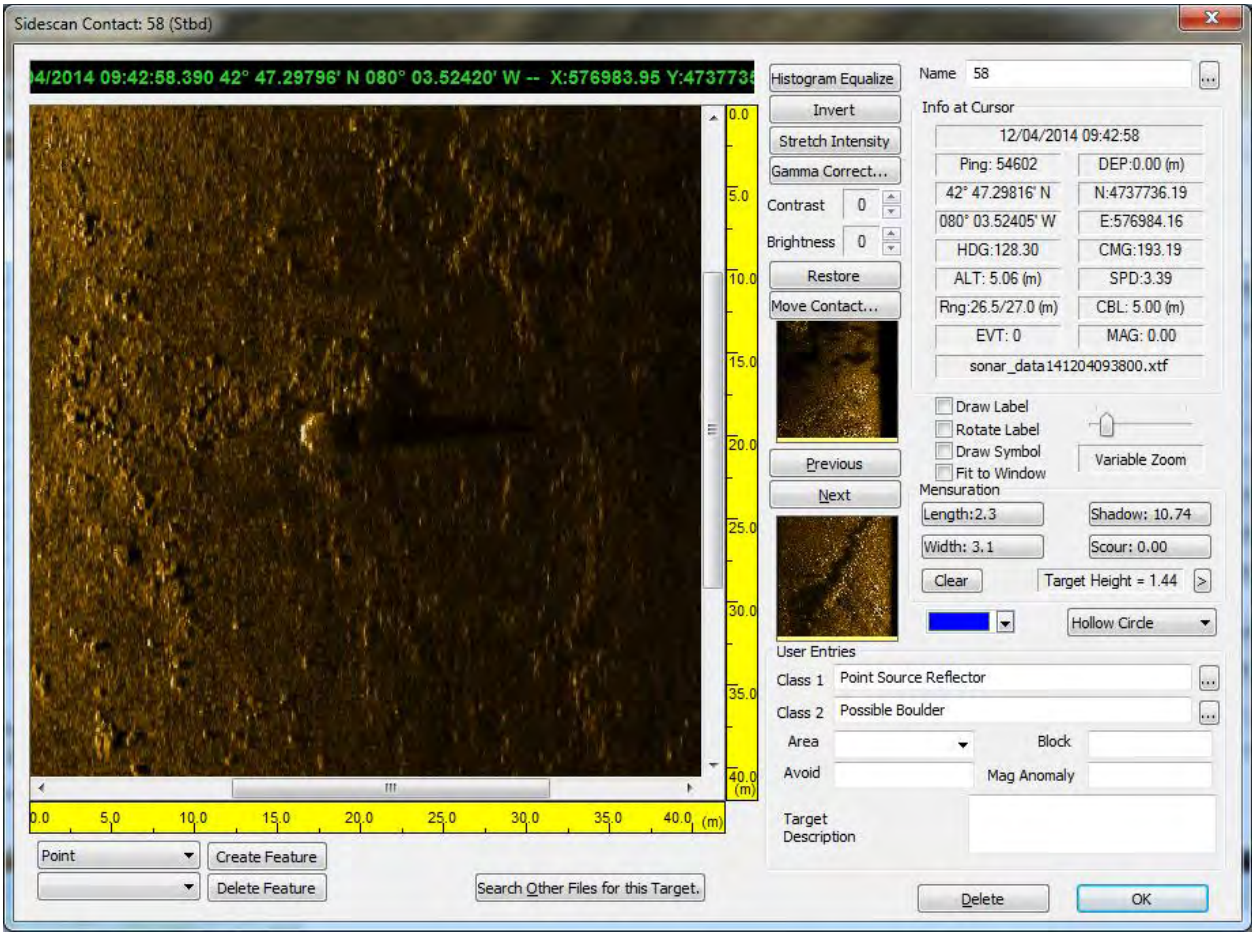
C56- Circular Contact (Probable Dredge Spoil)



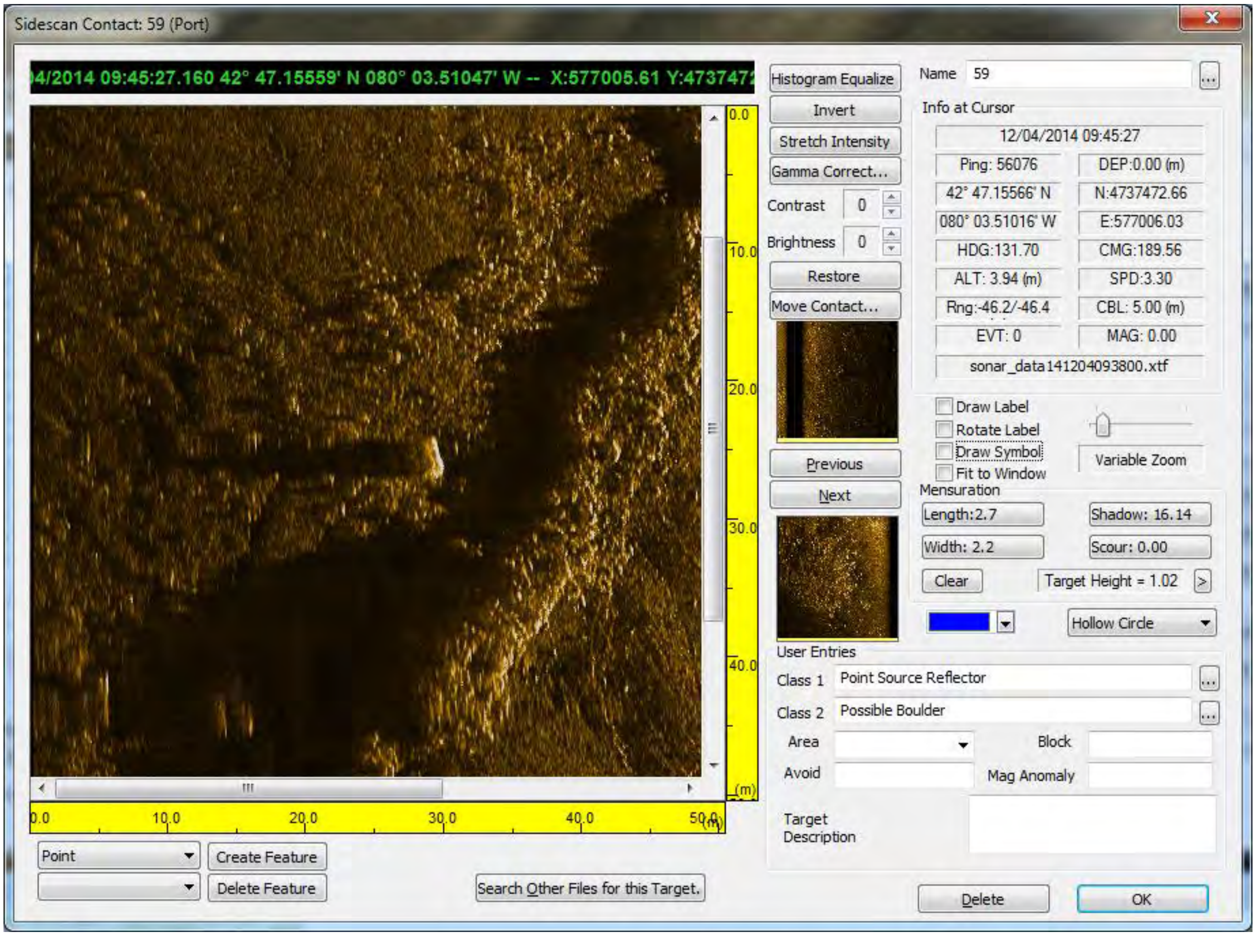
C57- Linear Contact



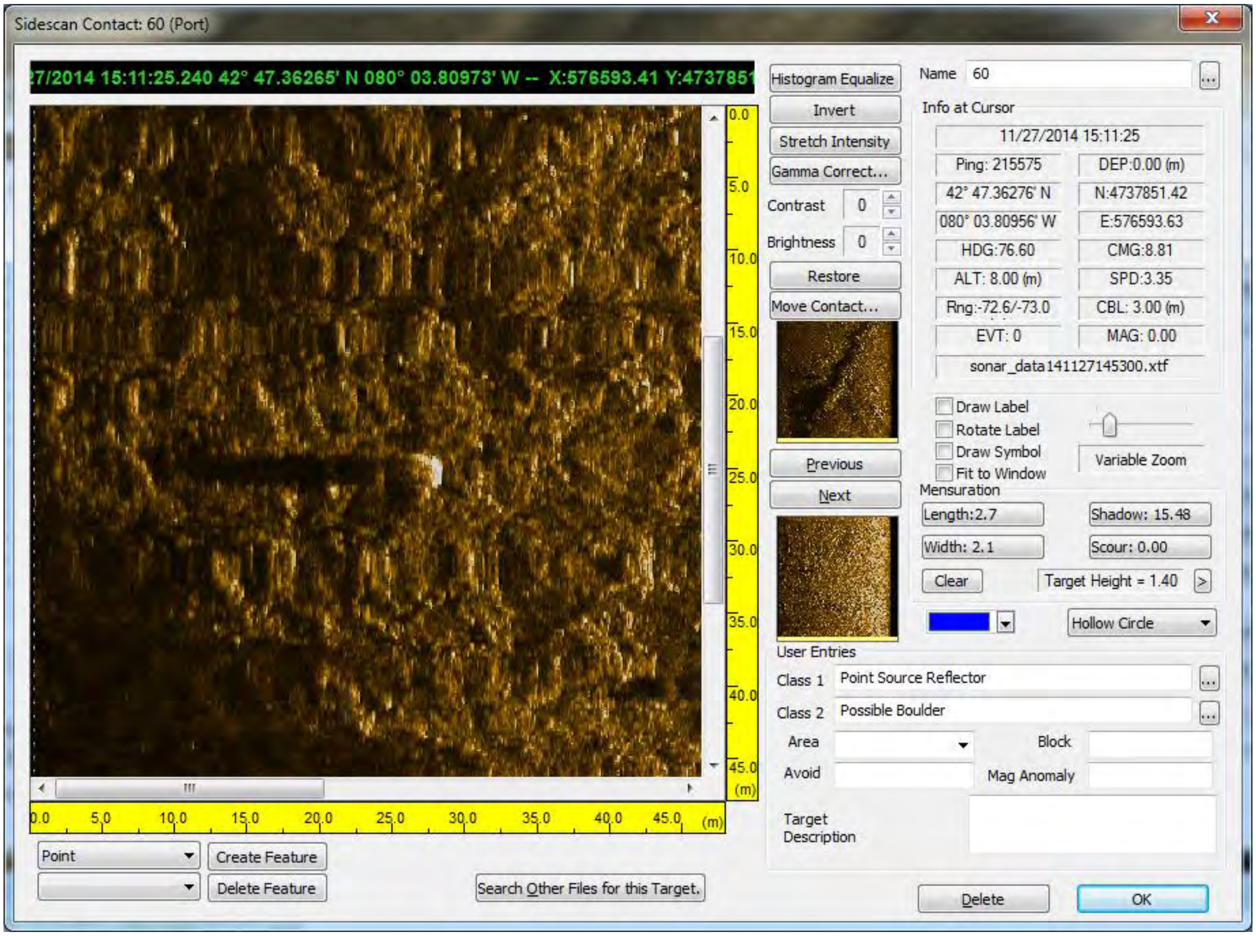
C58- Point Source Reflector (Probable Boulder)



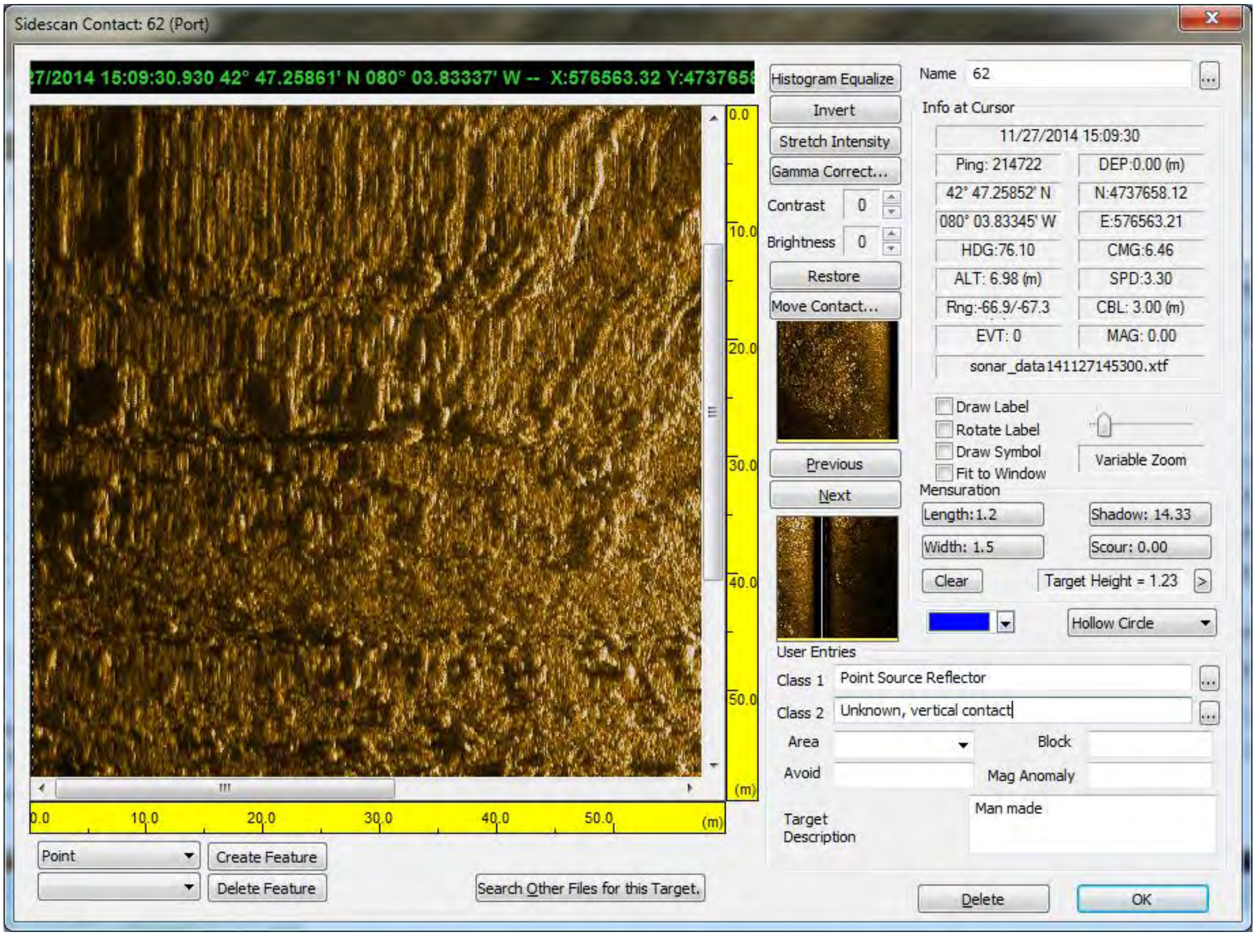
C59- Point Source Reflector (Probable Boulder)



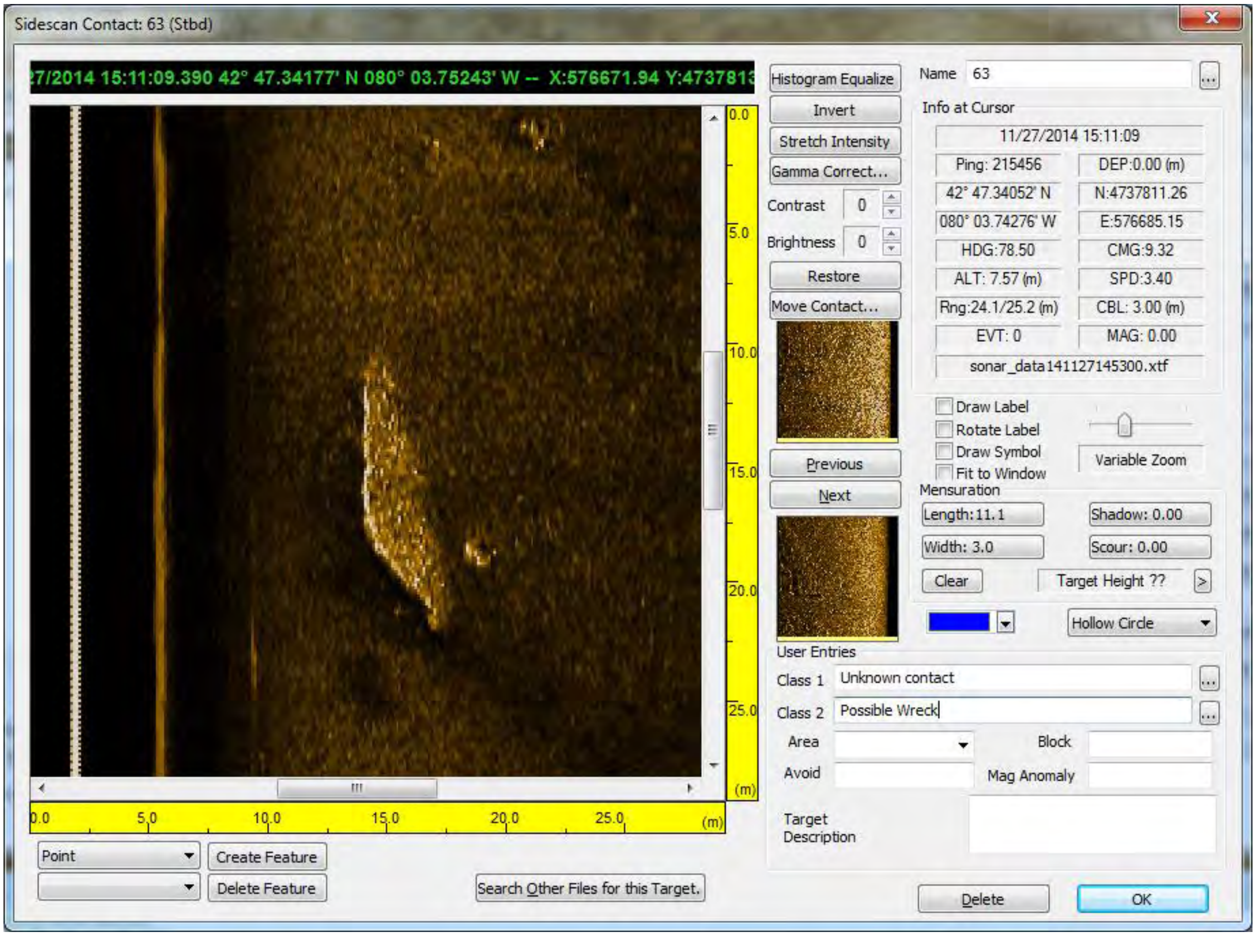
C60- Point Source Reflector (Probable Boulder)



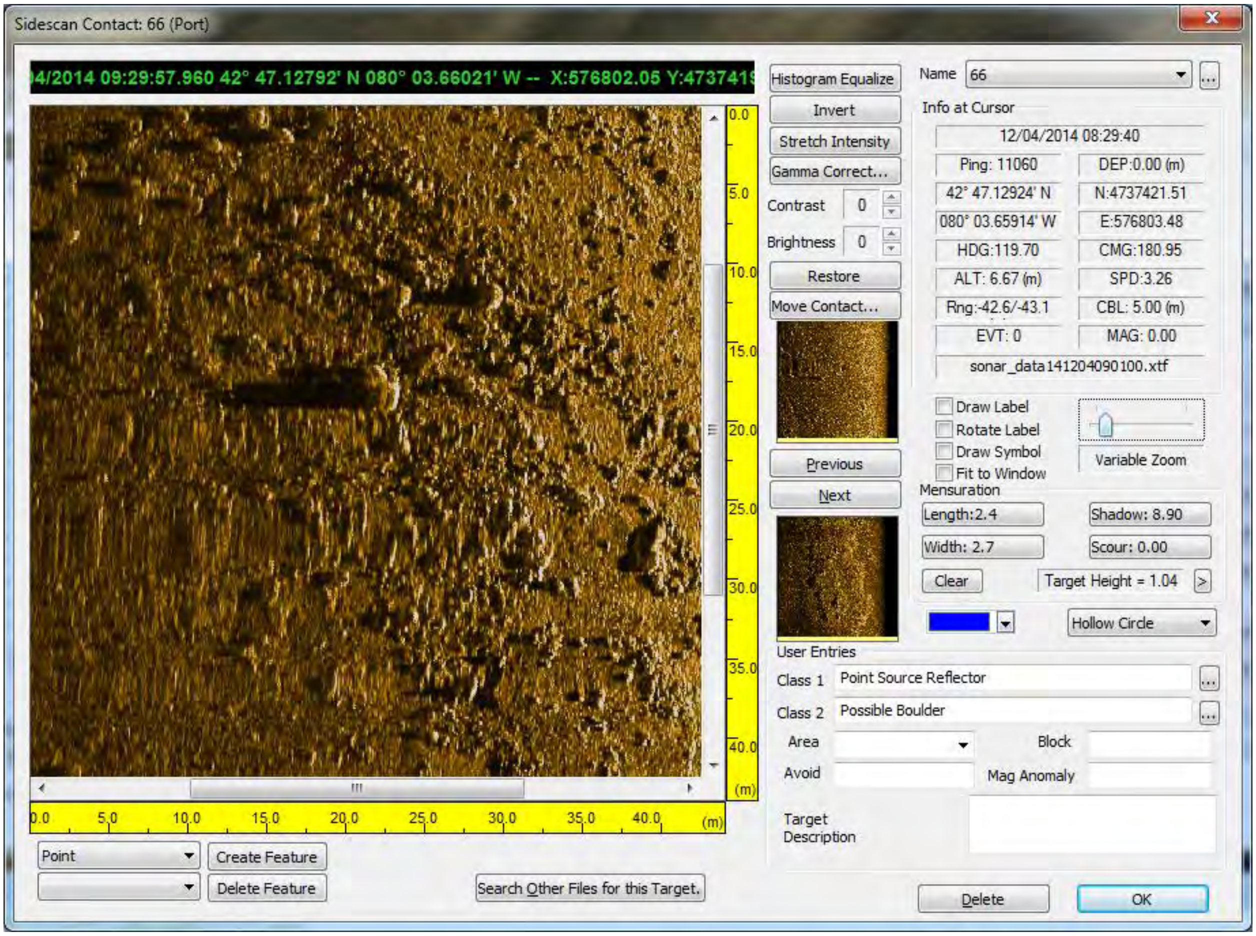
C62- Point Source Reflector (Probable Boulder)



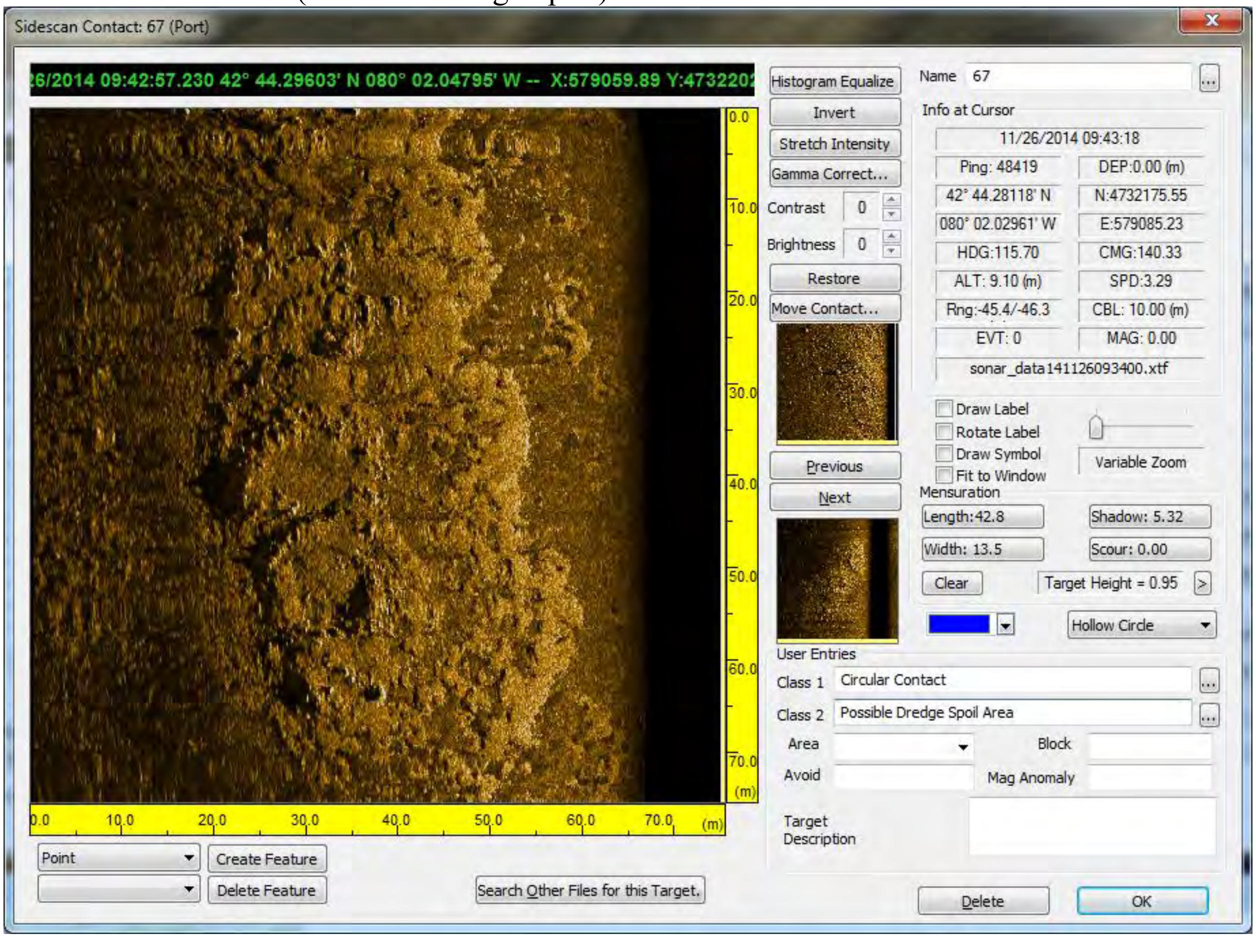
C63- Anthropogenic Contact



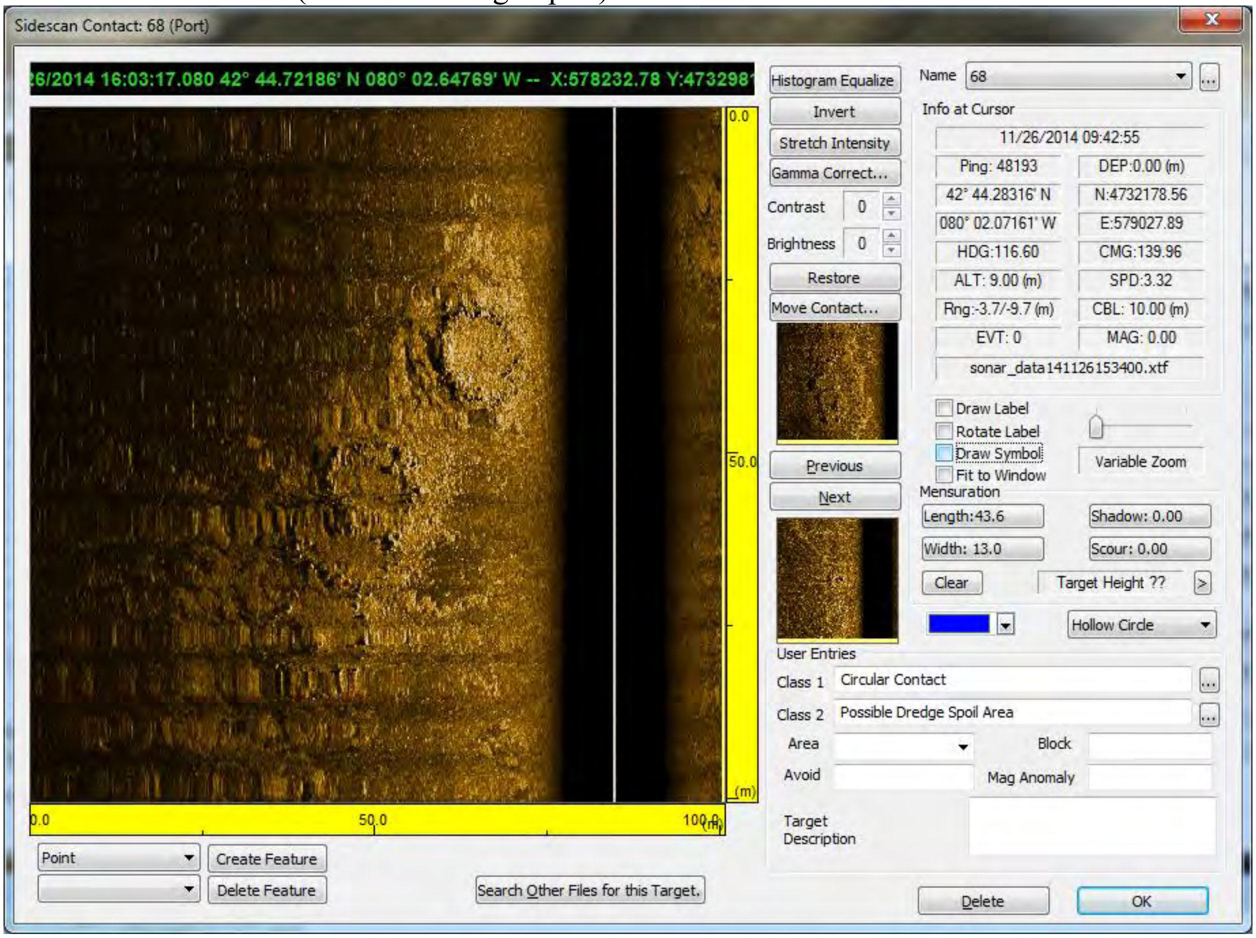
C66- Point Source Reflector (Probable Boulder)



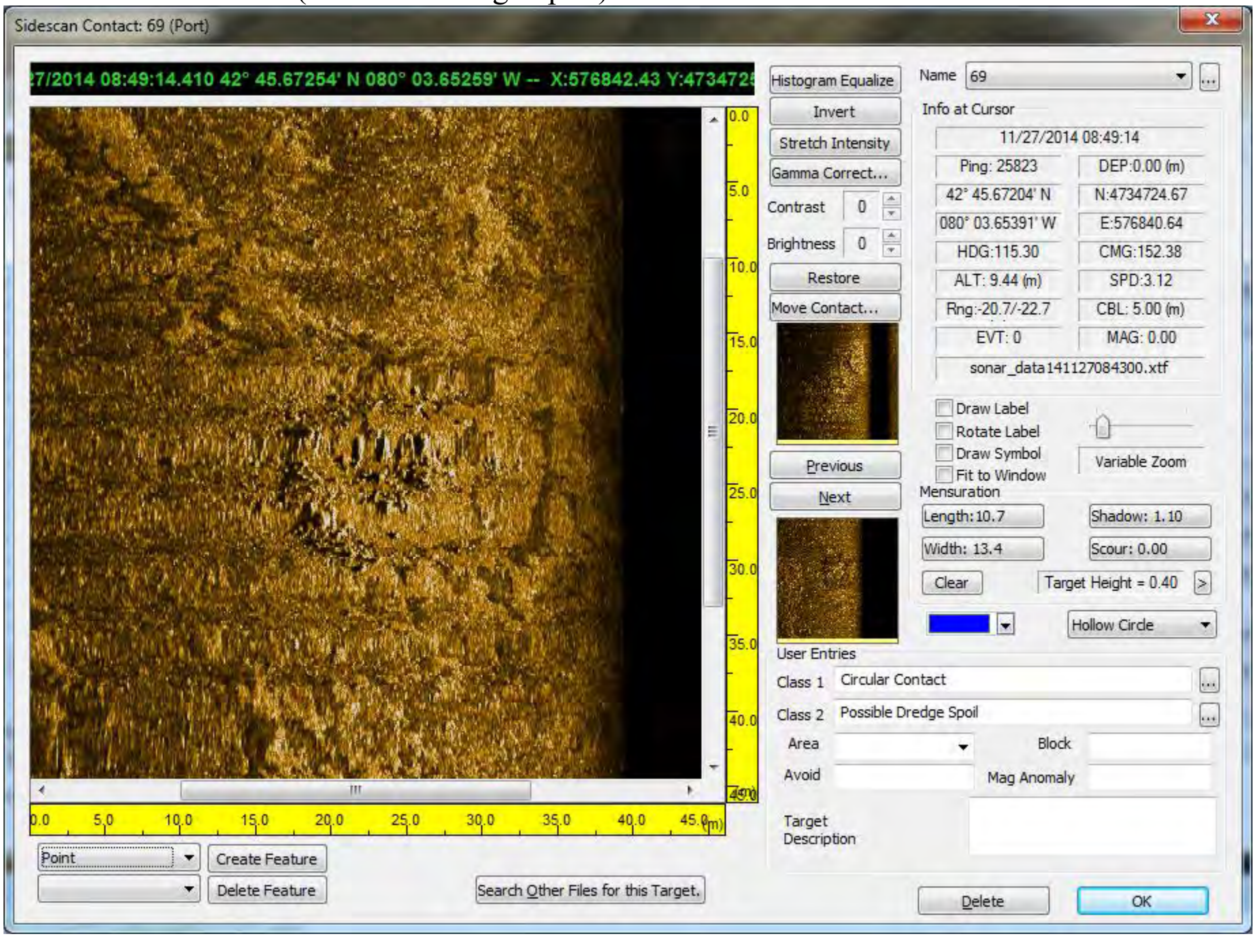
C67- Circular Contact (Probable Dredge Spoil)



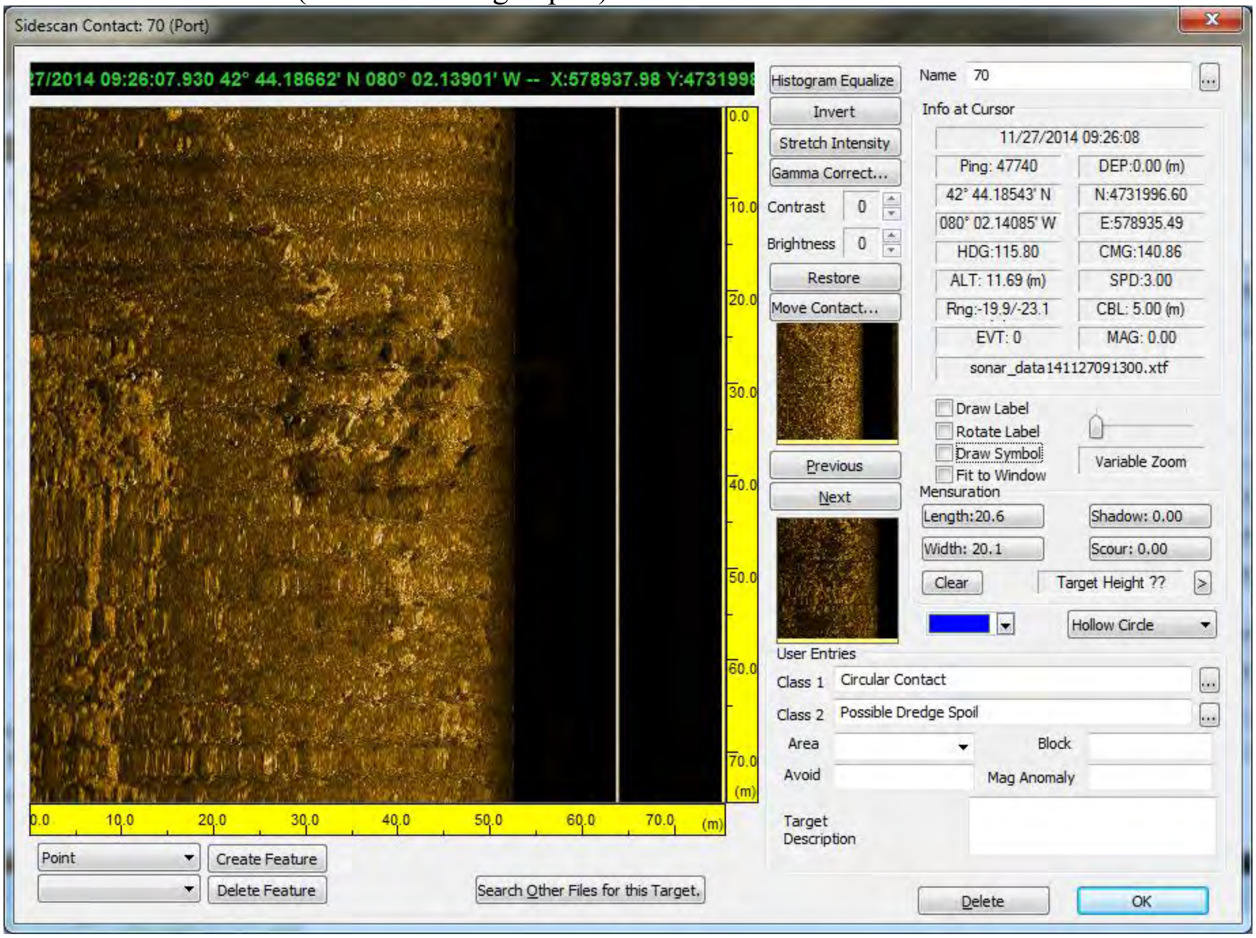
C68- Circular Contact (Probable Dredge Spoil)



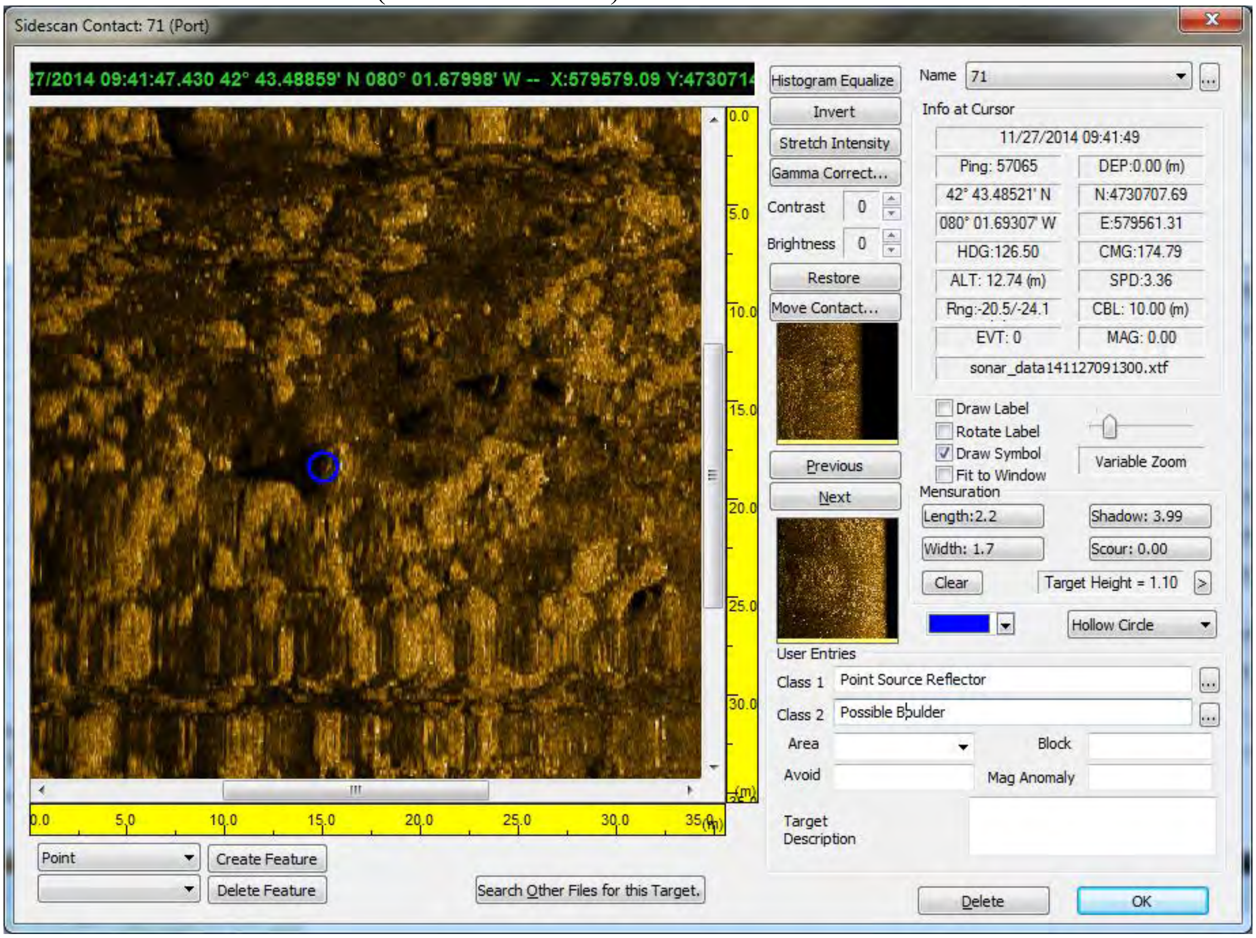
C69- Circular Contact (Probable Dredge Spoil)



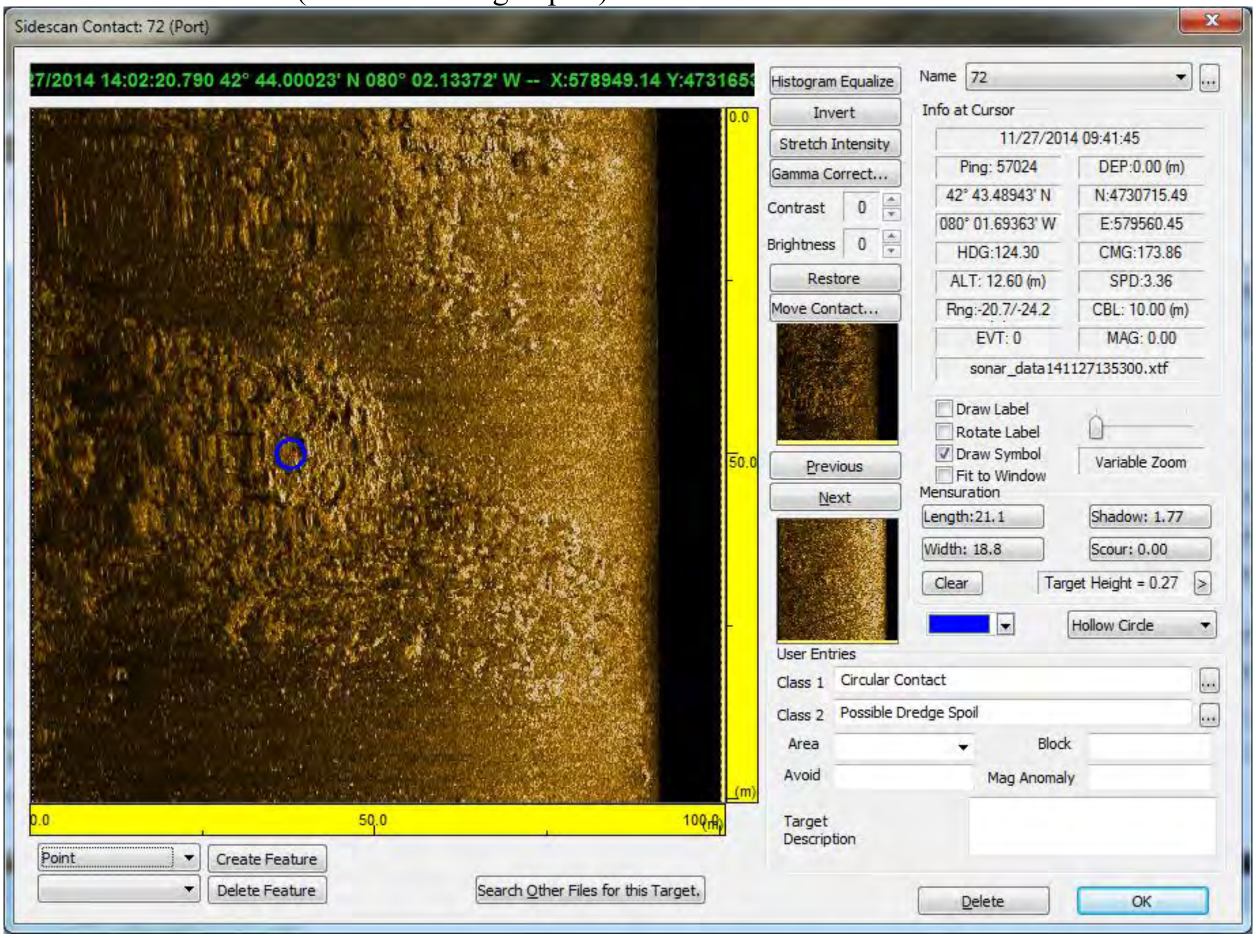
C70- Circular Contact (Probable Dredge Spoil)



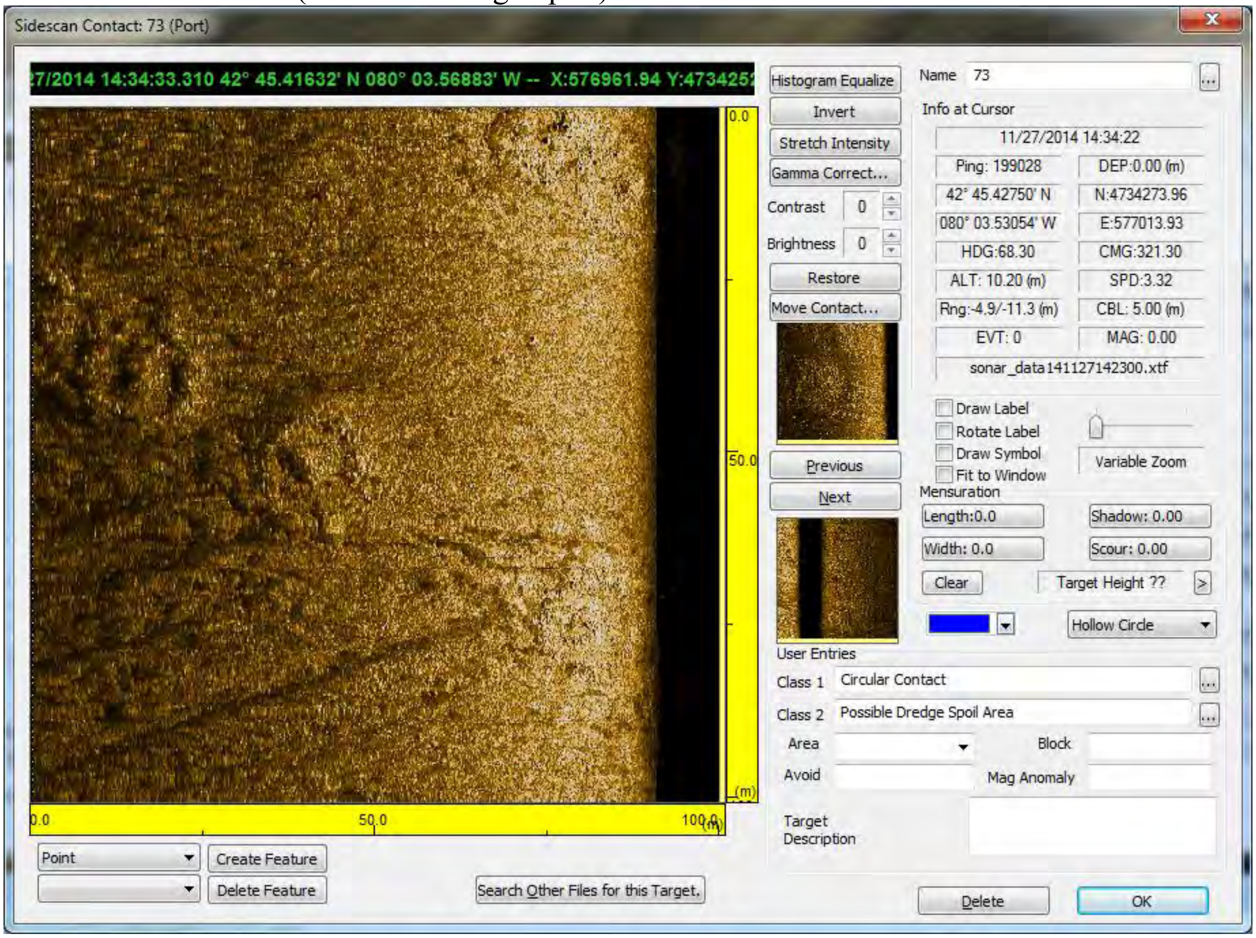
C71- Point Source Reflector (Probable Boulder)



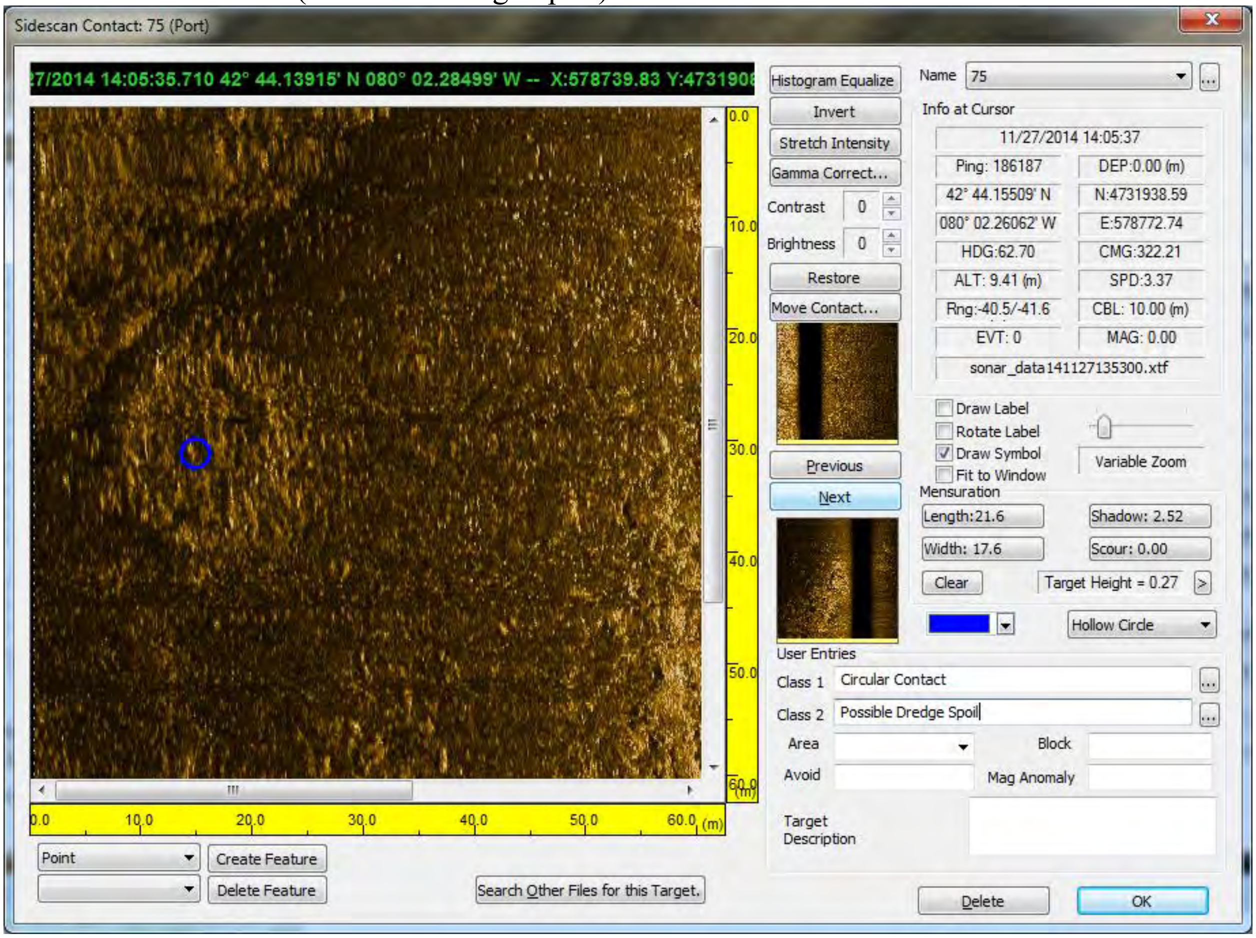
C72- Circular Contact (Probable Dredge Spoil)



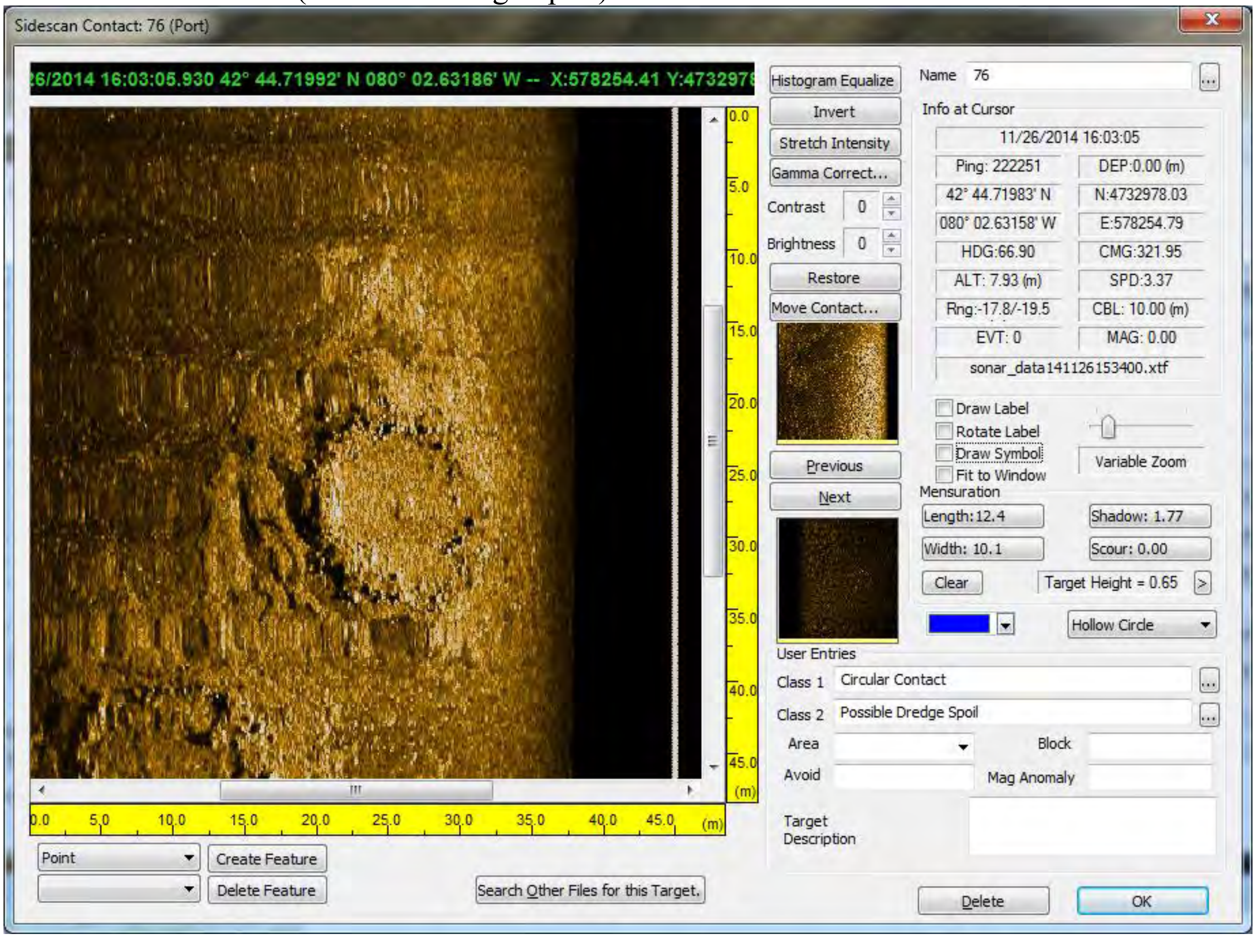
C73- Circular Contact (Probable Dredge Spoil)



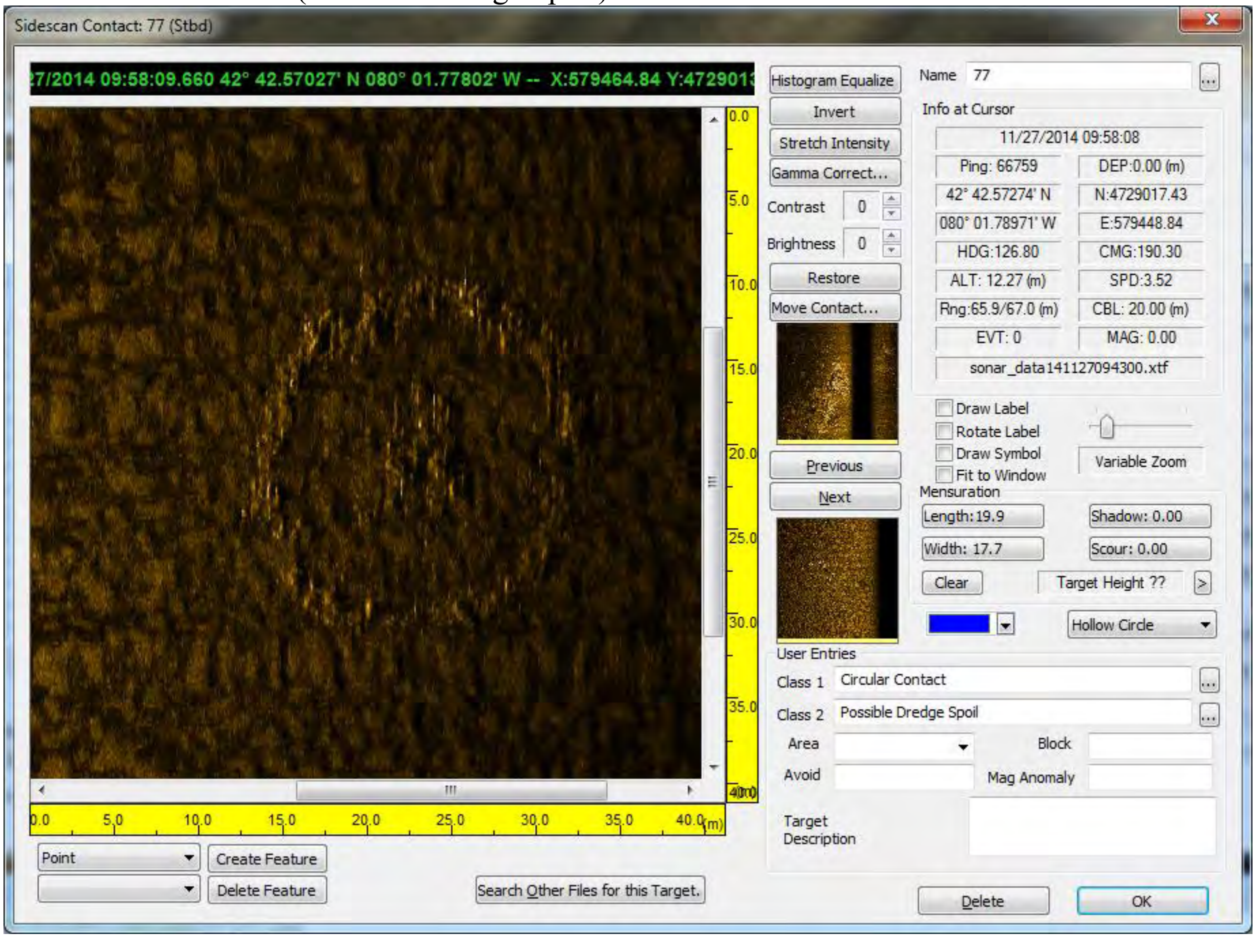
C75- Circular Contact (Probable Dredge Spoil)



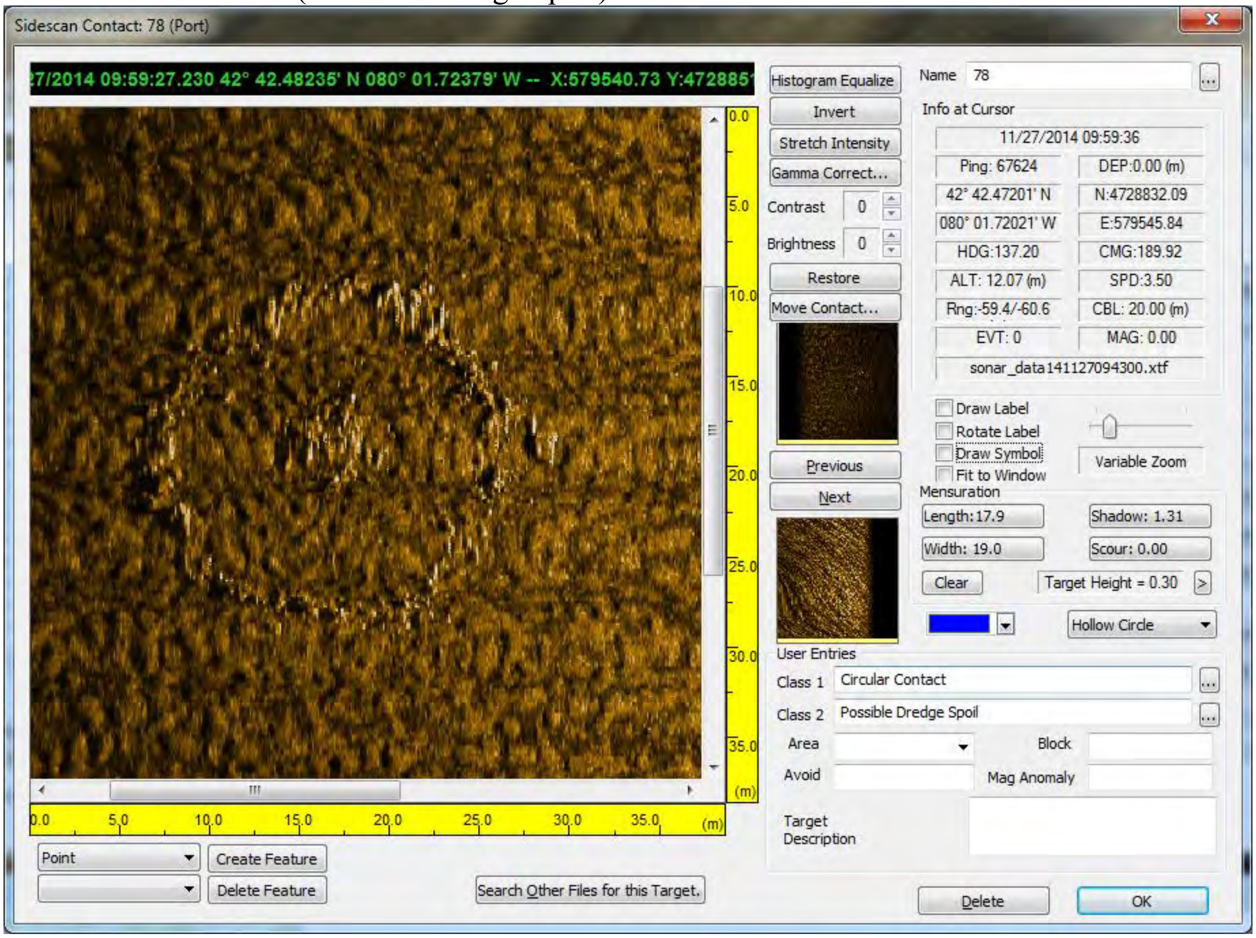
C76- Circular Contact (Probable Dredge Spoil)



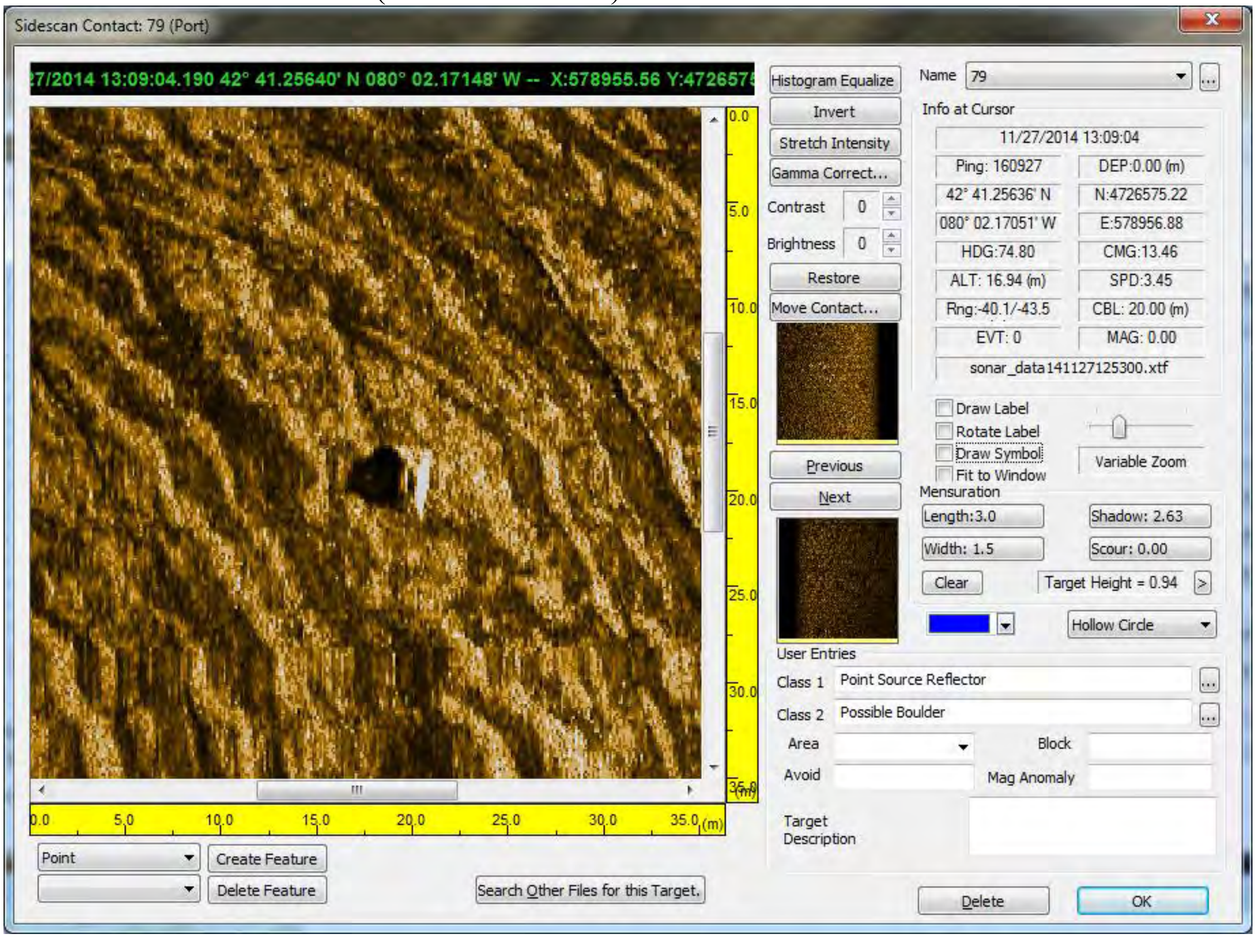
C77- Circular Contact (Probable Dredge Spoil)



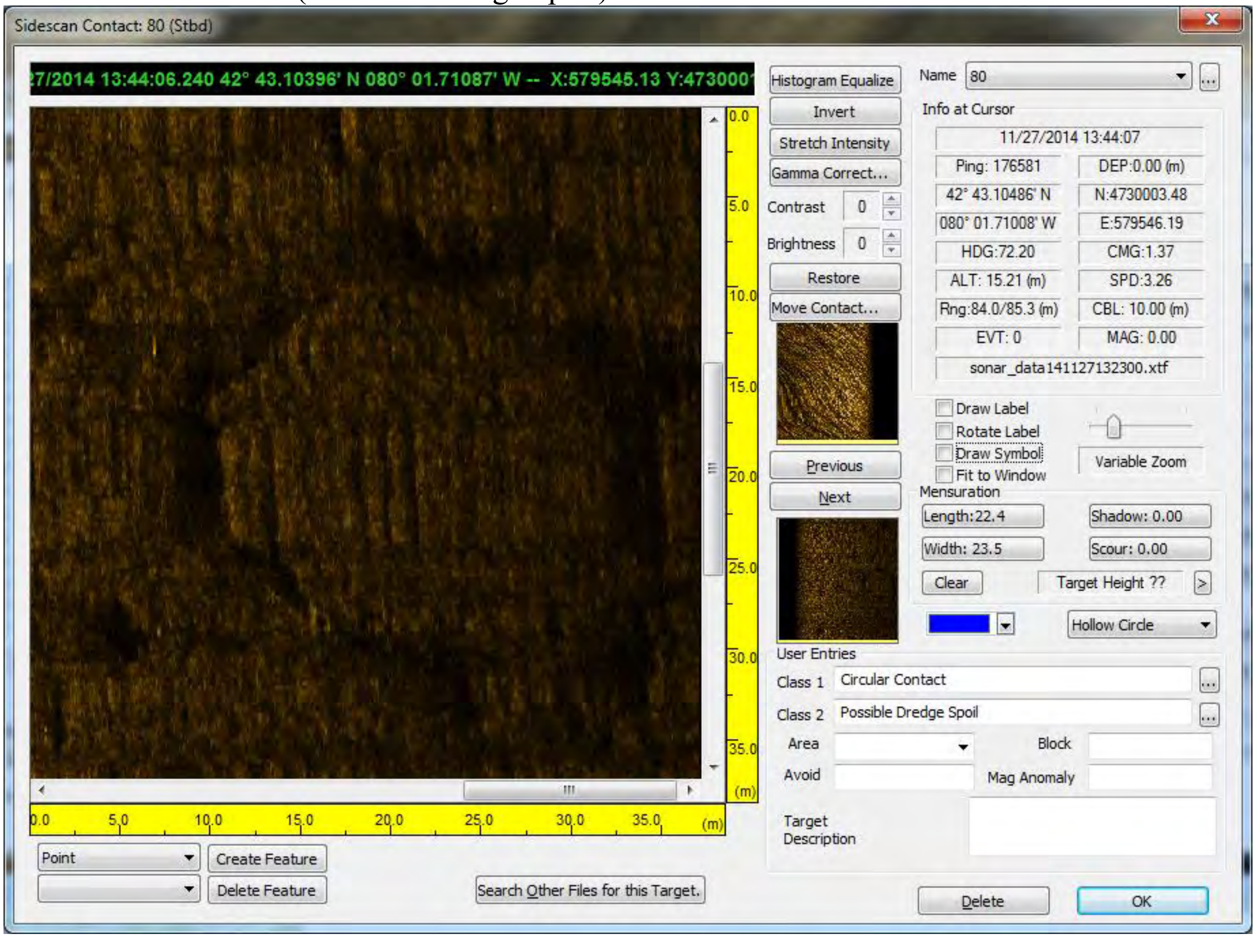
C78- Circular Contact (Probable Dredge Spoil)



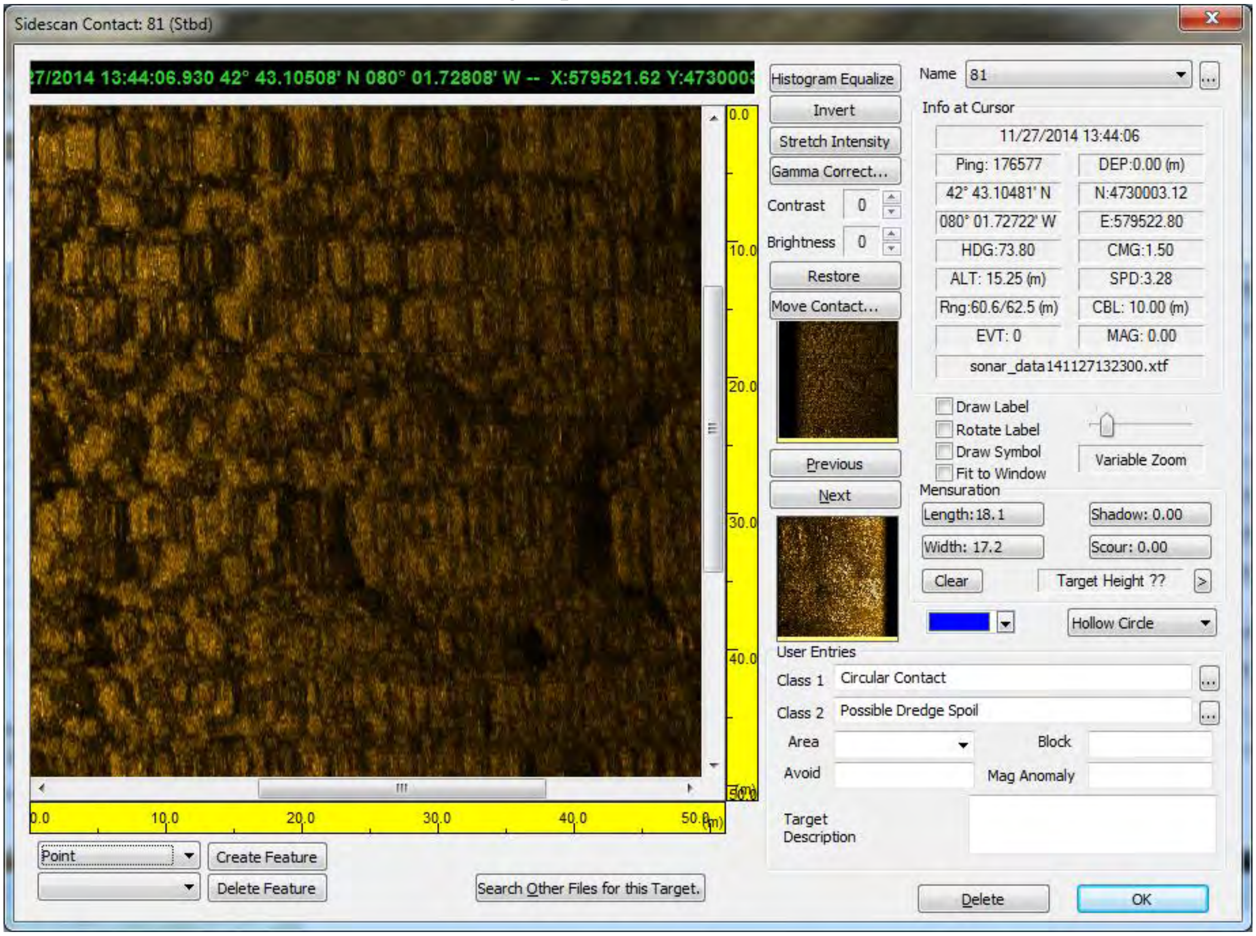
C79- Point Source Reflector (Probable Boulder)



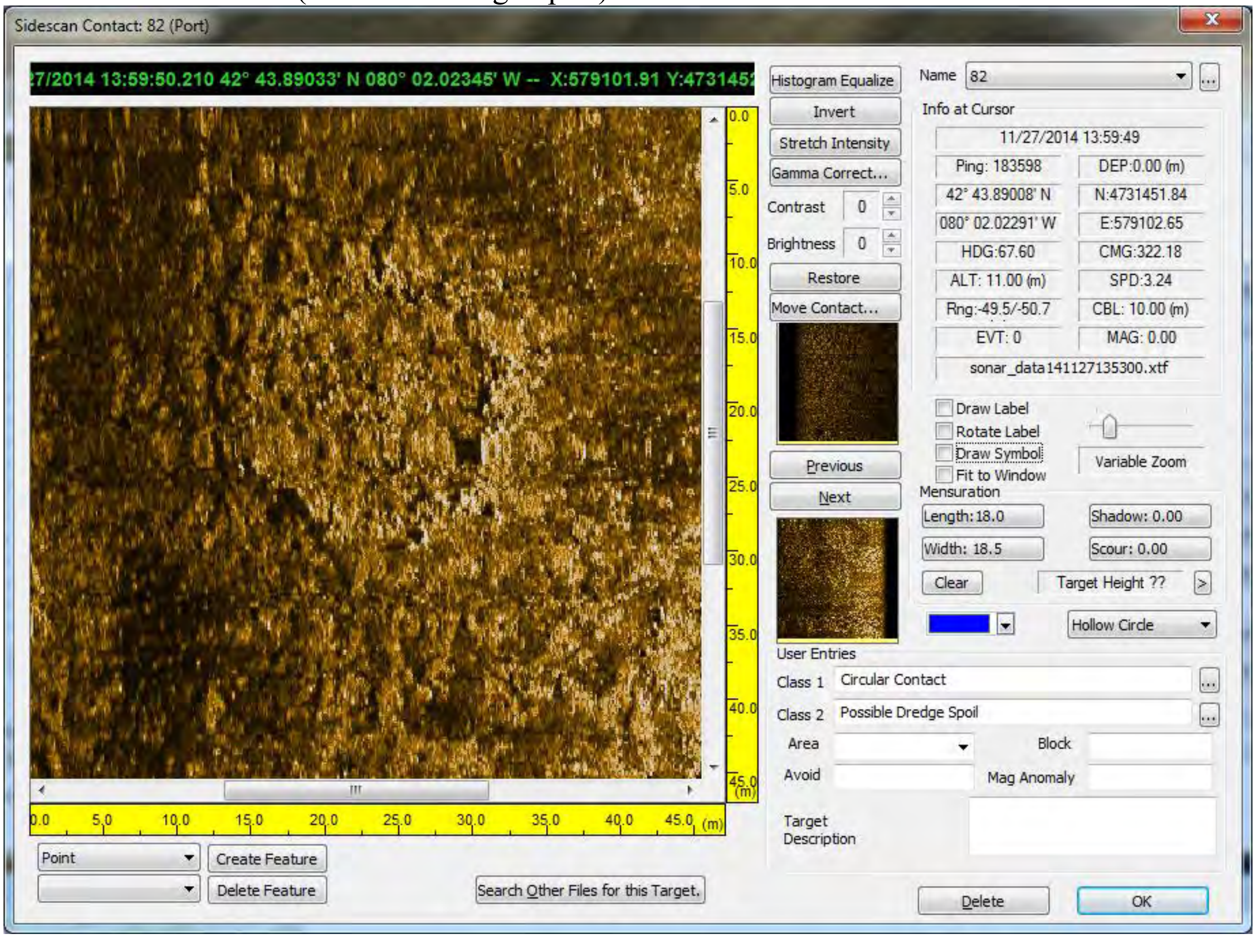
C80- Circular Contact (Probable Dredge Spoil)



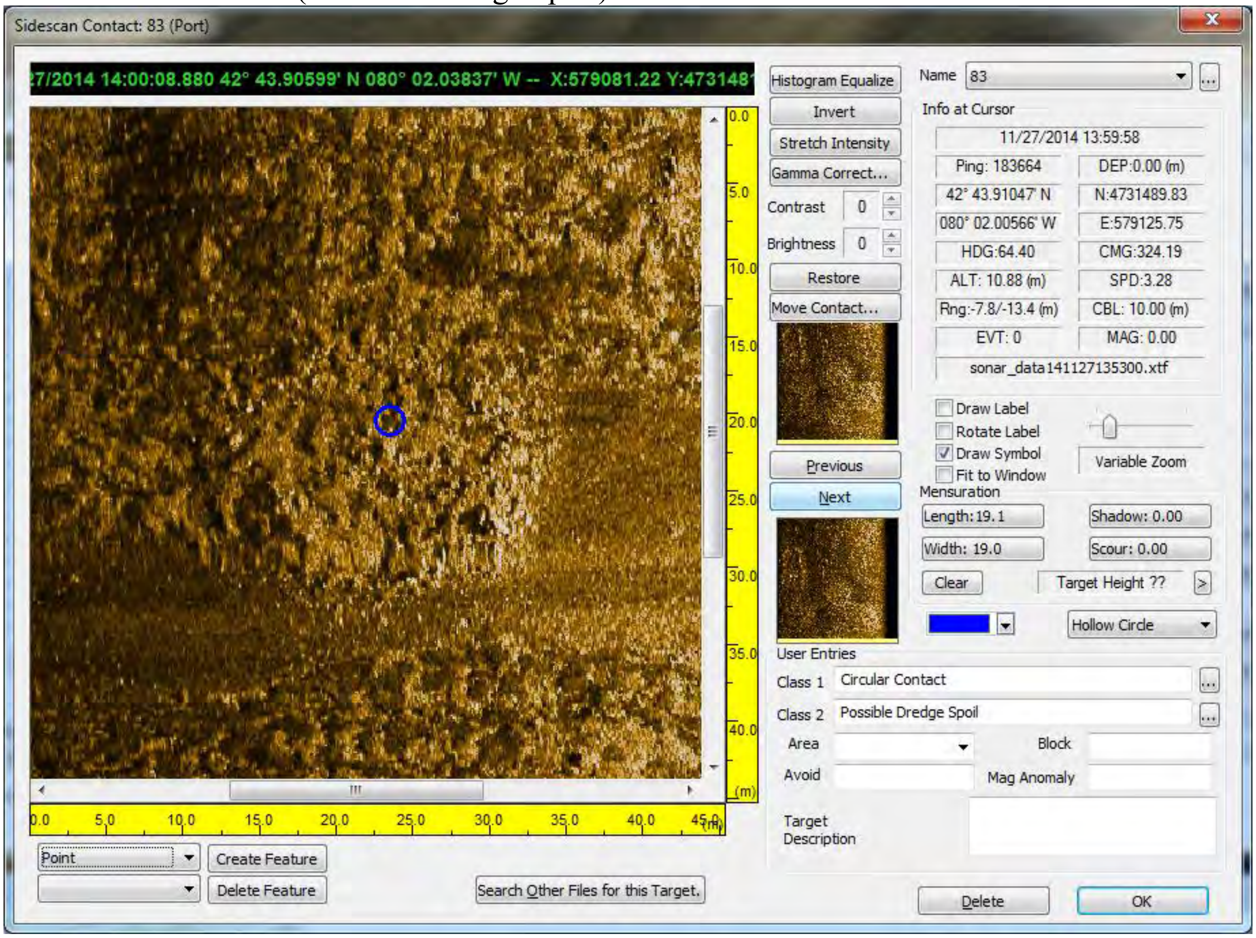
C81- Circular Contact (Probable Dredge Spoil)



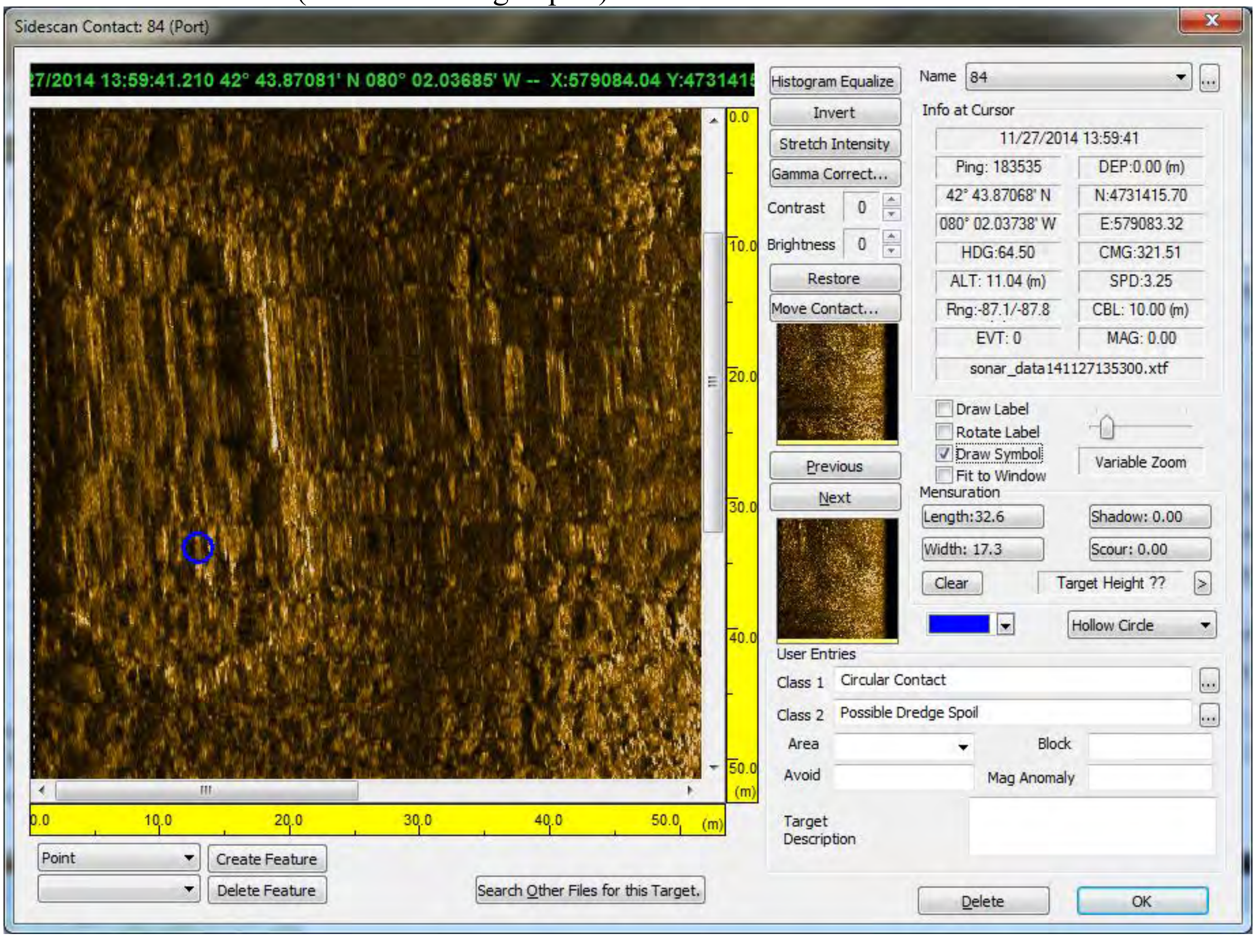
C82- Circular Contact (Probable Dredge Spoil)



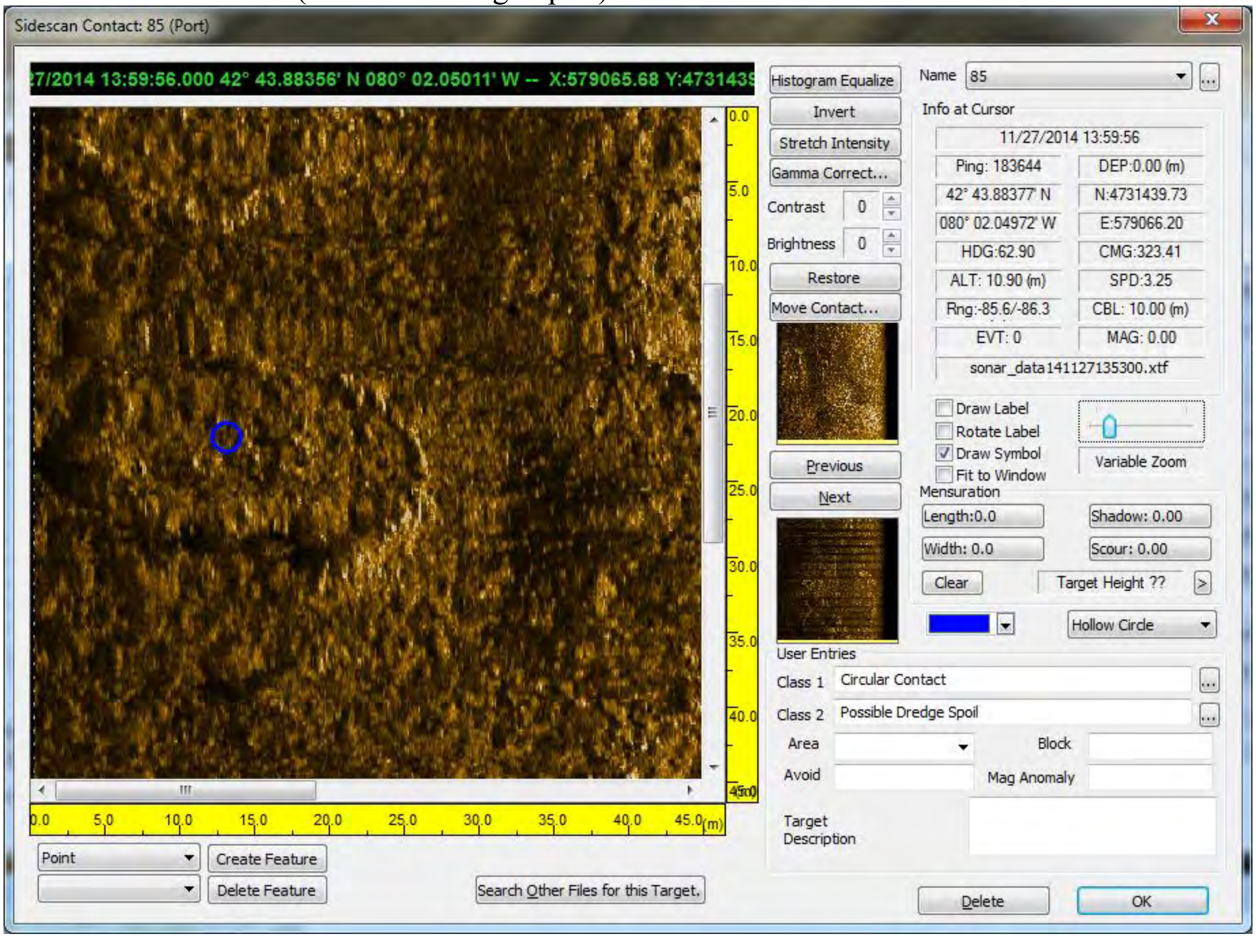
C83- Circular Contact (Probable Dredge Spoil)



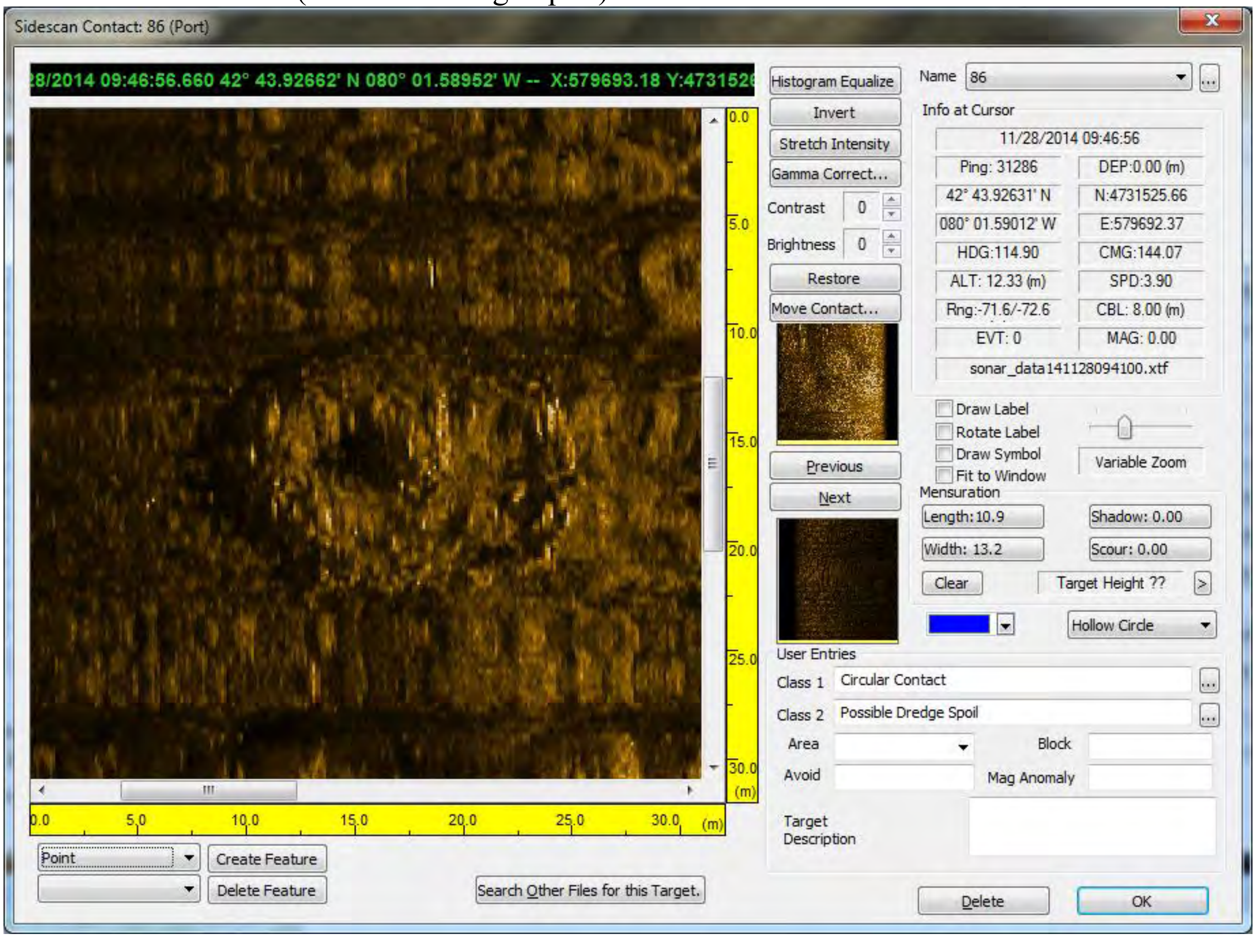
C84- Circular Contact (Probable Dredge Spoil)



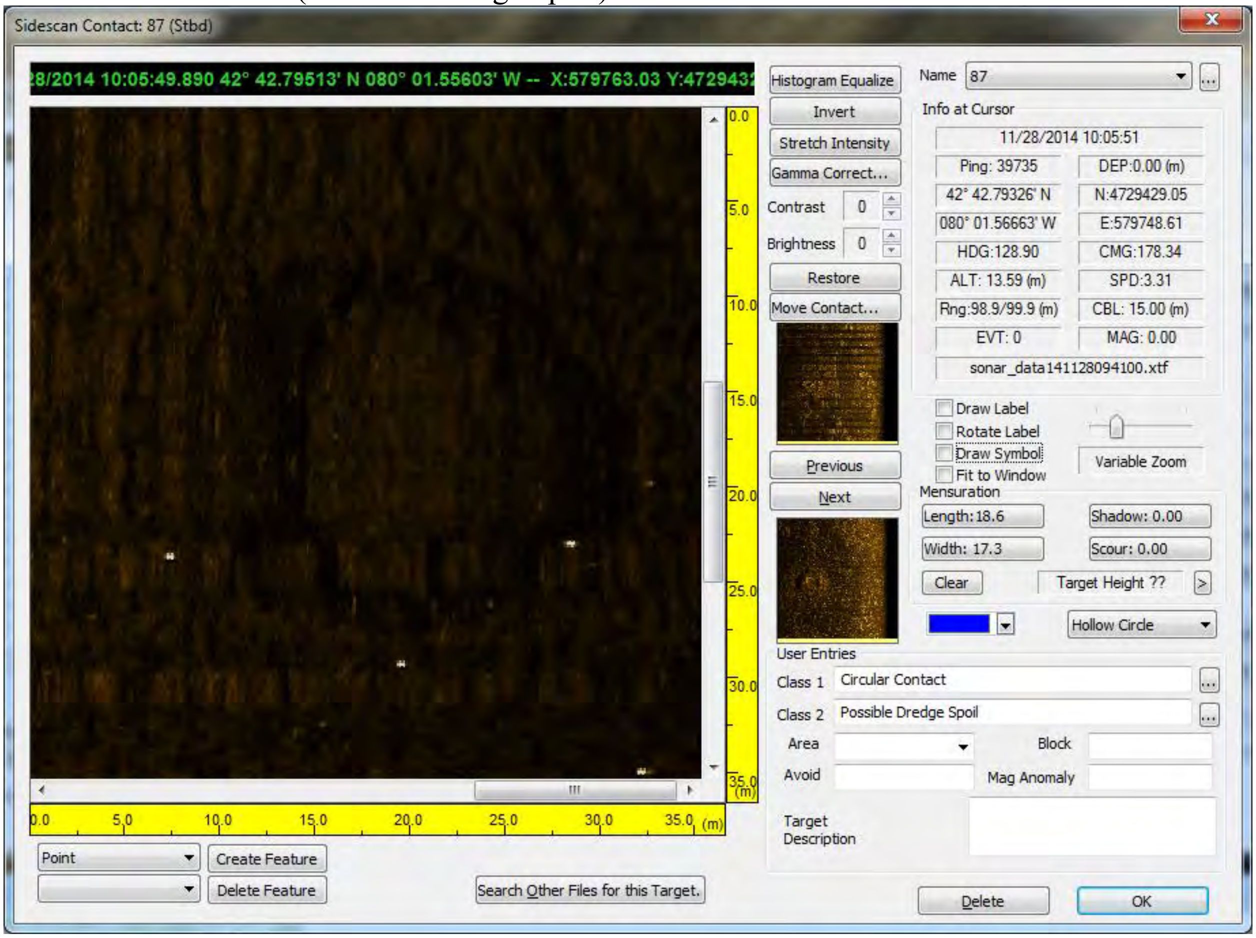
C85- Circular Contact (Probable Dredge Spoil)



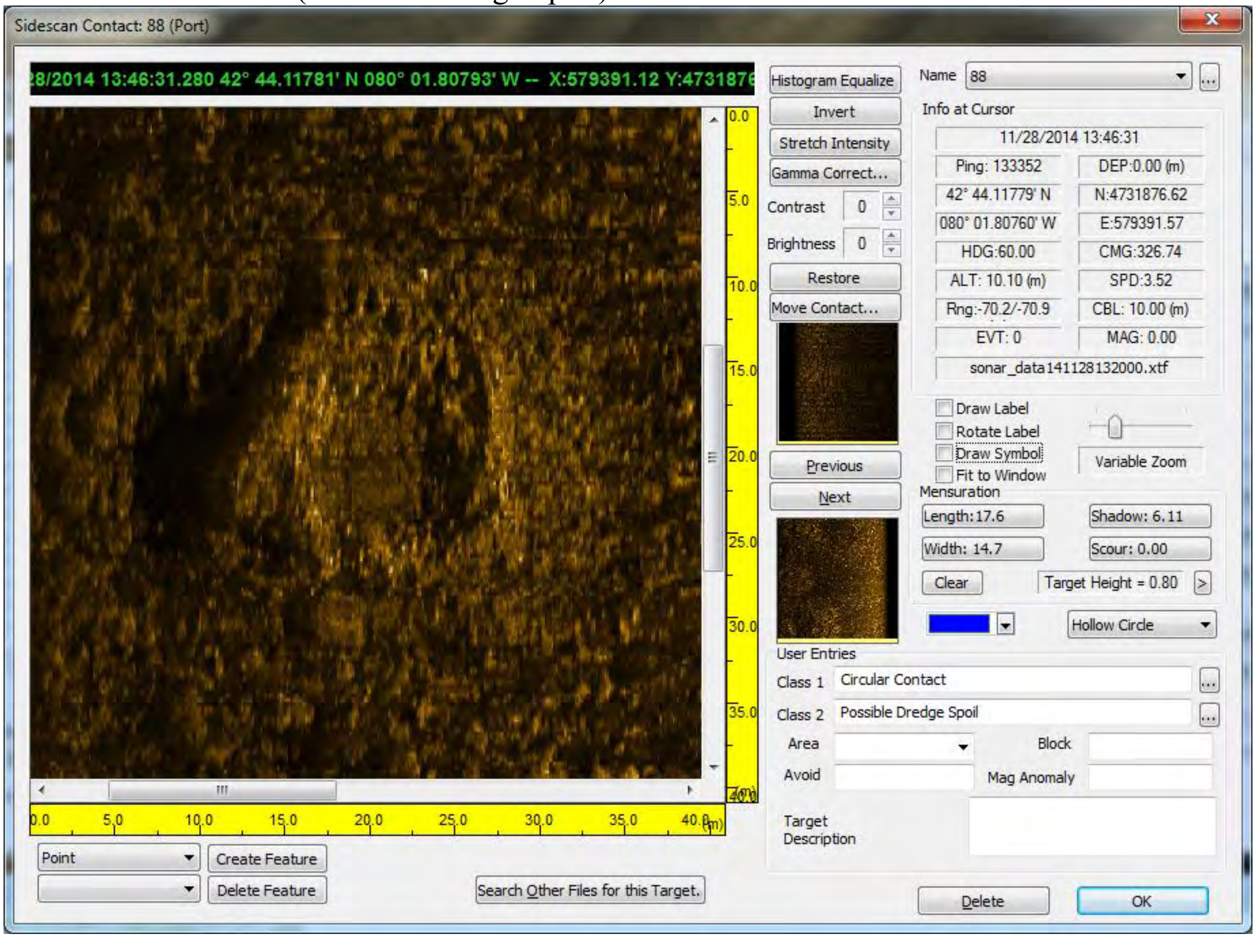
C86- Circular Contact (Probable Dredge Spoil)



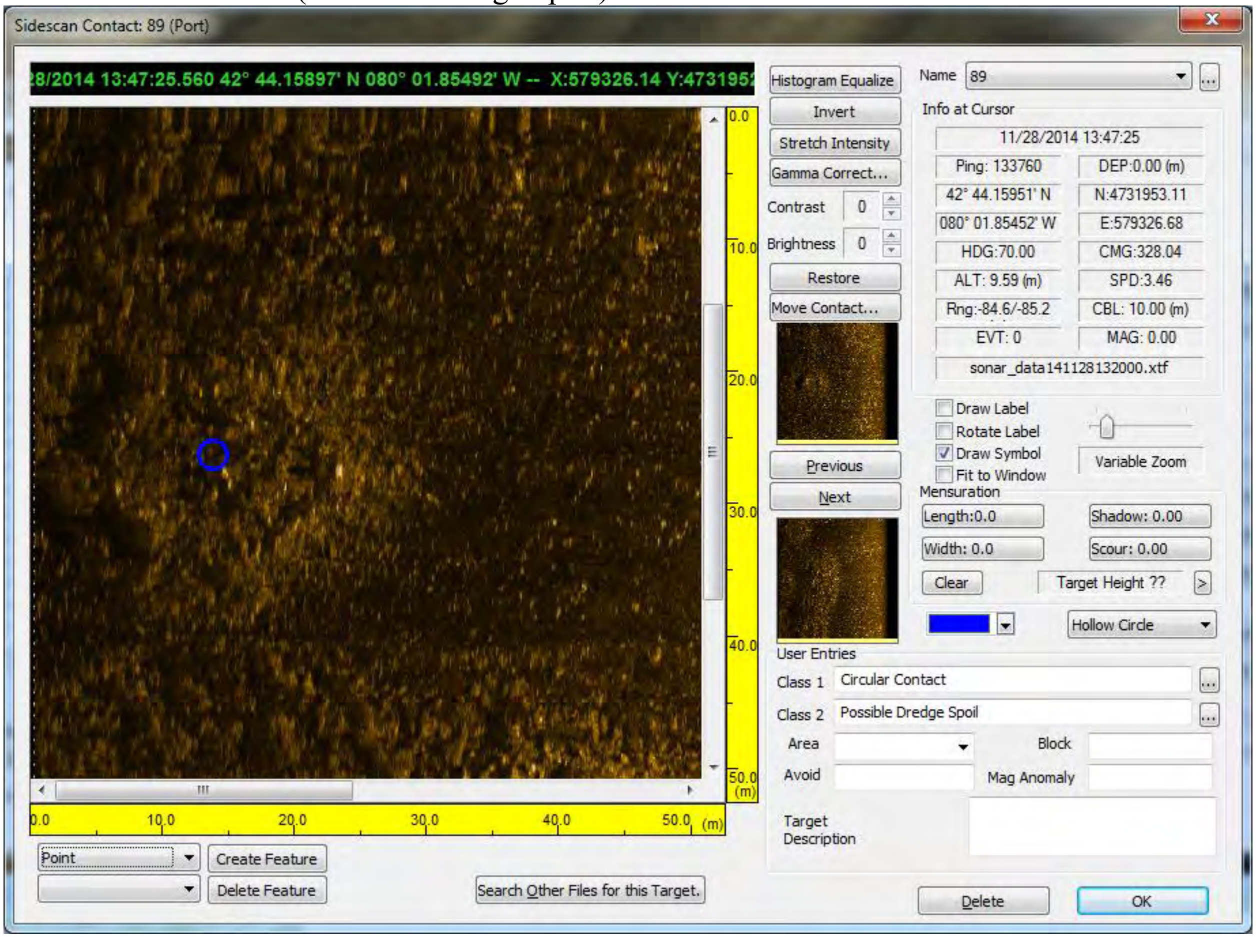
C87- Circular Contact (Probable Dredge Spoil)



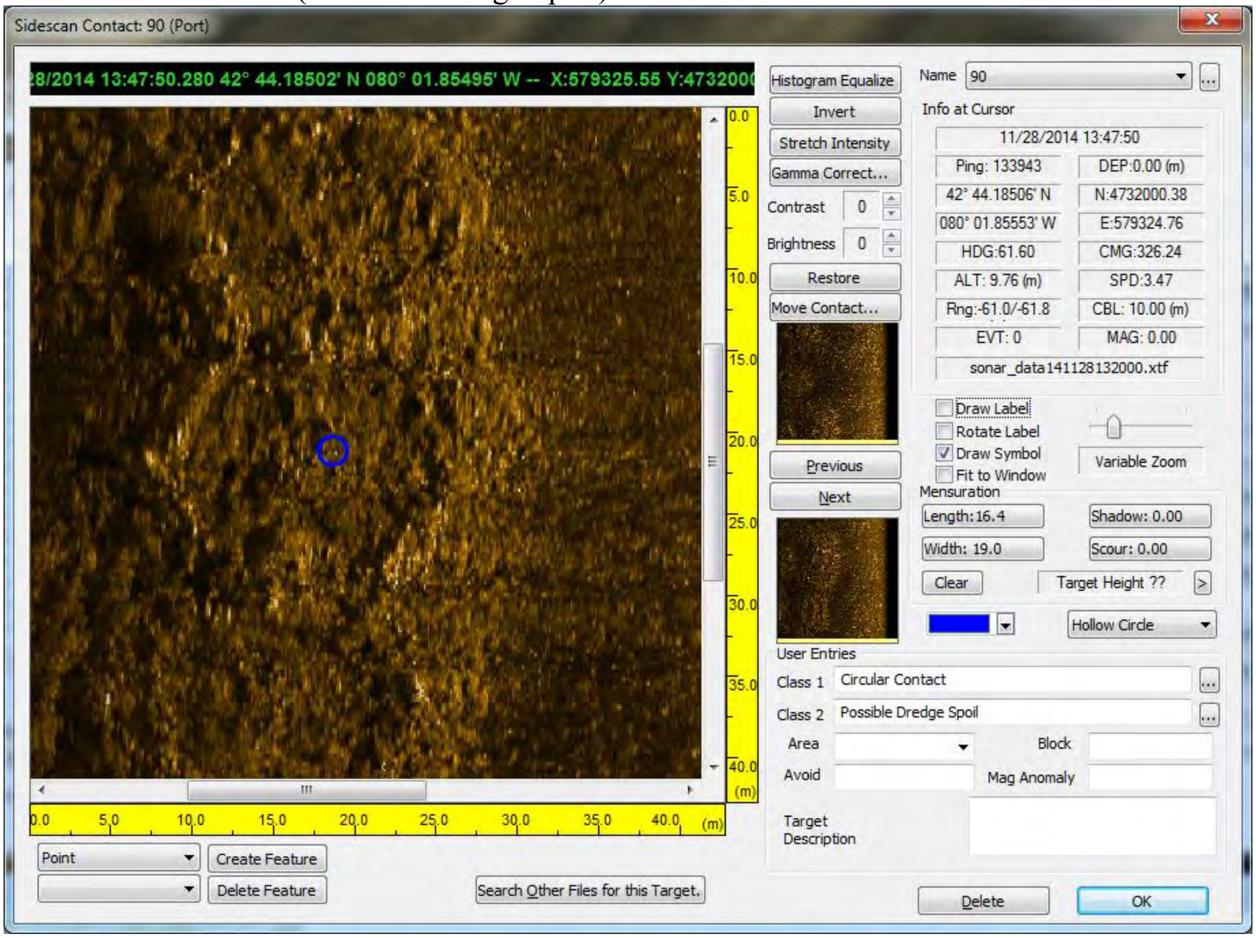
C88- Circular Contact (Probable Dredge Spoil)



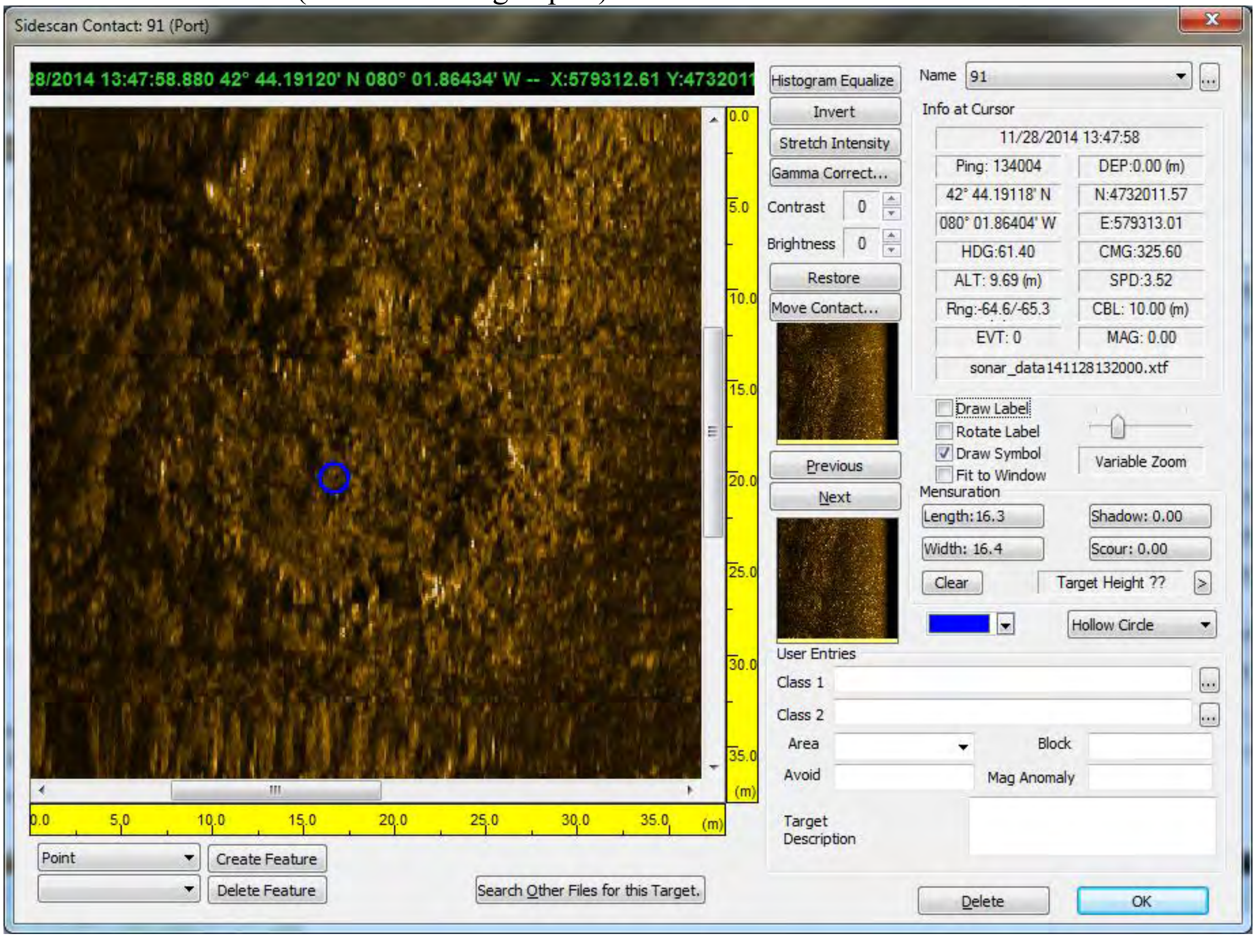
C89- Circular Contact (Probable Dredge Spoil)



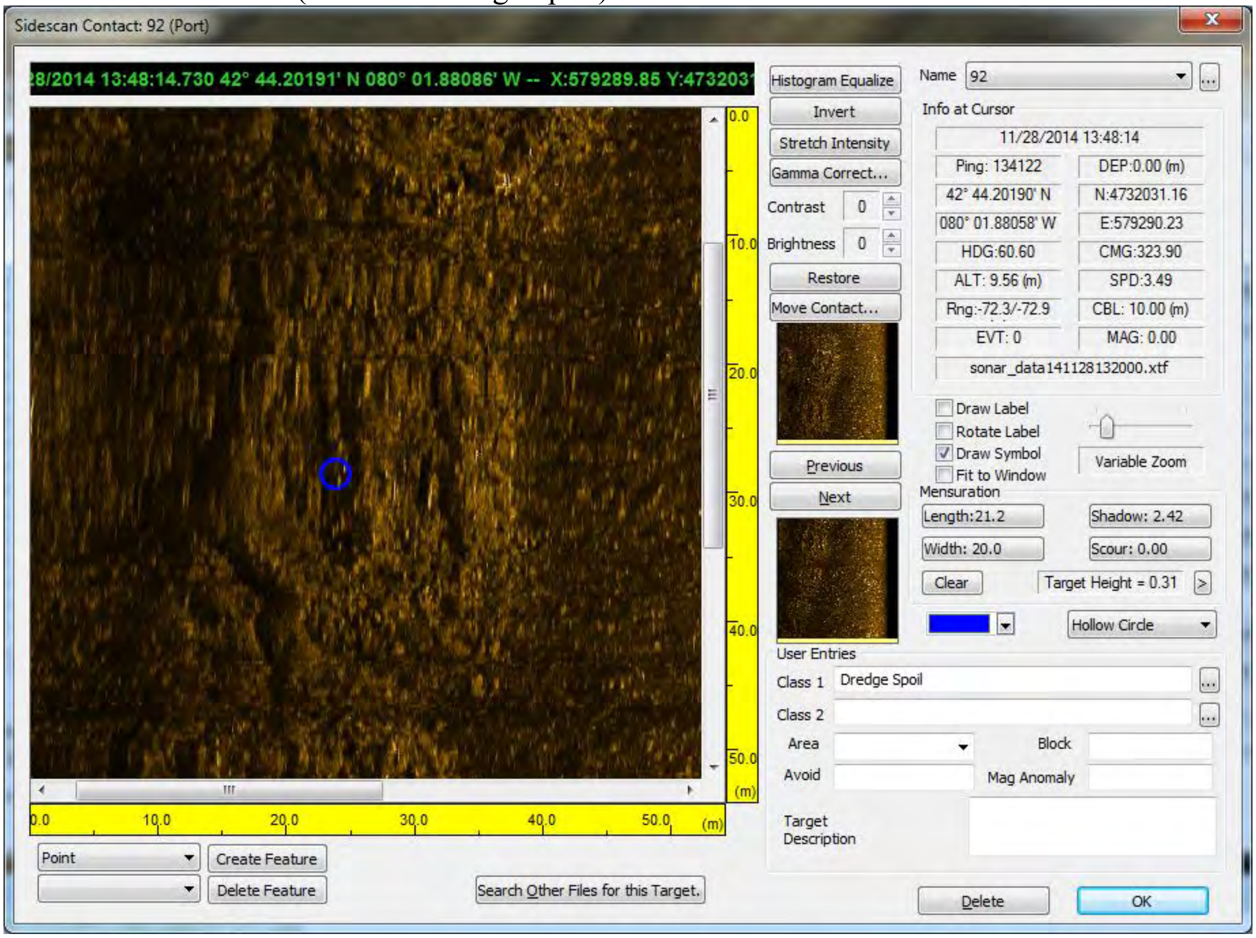
C90- Circular Contact (Probable Dredge Spoil)



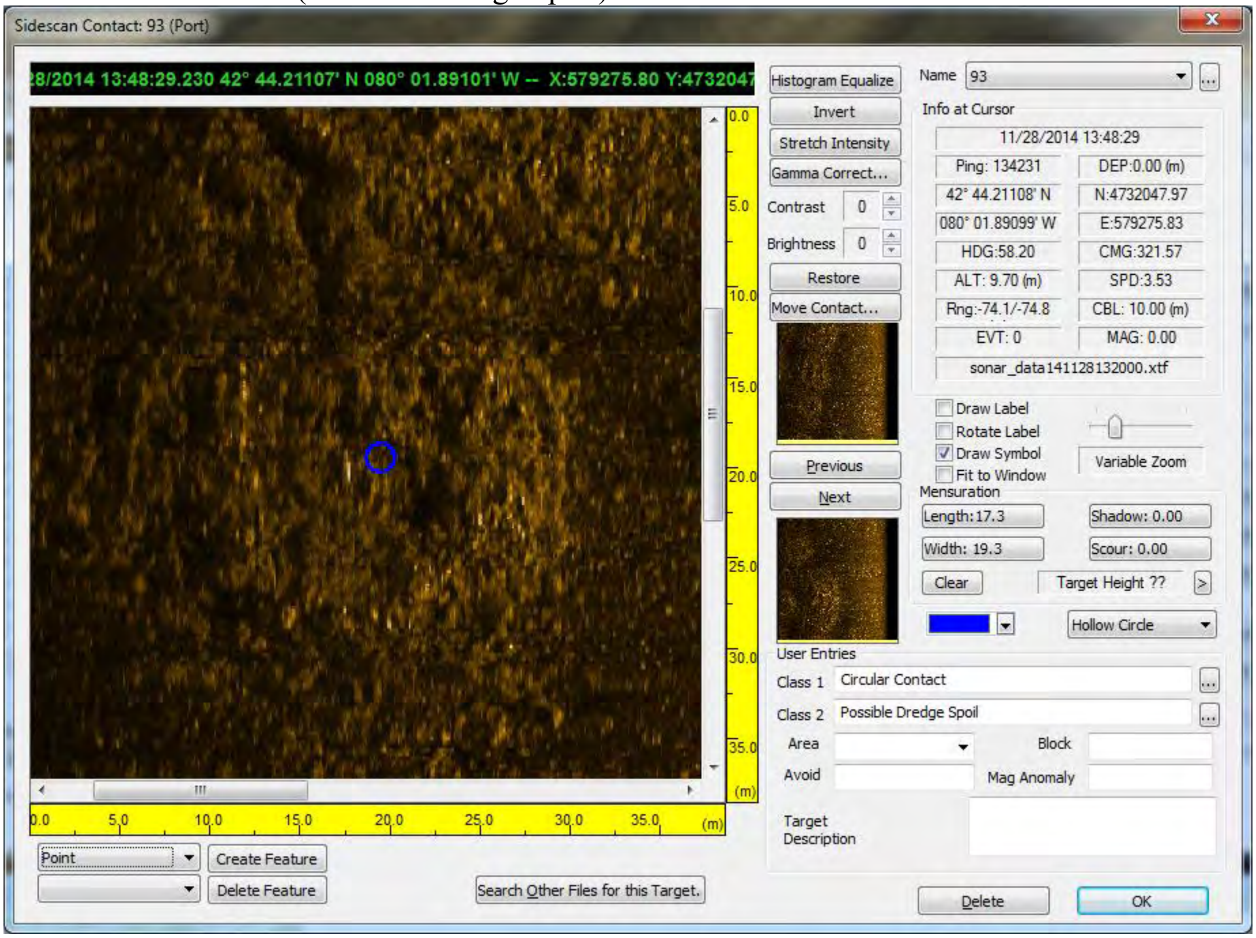
C91- Circular Contact (Probable Dredge Spoil)



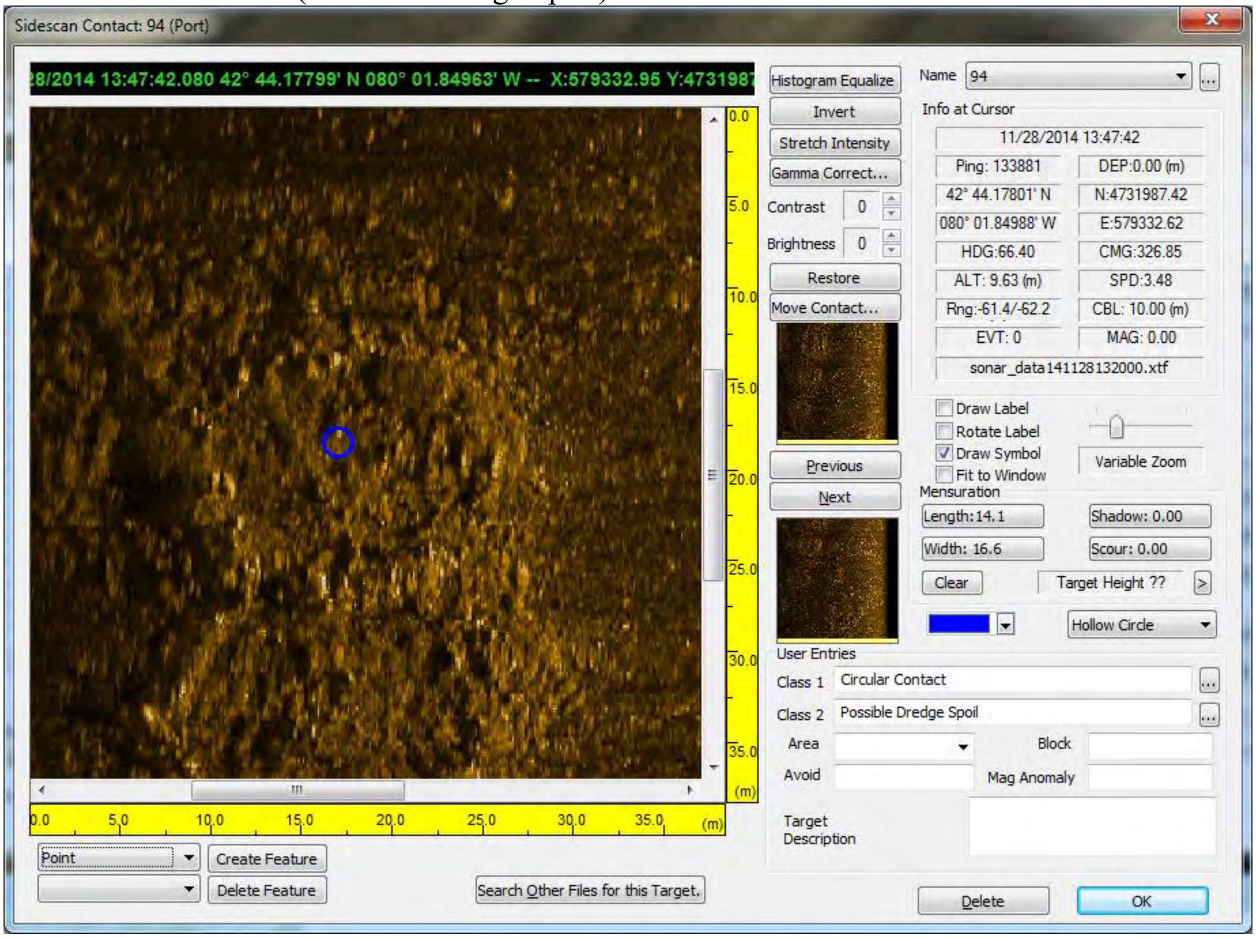
C92- Circular Contact (Probable Dredge Spoil)



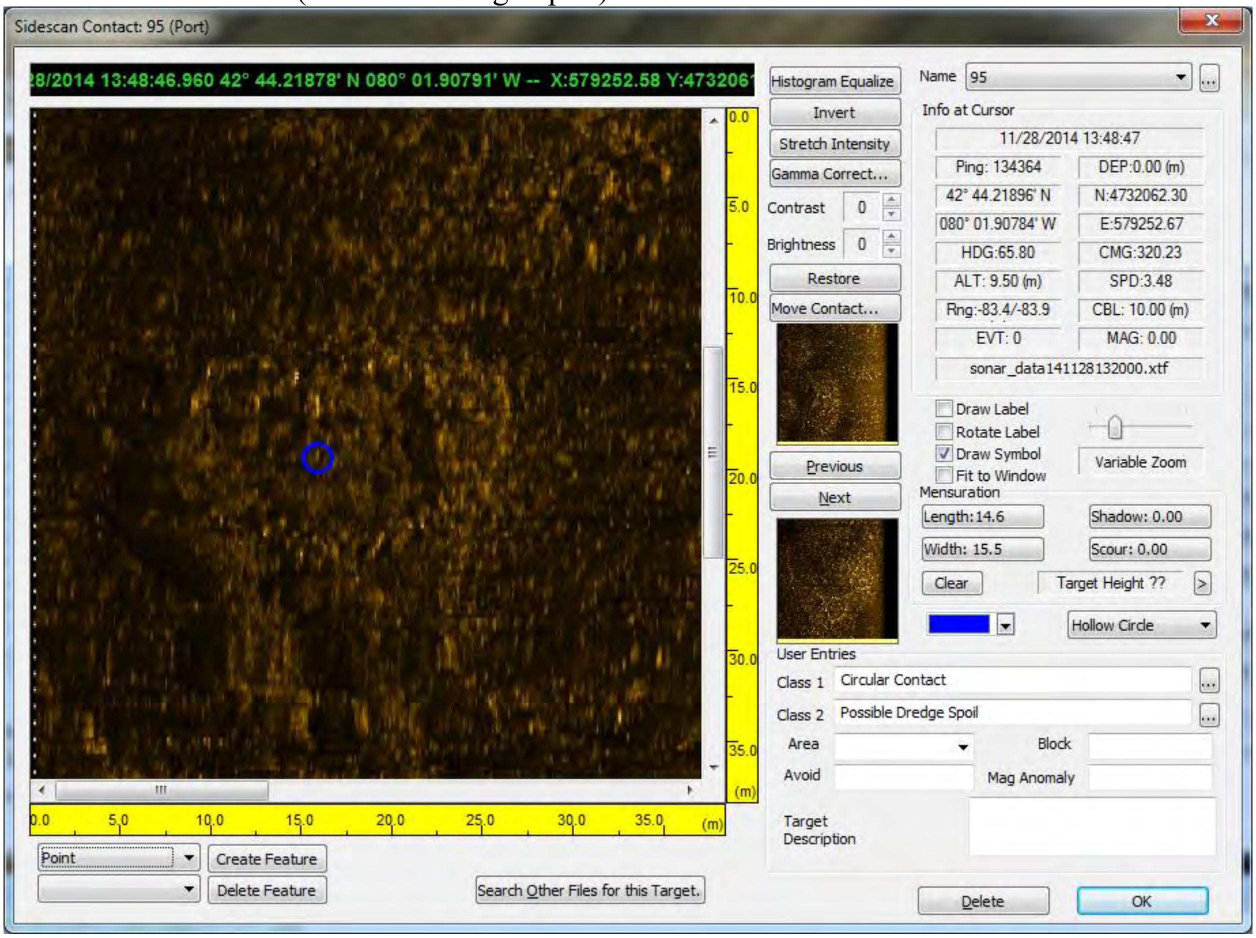
C93- Circular Contact (Probable Dredge Spoil)



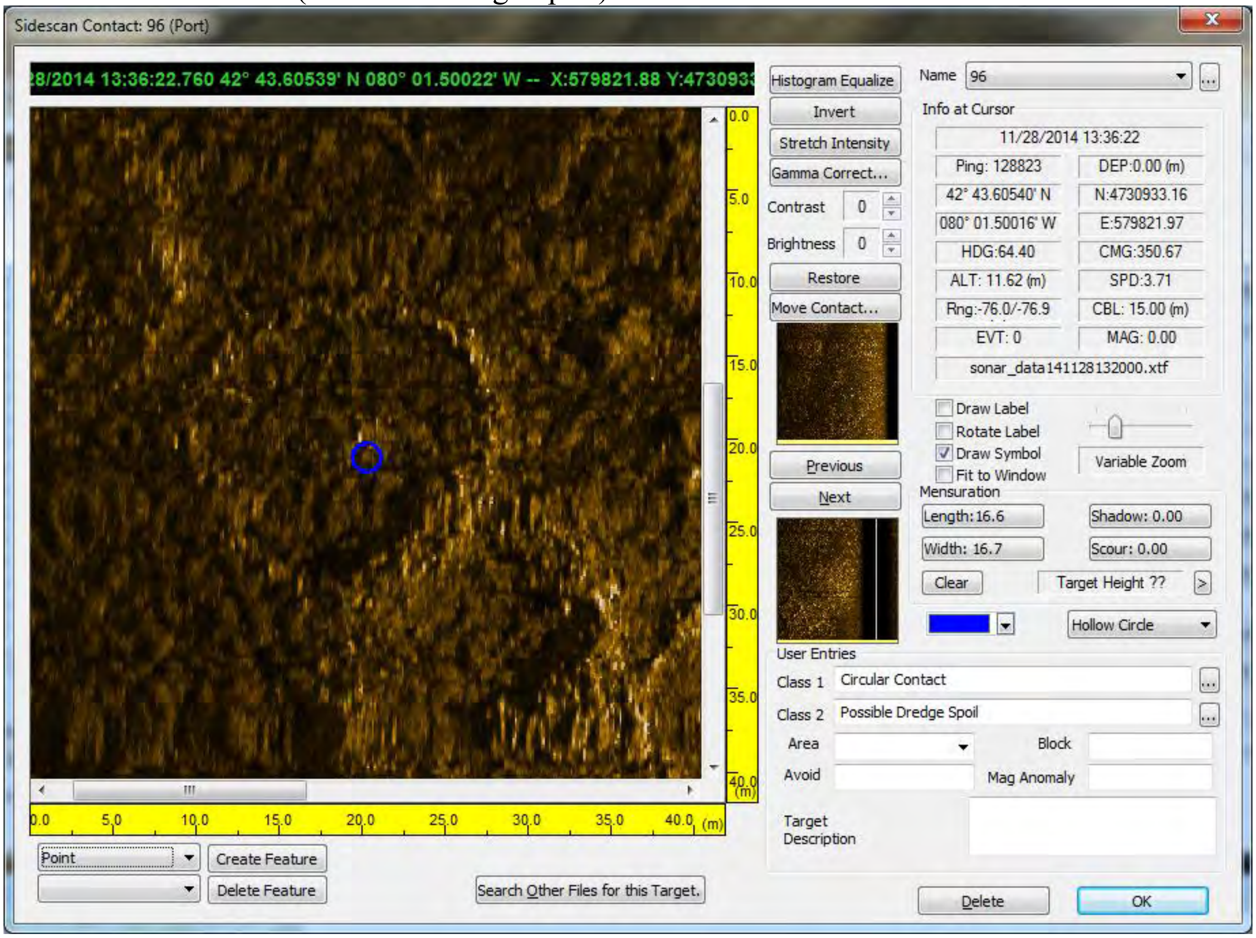
C94- Circular Contact (Probable Dredge Spoil)



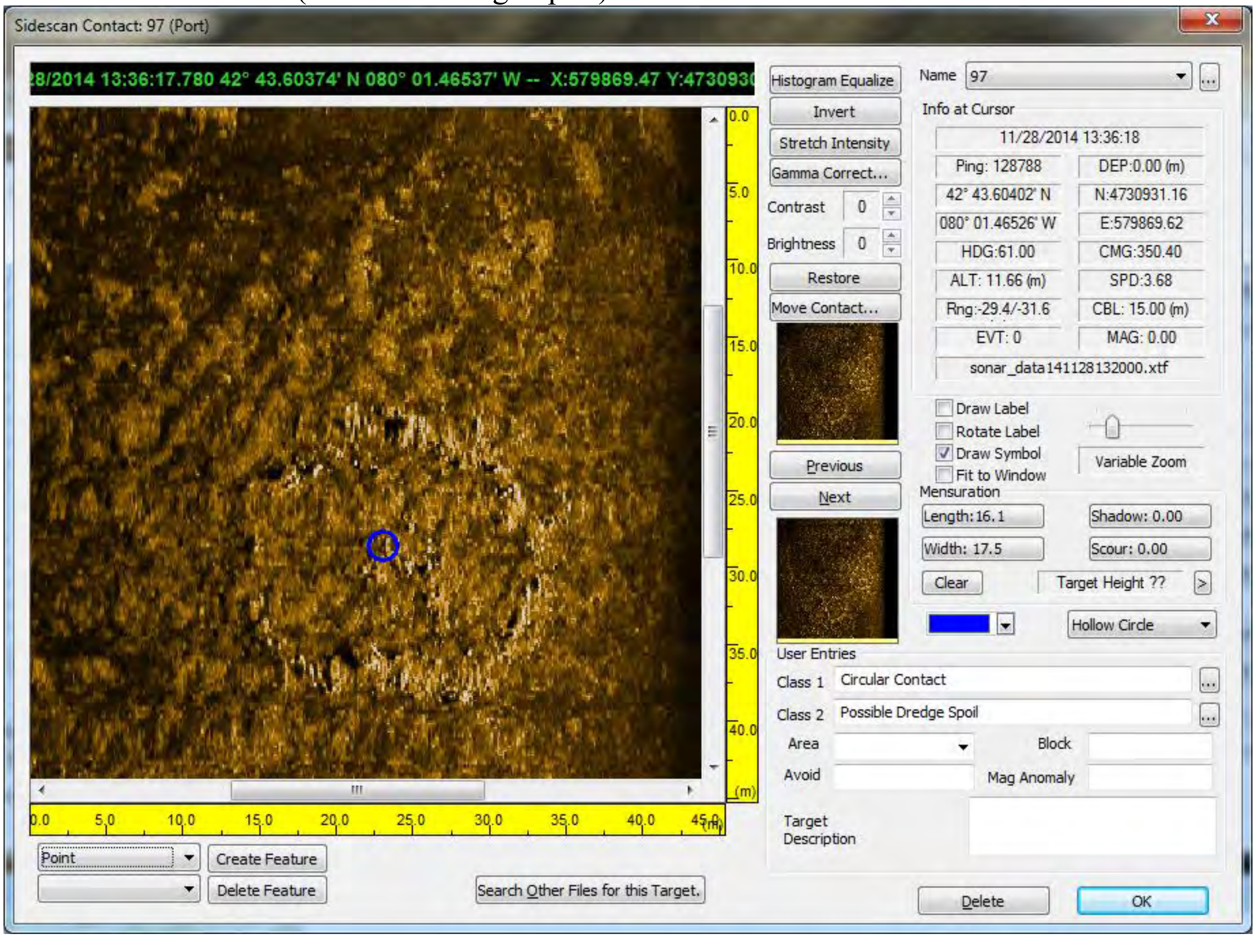
C95- Circular Contact (Probable Dredge Spoil)



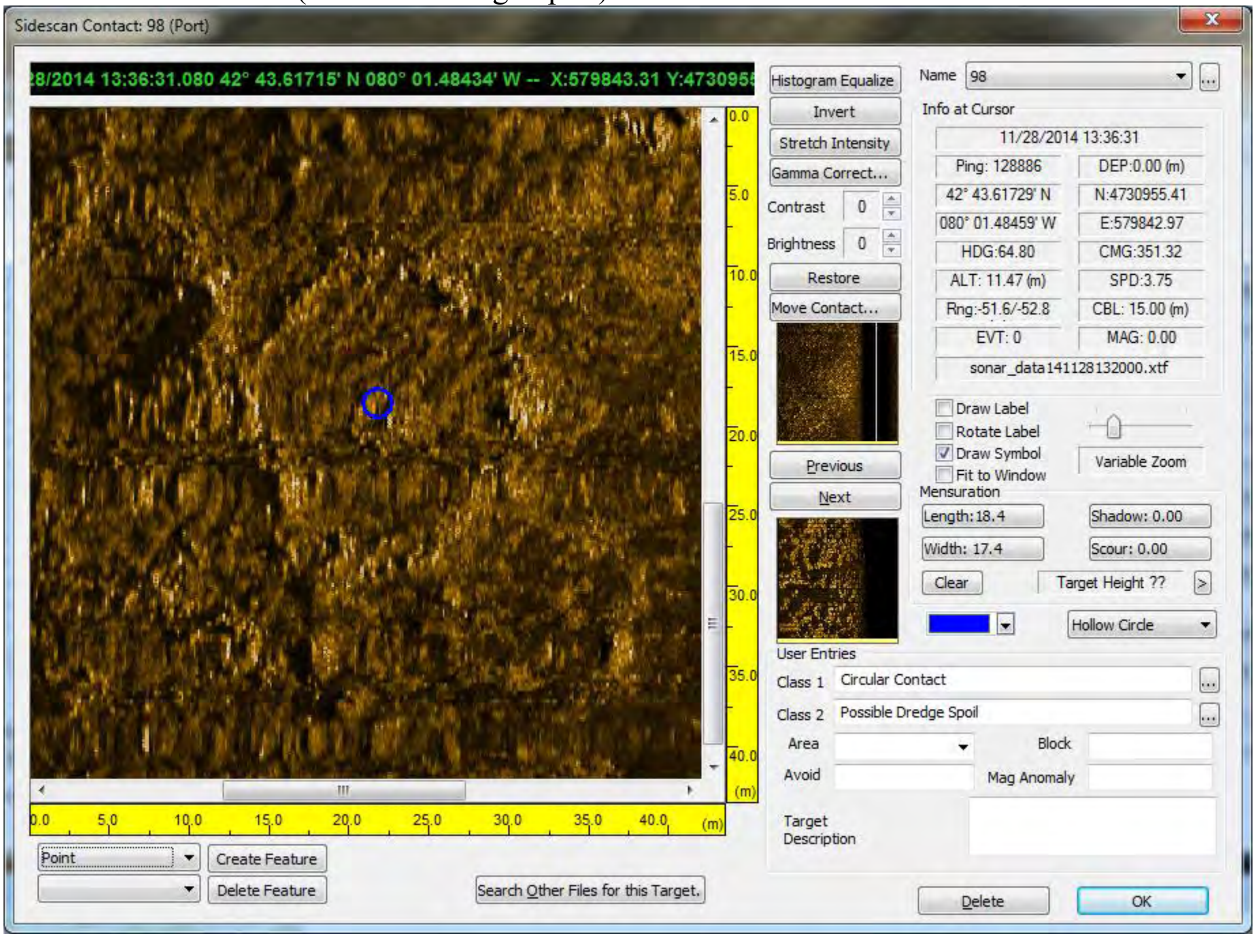
C96- Circular Contact (Probable Dredge Spoil)



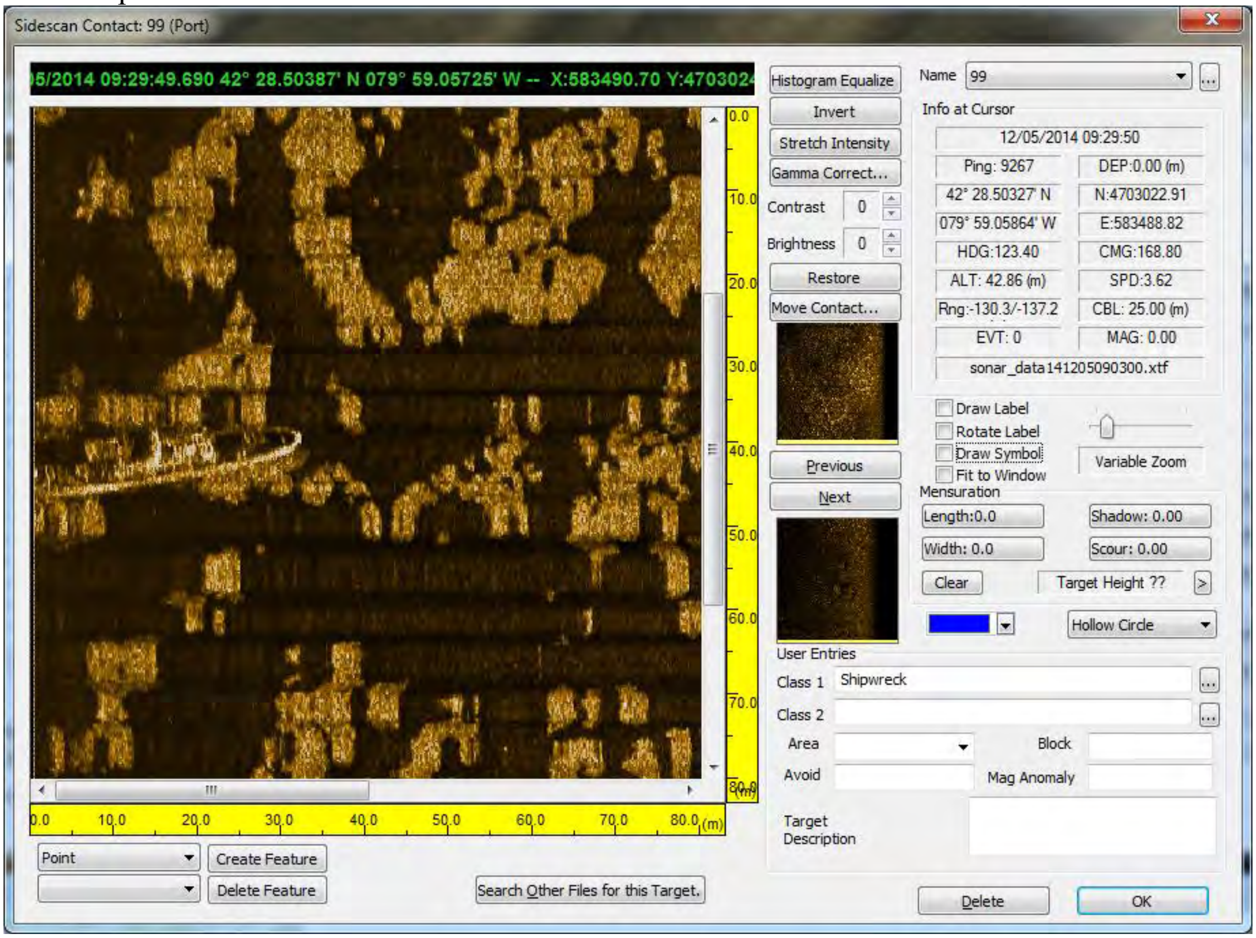
C97- Circular Contact (Probable Dredge Spoil)



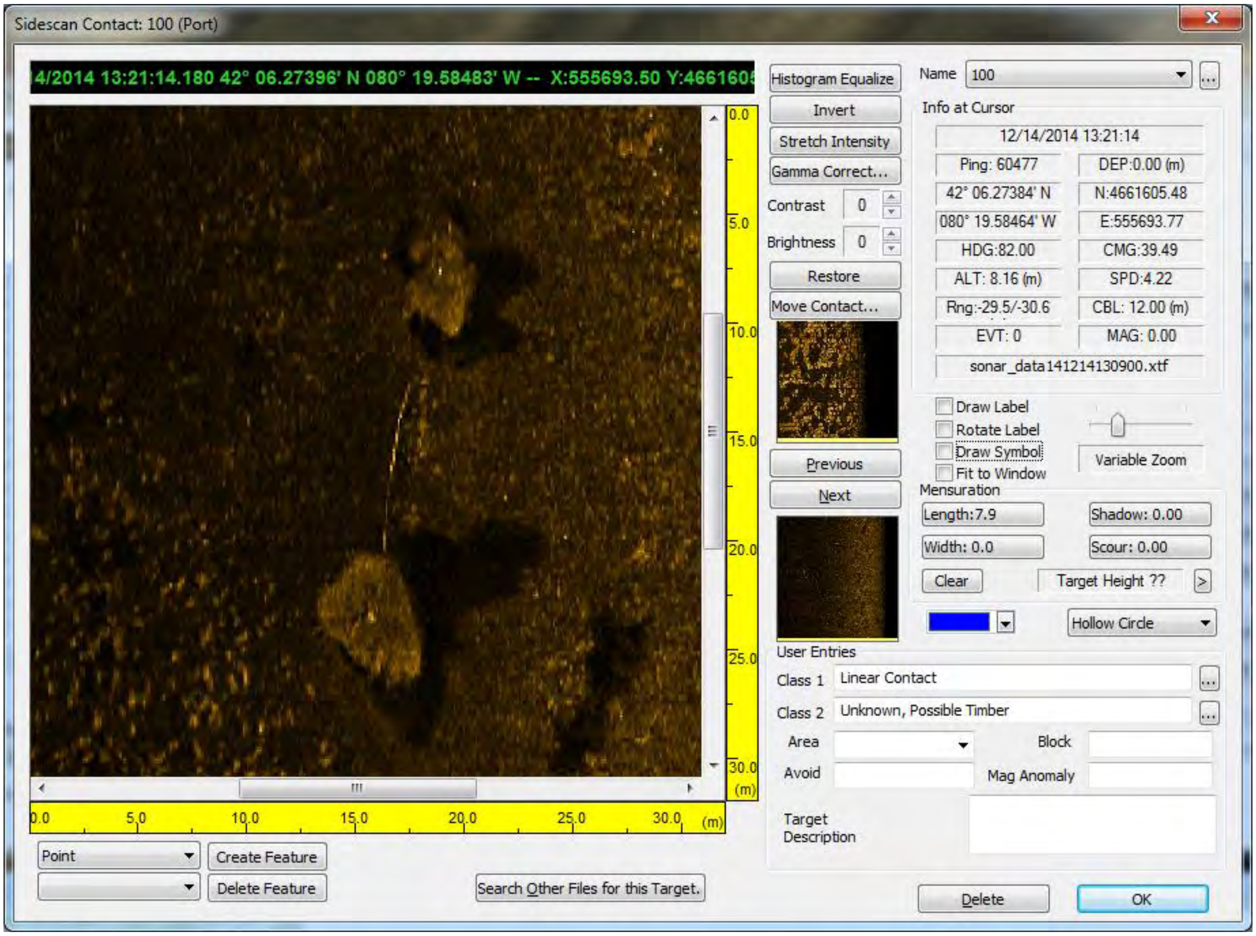
C98- Circular Contact (Probable Dredge Spoil)



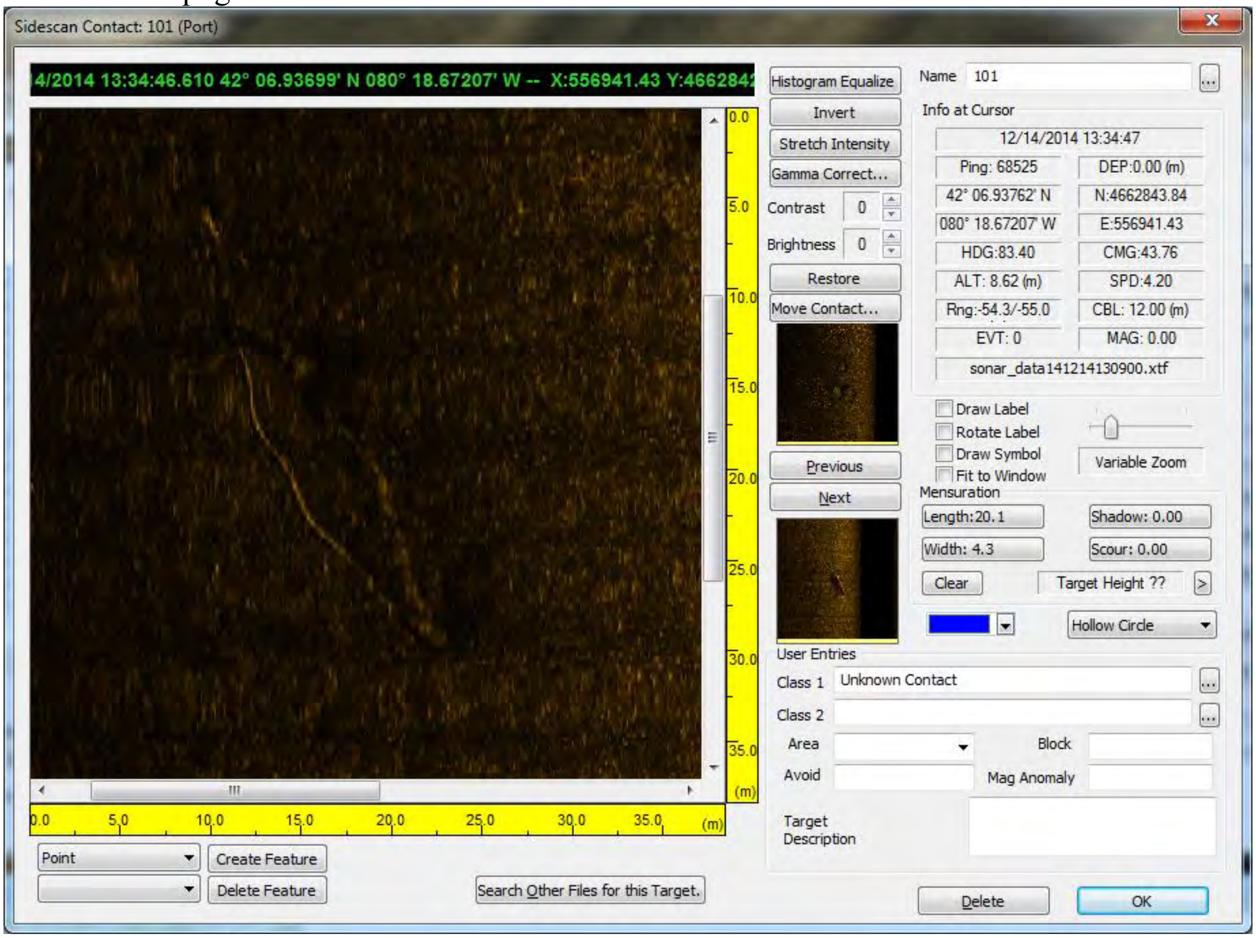
C99- Shipwreck



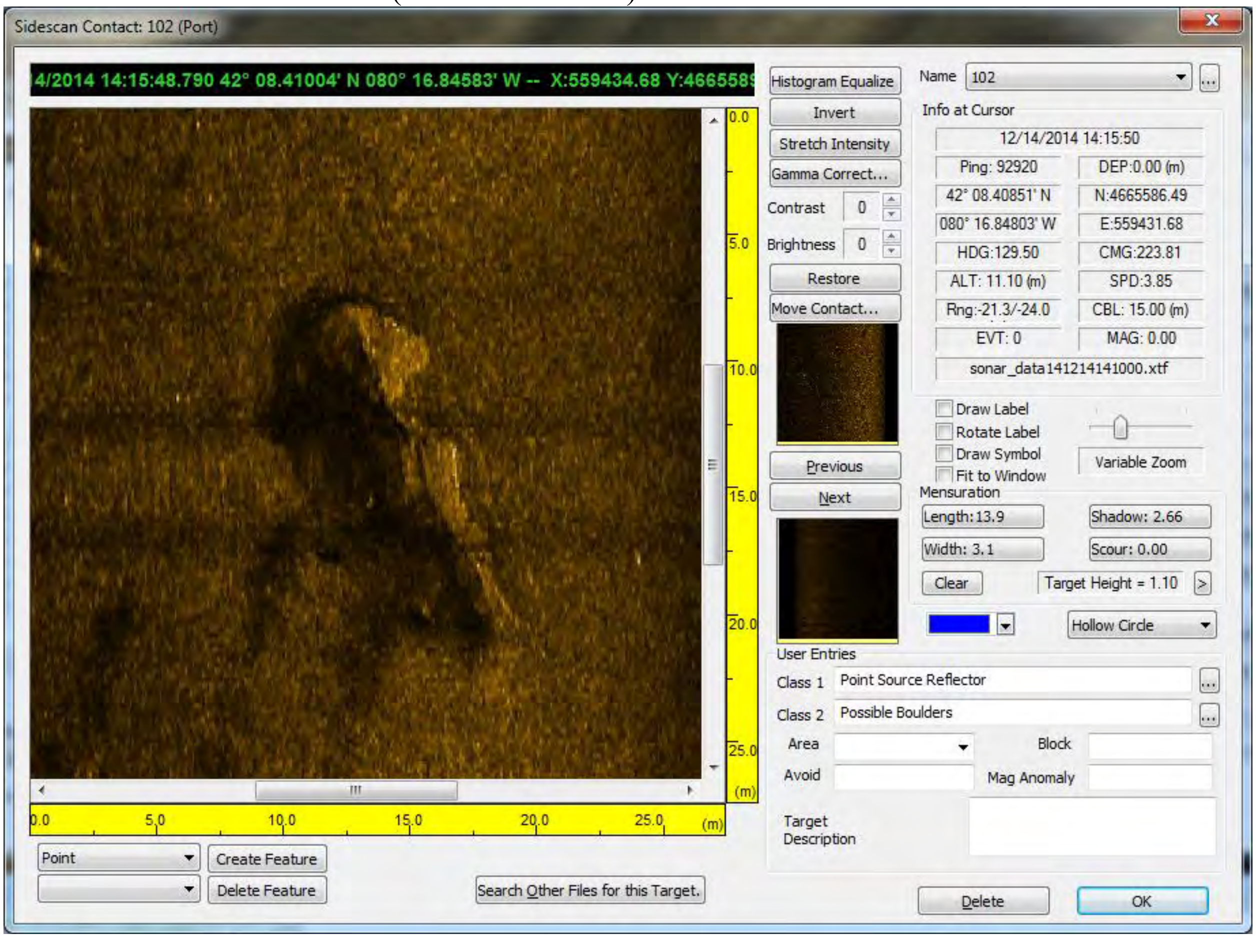
C100- Anthropogenic Contact



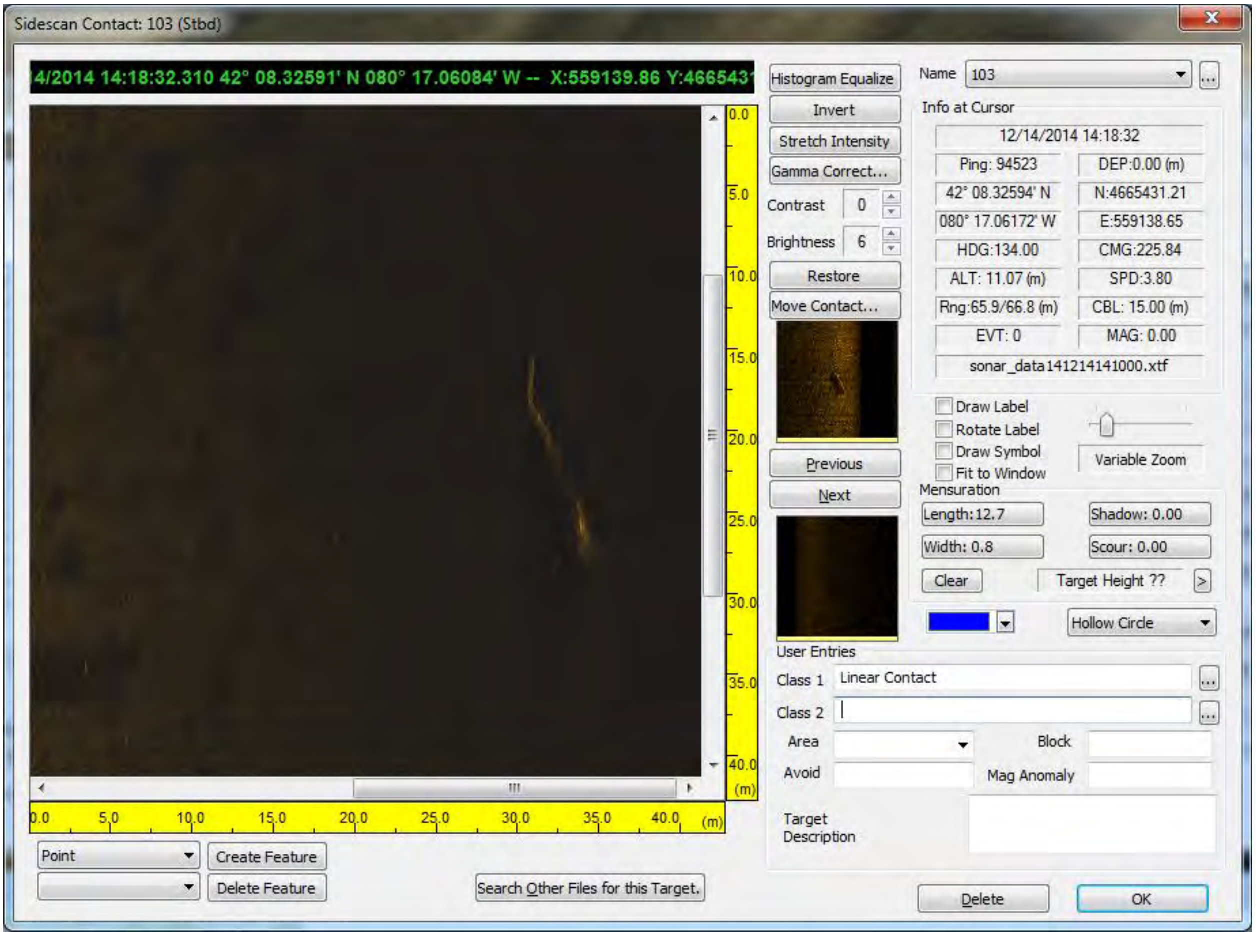
C101- Anthropogenic Contact



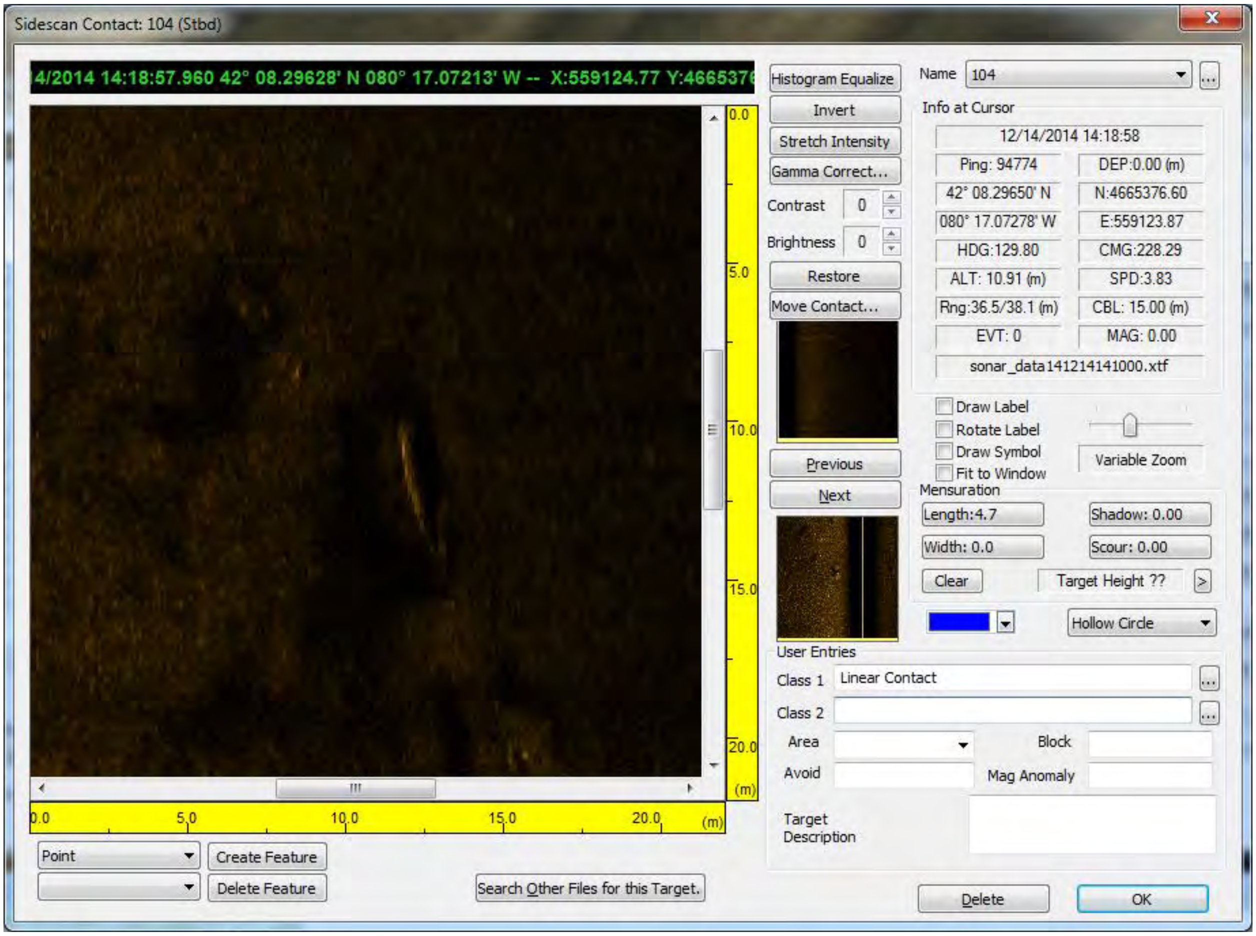
C102- Point Source Reflector (Probable Boulder)



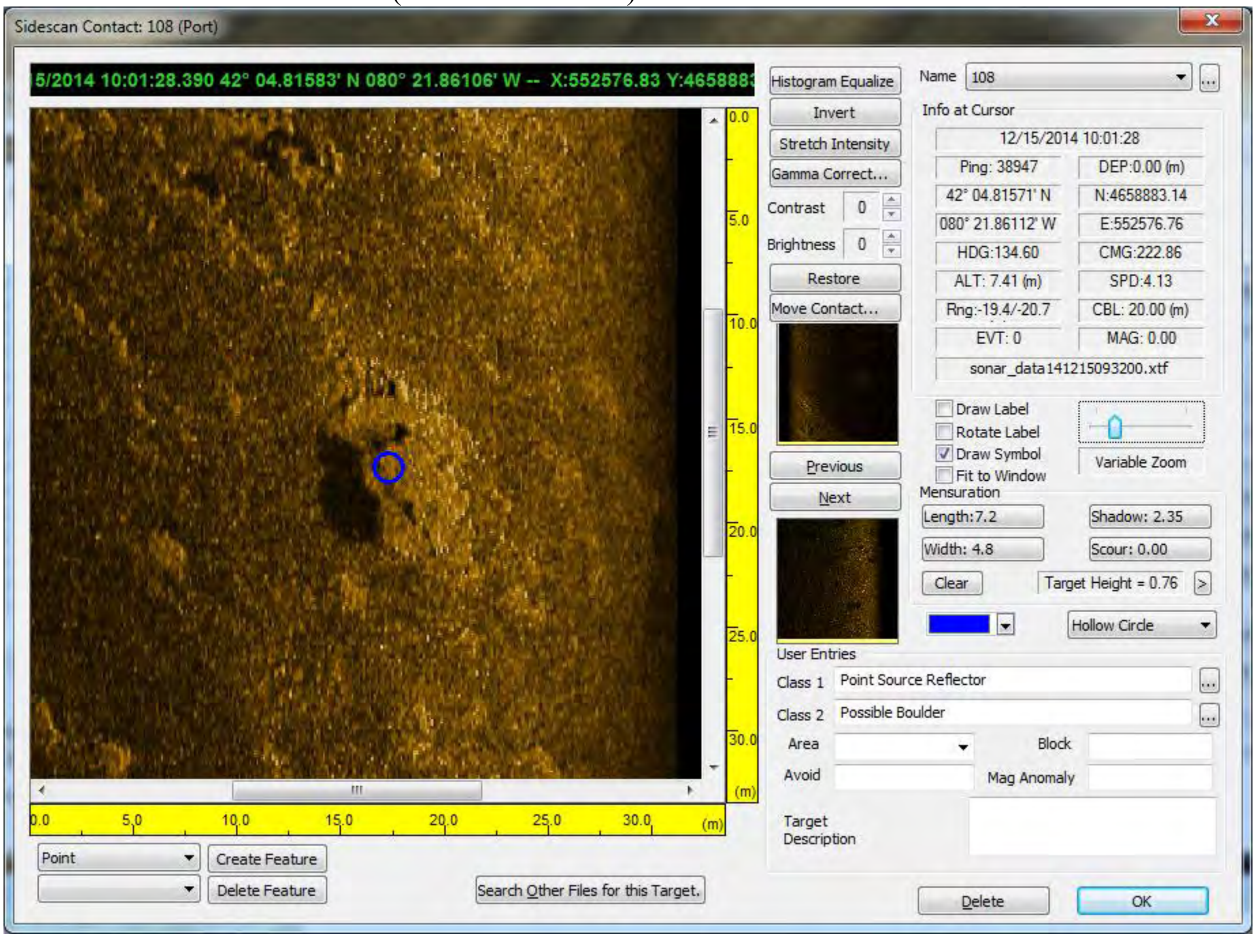
C103- Linear Contact



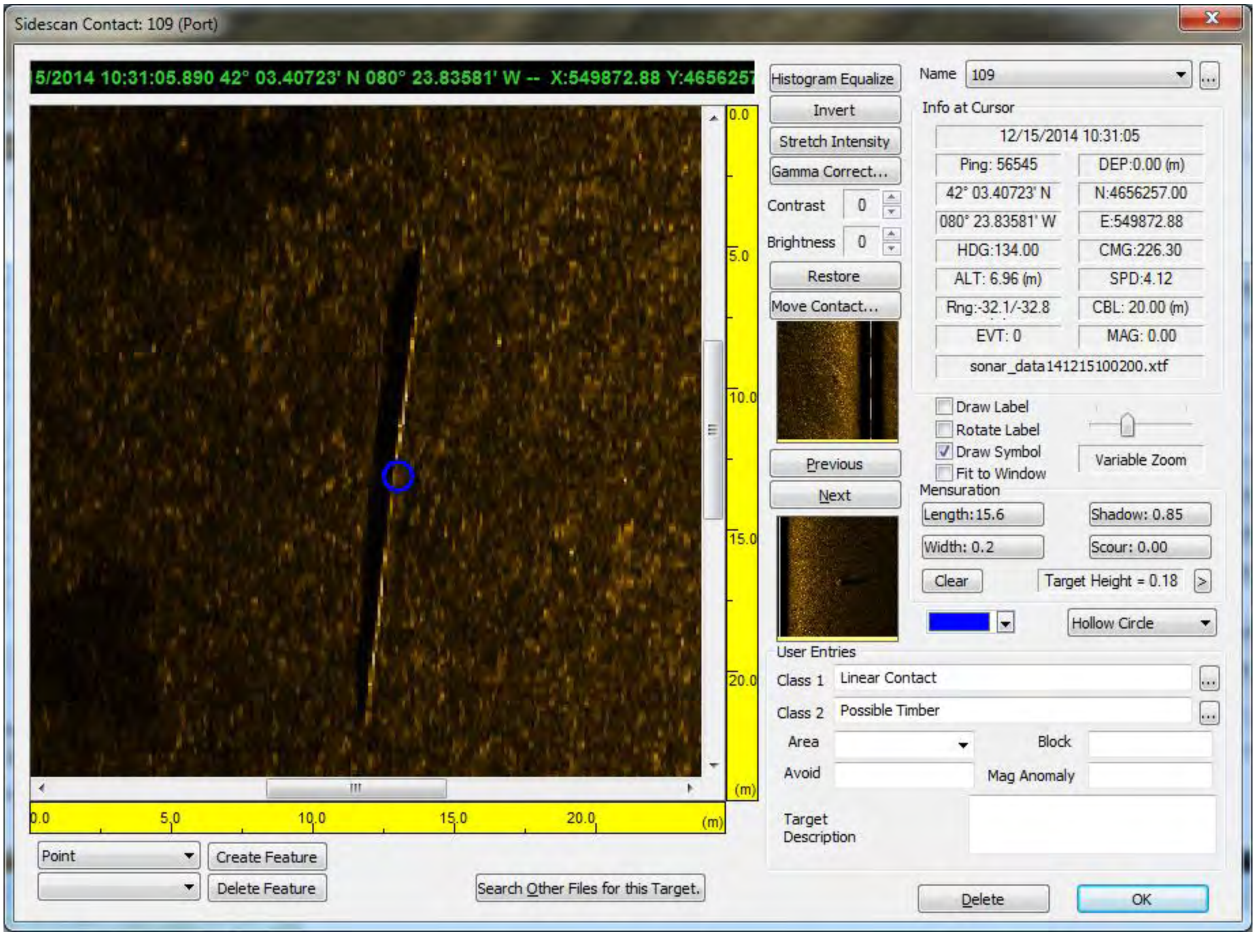
C104- Linear Contact



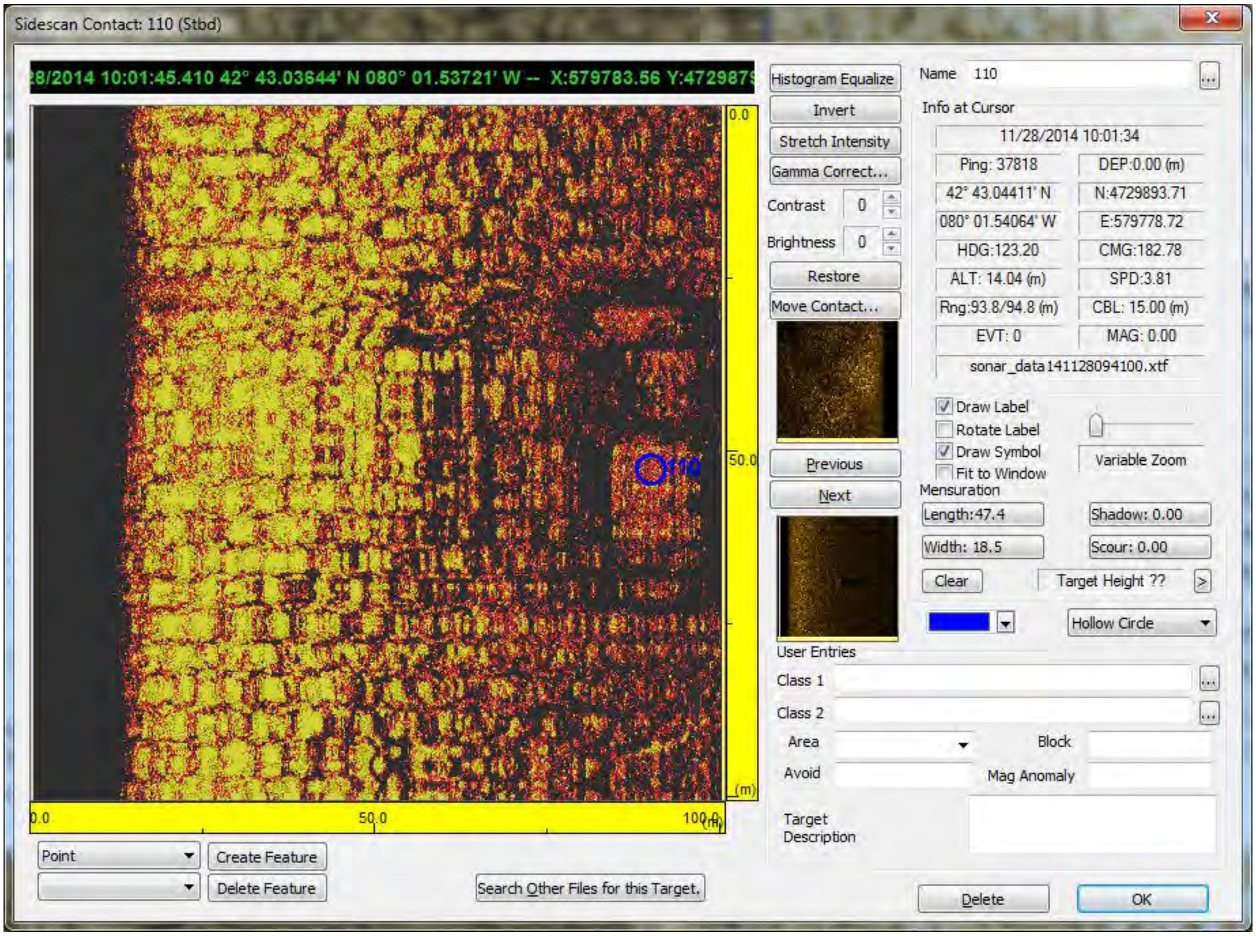
C108- Point Source Reflector (Probable Boulder)



C109- Linear Contact

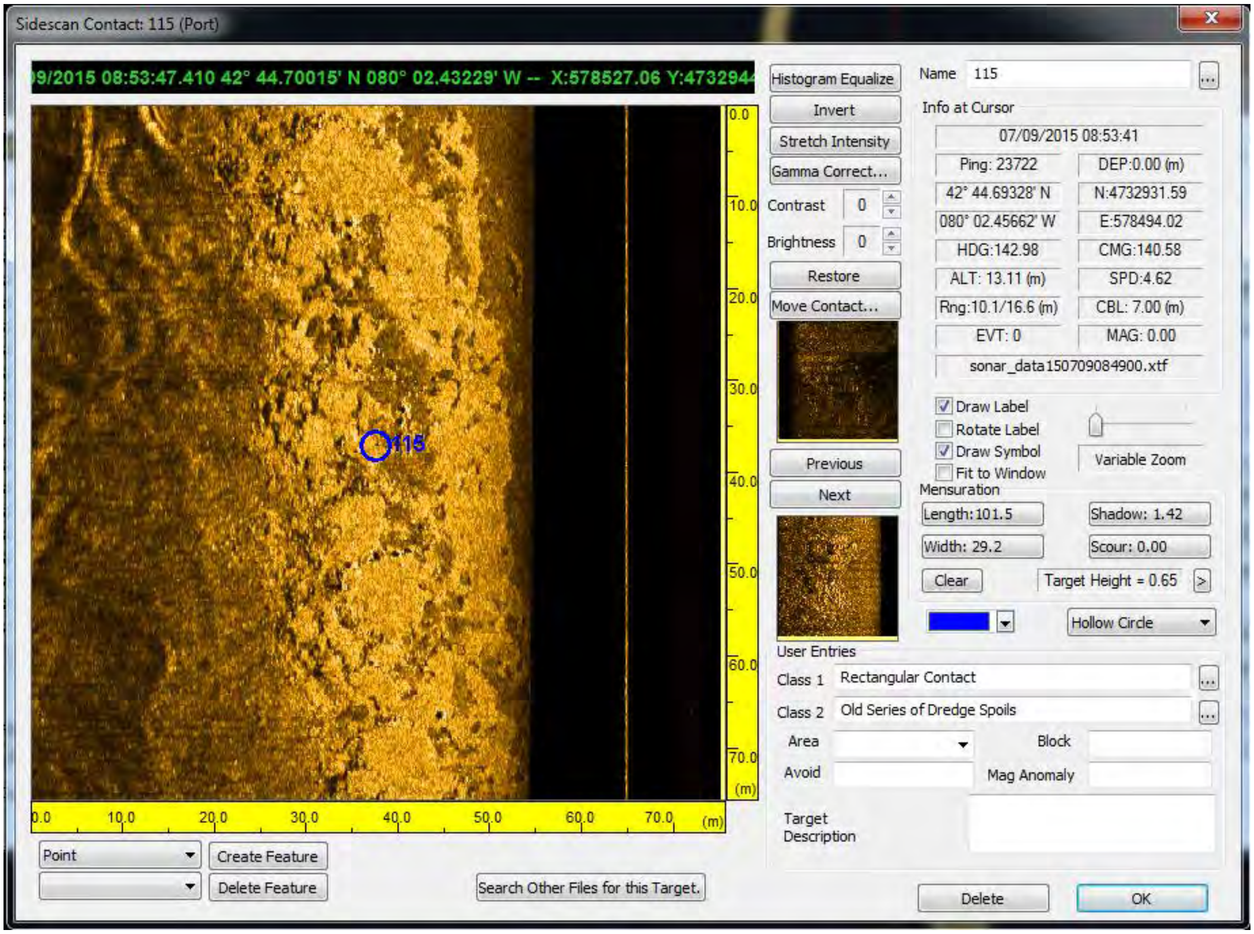


C110- Rectangular Feature

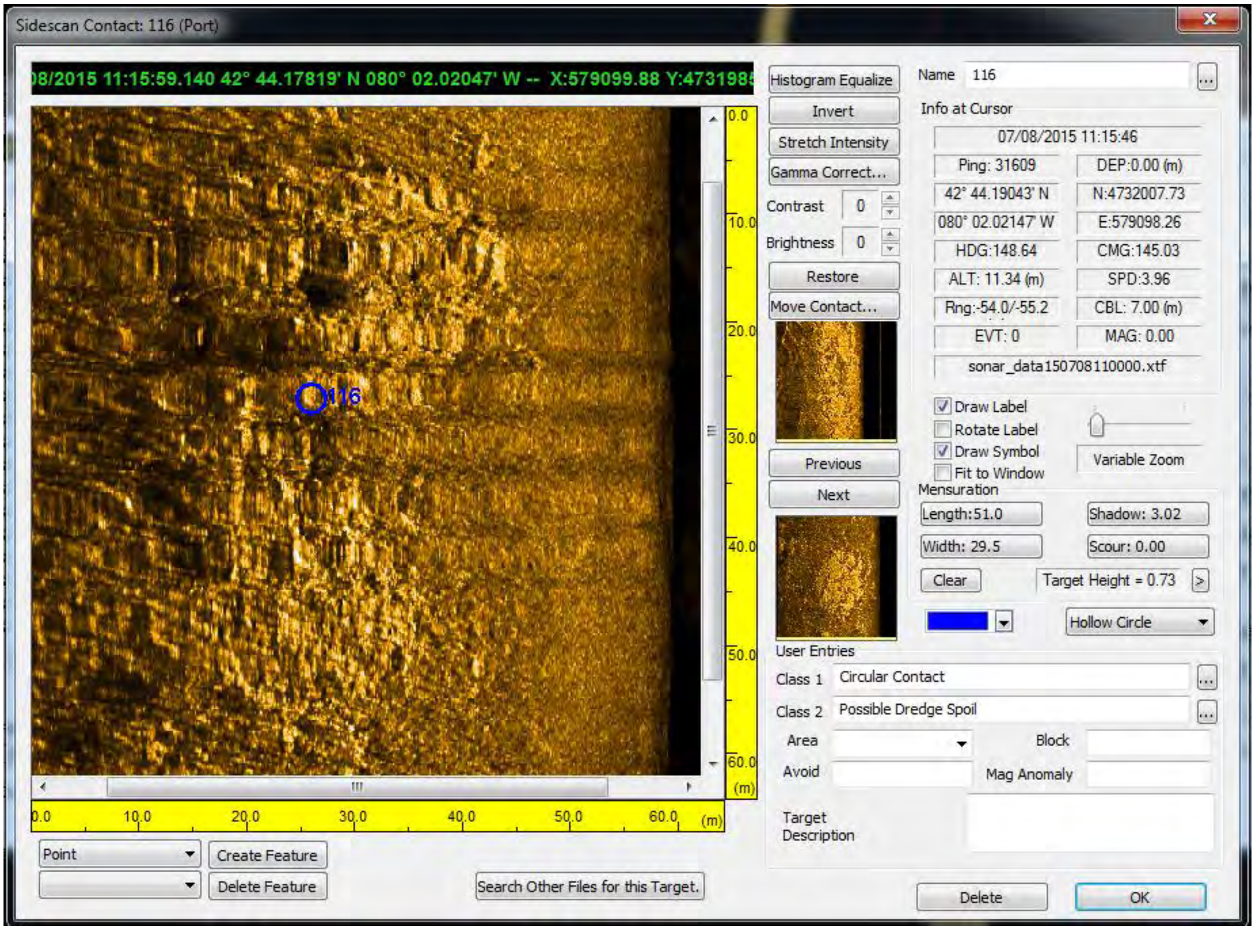


C111- Linear Contact

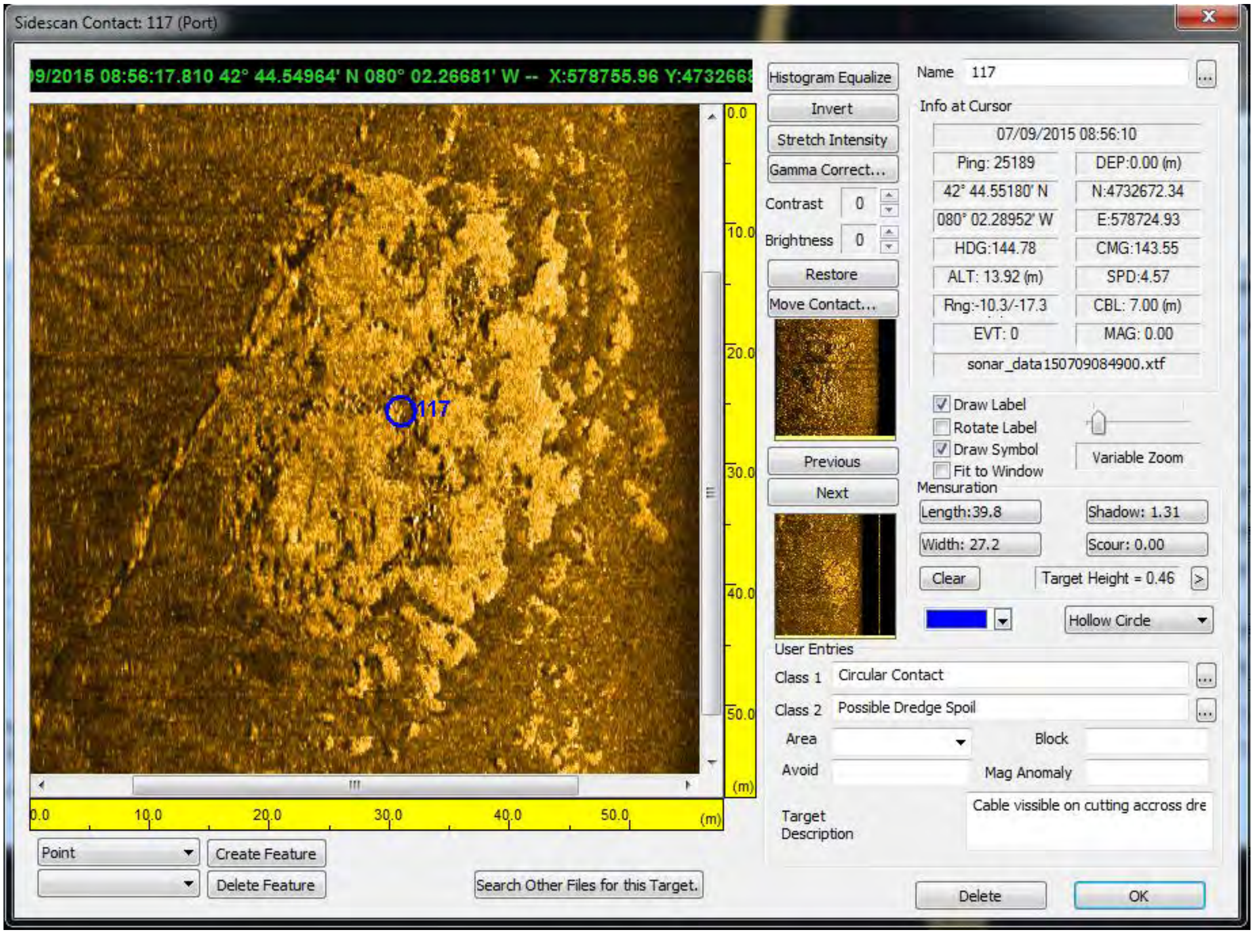
C115 - Rectangular Contact



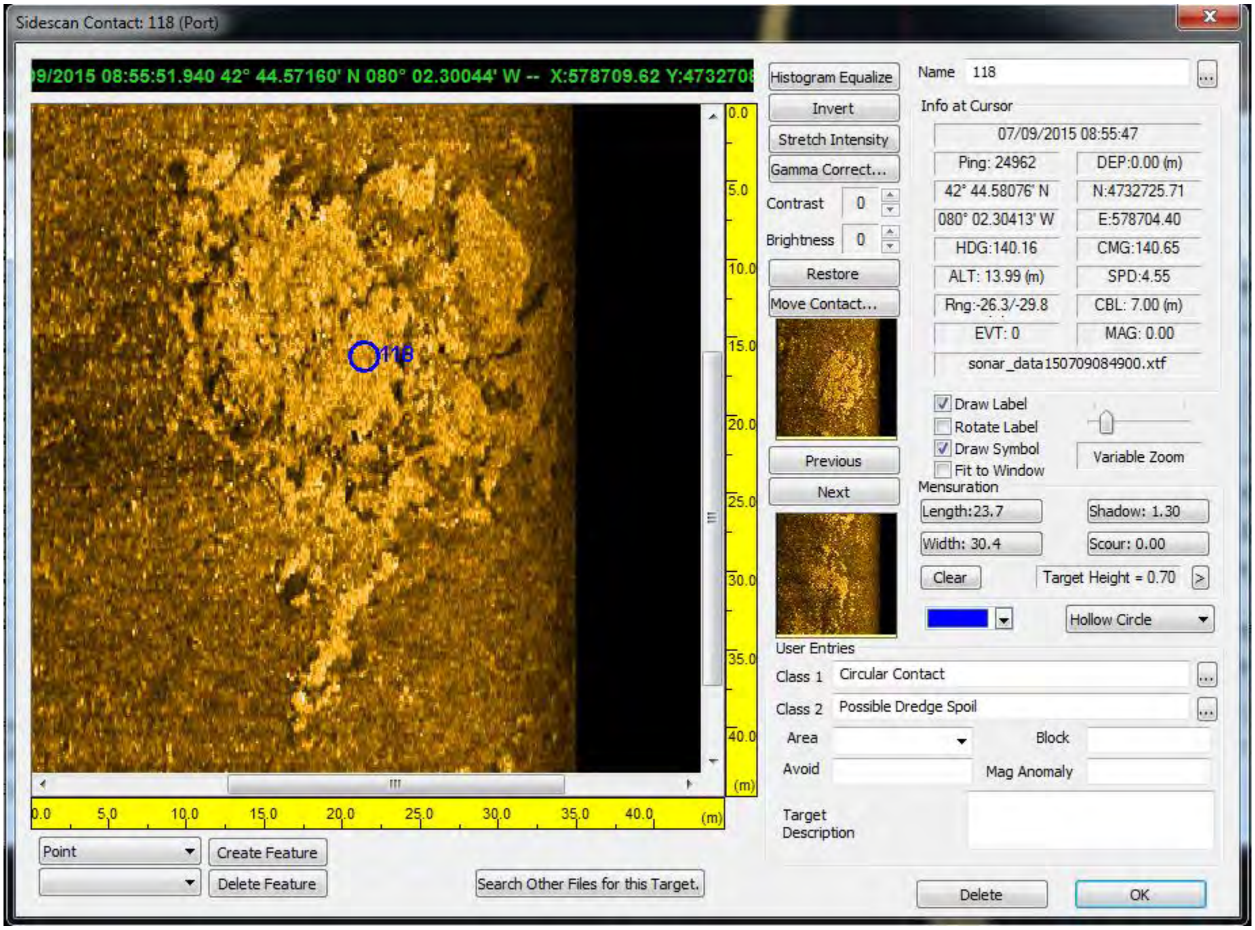
C116 - Circular Contact



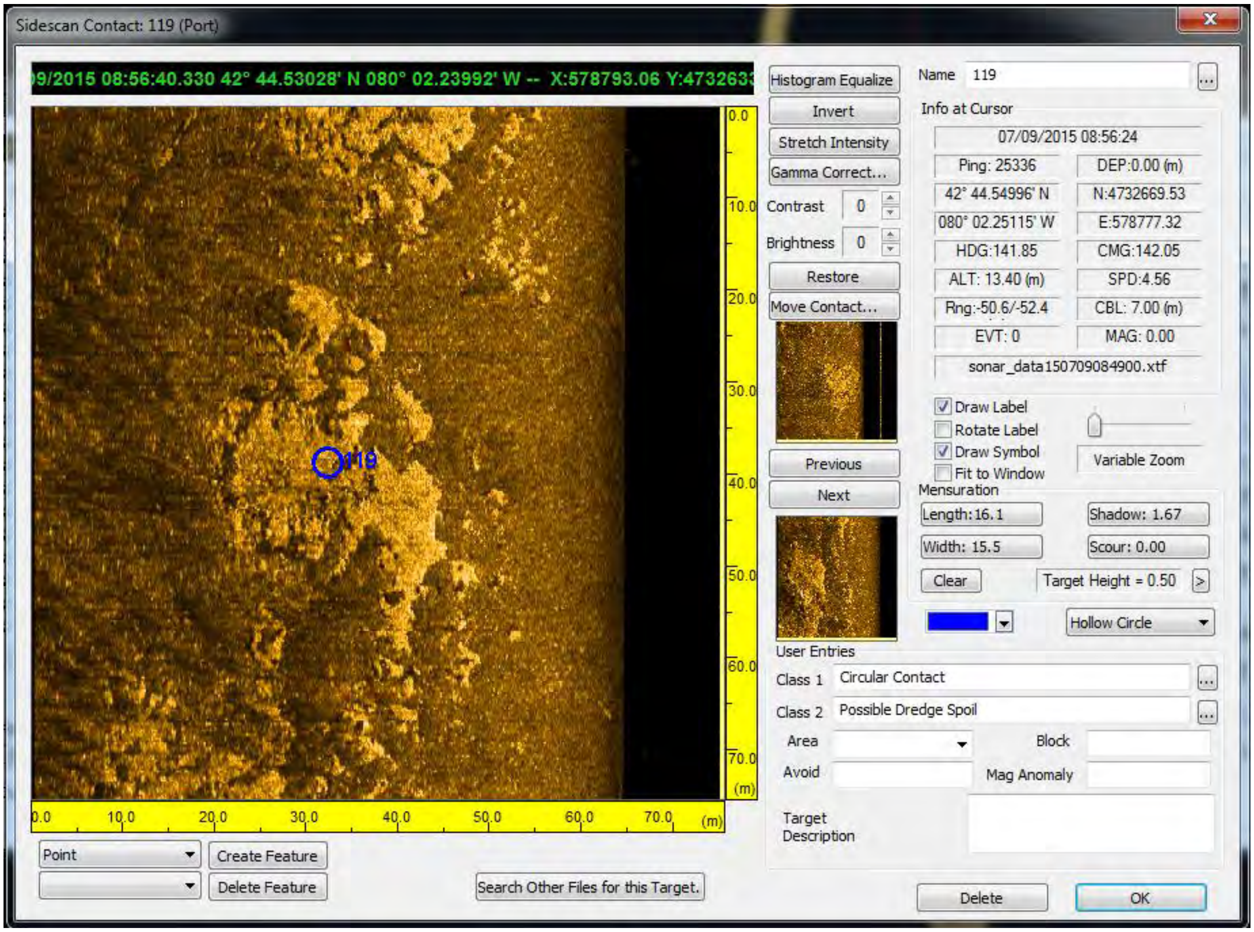
C117 - Circular Contact



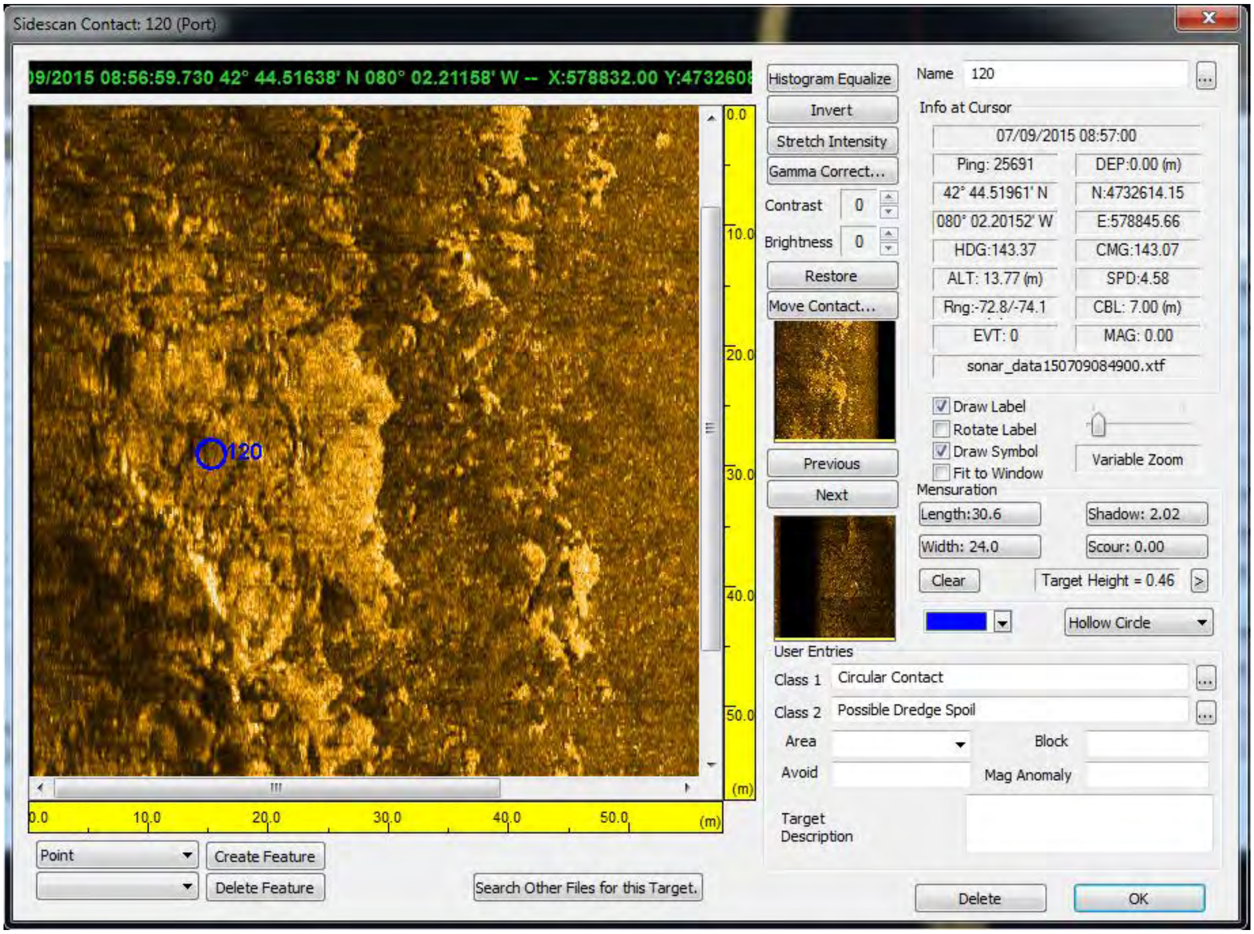
C118 - Circular Contact



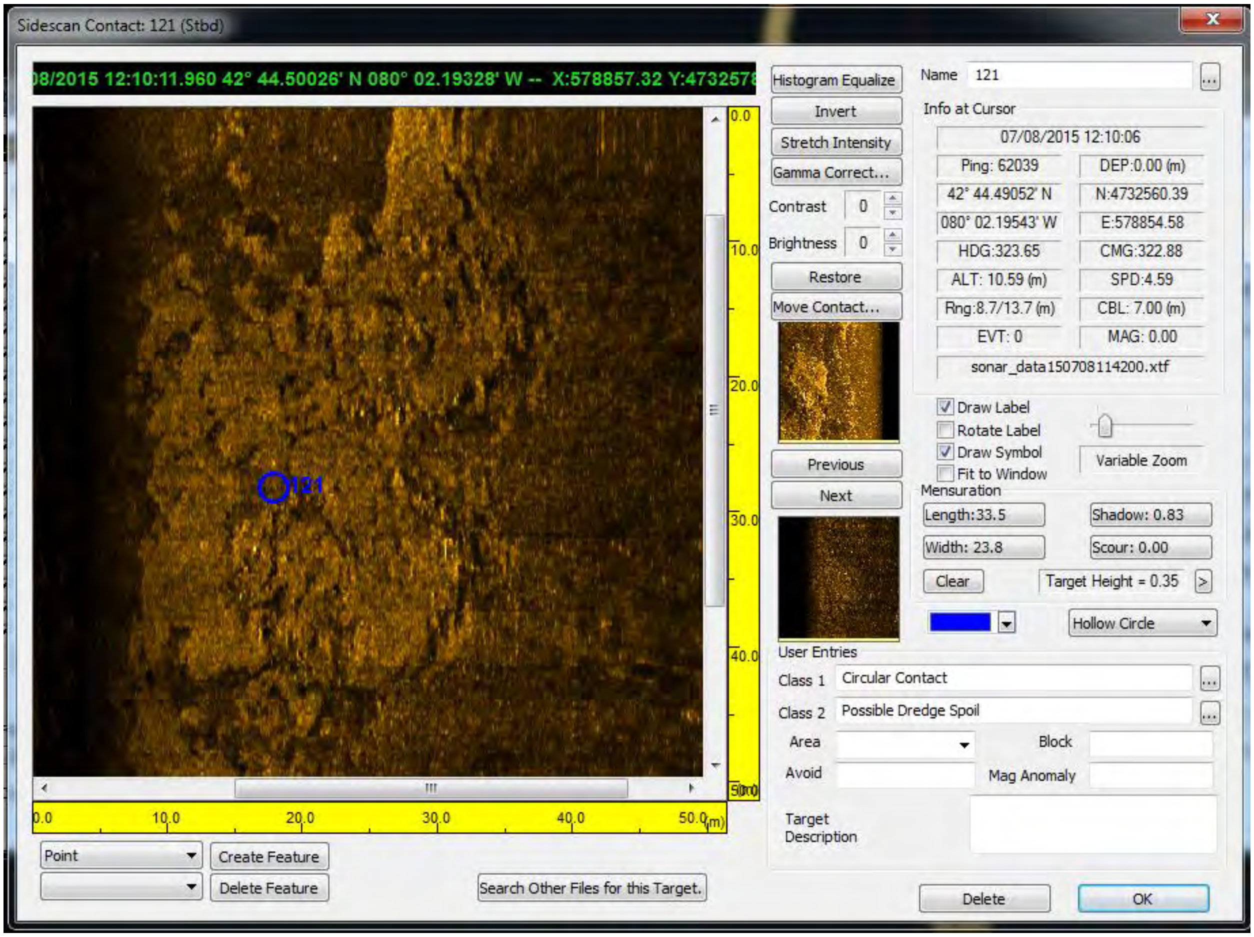
C119 - Circular Contact



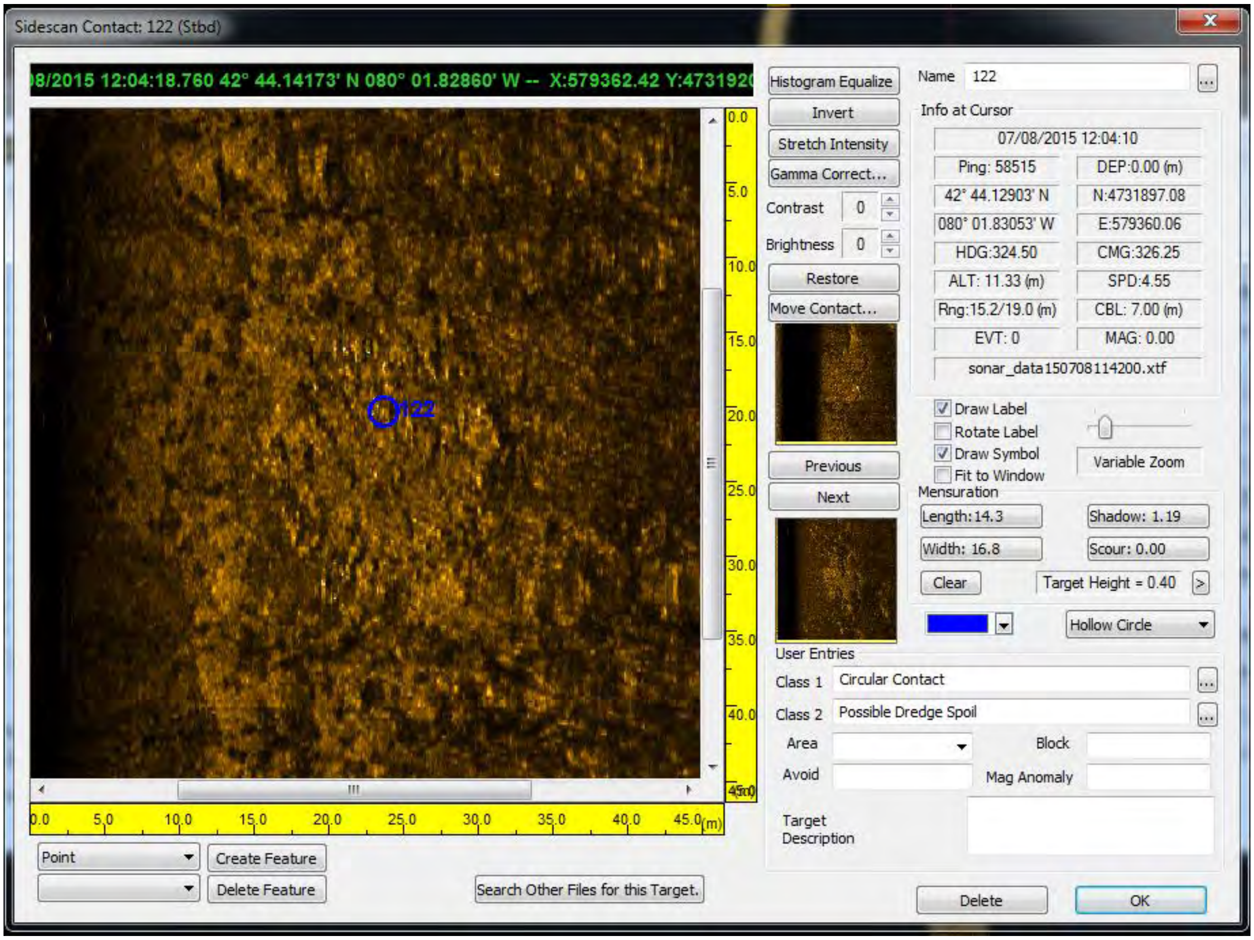
C120 - Circular Contact



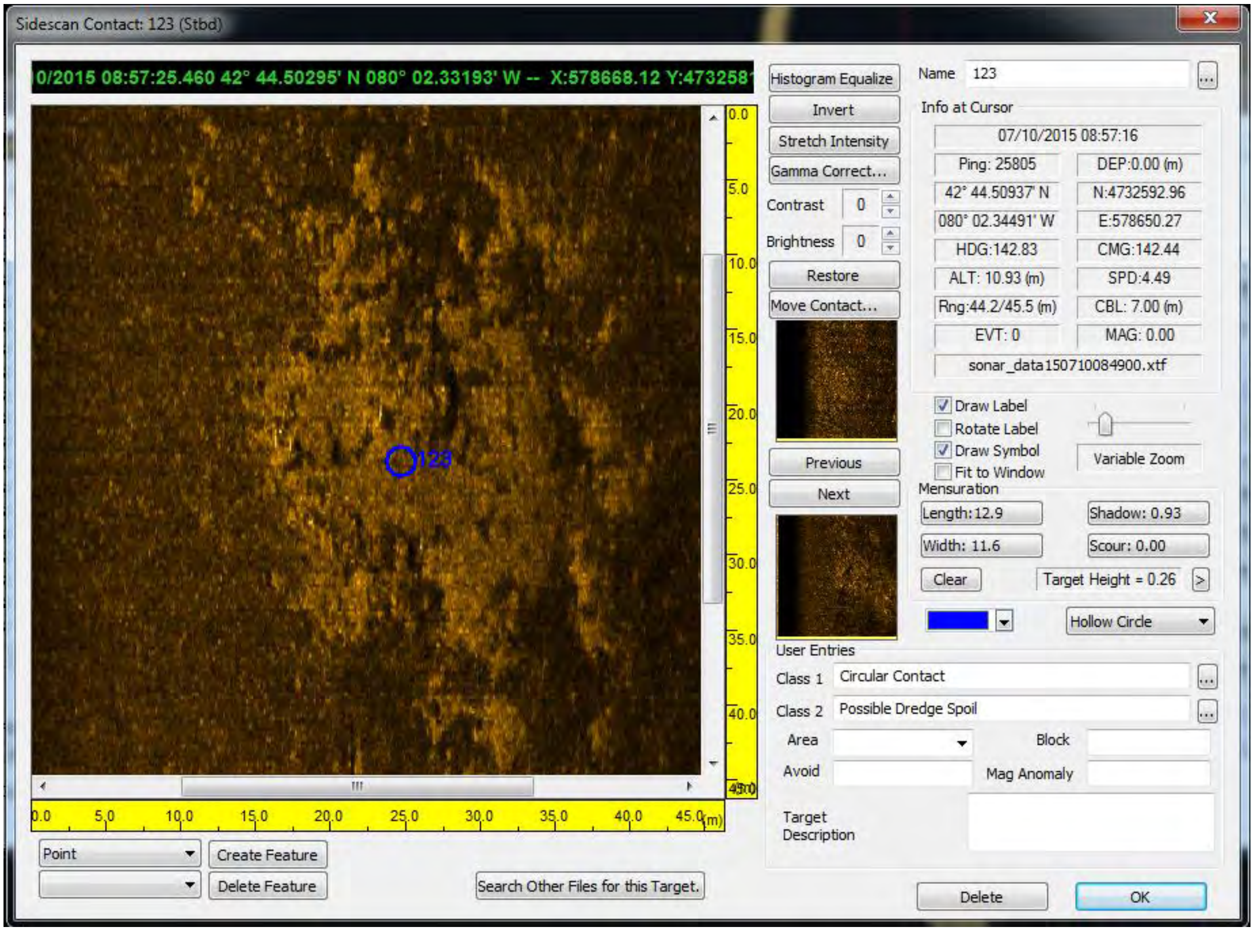
C121 - Circular Contact



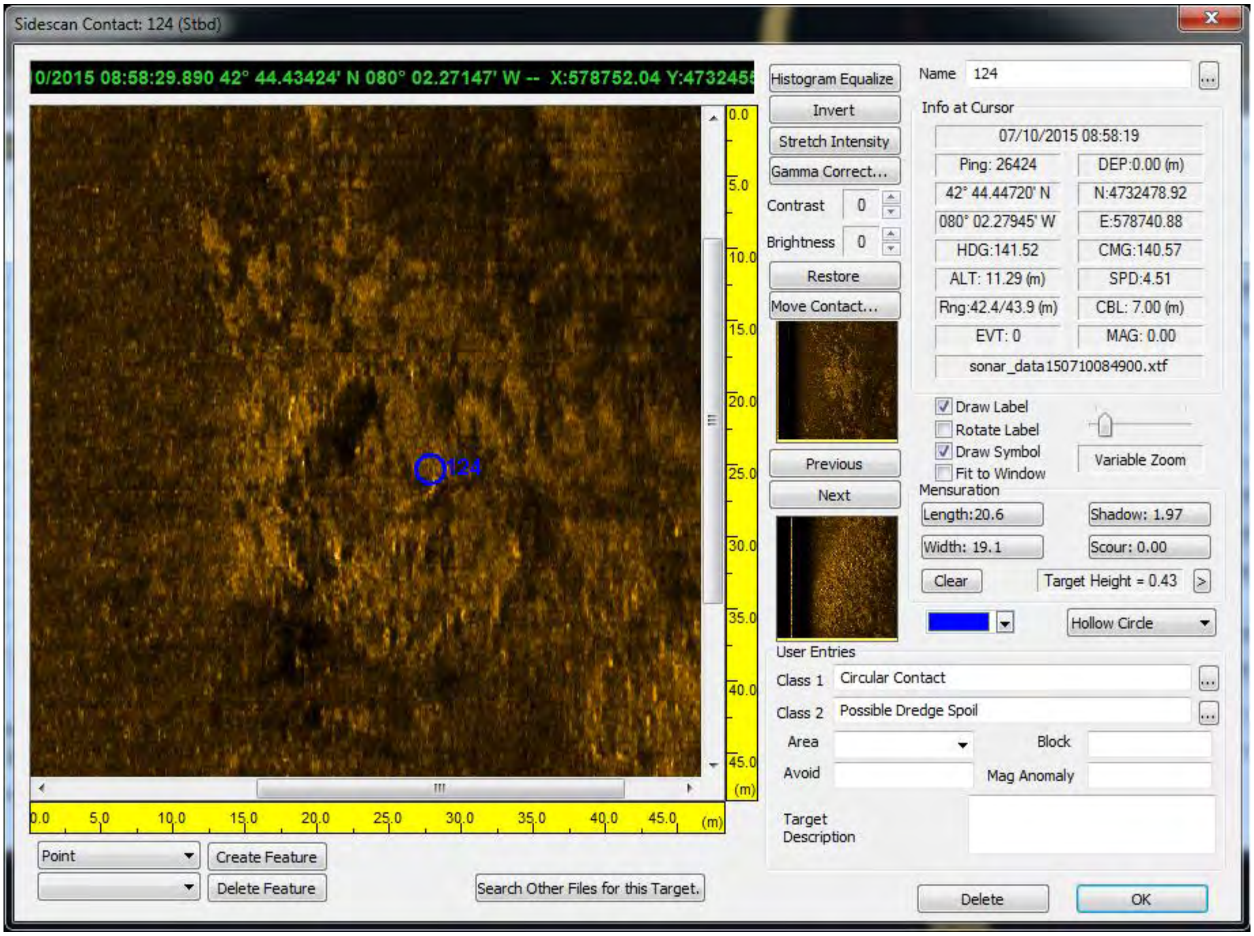
C122 - Circular Contact



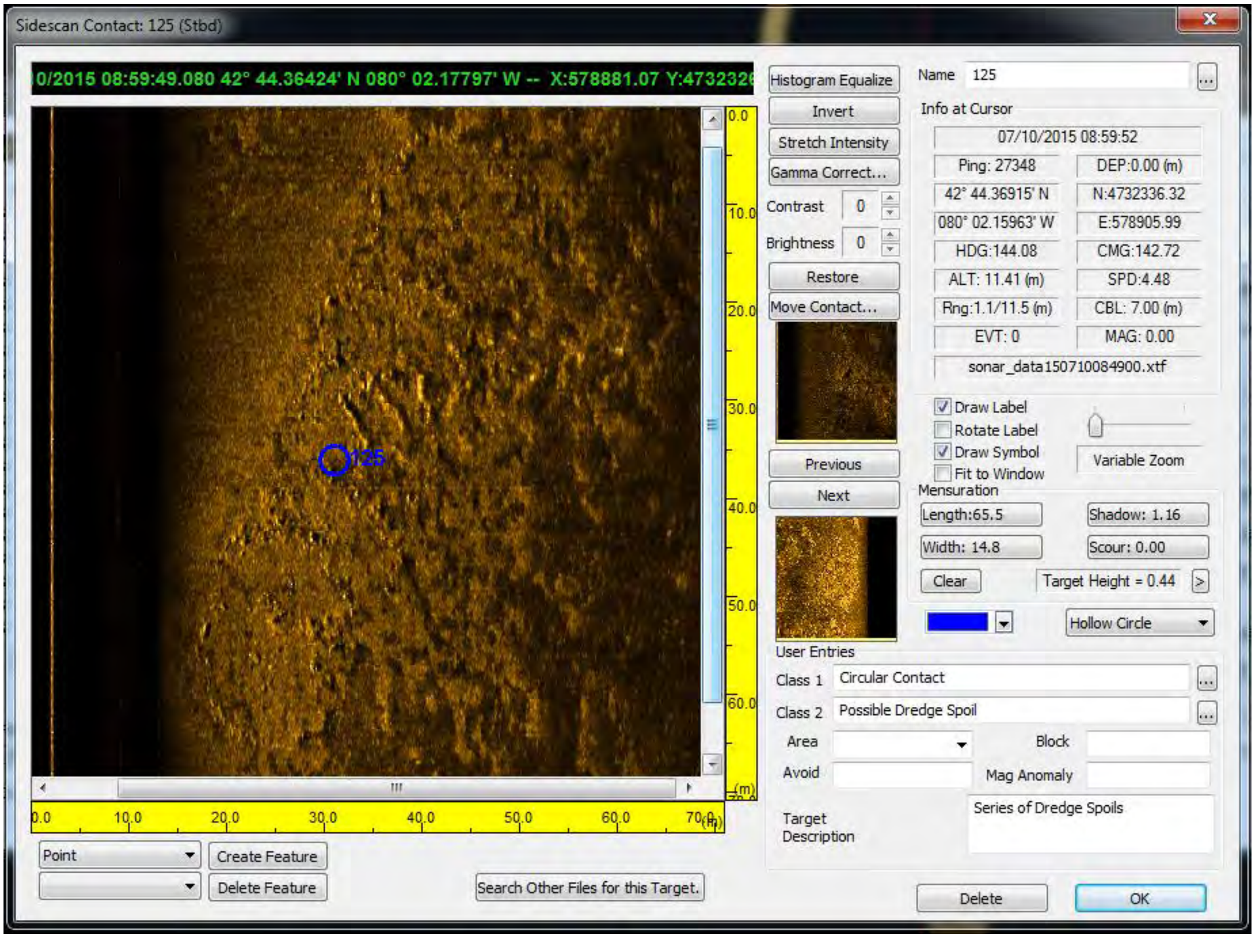
C123 - Circular Contact



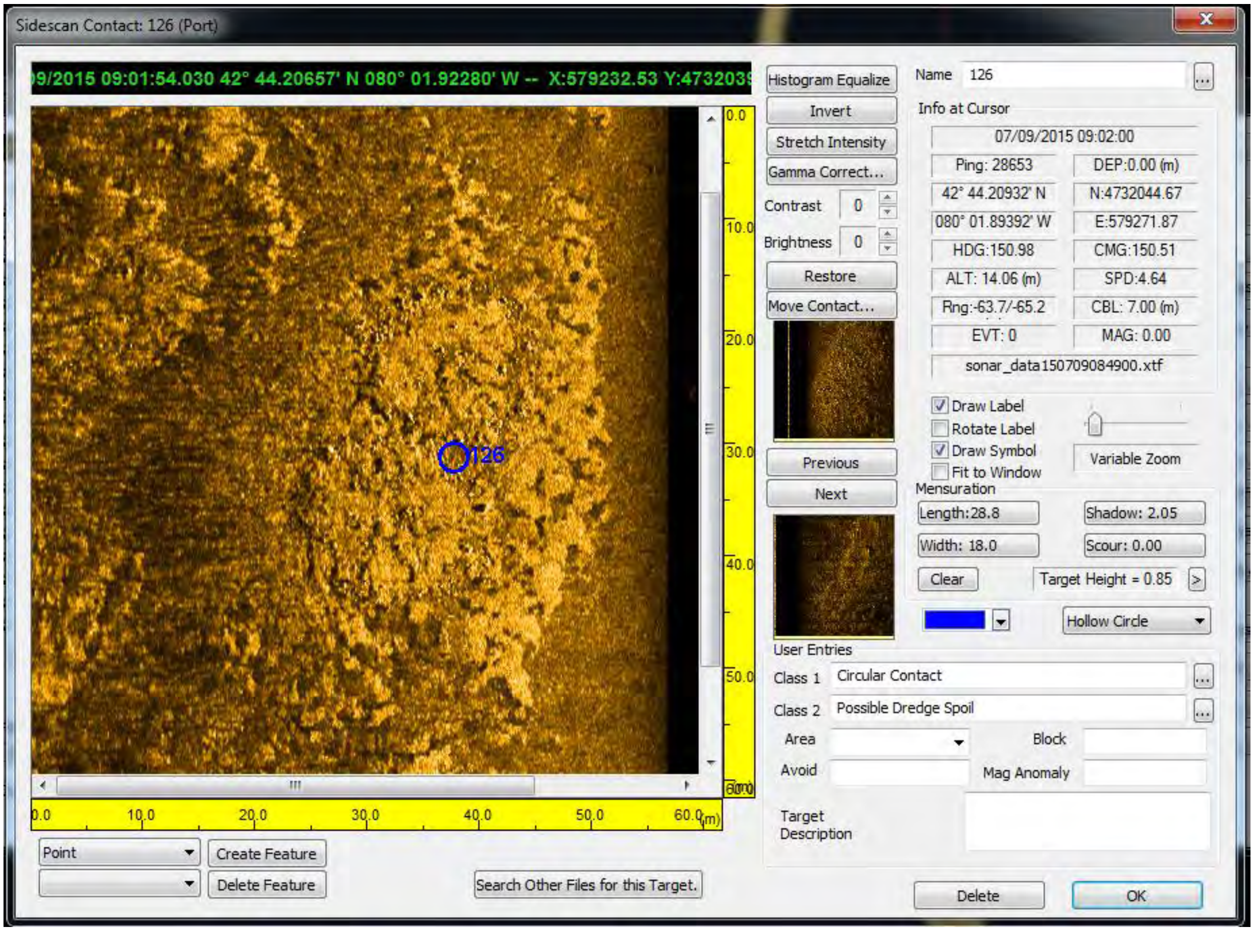
C124 - Circular Contact



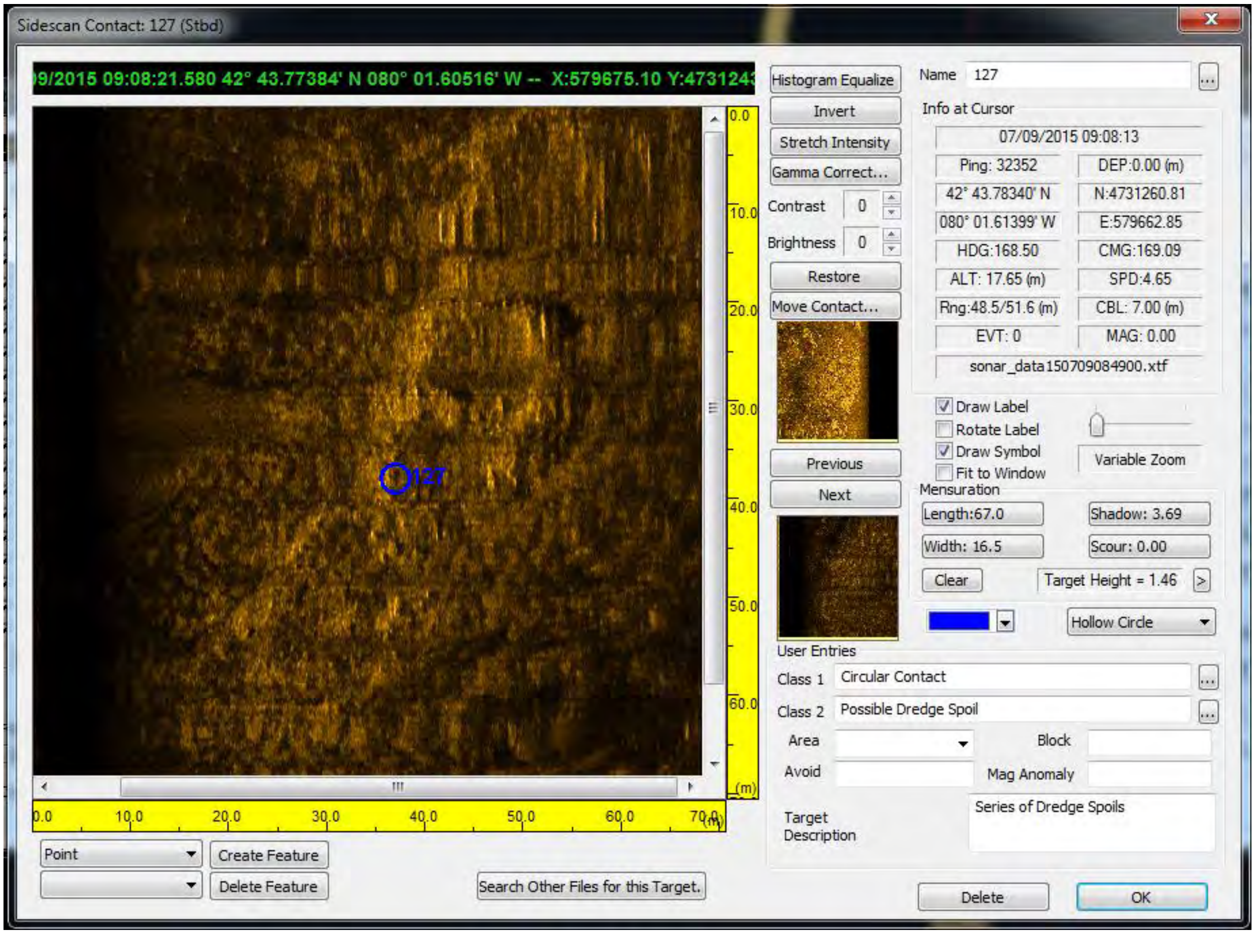
C125 - Circular Contact



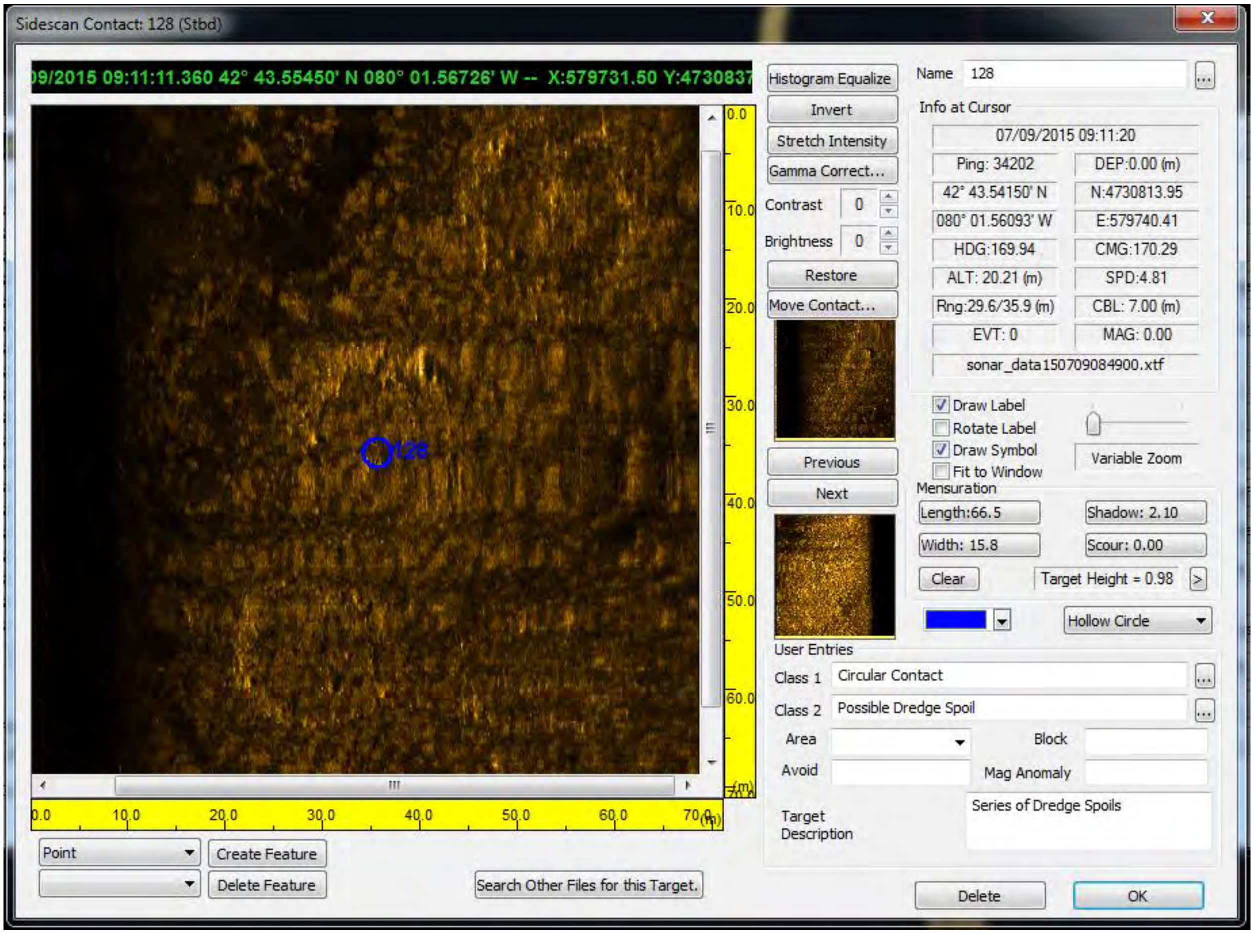
C126 - Circular Contact



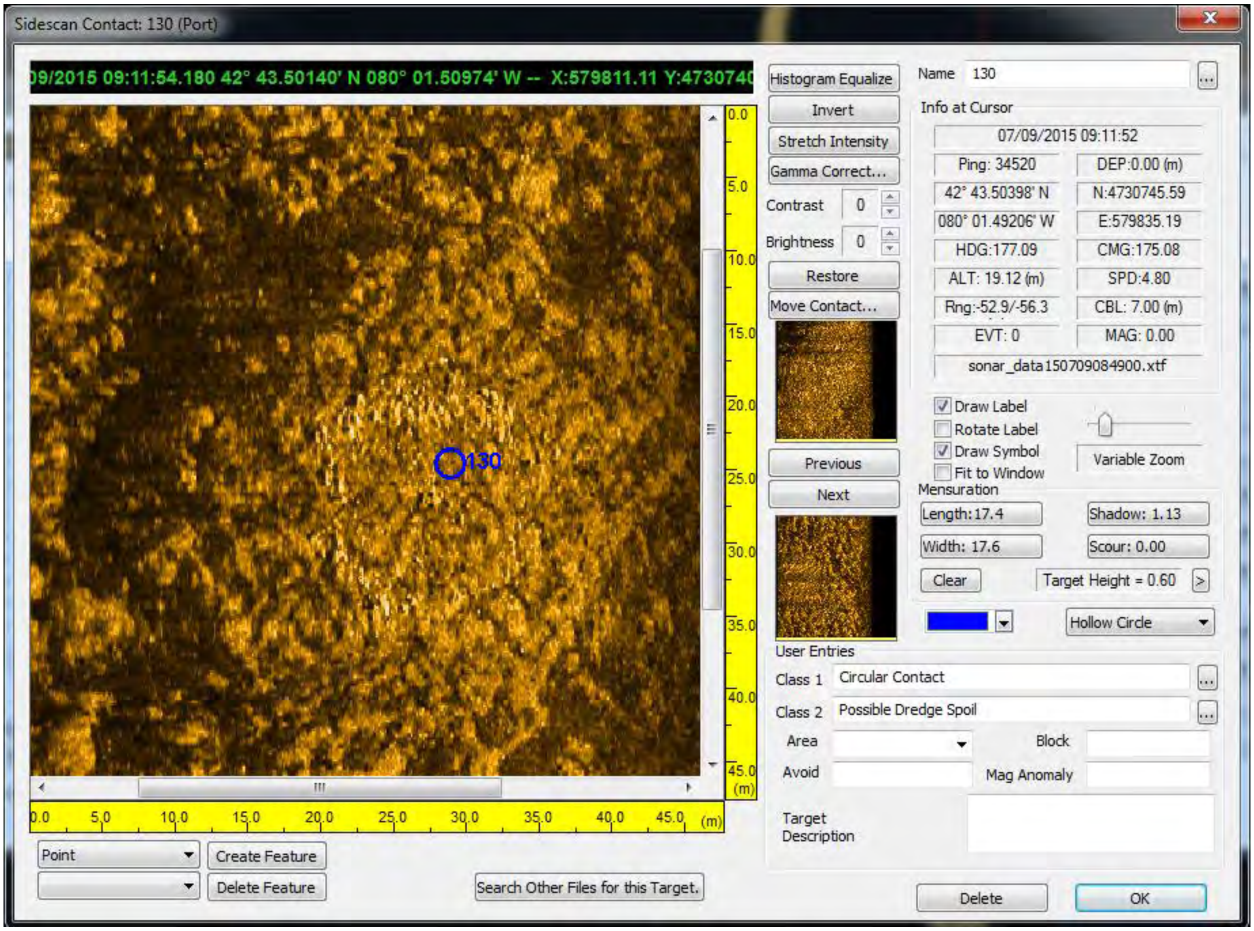
C127 - Circular Contact



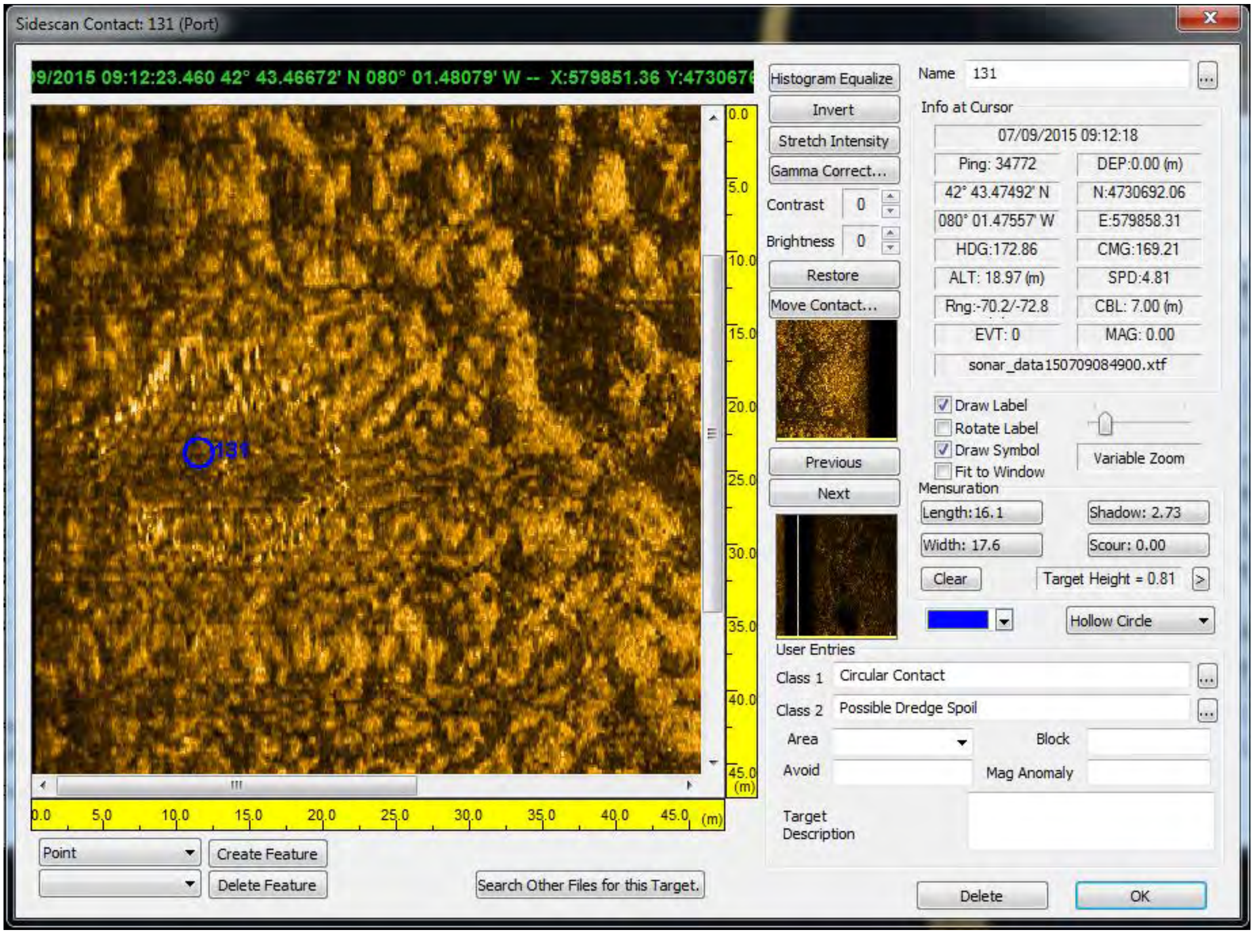
C128 - Circular Contact



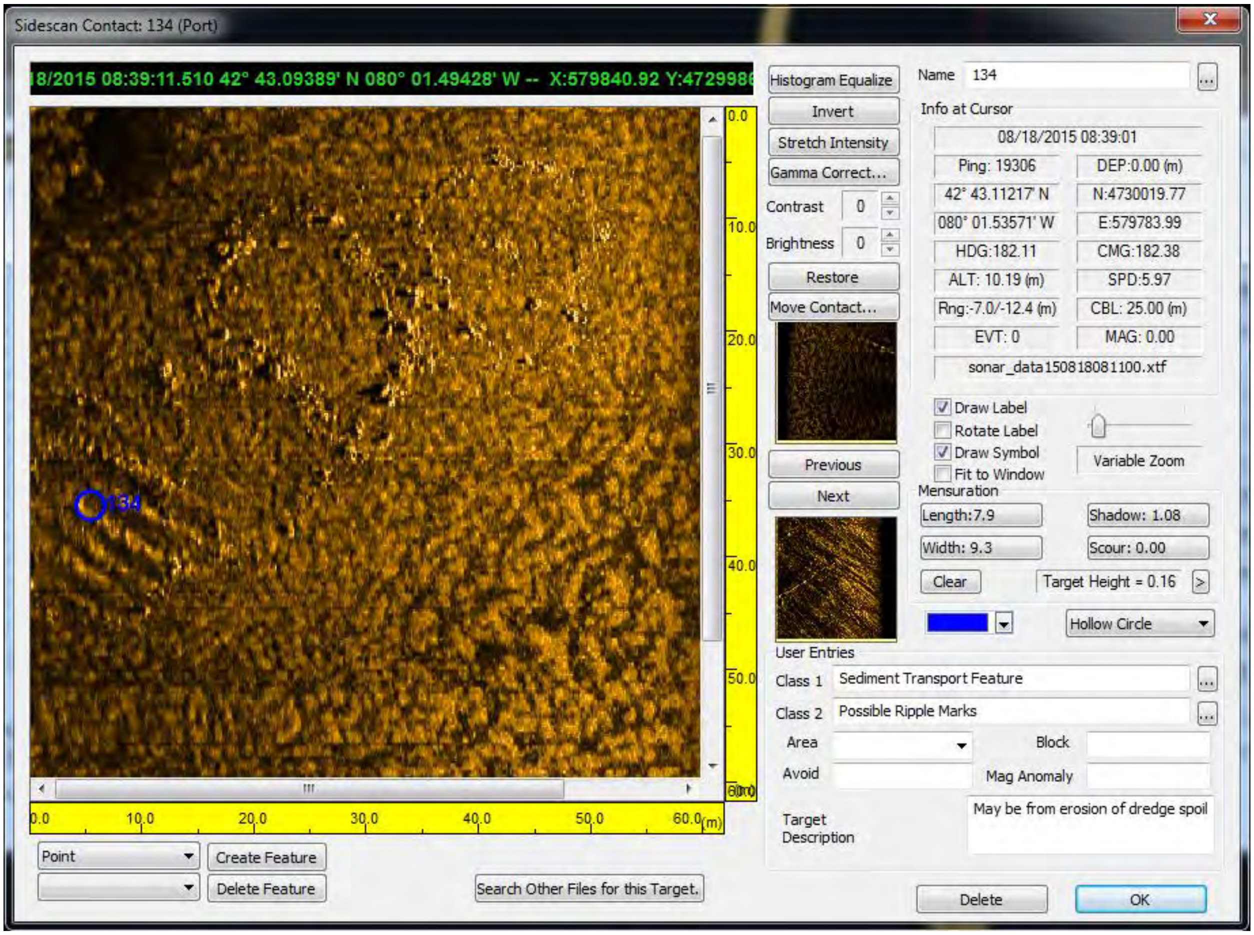
C130 - Circular Contact



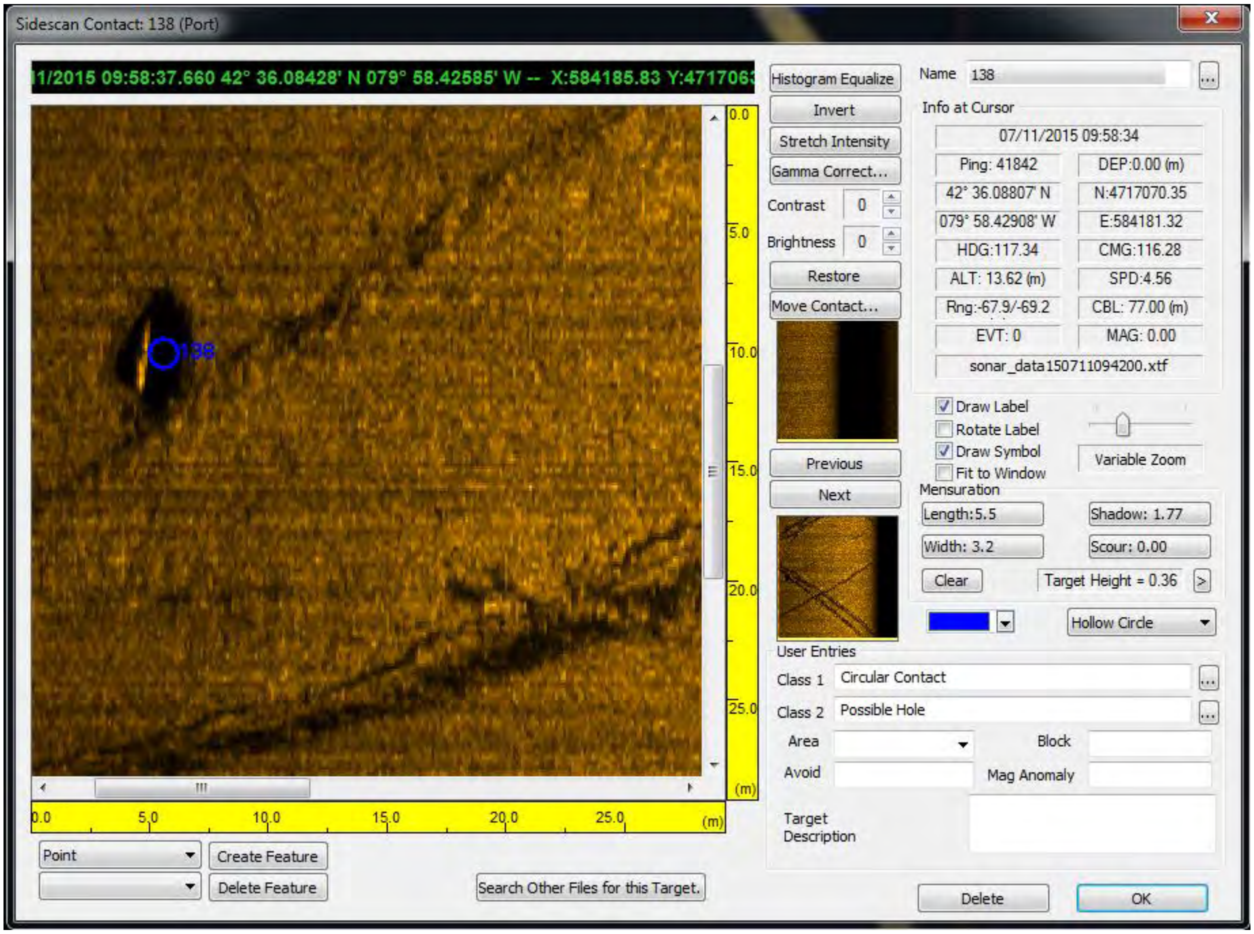
C131 - Circular Contact



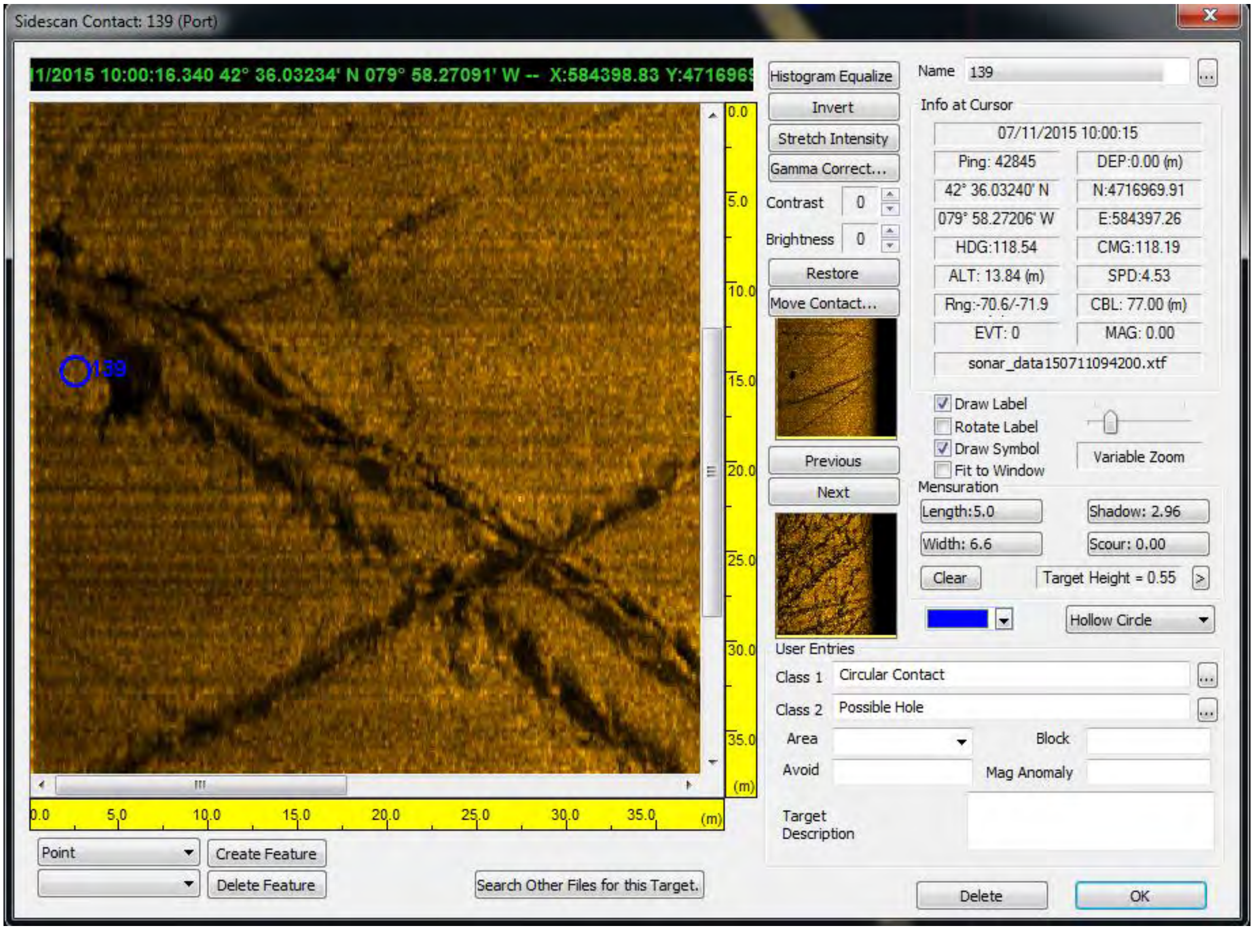
C134 - Sediment Transport Feature



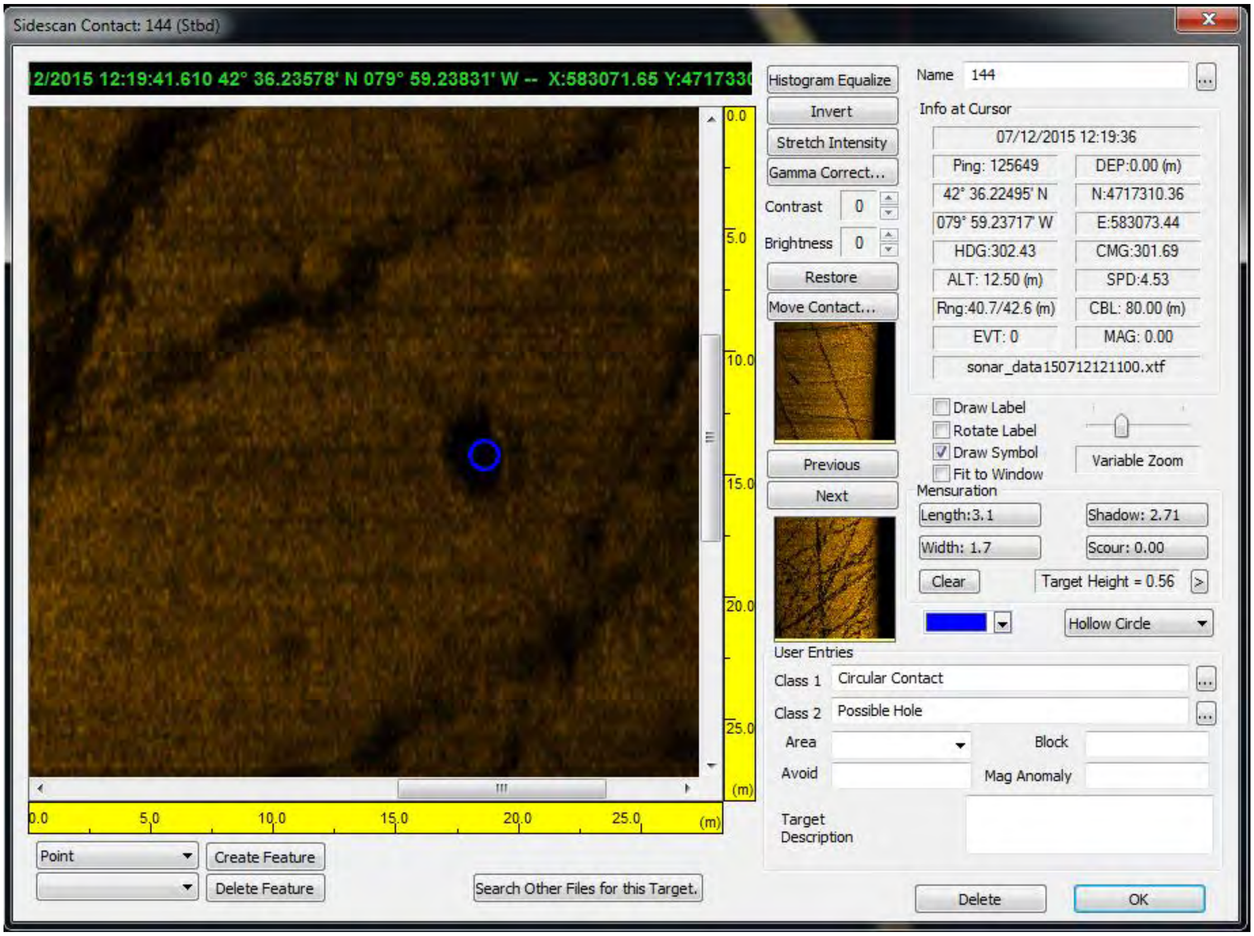
C138 - Circular Contact



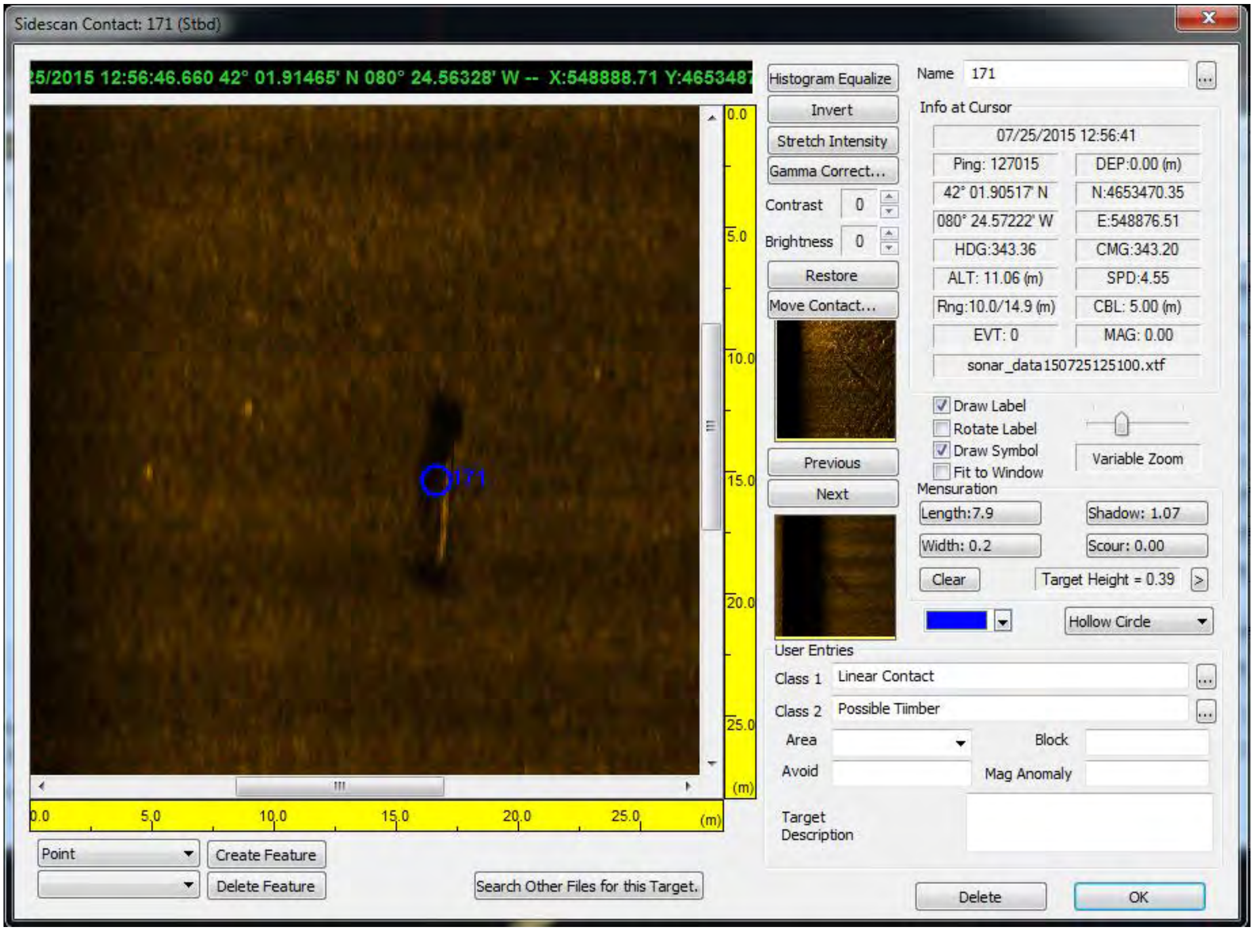
C139 - Circular Contact



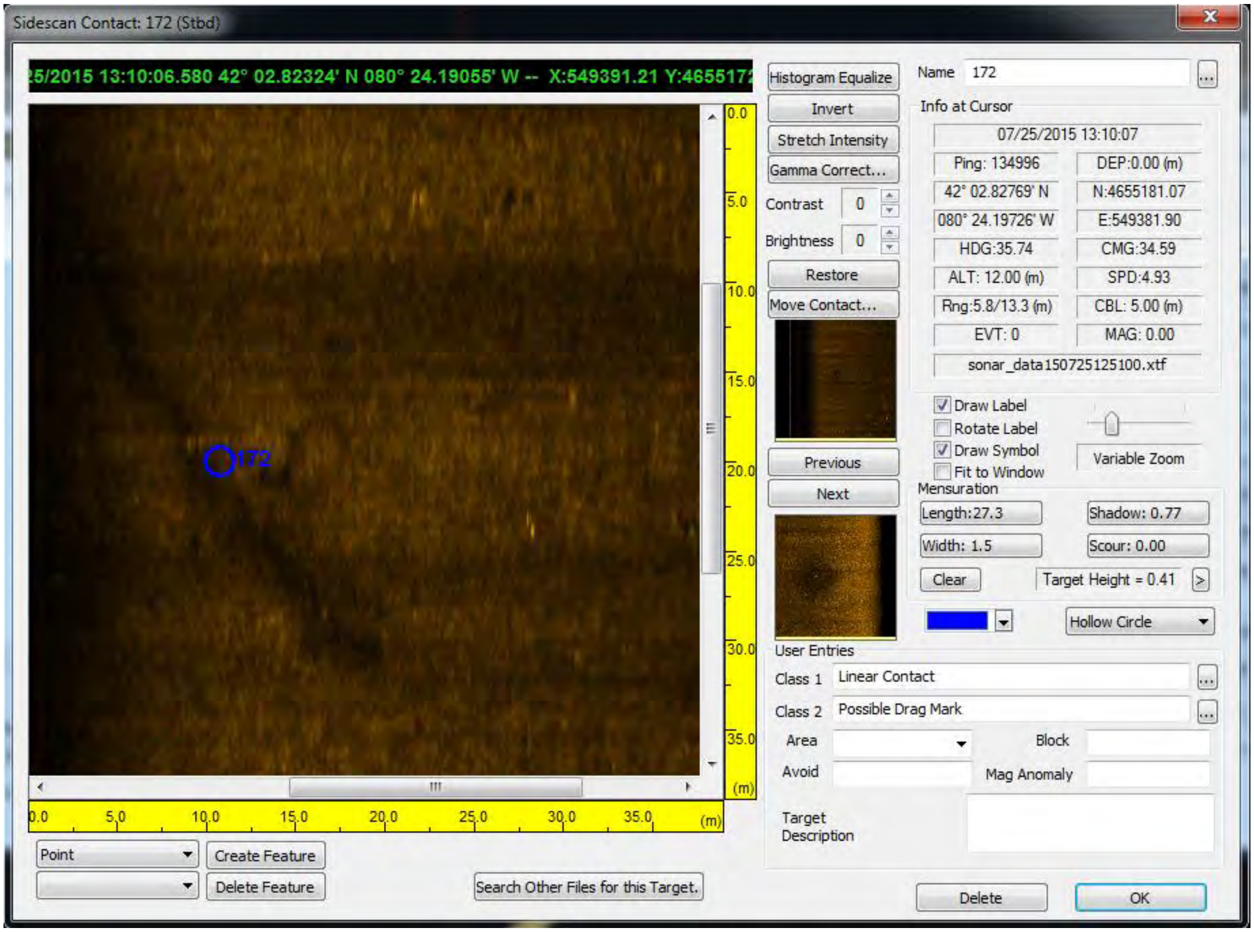
C144 - Circular Contact



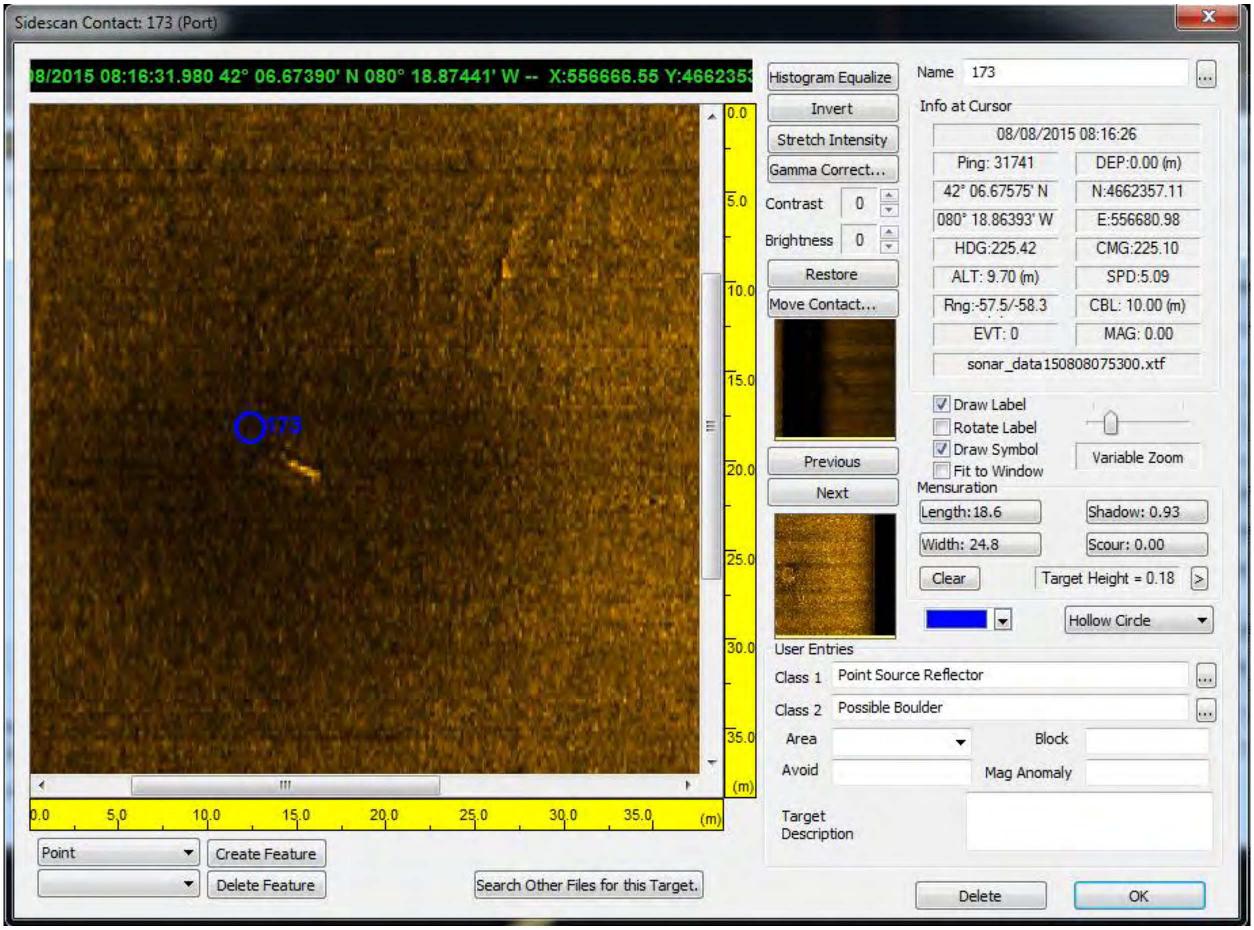
C171 - Linear Contact



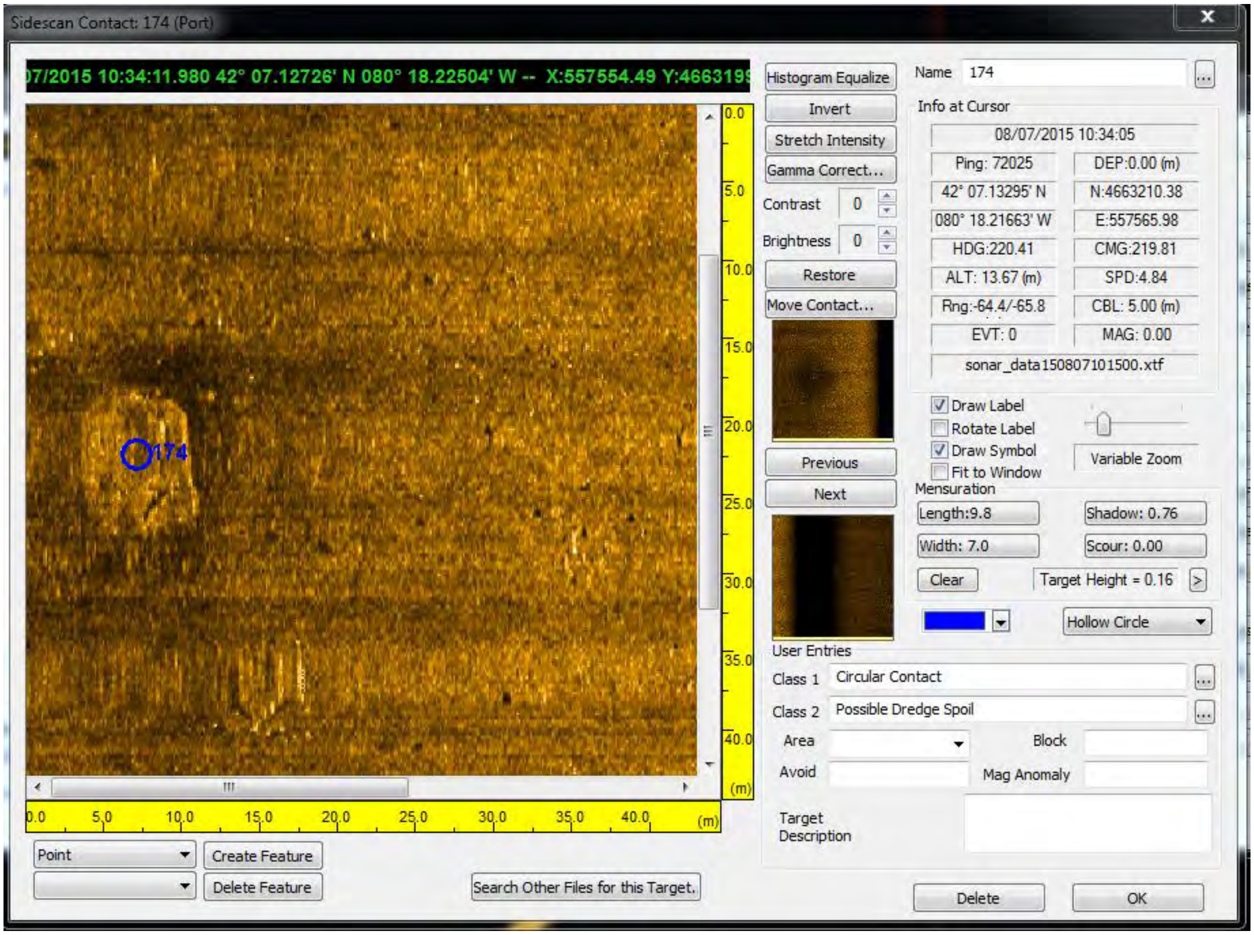
C172 - Linear Contact



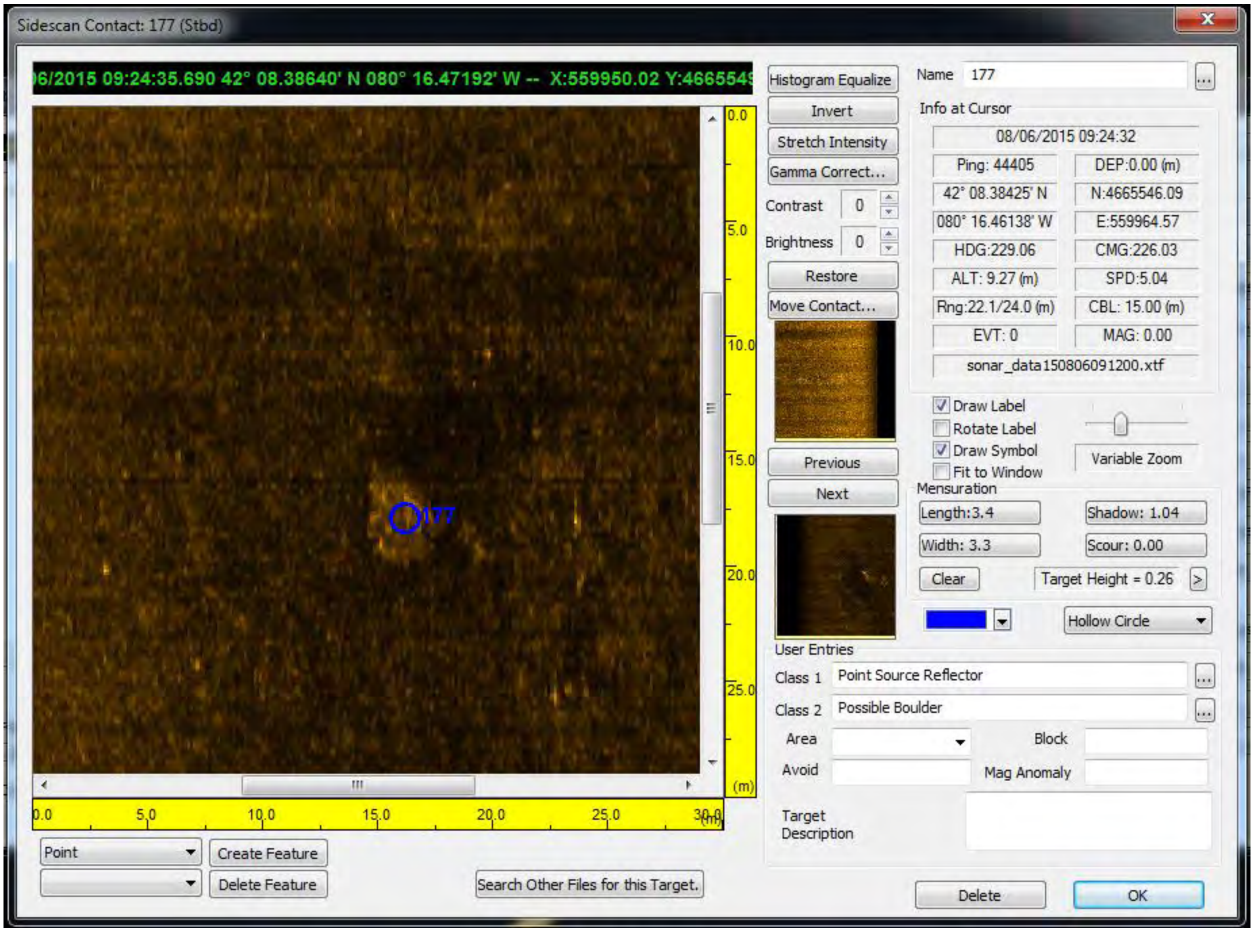
C173 - Point Source Reflector



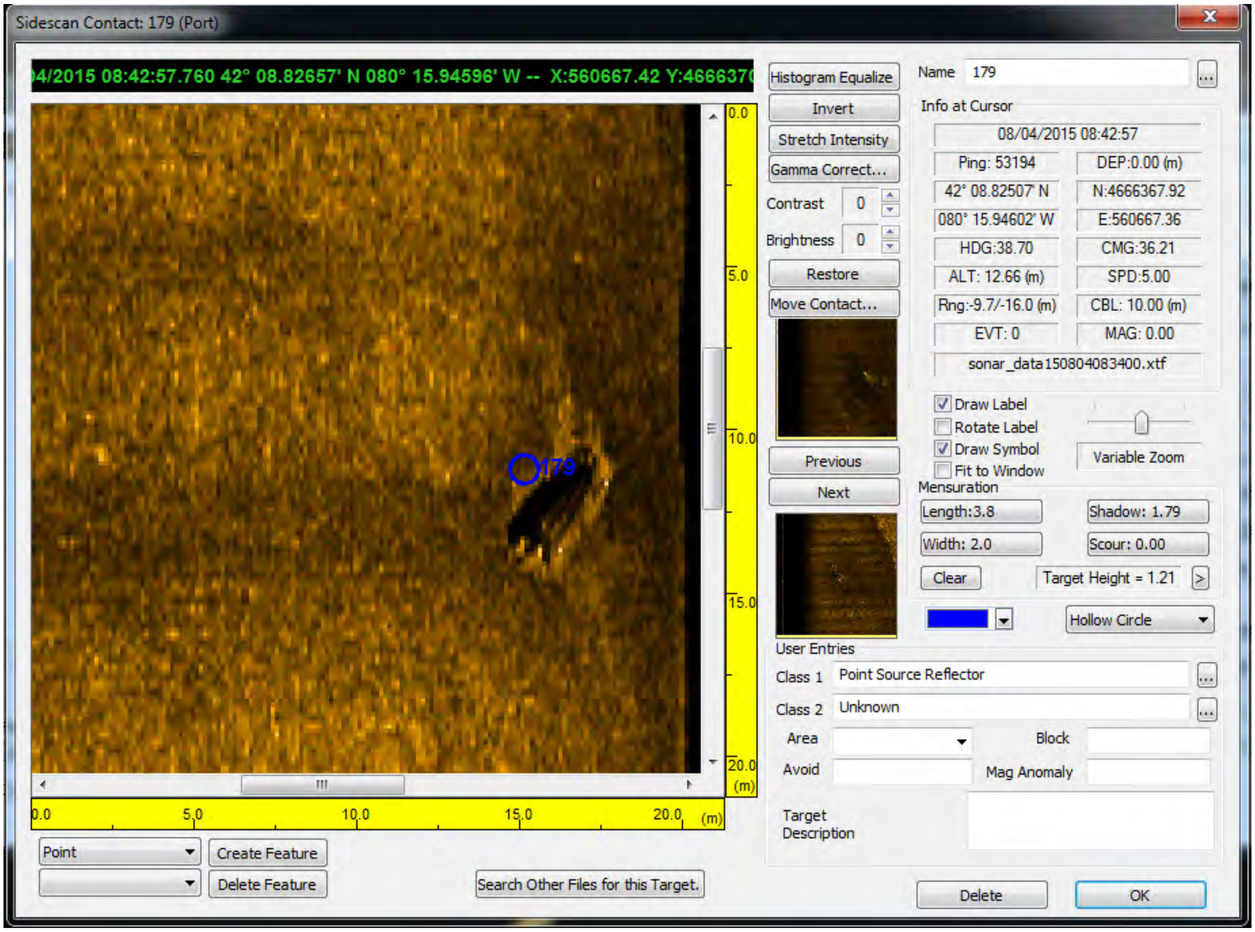
C174 - Circular Contact



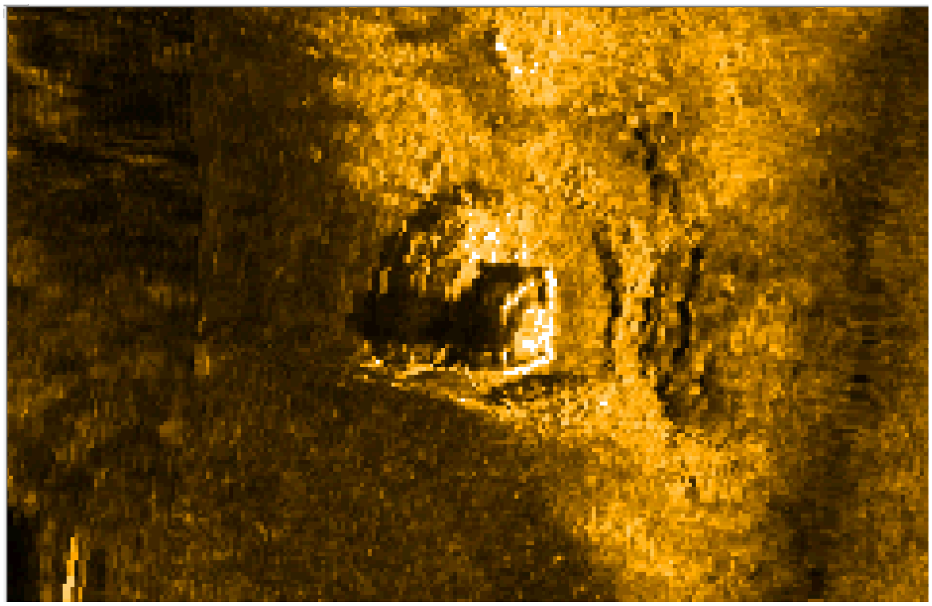
C177 - Point Source Reflector



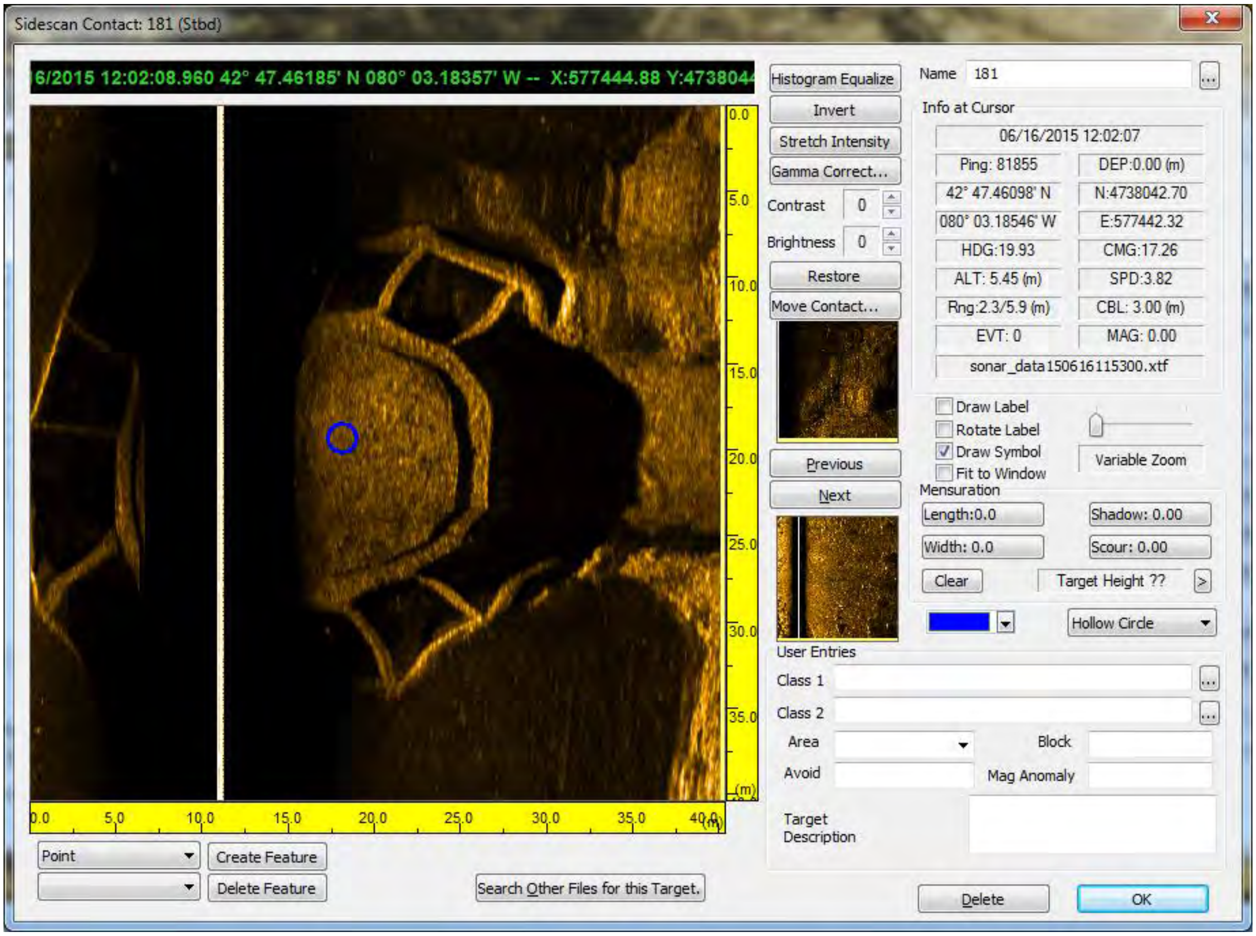
C179 - Point Source Reflector



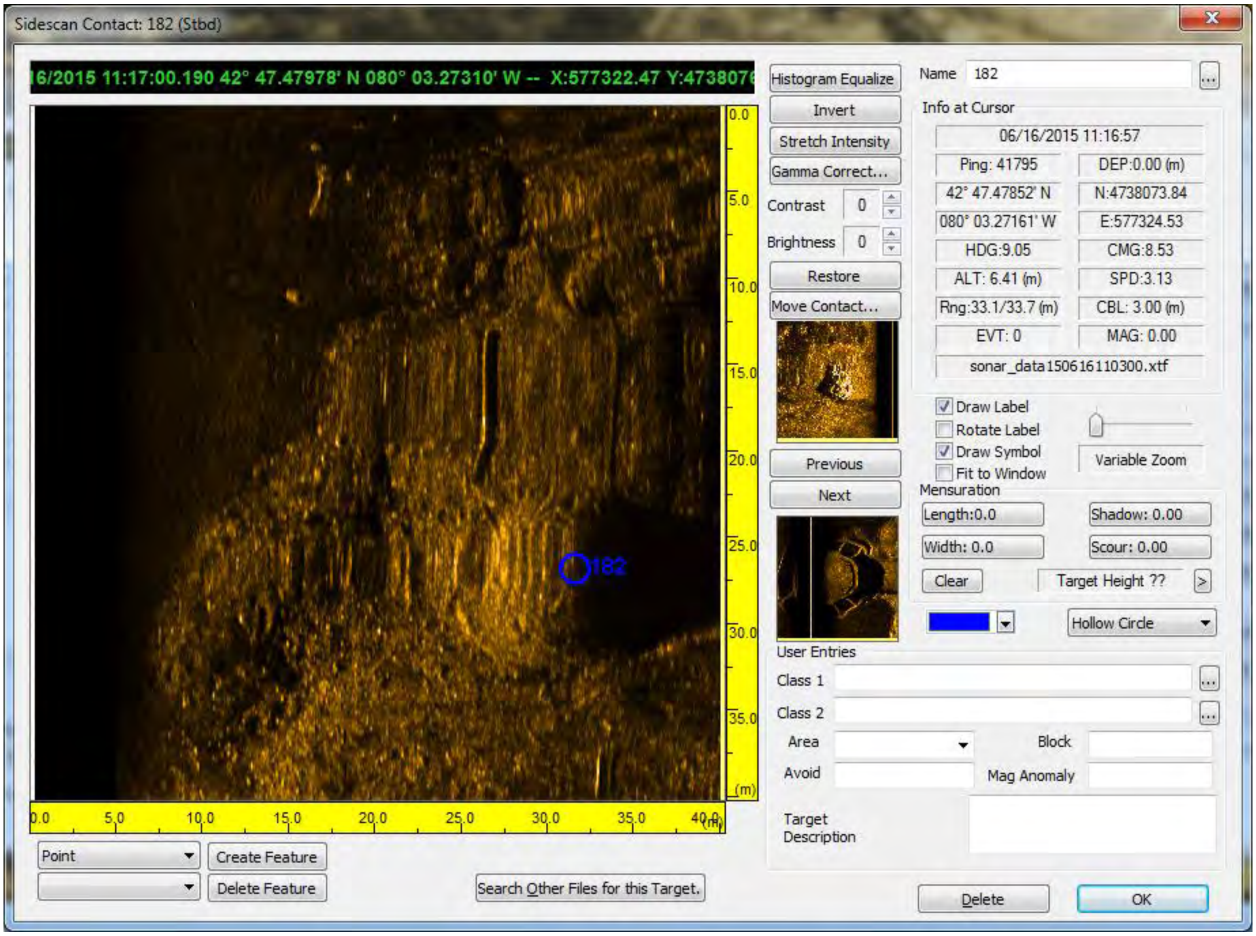
C180 - Rectangular Contact (Probable Water Intake)



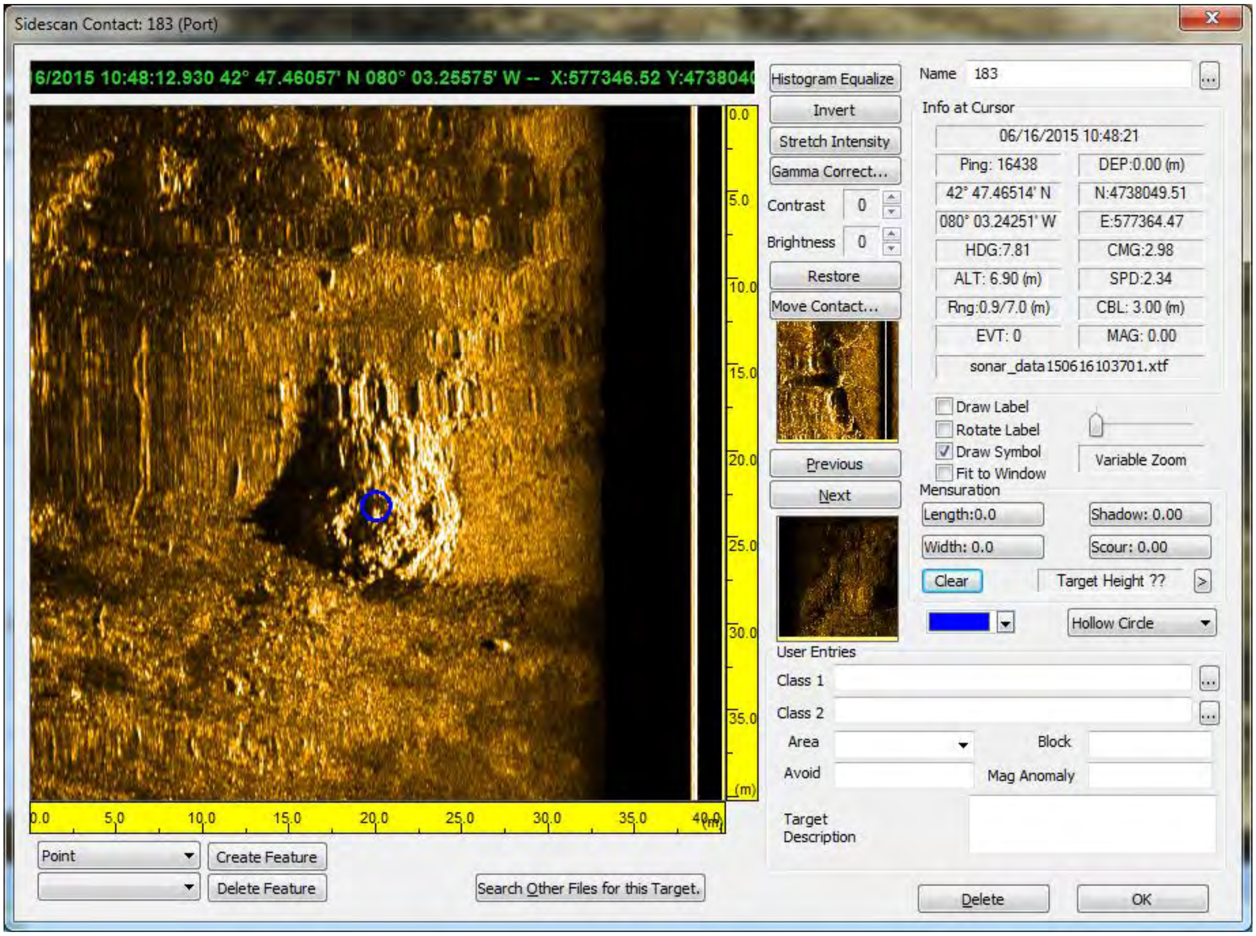
C181 - Crib (Probable Water Intake)



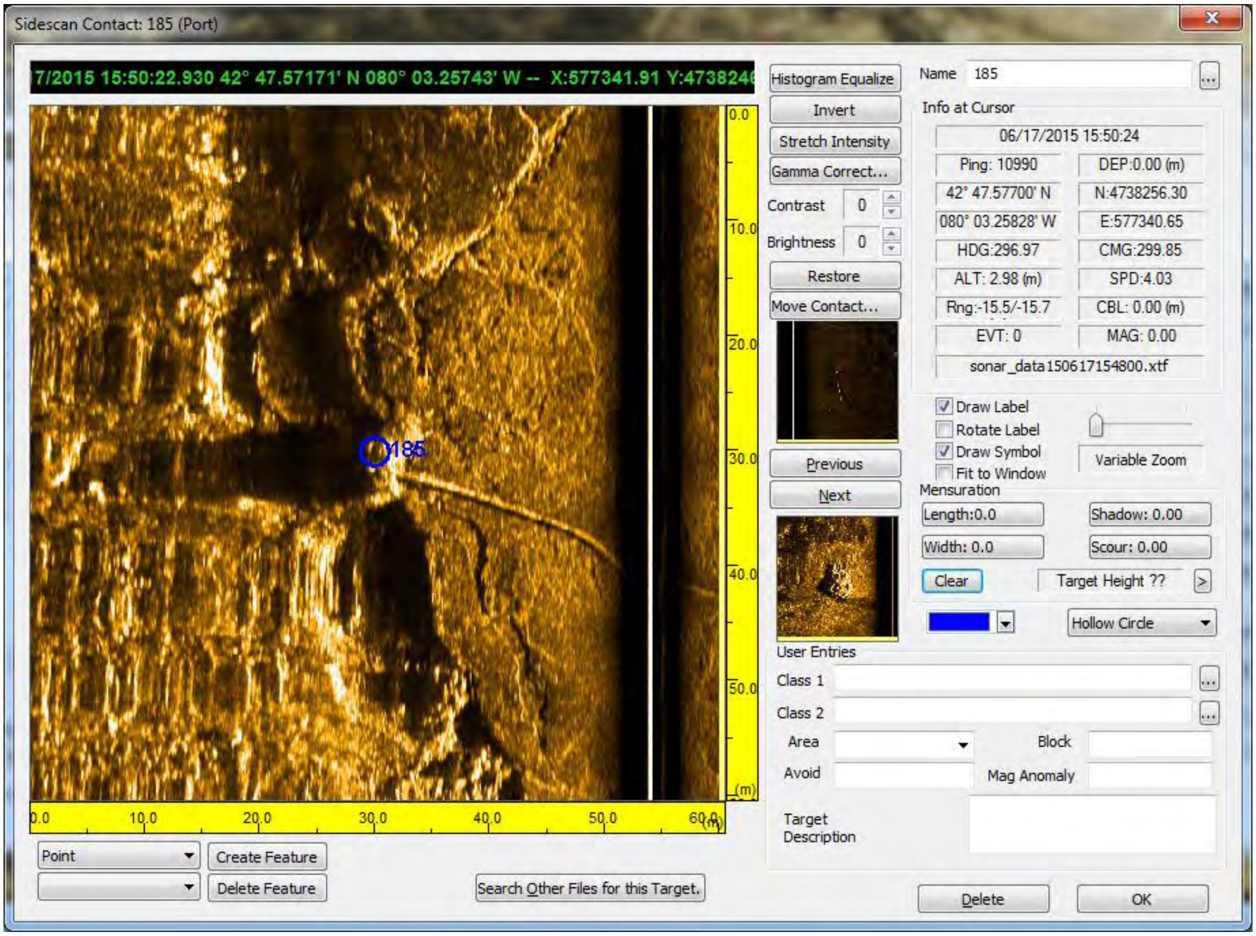
C182 - Point Source Reflector (Probable Boulder)



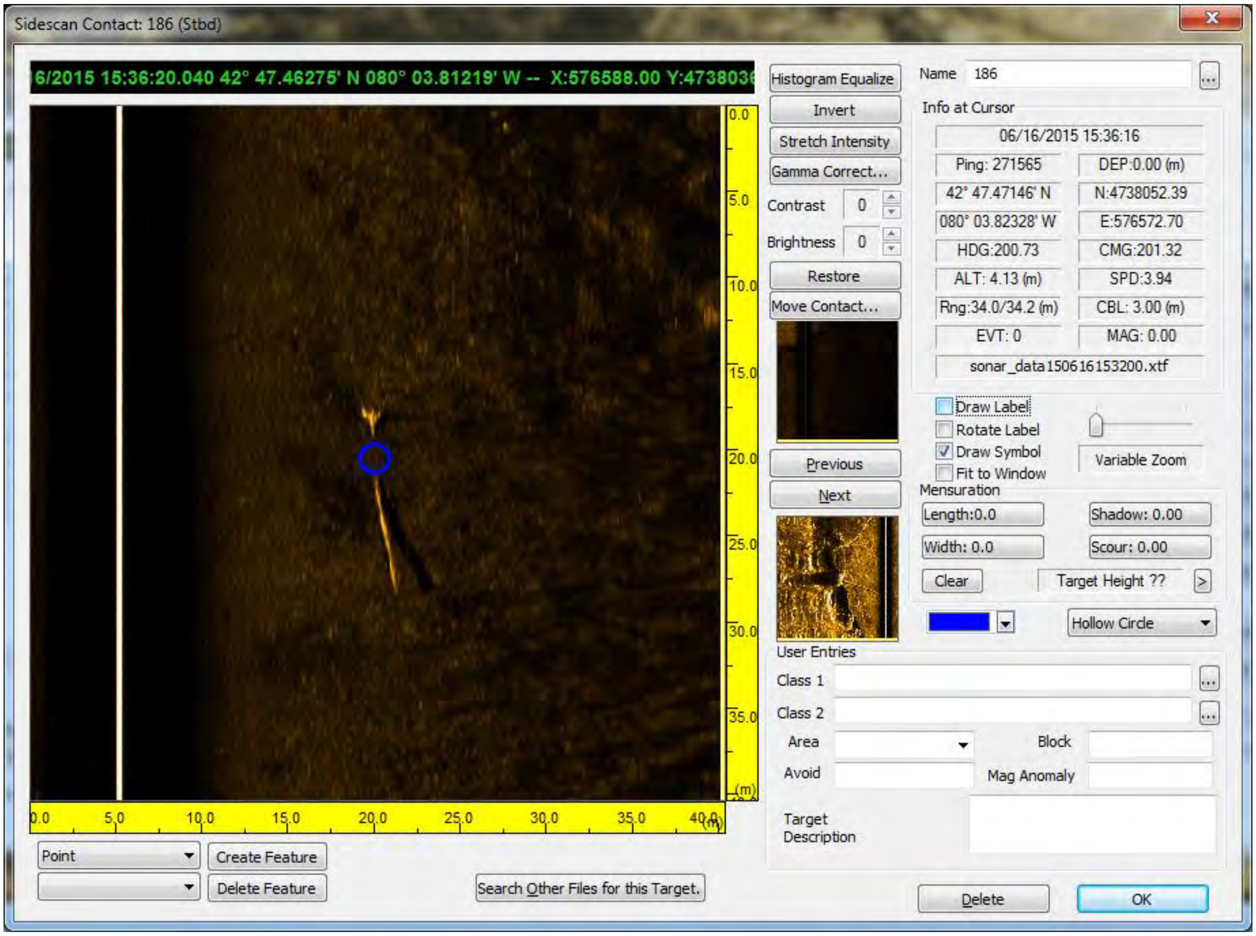
C183 - Point Source Reflector (Probable Boulder)



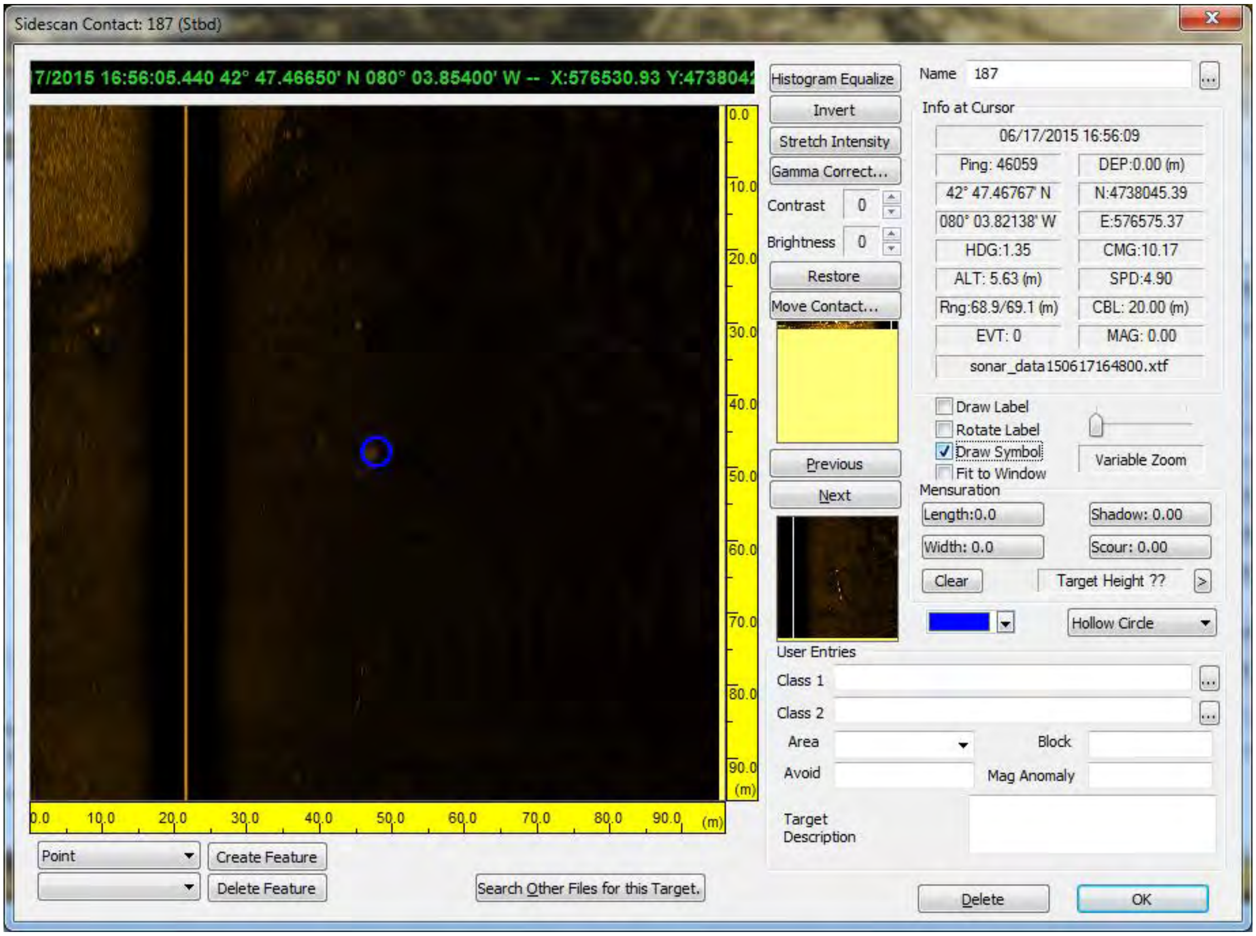
C185 - Point Source Reflector (Probable Boulder)



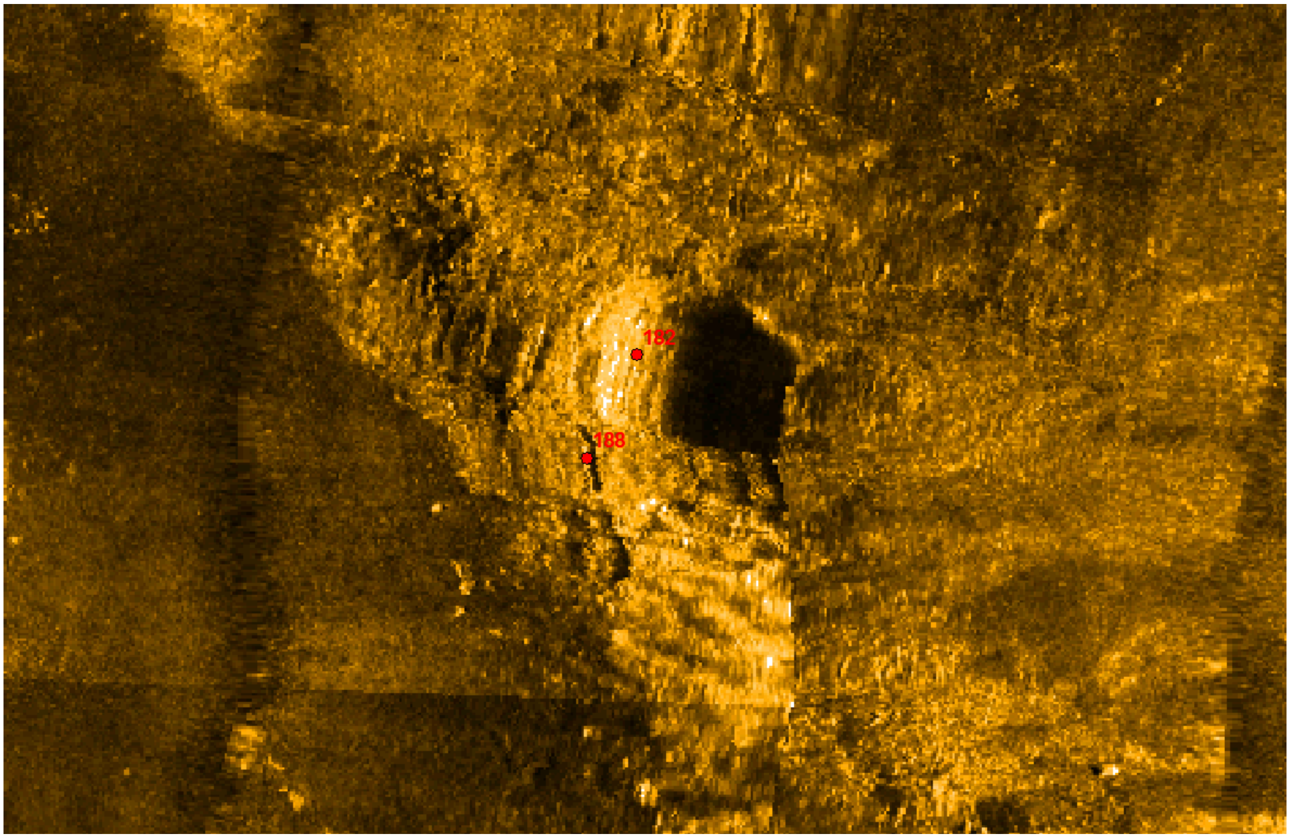
C186 - Linear Contact



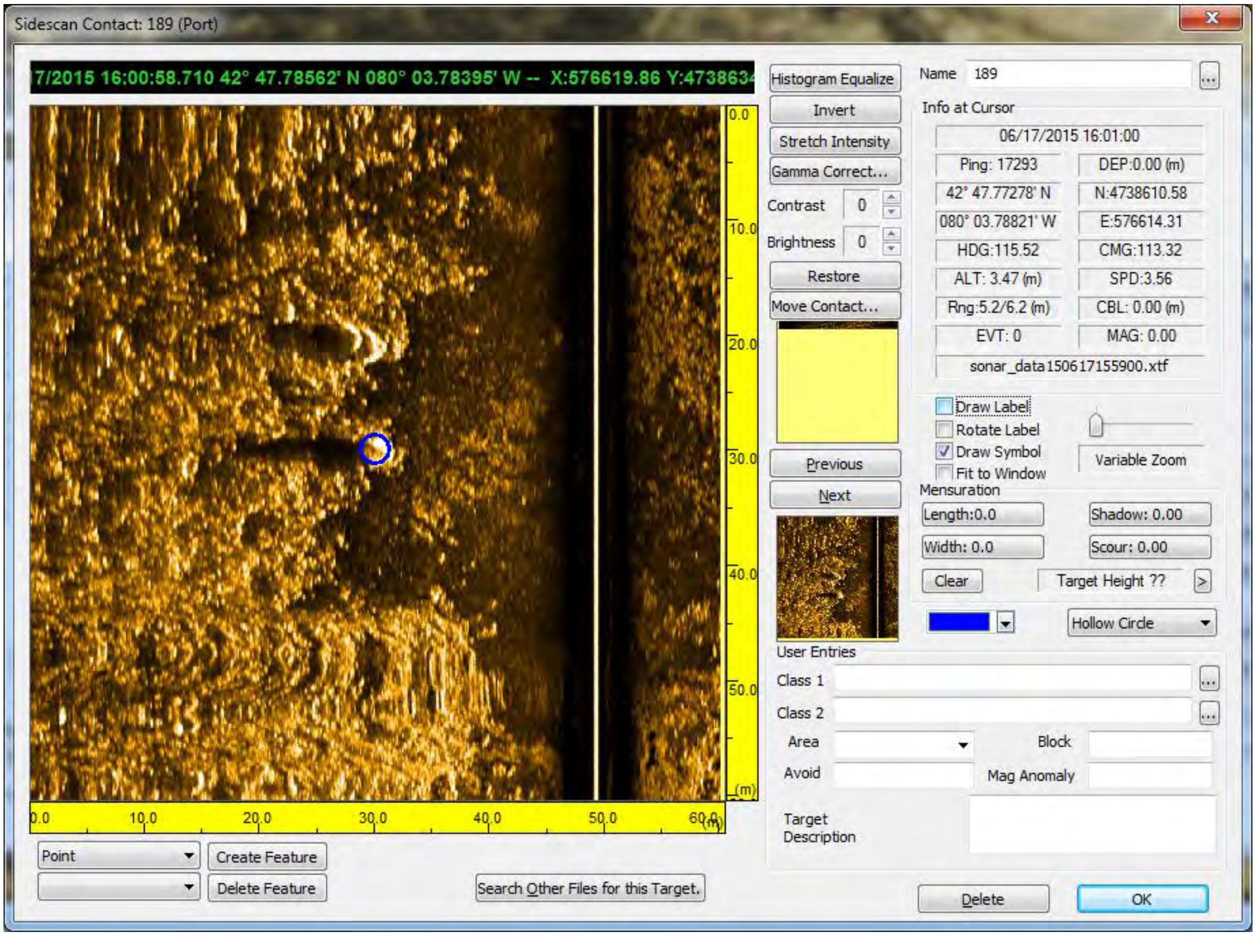
C187 - Point Source Reflector (Probable Boulder)



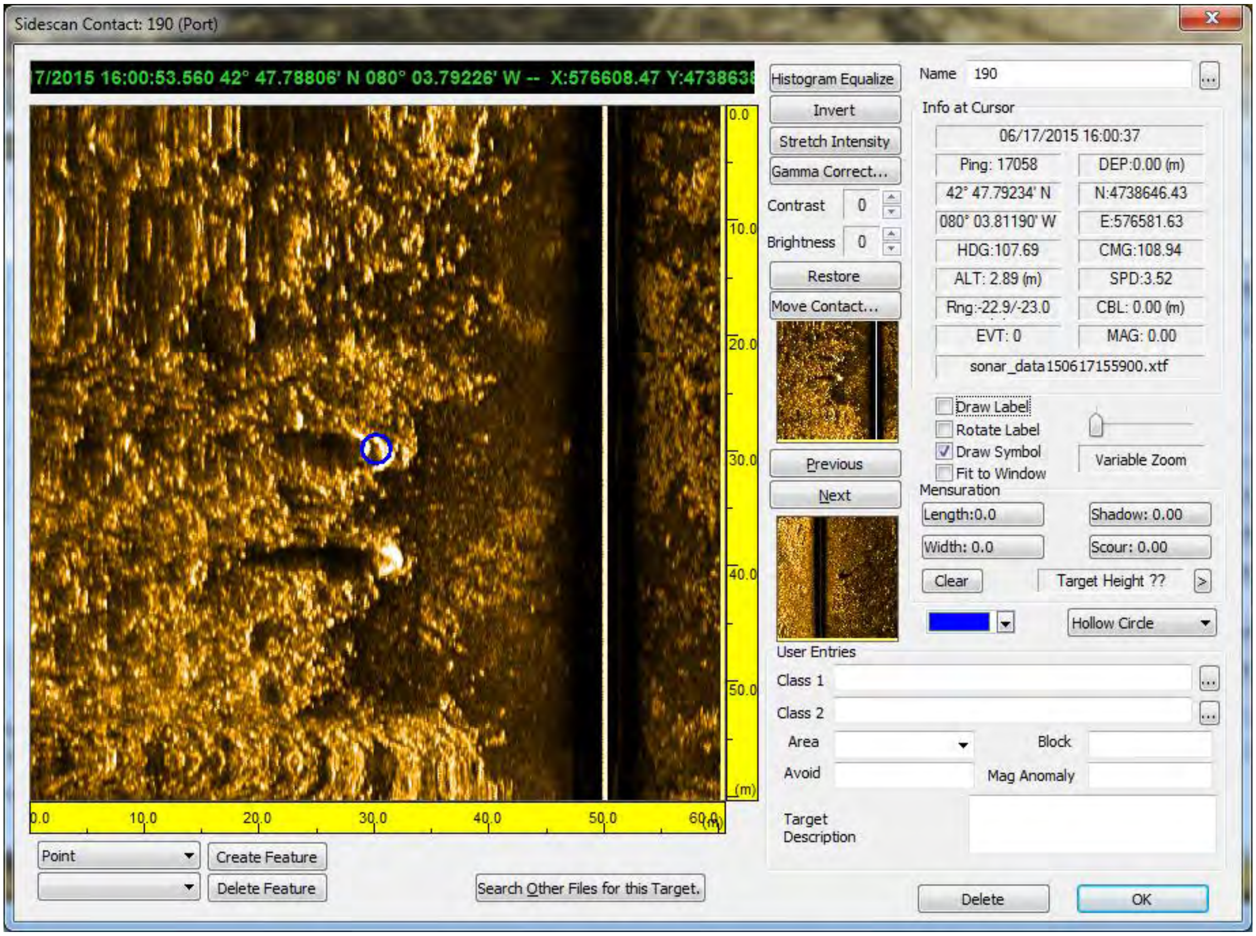
C188 - Linear Feature



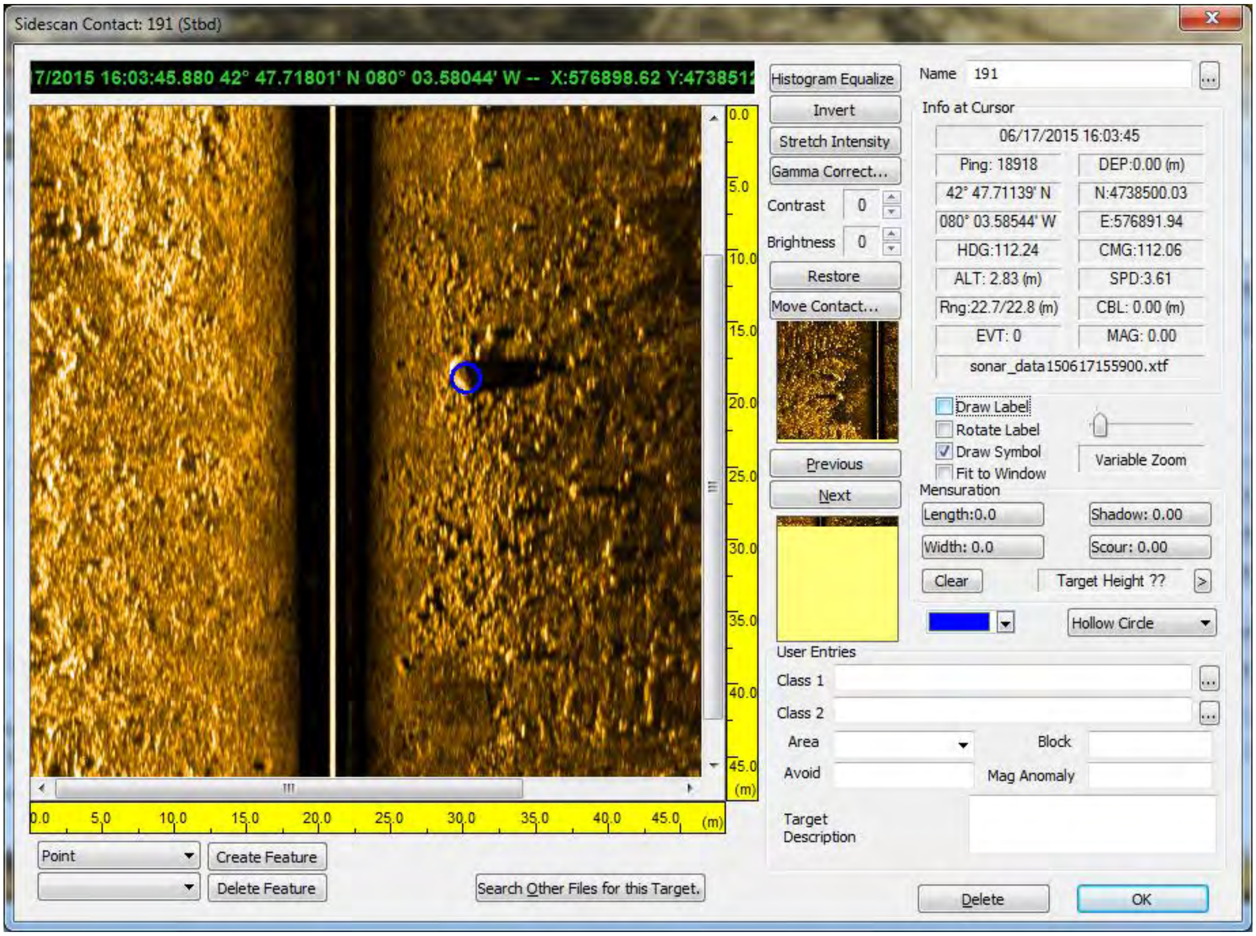
C189 - Point Source Reflector (Possible old Channel Marker)



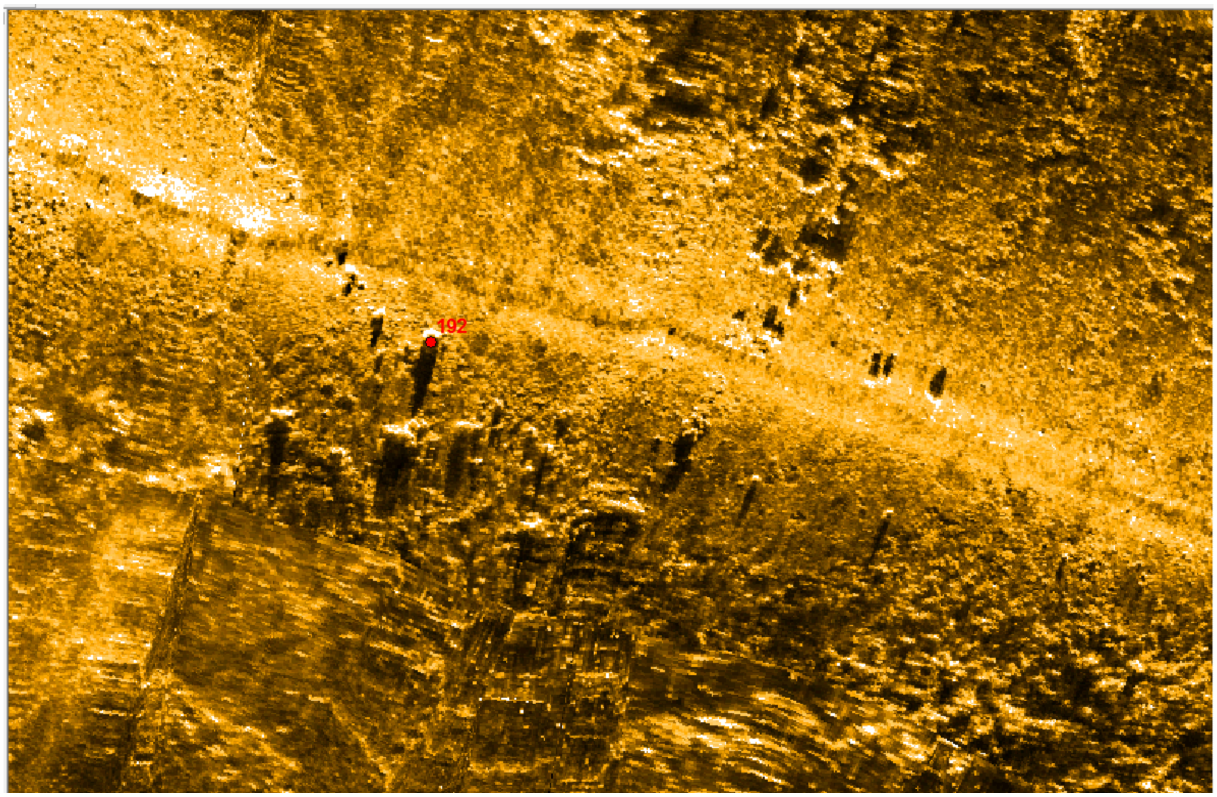
C190 - Point Source Reflector (Possible old Channel Marker)



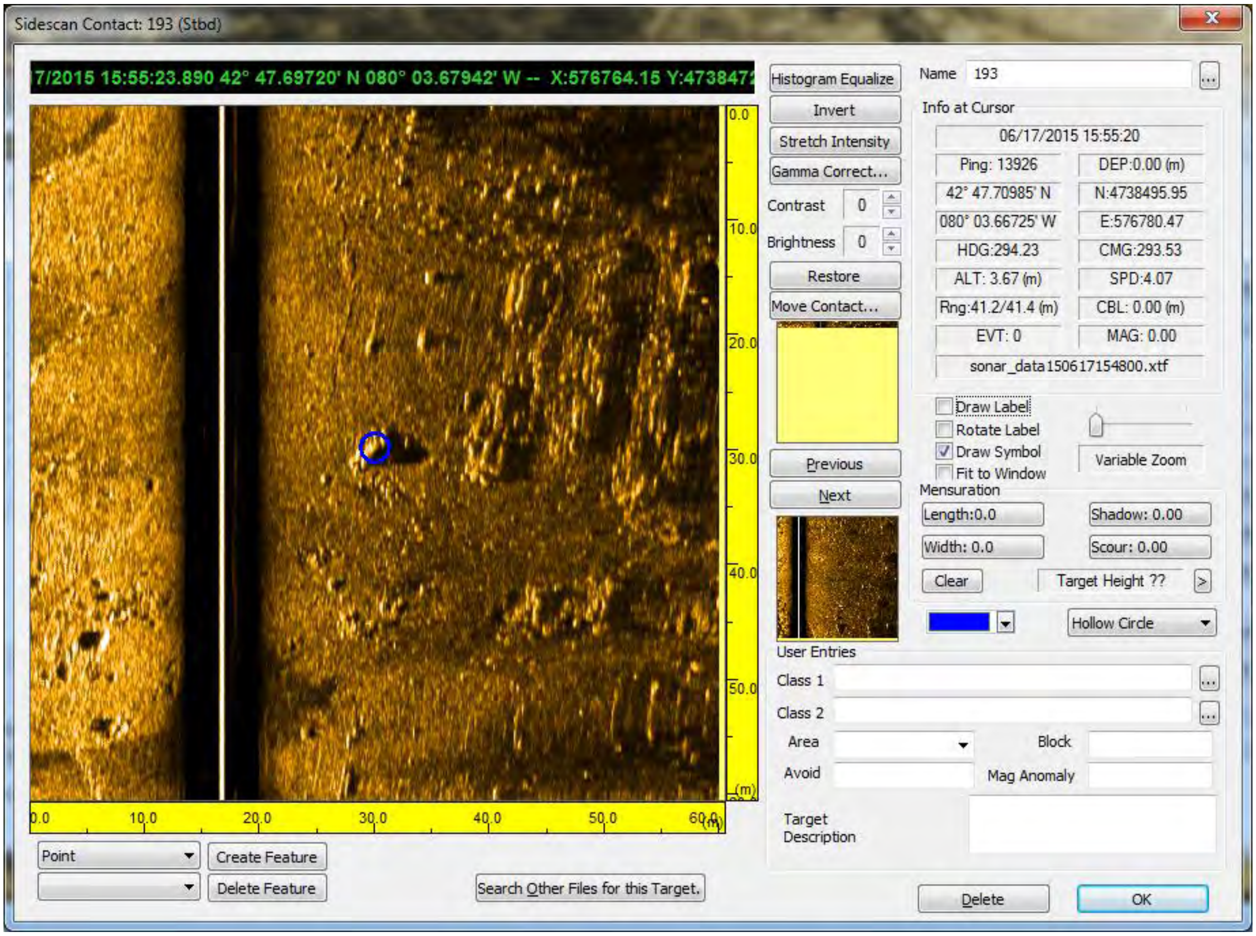
C191 - Point Source Reflector (Probable Boulder)



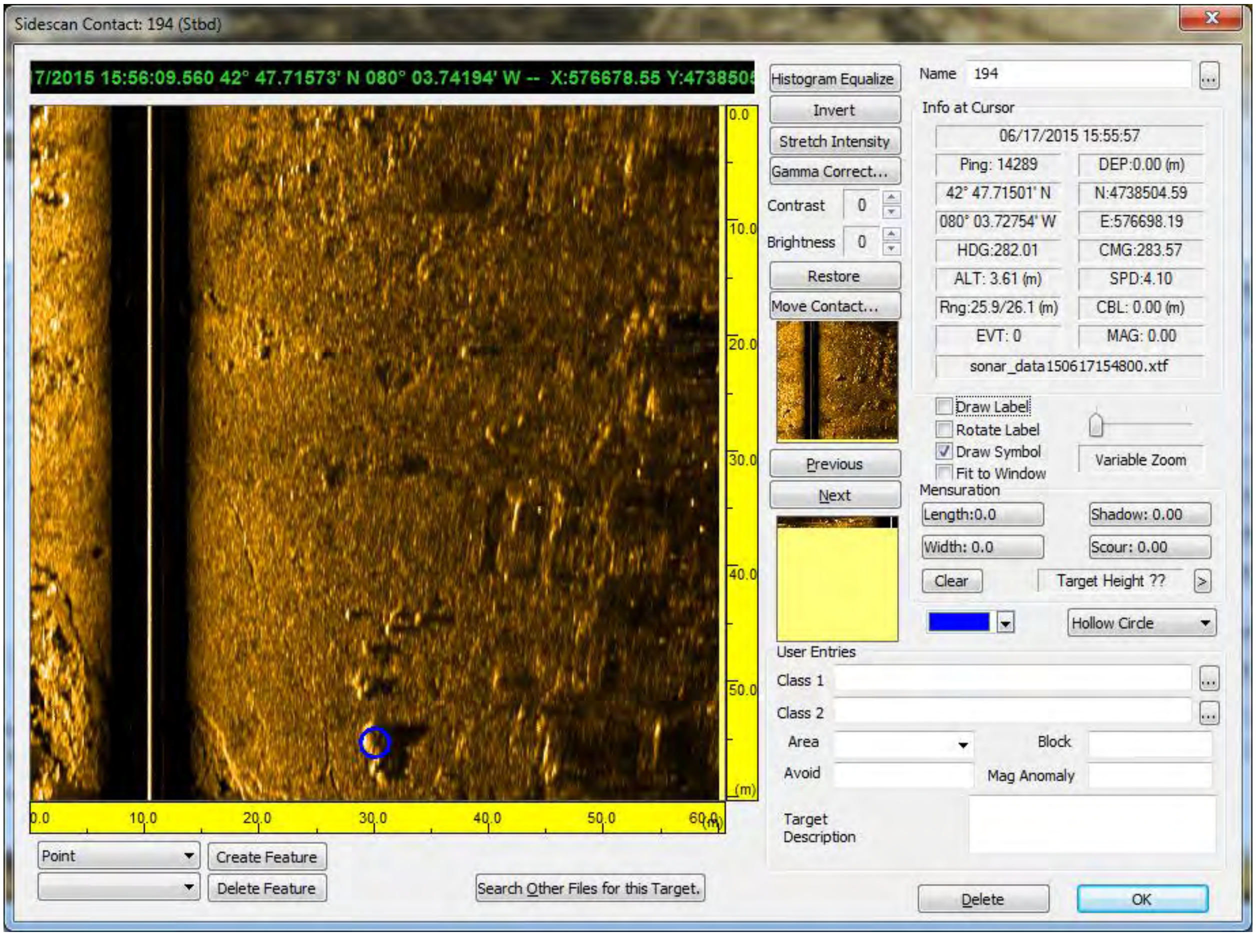
C192 - Point Source Reflector (Probable Boulder)



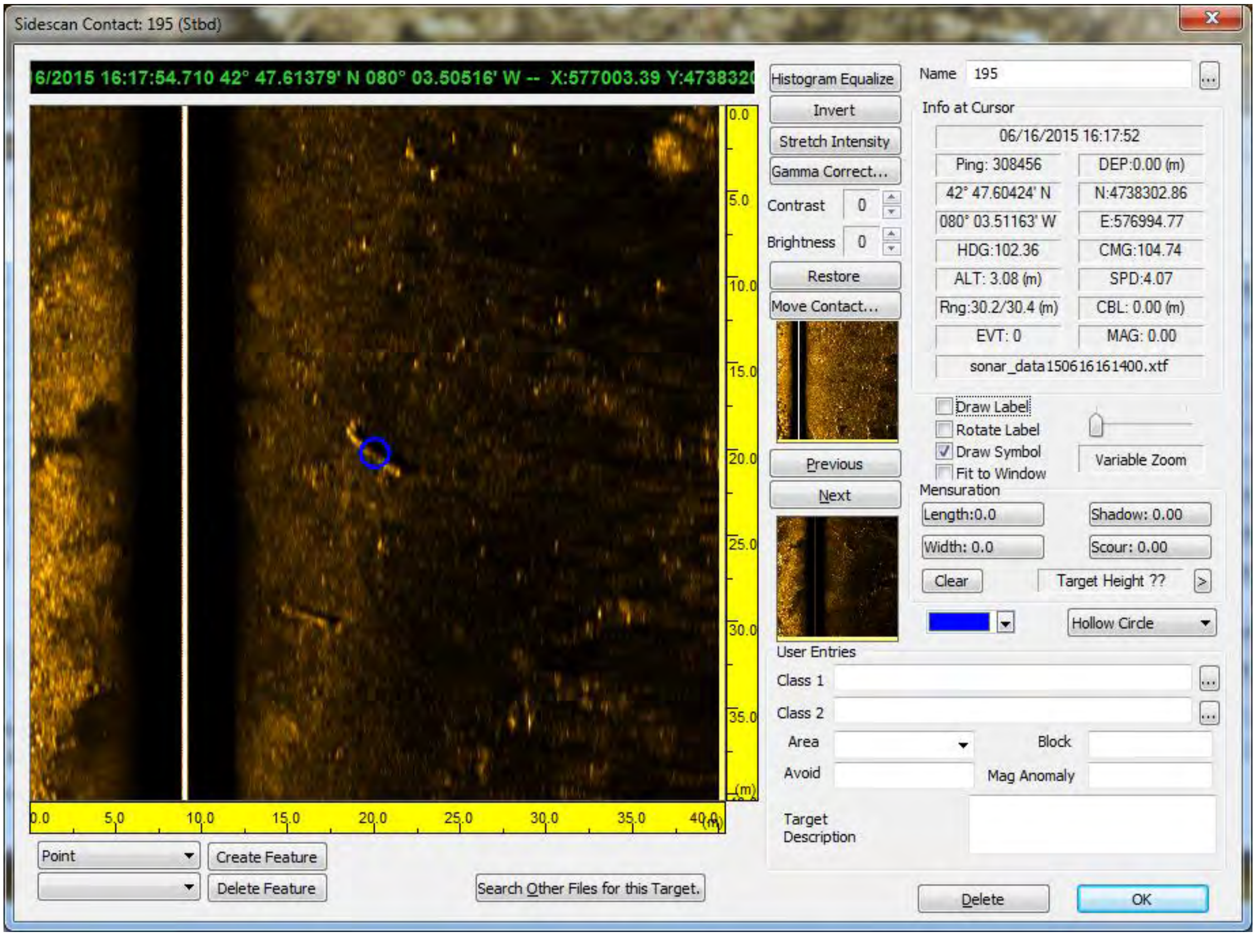
C193 - Point Source Reflector (Probable Boulder)



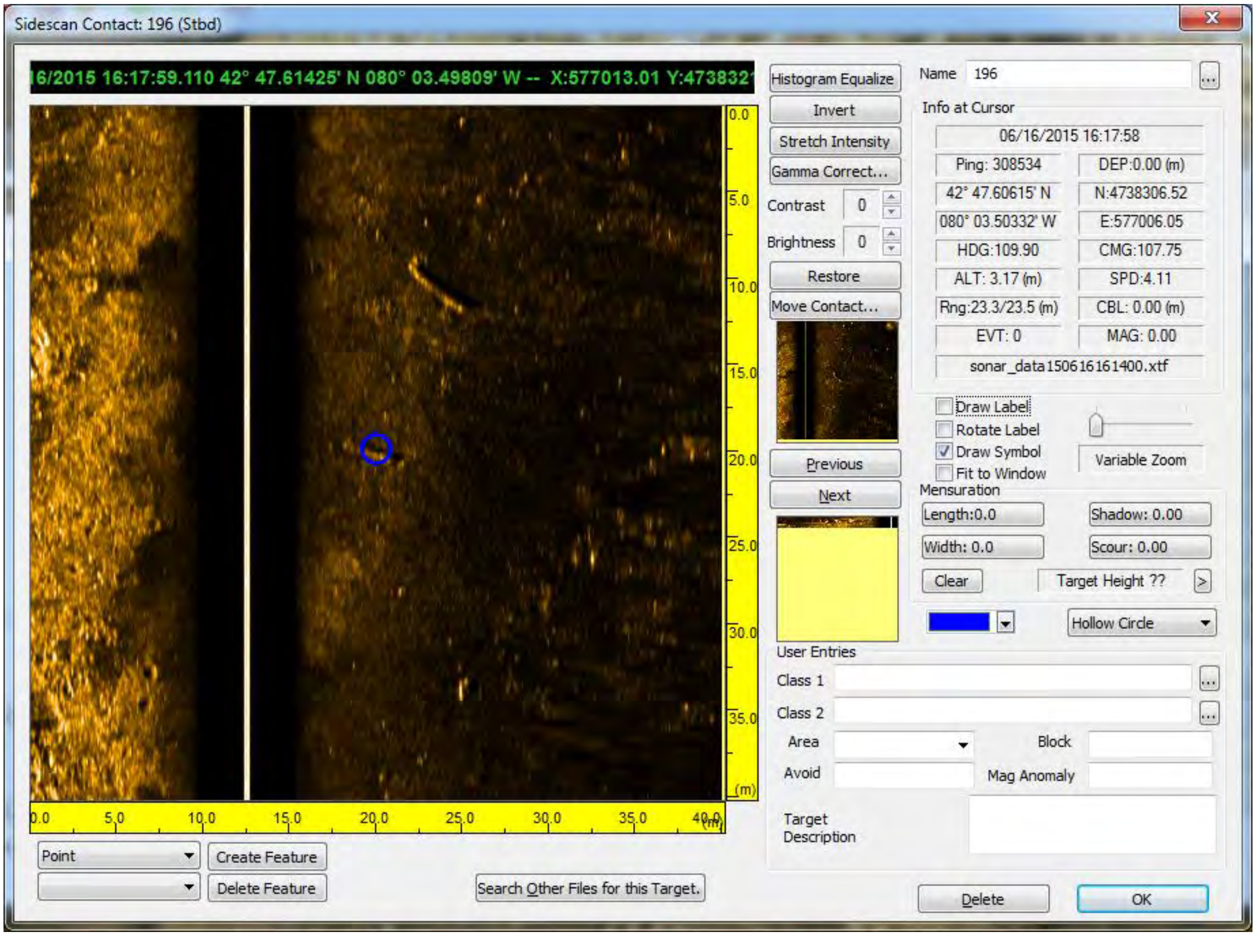
C194 - Point Source Reflector (Probable Boulder)



C195 - Linear Feature - Metal Debris



C196 - Linear Feature - Metal Debris



Location 6

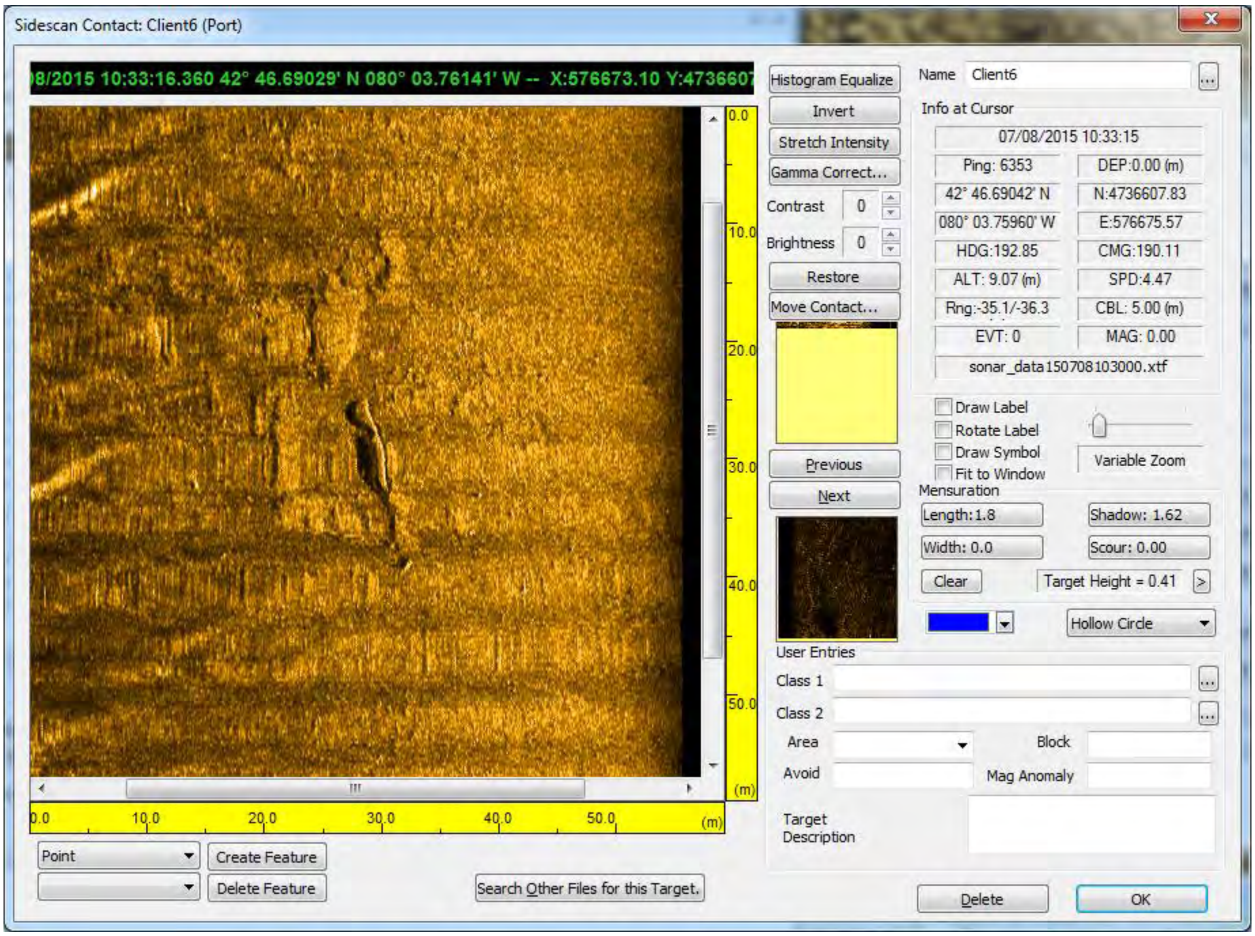
Possible drag mark.

-Linear target with no magnetometer hits.

Width: 1.8 m

Length: 13.4 m

Height: 0.4 m



Location 9

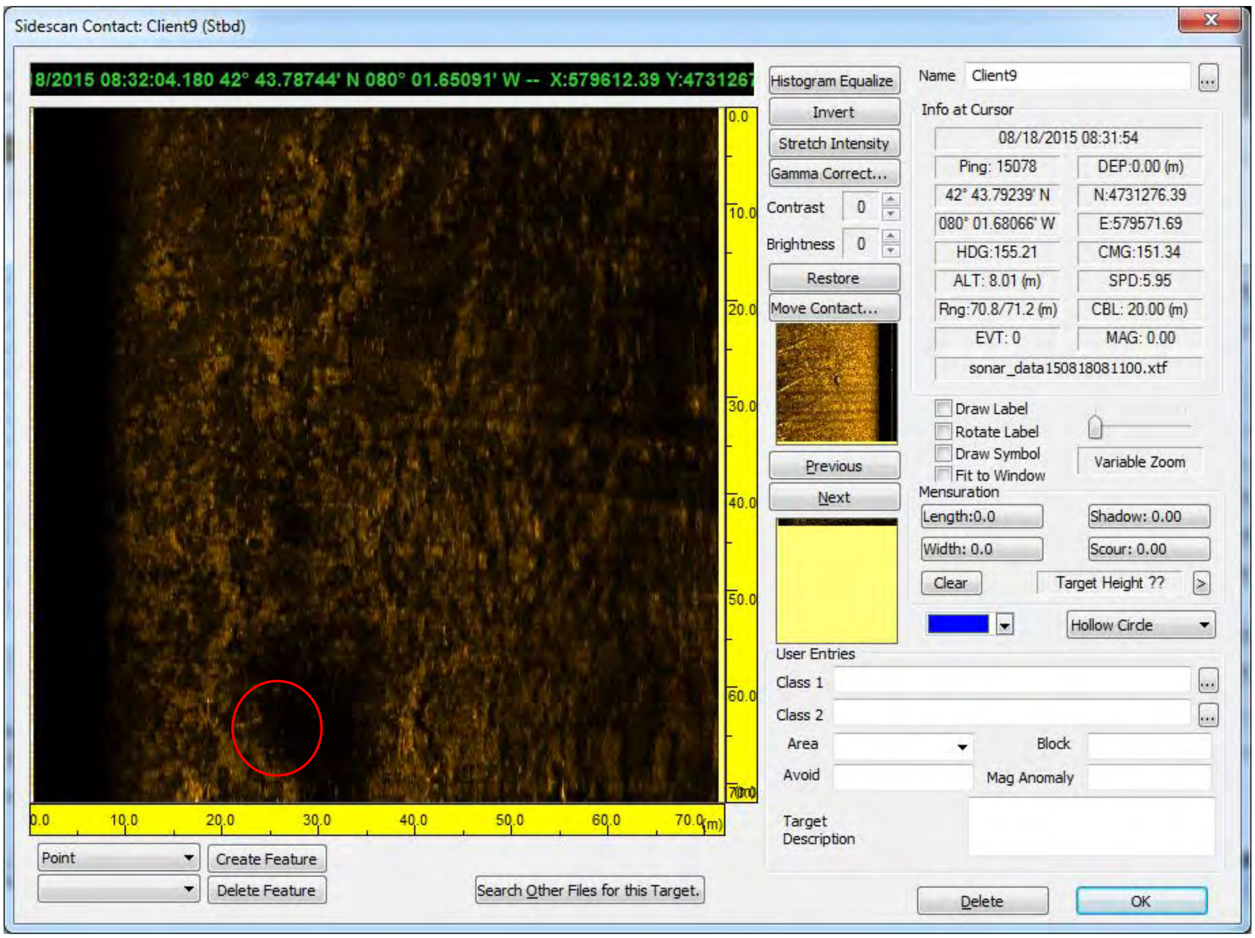
Small ridge

-Circular contact with no magnetometer hits.

Width: 9.5 m

Length: 13.4 m

Height: 0.2 m



Location 10

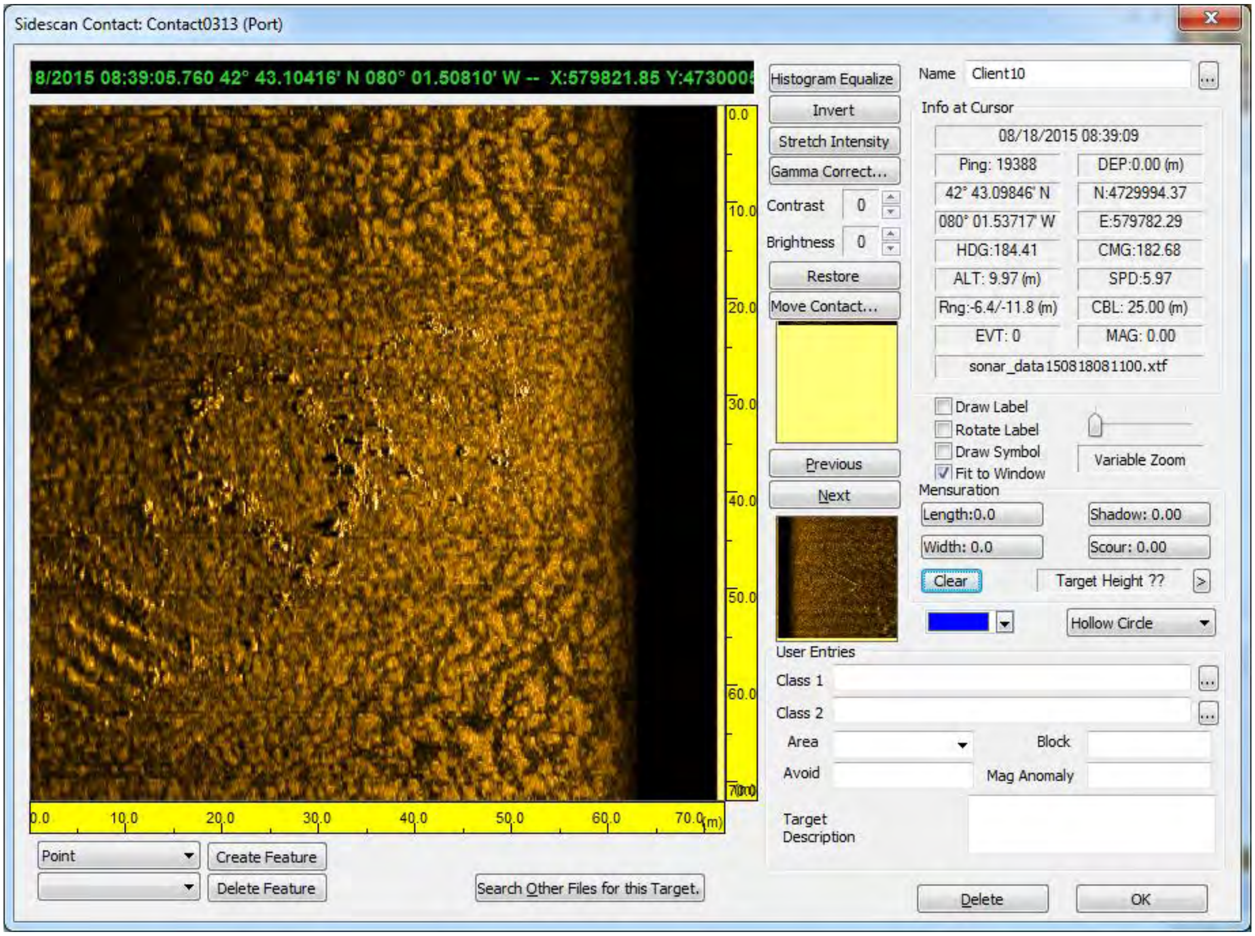
Dredge Spoils

-Circular target with no magnetometer hits.

Width: 16.7 m

Length: 20.2 m

Height: 0.3 m



Location 11

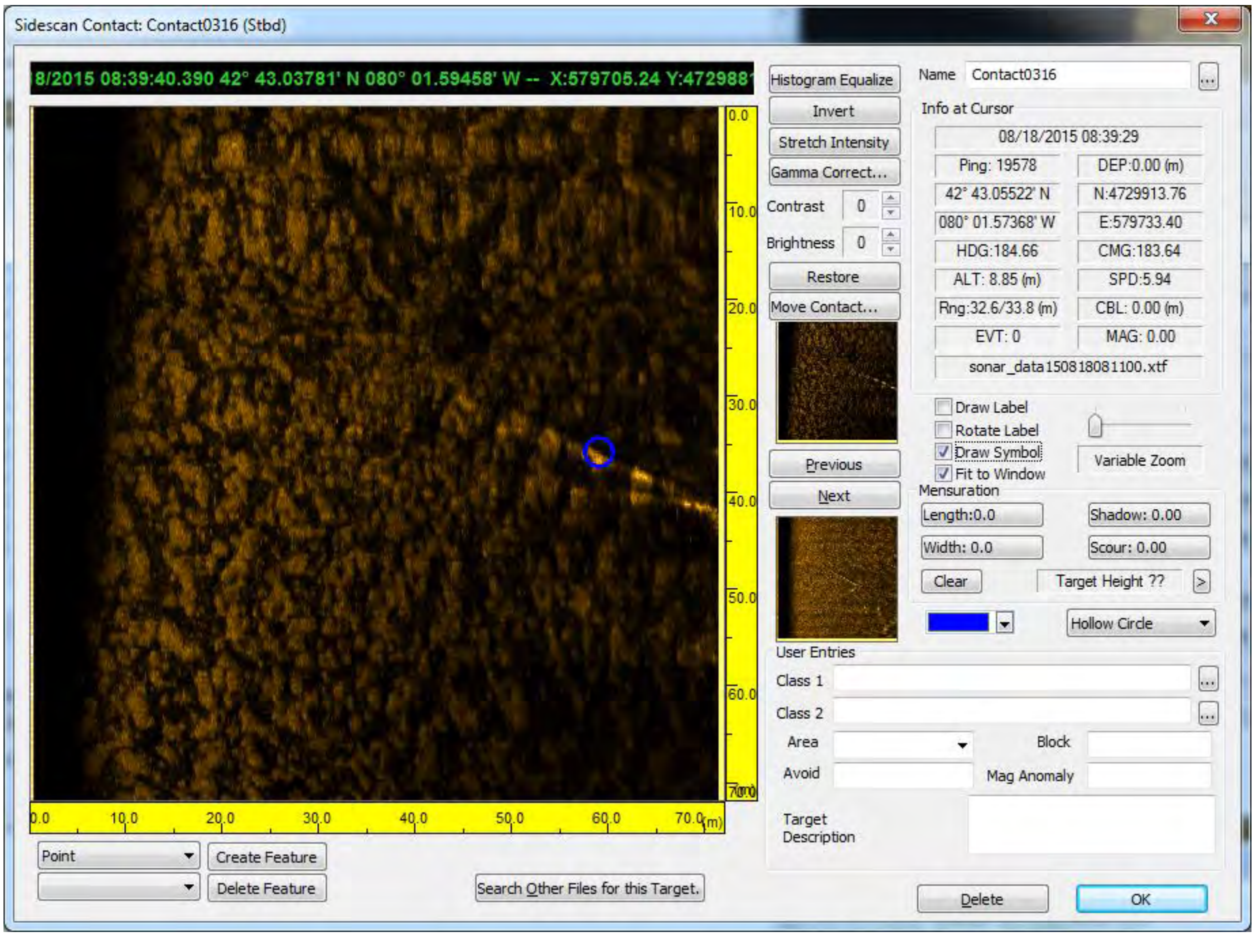
Poor data quality. No contact.

-Linear target with no magnetometer hits.

Width: 1.8 m

Length: 28.2 m

Height: NA



Location 12

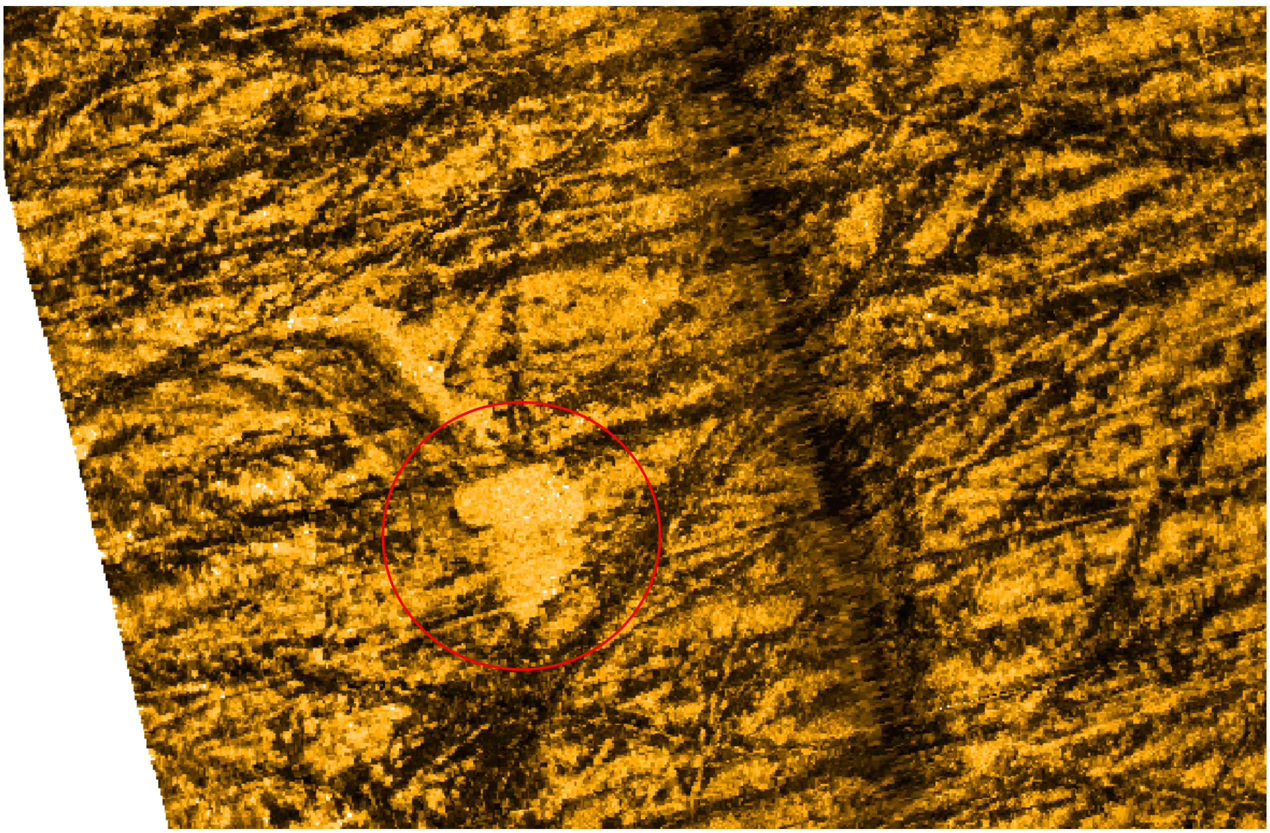
Possible sediment feature

-Circular target with no magnetometer hits. Not believed to be anthropogenic.

Width: 12.1 m

Length: 14.8 m

Height: NA



Location 13

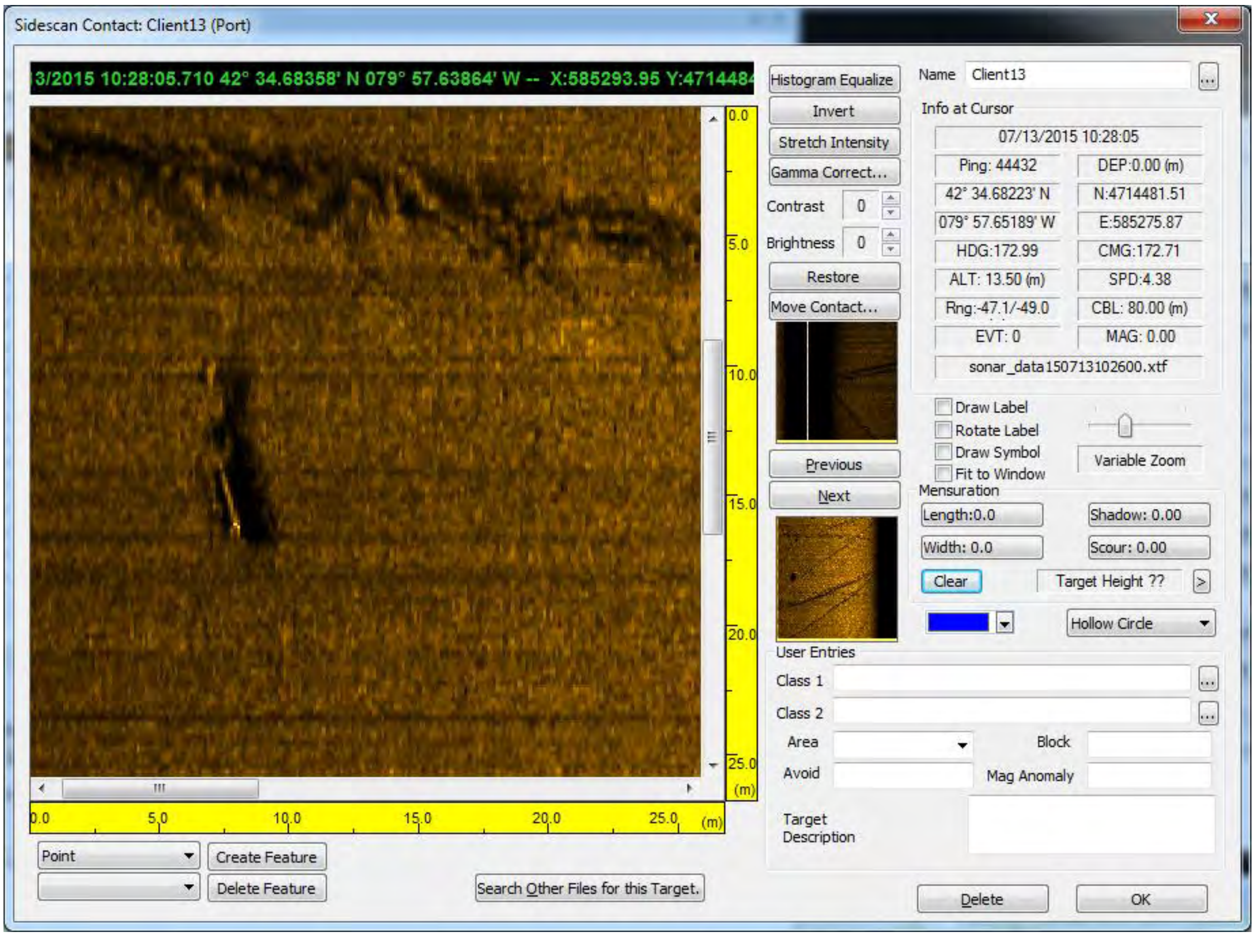
Linear feature - Possible timber

-Linear target with no magnetometer hits.

Width: 0.6 m

Length: 6.3 m

Height: 0.1 m



Appendix V – Sidescan Sonar Linear Features Table

								Linear Features					
ID	Northing Start	Easting Start	Latitude Start	Longitude Start	Northing End	Easting End	Latitude End	Longitude End	Length (m)	KP (km)	Depth (m)	Description	Associated Magnetic Anomaly
L15	4732553	579096.3	42.741417	-80.0336383	4732767.3	578468.6	42.7434111	-80.0412768	664.7	6.848	13.4	Pipeline	M91,M92,M93,M94,M95,M96,M97, M98
L18	4700228	582499.9	42.449994	-79.9967414	4702174.1	583682.5	42.4673904	-79.9820791	2322.4	42.89	43.9	Linear Feature - Probable Drag Mark	None
L30	4736407.5	576905.5	42.776347	-80.0598766	4736364.9	576985.2	42.775955	-80.058909	91.1	2.422	10	Linear Feature - Probable Drag Mark	None
L36	4729212.9	579563.6	42.711294	-80.0283997	4729281.4	579898.6	42.7118763	-80.0243005	344.3	10.682	20.1	Pipeline	M104,M105
L37	4713205.2	585164.5	42.566557	-79.9624117	4715969.4	584613.4	42.5915073	-79.968715	2989.9	27.991	50.7	Linear Feature - Possible Cable	None
L38	4713355.5	585158.3	42.567912	-79.962465	4713953.1	585740.2	42.5732277	-79.9552872	834.6	28.957	51.7	Linear Feature - Probable Drag Mark	None
L40	4707525.6	584650.8	42.515472	-79.9695113	4707939	585423.6	42.5191098	-79.960044	879.1	35.046	60.2	Linear Feature - Probable Drag Mark	None
L41	4717697.5	581839.6	42.607367	-80.0022696	4720686.6	580366.2	42.6344375	-80.0198073	3433.5	21.053	39.8	Linear Feature - Possible Cable	None
L42	4717796.4	582918.2	42.608142	-79.9891083	4717739.3	582556.4	42.6076672	-79.9935259	370.8	23.503	43.2	Linear Feature - Probable Drag Mark	None
L43	4716043	584557.2	42.592177	-79.9693888	4716474.8	585003.6	42.5960156	-79.9638843	621.7	26.214	47.6	Pipeline	M137, M138, M139, M140, M141, M142
L44	4717217.8	584054.9	42.602809	-79.9753368	4713545.1	585755.3	42.569552	-79.9551643	4063.4	25.497	50.7	Linear Feature - Possible Cable	None
L45	4711914.6	585221.6	42.55493	-79.961909	4712535.7	585810.8	42.5604569	-79.9546405	856.3	30.396	54.4	Linear Feature - Probable Drag Mark	None
L46	4712081.6	585822.5	42.556367	-79.9545656	4711741.1	585231.3	42.5533668	-79.9618168	683.9	30.705	55.4	Linear Feature - Probable Drag Mark	None
L47	4715265.4	585092.7	42.585116	-79.9629797	4715922.8	585062.7	42.5910383	-79.9632465	721.7	27.121	49.1	Linear Feature - Probable Drag Mark	None
L48	4715144.9	584979	42.584043	-79.9643834	4715083.2	585620.7	42.5834169	-79.9565737	645.5	27.481	49.4	Linear Feature - Probable Drag Mark	None
L49	4715330.3	585570	42.585647	-79.9571534	4714719.2	585036	42.5802041	-79.9637519	814	27.56	49.9	Linear Feature - Probable Drag Mark	None
L51	4713966.9	585733.7	42.573353	-79.9553639	4712500.6	585524	42.5601729	-79.9581382	1488.1	30.117	53.9	Linear Feature - Probable Drag Mark	None
L52	4710538.8	585280.1	42.542535	-79.9614017	4706849.4	585038.2	42.5093411	-79.9648965	3744.6	33.641	59.6	Linear Feature - Probable Drag Mark	None
L53	4709454	585294.8	42.532766	-79.9613856	4709779.3	585927.5	42.5356245	-79.9536328	715.7	33.015	57.5	Linear Feature - Probable Drag Mark	None
L54	4705883.5	584701.6	42.500681	-79.9691354	4705401.9	583772.9	42.4964452	-79.9805077	1049.3	37.2	59.9	Linear Feature - Probable Drag Mark	None
L56	4701053.4	583288.6	42.457342	-79.9870317	4700470.9	582535.9	42.4521768	-79.9962693	952.4	42.676	43.8	Linear Feature - Probable Drag Mark	None
L57	4700572.2	582575.5	42.453085	-79.9957731	4700969.1	583691.4	42.4565394	-79.9821462	1188.9	42.796	44.1	Linear Feature - Probable Drag Mark	None
L58	4700388.6	583145.3	42.451371	-79.9888712	4700270.7	582497.4	42.4503782	-79.996766	658.7	43.13	43.9	Linear Feature - Probable Drag Mark	None
L59	4700291.5	583119.9	42.450499	-79.9891944	4699995.3	582445.1	42.4479039	-79.9974409	737.8	43.322	44	Linear Feature - Probable Drag Mark	None
L60	4689789.8	576943.3	42.356571	-80.0657008	4691013.9	577276.1	42.3675604	-80.0614961	1319.7	54.171	35.6	Linear Feature - Probable Drag Mark	None
L61	4697480.9	582104.7	42.425299	-80.0019398	4697024.5	581065.6	42.4212984	-80.0146328	1136.2	46.479	43.1	Linear Feature - Probable Drag Mark	None
L62	4691330.7	578019.2	42.37034	-80.0524292	4690901.7	577251.7	42.3665526	-80.061807	879.8	54.003	35.2	Linear Feature - Probable Drag Mark	None
L63	4669081.7	562041.8	42.171416	-80.2488453	4669090.3	562132.4	42.1714865	-80.2477471	92.1	80.77	21.2	Linear Feature - Probable Drag Mark	None
L64	4669024.9	562127	42.170898	-80.2478201	4669120.1	562284.4	42.1717431	-80.2459036	184	80.656	21.3	Linear Feature - Probable Drag Mark	None
L65	4668913.9	562229.1	42.16989	-80.2465958	4668805.5	561896.1	42.1689403	-80.2506386	350.7	80.854	21.1	Linear Feature - Probable Drag Mark	None
L66	4668811.5	561890.9	42.168995	-80.2507005	4668882.4	562036.9	42.1696214	-80.2489256	162.7	80.994	21	Linear Feature - Probable Drag Mark	None
L67	4668465.9	561588.6	42.165906	-80.2543967	4668382.4	561595.8	42.1651541	-80.2543187	84.1	81.658	19.7	Linear Feature - Probable Drag Mark	None
L69	4732231.3	579161.1	42.738514	-80.0328926	4732308.4	578968.2	42.7392277	-80.0352381	208.6	7.41	13.7	Linear Feature - Probable Drag Mark	None
L70	4733919.3	577488	42.753884	-80.0530985	4733780	577902.6	42.752588	-80.0480518	444.8	5.395	11.5	Linear Feature - Probable Drag Mark	None
L71	4733828.7	577804.3	42.753036	-80.0492459	4733707.9	577989.7	42.7519292	-80.0469976	221.9	5.495	11.8	Linear Feature - Probable Drag Mark	None
L72	4733937.5	577770.6	42.754019	-80.0496425	4733896.3	577892.2	42.753636	-80.0481633	128.5	5.388	11.5	Linear Feature - Probable Drag Mark	None
L73	4734055.9	577760.4	42.755086	-80.0497515	4734061.8	577649.6	42.7551506	-80.0511041	111.5	5.216	11.2	Linear Feature - Probable Drag Mark	None
L74	4734173.7	577496.2	42.756174	-80.0529635	4734165.9	577616	42.7560914	-80.0515011	120.1	5.033	11.8	Linear Feature - Probable Drag Mark	None
L75	4734190.6	577673.9	42.756308	-80.0507899	4733845.3	577711.9	42.7531953	-80.0503735	347.6	5.385	11.5	Linear Feature - Probable Drag Mark	None

							Linear Features						
ID	Northing Start	Easting Start	Latitude Start	Longitude Start	Northing End	Easting End	Latitude End	Longitude End	Length (m)	KP (km)	Depth (m)	Description	Associated Magnetic Anomaly
L76	4733841.8	577912.6	42.753143	-80.0479207	4733899	577670.8	42.7536823	-80.0508683	248.6	5.383	11.6	Linear Feature - Probable Drag Mark	None
L85	4709092.4	585188.7	42.529522	-79.9627309	4709580.9	585898.5	42.533842	-79.9540167	866.8	33.276	58.2	Linear Feature - Probable Drag Mark	None
L87	4695041.7	580488.3	42.403504	-80.0219274	4695694.6	580195.1	42.4094138	-80.025398	737	48.67	41	Linear Feature - Probable Drag Mark	None
L109	4668934.6	562294.5	42.170071	-80.2458021	4668790.1	562154.5	42.1687809	-80.2475117	202	80.799	21.2	Linear Feature - Probable Drag Mark	None
L112	4669063.1	562339.1	42.171225	-80.2452476	4669062.1	562379.2	42.1712128	-80.2447632	40.3	80.646	21.4	Linear Feature - Probable Drag Mark	None
L135	4711597.3	585250.6	42.55207	-79.9616035	4711582.5	585377.8	42.551922	-79.9600566	128.1	31.028	55.5	Linear Feature - Probable Drag Mark	None
L137	4677957.6	569033.2	42.250761	-80.1631526	4677946.8	569005.7	42.2506666	-80.1634869	29.8	69.545	23.9	Linear Feature - Probable Drag Mark	None
L138	4680801.7	570437	42.276248	-80.1457905	4680851.8	570436.6	42.2766993	-80.1457903	51.2	66.375	23.2	Linear Feature - Probable Drag Mark	None
L139	4735928.2	576989.1	42.772023	-80.0589203	-	-	42.7674551	-80.0585569	598.5	3.104	10.9	Possible Dredge Boundary	None
L140	4738549.7	577146.6	42.795611	-80.0566375	-	-	42.7924854	-80.0553398	363.7	0.262	1.1	Pipeline	M25,M29,M38,M45,M46,M51,M58,M60,M66
L141	4738462.7	577258	42.794817	-80.0552875	-	-	42.7943796	-80.0568447	136.5	0.391	1.9	Trench	None
L142	4738393.2	577484.2	42.794168	-80.0525312	-	-	42.7912512	-80.0529842	326.5	0.455	3.2	Pipeline	M52, M65

APPENDIX VI
ICE SCOUR DATABASE STRUCTURE AND FIELD DESCRIPTIONS

DATABASE STRUCTURE

DATABASE: LEC Ice Scour Database

FORMAT: ESRI Shape & Microsoft Excel

Total Number of Records: 25

FIELD	NAME (ALIAS)	TYPE	LENGTH	PRECISION	SCALE
1	SCOUR_ID	Long	6	6	0
2	YEAR	Long	8	8	0
3	LOCATION	Text	10	0	0
4	FORM	Short	2	2	0
5	SMOOTH	Short	2	2	0
6	MIN_BATHY	Short	2	2	0
7	MAX_BATHY	Short	2	2	0
8	ORIENT	Short	3	3	0
9	WIDTH	Float	6	5	1
10	LENGTH	Float	8	7	1
11	LENGTH_Q	Short	2	2	0
12	DEPTH	Float	7	6	2
13	DEPTH_Q	Short	2	2	0
14	INFILL	Float	6	5	1
15	STYPE	Text	5	0	0
16	SBP	Short	3	3	0
17	SYSTEM	Text	15	0	0
18	QUAL	Text	4	0	0
19	COMMENTS	Text	99	0	0
20	X_START	Double	11	10	1
21	Y_START	Double	11	10	1
22	X_END	Double	11	10	1
23	Y_END	Double	11	10	1

1) SCOUR_ID
Each ice scour event was assigned a unique id number.

2) YEAR
This field defines the year of data acquisition.

3) LOCATION
This field contains the general location of the ice scour; Canada or USA.

4) FORM **SCOUR TYPE**
This field defines the type of scour, see Figure 1. Scour type is determined visually from the sidescan sonar or multibeam sonar data sets.

Code	Description
1	Single keeled scour
2	Multi-keeled scour

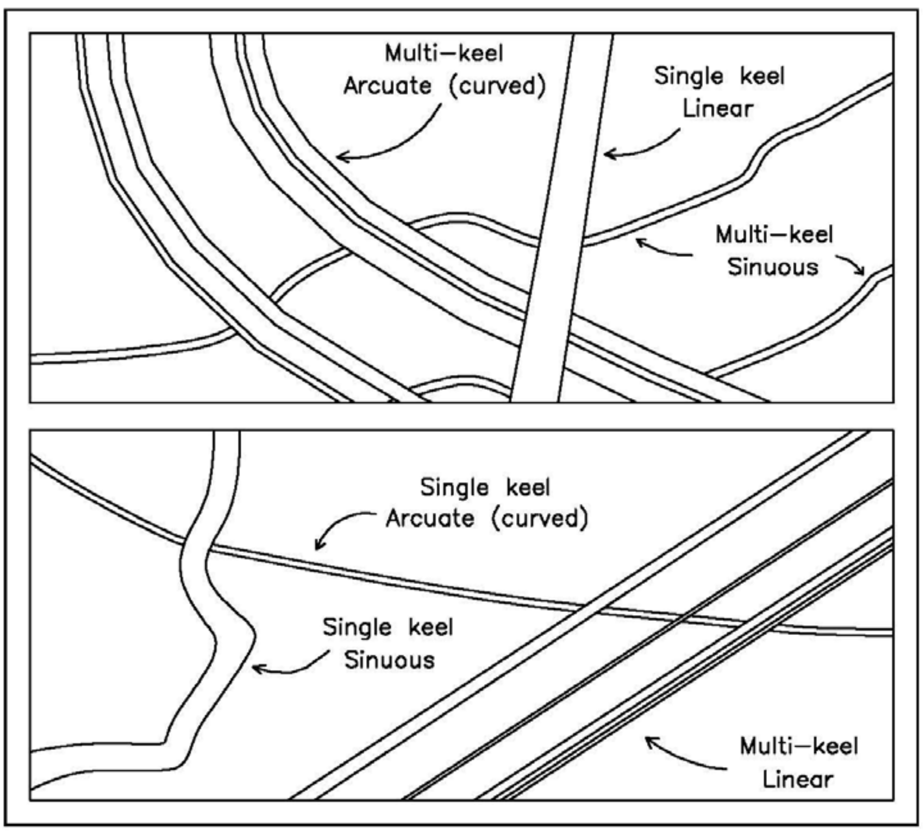


Figure 1 – Illustration of scour form (type) and morphology (shape).

5) SMOOTH SCOUR SMOOTHNESS

Smoothness is a subjective description based on the sharpness of acoustic returns, which may vary dependent on; angle of scour sonification, data quality, water depth and sediment type. All smoothness codes were determined from sidescan and multibeam sonar data.

Code	Description
7	Very rough: opaque reflectance from scour floor with sharply defined berm walls. This value may relate to the most recent scour events.
8	Rough: strong acoustic signature, evidence of rubble on berm or in scour.
9	Moderately smooth.
10	Very smooth: reduced signal contrast, no rubble, often infilled. New or Fresh scours in sand may appear smooth

6, 7) MIN_BATHY, MAX_BATHY BATHYMETRY

Water depth interval of the unscoured seafloor at the scour location measured in metres. The vertical datum is Chart datum.

8) ORIENT ORIENTATION

Scour orientation in degrees, referenced to grid north and expressed, by convention, between 0-179 degrees inclusive. The orientation value infers no actual directionality of ice movement. Orientation was calculated from the UTM grid scour end point coordinates and does not reflect a change in scour orientation.

9) WIDTH SCOUR WIDTH

Scour width is measured in metres and represents an average value of the distance from berm crest to berm crest, perpendicular to the long axis of the scour. For multi-keel events this measurement represents the distance from outer berm crest to outer berm crest.

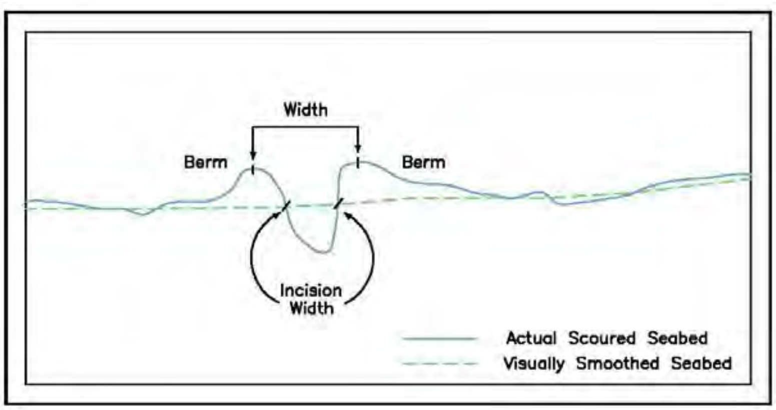


Figure 2 – Illustration of scour width and incision width measurements

10) LENGTH SCOUR LENGTH

Scour length in metres, measured automatically within ArcGIS along the digitized scour centerline. Measured length value represents true length for scours where both endpoints were observed, but is less than the true scour length for events which extend beyond the edge of the sidescan swath, see Figure 3 and length qualifier below.

11) LENGTH_Q LENGTH QUALIFIER

A length qualifier is used to inform the user about the scour length measurement. This field describes the presence of end points and thus the quality of the length measurement. The following table describes the codes used.

Code	Description
1	1 Endpoint - Seen or Inferred with Confidence
2	2 Endpoints - Seen or Inferred with Confidence
3	No Endpoints – Scour Extends Beyond Swath or mosaic area

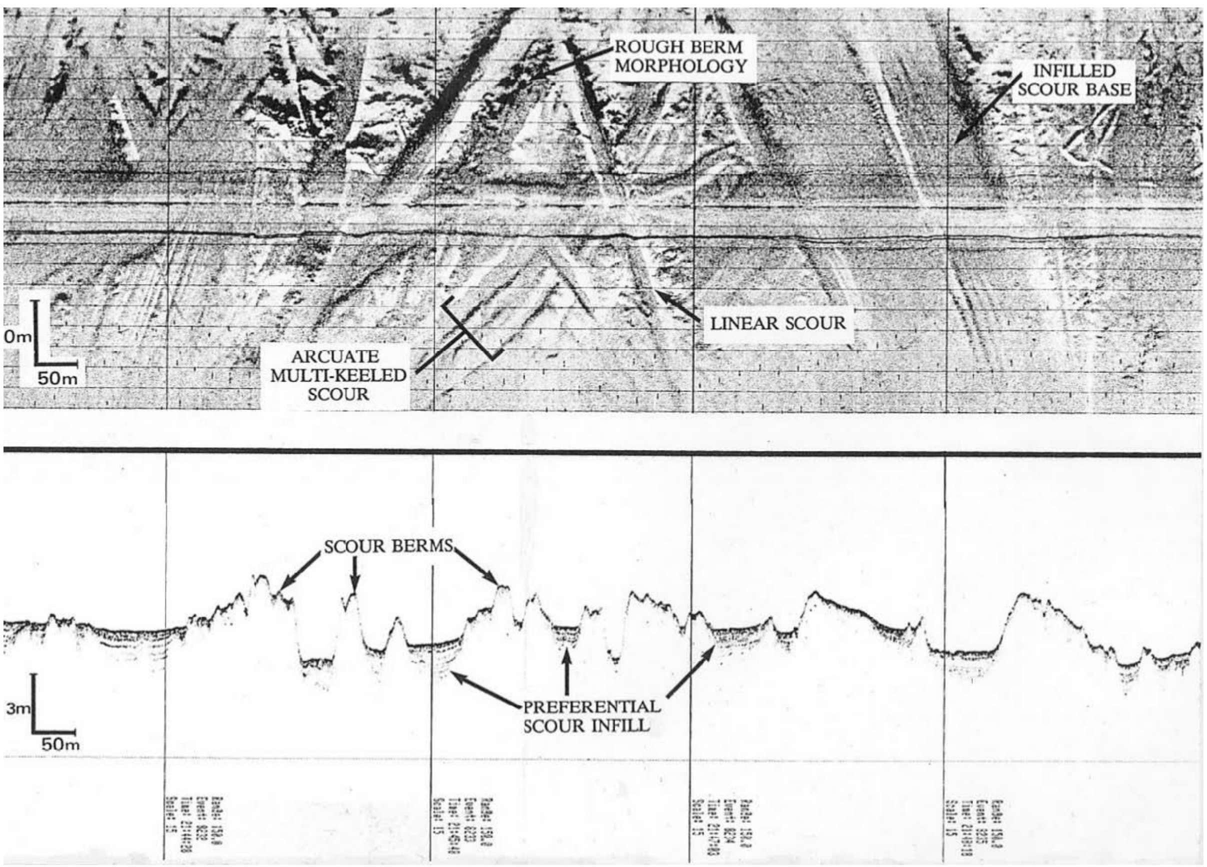


Figure 3 – Combined Sidescan & Microprofiler record illustrating gouge depth, sediment infill, berms, and length

12) DEPTH SCOUR DEPTH

Scour depth is measured in metres from an unscoured smoothed seabed datum to the deepest point of the scour, see Figure 4. Accuracy of scour depth measurement is dependent on the pick of the smoothed seabed datum, resolution of the data and quality of the data. If scour depth was not measurable, a system resolution value was entered, as well as a Depth_Q value of 2, see Depth_Q below.

13) DEPTH_Q DEPTH QUALITY CODE

The depth qualifier is used to describe the scour depth measurement or the lack of depth measurement.

Code	Description
1	Scour depth measured.
2	Confident the true scour depth is less than or equal to the recorded scour depth. The value entered in the depth field for scours with a depth_q = 2 is a function of the data quality, and profiler resolution.

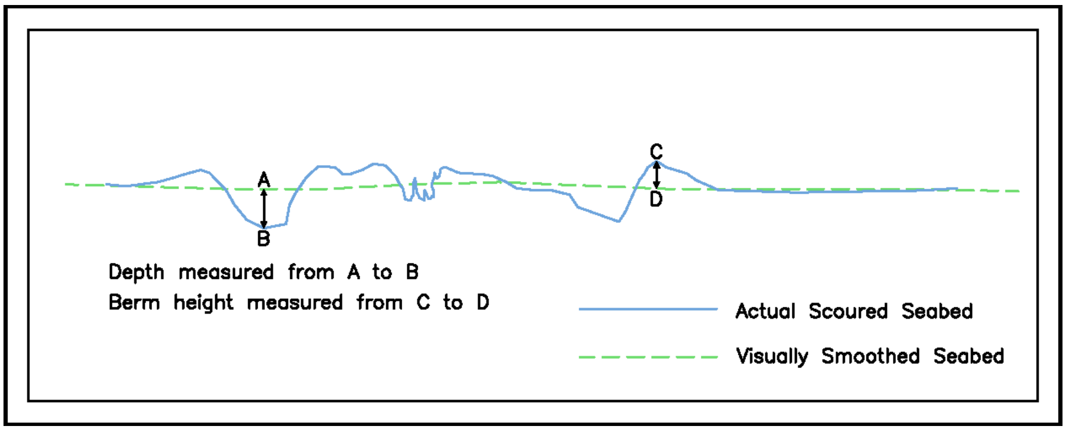


Figure 4 – Illustration of seabed smoothing, gouge depth, and berm height measurement

14) INFILL SEDIMENT INFILL

This field records the thickness of sediment infill in metres within the scour trough as measured from available chirp profiler data, see Figure 3. Ice scours with sediment infill are interpreted to represent an older population. Sediment infill cannot be measured from sidescan sonar or multibeam sonar data.

15) STYPE SEDIMENT TYPE

Surficial sediment type was interpreted from acoustic data sets and geological sample data. Sediment Type codes include the following.

Code	Description
G	Gravel
S	Sand
Si	Silt
C	Clay

16) SBP PROFILER SYSTEM

SBP refers to the type of profiling instrument / system utilized in recording the data from which scour depth was measured.

Code	Description
1	Single beam Echosounder (200 kHz)
2	Multibeam Sonar System (220 kHz)

17) SYSTEM MAPPING SYSTEM

This field refers to the type of sidescan system utilized for ice scour mapping.

Code	Description
Klein3000	Klein 3000 sidescan sonar

18) QUAL DATA QUALITY

A subjective description of general data quality that may vary dependant on weather conditions and equipment malfunctions.

Code	Description
E	Excellent
G	Good
F	Fair
P	Poor

19) COMMENTS

This field contains interpreter comments.

20, 21, 22, 23) X_START, Y_START, X_END, Y_END

This field contains the UTM Easting and Northing coordinates for the start and end of the digitized ice scour centerline vector, referenced to NAD83 UTM Zone 17.

Appendix VII – Magnetic Anomaly Table

Marine Magnetometer Anomalies									
Label	Latitude	Longitude	Easting (m)	Northing (m)	Route Offset (m)	Polarity	Amplitude (nT)	Corresponding Sidescan Contacts/Linear Features	Sidescan Contacts Description
M3	42.7970386	-80.0623539	576677.6	4738702.0	399.716	M	16.26	None	
M5	42.7968260	-80.0633080	576599.9	4738677.6	481.126	M	38.81	None	
M9	42.7966408	-80.0630351	576622.4	4738657.2	465.117	M	275.97	C189,C190	Point Source Reflectors (possible old channel marker)
M1	42.7970718	-80.0609788	576790.0	4738707.0	290.281	M	24.57	None	
M8	42.7966489	-80.0629070	576632.9	4738658.3	454.814	M	81.58	C189,C190	Point Source Reflectors (possible old channel marker)
M2	42.7970455	-80.0608779	576798.3	4738704.1	283.176	M	18.59	None	
M10	42.7965488	-80.0630778	576619.0	4738647.0	471.339	D	319.11	C189,C190	Point Source Reflectors (possible old channel marker)
M13	42.7958111	-80.0654848	576423.1	4738562.9	683.276	D	19.05	None	
M4	42.7968811	-80.0596321	576900.4	4738687.0	190.522	M	27.83	None	
M12	42.7958206	-80.0645273	576501.4	4738564.8	607.828	D	90.12	None	
M11	42.7963355	-80.0618348	576720.9	4738624.4	380.434	D	18.03	None	
M6	42.7967255	-80.0598435	576883.3	4738669.5	211.973	D	24.53	None	
M7	42.7966490	-80.0596672	576897.8	4738661.2	200.512	M	49.38	None	
M20	42.7953241	-80.0636533	576573.5	4738510.5	554.713	D	28.66	None	
M22	42.7949942	-80.0648709	576474.3	4738472.7	660.577	M	59.11	None	
M21	42.7950486	-80.0634069	576594.0	4738480.1	543.967	M	43.96	None	
M18	42.7954689	-80.0609152	576797.2	4738529.0	335.279	D	9.76	None	
M23	42.7949199	-80.0631453	576615.5	4738466.0	527.450	D	72.06	None	
M24	42.7948985	-80.0631172	576617.8	4738463.7	525.874	D	39.77	None	
M14	42.7957260	-80.0584533	576998.2	4738559.8	133.660	M	83.81	None	
M15	42.7955640	-80.0574041	577084.2	4738542.8	53.609	D	56.10	None	
M16	42.7955527	-80.0573969	577084.8	4738541.5	53.264	D	38.42	None	
M17	42.7955401	-80.0574242	577082.6	4738540.1	55.692	D	66.38	None	
M19	42.7953117	-80.0581276	577025.4	4738514.1	116.492	M	24.78	None	
M25	42.7945520	-80.0561476	577188.3	4738431.6	40.752	D	177.03	L140	Pipeline
M26	42.7944372	-80.0601323	576862.5	4738415.2	284.070	M	20.97	None	
M29	42.7939738	-80.0559125	577208.2	4738367.6	64.537	M	156.81	L140	Pipeline
M27	42.7943827	-80.0620244	576707.8	4738407.4	436.447	D	51.48	None	

Marine Magnetometer Anomalies									
Label	Latitude	Longitude	Easting (m)	Northing (m)	Route Offset (m)	Polarity	Amplitude (nT)	Corresponding Sidescan Contacts/Linear Features	Sidescan Contacts Description
M38	42.7934002	-80.0556692	577228.8	4738304.1	94.644	D	217.84	L140	Pipeline
M33	42.7936486	-80.0583236	577011.4	4738329.3	123.136	M	198.95	C195,C196	Linear Feature-Metal Debris
M45	42.7929755	-80.0555321	577240.5	4738257.1	116.678	M	253.56	L140	Pipeline
M36	42.7935732	-80.0585057	576996.6	4738320.7	135.404	M	262.74	C195,C196	Linear Feature-Metal Debris
M46	42.7929434	-80.0555420	577239.8	4738253.5	116.876	D	65.22	L140	Pipeline
M28	42.7940583	-80.0608725	576802.4	4738372.4	336.323	M	53.04	None	
M31	42.7939572	-80.0605692	576827.4	4738361.5	309.377	M	19.49	None	
M52	42.7923075	-80.0528837	577458.0	4738185.3	345.354	M	2678.26	L142	Pipeline
M30	42.7940083	-80.0612427	576772.2	4738366.5	363.628	M	76.04	None	
M51	42.7923382	-80.0553002	577260.3	4738186.5	156.442	M	52.58	L140	Pipeline
M65	42.7913555	-80.0529632	577452.7	4738079.5	374.207	M	1359.37	L142	Pipeline
M58	42.7919279	-80.0550961	577277.5	4738141.1	188.692	M	97.28	L140	Pipeline
M60	42.7918680	-80.0550979	577277.4	4738134.5	191.130	M	85.52	L140	Pipeline
M39	42.7933821	-80.0600312	576872.1	4738298.1	245.838	M	17.74	None	
M62	42.7917192	-80.0551400	577274.2	4738117.9	194.742	M	72.80	C180	Rectangular Contact (probable water intake)
M66	42.7913498	-80.0549430	577290.7	4738077.1	227.004	M	68.96	L140	Pipeline
M35	42.7935961	-80.0612459	576772.5	4738320.8	345.461	M	109.66	None	
M68	42.7905682	-80.0536583	577396.8	4737991.5	360.362	D	77.41	None	
M37	42.7934687	-80.0609738	576794.9	4738306.9	319.159	D	161.08	None	
M48	42.7929502	-80.0598344	576888.7	4738250.3	209.726	M	18.48	None	
M41	42.7933148	-80.0607987	576809.4	4738289.9	298.237	M	30.22	None	
M50	42.7927963	-80.0604546	576838.2	4738232.7	245.917	D	90.05	None	
M49	42.7928343	-80.0605906	576827.0	4738236.8	257.747	D	49.69	None	
M71	42.7903591	-80.0548626	577298.6	4737967.2	284.314	M	25.26	None	
M34	42.7936706	-80.0640192	576545.6	4738326.5	549.966	M	108.56	None	
M32	42.7938336	-80.0647380	576486.6	4738344.0	610.610	D	110.22	None	
M47	42.7929933	-80.0626019	576662.3	4738252.6	412.602	M	13.77	None	
M61	42.7917863	-80.0594335	576922.9	4738121.5	120.870	D	42.04	None	

Marine Magnetometer Anomalies									
Label	Latitude	Longitude	Easting (m)	Northing (m)	Route Offset (m)	Polarity	Amplitude (nT)	Corresponding Sidescan Contacts/Linear Features	Sidescan Contacts Description
M40	42.7934031	-80.0638018	576563.7	4738297.0	520.722	M	149.33	None	
M63	42.7916203	-80.0591644	576945.2	4738103.3	92.922	D	101.15	None	
M64	42.7915907	-80.0591584	576945.7	4738100.0	91.003	D	110.18	None	
M43	42.7930546	-80.0635255	576586.7	4738258.6	483.126	M	38.27	None	
M44	42.7930435	-80.0634942	576589.3	4738257.4	480.290	M	29.66	None	
M42	42.7930803	-80.0636735	576574.6	4738261.3	495.229	M	177.54	None	
M53	42.7922174	-80.0640644	576543.7	4738165.1	485.744	D	17.52	None	
M54	42.7922096	-80.0652321	576448.2	4738163.2	576.904	D	94.15	None	
M55	42.7921626	-80.0651264	576456.9	4738158.1	567.195	D	124.68	None	
M56	42.7921235	-80.0640181	576547.6	4738154.7	478.932	M	74.54	None	
M57	42.7920352	-80.0643460	576520.9	4738144.6	501.894	D	40.06	None	
M59	42.7919679	-80.0650264	576465.3	4738136.5	553.987	D	382.97	None	
M67	42.7912933	-80.0632361	576612.6	4738063.2	395.358	D	87.58	None	
M69	42.7906573	-80.0647157	576492.3	4737991.3	499.947	D	19.89	None	
M70	42.7905374	-80.0648931	576478.0	4737977.8	511.522	D	13.66	None	
M72	42.7883829	-80.0563700	577177.7	4737746.3	219.226	M	23.60	None	
M75	42.7868180	-80.0530838	577448.4	4737575.5	517.194	M	29.70	None	
M73	42.7869379	-80.0651664	576460.1	4737577.8	454.065	D	53.54	None	
M74	42.7869246	-80.0651989	576457.4	4737576.3	456.377	M	41.96	None	
M76	42.7845795	-80.0599516	576889.5	4737320.7	16.001	M	12.26	None	
M77	42.7841181	-80.0581348	577038.7	4737271.1	171.825	D	6.72	None	
M78	42.7838166	-80.0601498	576874.2	4737235.8	16.935	M	13.00	None	
M80	42.7828291	-80.0593839	576938.1	4737126.8	100.119	M	37.67	None	
M79	42.7837078	-80.0686145	576182.0	4737216.0	659.288	M	32.27	None	
M81	42.7742168	-80.0637529	576591.3	4736166.5	68.054	M	17.00	None	
M82	42.7702136	-80.0635660	576611.6	4735722.2	17.194	M	16.00	None	
M83	42.7647929	-80.0633953	576632.2	4735120.4	94.258	D	56.38	None	
M84	42.7645960	-80.0632797	576641.9	4735098.6	99.607	M	26.00	None	

Marine Magnetometer Anomalies									
Label	Latitude	Longitude	Easting (m)	Northing (m)	Route Offset (m)	Polarity	Amplitude (nT)	Corresponding Sidescan Contacts/Linear Features	Sidescan Contacts Description
M85	42.7502978	-80.0470718	577986.0	4733525.7	16.184	M	24.85	None	
M86	42.7502784	-80.0470558	577987.3	4733523.6	16.565	M	61.49	None	
M87	42.7498800	-80.0475739	577945.4	4733478.8	77.473	M	16.91	None	
M88	42.7495858	-80.0478291	577924.9	4733446.0	114.451	M	17.00	None	
M90	42.7492701	-80.0475574	577947.5	4733411.1	119.876	M	62.00	None	
M89	42.7495686	-80.0464732	578035.9	4733445.3	30.528	M	29.00	None	
M91	42.7437633	-80.0435671	578281.0	4732803.3	210.840	M	24.42	L15	Pipeline
M92	42.7433645	-80.0415122	578449.7	4732761.0	102.281	M	78.88	L15	Pipeline
M96	42.7429484	-80.0412149	578474.6	4732715.0	110.318	D	49.00	L15	Pipeline
M93	42.7432771	-80.0404679	578535.3	4732752.2	39.472	M	13.83	L15	Pipeline
M94	42.7430579	-80.0396916	578599.1	4732728.6	2.996	M	23.33	L15	Pipeline
M95	42.7430293	-80.0392393	578636.2	4732725.8	24.820	M	36.54	L15	Pipeline
M97	42.7428590	-80.0394401	578619.9	4732706.8	0.345	M	24.80	L15	Pipeline
M98	42.7428308	-80.0384886	578697.9	4732704.5	60.990	M	114.25	L15	Pipeline
M99	42.7427425	-80.0385187	578695.5	4732694.7	53.160	M	85.27	None	
M100	42.7422934	-80.0388990	578664.9	4732644.5	1.574	D	36.00	None	
M101	42.7291672	-80.0296389	579439.6	4731195.5	218.586	D	32.58	None	
M102	42.7289888	-80.0278887	579583.1	4731177.4	86.232	D	41.27	None	
M103	42.7259715	-80.0275725	579612.9	4730842.6	101.984	D	6.00	None	
M104	42.7115650	-80.0260996	579751.9	4729244.2	63.382	M	8.00	L36	Pipeline
M105	42.7113800	-80.0276416	579625.9	4729222.2	62.128	M	10.00	L36	Pipeline
M106	42.7106270	-80.0254411	579807.1	4729140.7	120.801	D	45.80	None	
M107	42.6983021	-80.0303739	579418.8	4727767.5	100.428	D	10.00	None	
M108	42.6885534	-80.0364712	578931.7	4726679.2	389.734	M	27.49	None	
M109	42.6663826	-80.0385640	578788.3	4724215.3	416.008	D	7.00	None	
M110	42.6659775	-80.0371030	578908.6	4724171.7	302.892	D	17.32	None	
M111	42.6298953	-80.0225443	580147.9	4720178.7	80.208	D	13.65	None	
M112	42.6288279	-80.0202159	580340.2	4720062.4	60.173	D	7.98	None	

Marine Magnetometer Anomalies									
Label	Latitude	Longitude	Easting (m)	Northing (m)	Route Offset (m)	Polarity	Amplitude (nT)	Corresponding Sidescan Contacts/Linear Features	Sidescan Contacts Description
M133	42.6053055	-80.0144689	580841.9	4717455.9	994.438	M	11.28	None	
M134	42.6053055	-80.0144689	580841.9	4717455.9	994.438	M	11.28	None	
M135	42.6051370	-80.0175768	580587.2	4717434.2	1161.828	M	6.96	None	
M136	42.6051140	-80.0175741	580587.4	4717431.7	1163.591	M	11.21	None	
M129	42.6071428	-80.0036244	581729.1	4717670.3	379.655	M	48.73	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M130	42.6071428	-80.0036244	581729.1	4717670.3	379.655	M	48.73	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M113	42.6140133	-79.9966364	582293.2	4718440.0	566.411	M	450.54	None	
M126	42.6075659	-80.0009688	581946.3	4717719.9	231.833	D	14.77	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M125	42.6077599	-79.9992867	582084.1	4717743.1	145.361	D	30.12	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M124	42.6078132	-79.9977621	582209.1	4717750.5	78.836	M	30.56	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M122	42.6079249	-79.9961582	582340.5	4717764.4	3.474	D	43.63	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M123	42.6078822	-79.9958630	582364.7	4717760.0	4.280	D	49.95	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M120	42.6080860	-79.9943497	582488.6	4717784.1	84.910	D	73.18	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M121	42.6080340	-79.9942274	582498.7	4717778.4	84.806	D	73.18	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M114	42.6094650	-79.9922715	582657.2	4717939.2	302.001	M	9.38	None	
M119	42.6082182	-79.9909972	582763.4	4717802.0	232.663	D	10.95	None	Abandoned & Uncharted Pipeline (from Table 5.4.2)
M115	42.6090382	-79.9782984	583803.9	4717905.6	813.288	M	6.72	None	
M116	42.6090382	-79.9782984	583803.9	4717905.6	813.288	M	7.03	None	
M117	42.6087719	-79.9656429	584842.3	4717888.6	1248.490	M	27.05	None	
M118	42.6087719	-79.9656429	584842.3	4717888.6	1248.490	M	26.62	None	
M131	42.6064766	-79.9534343	585846.9	4717646.1	1670.857	M	9.24	None	
M132	42.6064766	-79.9534343	585846.9	4717646.1	1670.857	M	8.26	None	
M127	42.6068577	-79.9477599	586311.8	4717694.2	2075.422	D	95.49	None	
M128	42.6068577	-79.9477599	586311.8	4717694.2	2075.422	D	95.49	None	
M137	42.5957318	-79.9646713	584939.8	4716441.6	229.293	D	20.39	L43	Pipeline
M138	42.5947160	-79.9659841	584833.4	4716327.5	76.218	M	63.99	L43	Pipeline
M139	42.5942019	-79.9665113	584790.9	4716269.9	7.947	M	341.80	L43	Pipeline
M140	42.5941110	-79.9666521	584779.4	4716259.6	7.318	D	94.40	L43	Pipeline
M141	42.5935002	-79.9672300	584732.9	4716191.2	85.195	M	25.89	L43	Pipeline

Marine Magnetometer Anomalies									
Label	Latitude	Longitude	Easting (m)	Northing (m)	Route Offset (m)	Polarity	Amplitude (nT)	Corresponding Sidescan Contacts/Linear Features	Sidescan Contacts Description
M142	42.5926250	-79.9687627	584608.3	4716092.5	243.988	M	22.01	L43	Pipeline
M143	42.5830553	-79.9579469	585508.8	4715040.8	196.355	D	2.71	None	
M144	42.5215978	-79.9625920	585211.2	4708211.8	76.587	M	21.54	None	
M145	42.5090968	-79.9687005	584726.3	4706817.5	80.934	M	61.41	None	
M146	42.4646003	-79.9830047	583610.4	4701862.4	666.849	M	4.42	None	
M149	42.4472195	-79.9903240	583031.6	4699925.3	280.649	M	4.93	None	
M147	42.4484192	-79.9981965	582382.6	4700050.8	380.248	M	4.33	None	
M148	42.4483393	-79.9980798	582392.3	4700042.1	368.939	D	6.68	None	
M150	42.4307728	-80.0034123	581976.7	4698086.4	141.782	M	10.13	None	
M151	42.4301456	-80.0058448	581777.4	4698014.4	267.928	M	2.61	None	
M152	42.4270365	-80.0087509	581542.4	4697666.3	271.085	D	6.15	None	
M153	42.3541823	-80.0751807	576165.8	4689515.1	238.600	D	34.03	None	
M154	42.3301467	-80.0915282	574847.9	4686831.8	148.678	M	12.67	None	
M155	42.3044669	-80.1157193	572884.5	4683959.4	102.833	M	22.33	None	
M156	42.2725592	-80.1519710	569931.8	4680386.1	379.077	M	16.85	None	
M157	42.2455380	-80.1741487	568132.0	4677367.8	207.869	M	7.47	None	
M158	42.2124994	-80.2020161	565867.3	4673677.5	111.780	D?	12.05	None	
M159	42.2093730	-80.2090615	565289.0	4673324.9	345.574	M	6.75	None	
M160	42.2064462	-80.2120424	565045.9	4672997.7	265.085	M	9.55	None	
M161	42.2025647	-80.2091358	565289.9	4672568.9	187.961	M	11.06	None	
M162	42.1911848	-80.2291219	563651.3	4671290.3	361.257	D	10.91	None	
M163	42.1819491	-80.2307189	563528.7	4670263.6	154.163	M	23.97	None	
M164	42.1804816	-80.2351157	563167.1	4670097.4	36.402	M	24.87	None	
M165	42.1544074	-80.2616855	560997.9	4667183.0	38.208	D	37.72	None	
M166	42.1410983	-80.2768778	559755.2	4665694.5	121.309	M	14.05	None	
M167	42.1195115	-80.3026181	557647.8	4663280.0	123.171	D	37.29	None	
M168	42.1194933	-80.3060669	557362.7	4663275.6	97.963	M	27.53	None	
M169	42.1160124	-80.3091202	557113.4	4662887.1	33.761	M	33.36	None	

Marine Magnetometer Anomalies									
Label	Latitude	Longitude	Easting (m)	Northing (m)	Route Offset (m)	Polarity	Amplitude (nT)	Corresponding Sidescan Contacts/Linear Features	Sidescan Contacts Description
M170	42.1040453	-80.3259578	555732.0	4661547.3	43.942	M	26.48	None	
M171	42.0995567	-80.3314452	555282.2	4661045.3	26.965	M	4.83	None	
M172	42.0970155	-80.3380492	554738.3	4660758.9	106.783	M	29.21	None	
M173	42.0699428	-80.3745349	551743.2	4657730.3	25.962	M	4.33	None	
M174	42.0526637	-80.4003145	549623.9	4655796.5	103.674	D	32.44	None	
M175	42.0316783	-80.4124944	548632.1	4653459.5	180.760	M	3.38	None	
M176	42.0269868	-80.4085395	548963.0	4652940.8	1.937	M	24.01	None	
M177	42.0241998	-80.4115805	548713.4	4652629.7	326.225	M	2.92	None	
M178	42.0237601	-80.4078646	549021.4	4652583.0	42.273	M	13.84	None	
M179	42.0206919	-80.4084424	548975.9	4652242.0	178.036	M	14.97	None	
M180	42.0171487	-80.4020347	549509.2	4651852.3	231.604	D	7.25	None	
M181	42.0160972	-80.4060737	549175.6	4651733.2	121.595	M	18.81	None	
M182	42.0160493	-80.4060565	549177.0	4651727.9	121.588	M	23.62	None	
M185	42.0151735	-80.4101035	548842.6	4651628.3	470.417	D	8.56	None	
M184	42.0155048	-80.4084346	548980.5	4651666.0	327.417	D	4.19	None	
M187	42.0150473	-80.4104136	548817.0	4651614.1	498.835	M	6.20	None	
M186	42.0151120	-80.4097368	548873.0	4651621.7	442.832	D	8.62	None	
M183	42.0158317	-80.4022649	549491.1	4651705.9	175.580	D	5.64	None	
M188	42.0148214	-80.4062730	549160.0	4651591.4	173.977	M	23.45	None	
M189	42.0132869	-80.4097851	548870.4	4651419.0	498.821	D	14.60	None	

Marine Magnetometer Anomalies									
Label	Latitude	Longitude	Easting (m)	Northing (m)	Route Offset (m)	Polarity	Amplitude (nT)	Corresponding Sidescan Contacts/Linear Features	Sidescan Contacts Description
M189	42.0132869	-80.4097851	548870.4	4651419.0	498.821	D	14.60	None	

APPENDIX VIII
LEC PROPOSED ROUTE RPL TABLE

LEC Proposed Route RPL from Canadian HDD Exit to Survey Bathymetric Extent on USA Side
Version 1 (January 19,2016)

Point #	Comment	Latitude* NAD83	Longitude* NAD83	Northing** (UTM 17N)	Easting** (UTM 17N)	Bearing (Grid°)	Alter Course (Grid°)	Depth*** Chart Datum (m)	Horiz.Leg Distance † (m)	Cum. Horiz Distance † (m)	Station †† (KP)	Est. Cable Length (Slope) ‡ (m)	Est. Cum. Cable Length (Slope) ‡ (m)	Notes
1	HDD Exit	42.79186508 N	80.05771561 W	4738132.7	577063.0			6			0.693			Canadian HDD exit
						206.1			129.3			129.4		
2	AC-1	42.79082500 N	80.05842700 W	4738016.6	577006.2		15.3 Port	7		129.3	0.823		129.4	
						190.8			1705.3			1706.1		
3	AC-2	42.77577504 N	80.06256711 W	4736341.6	576686.1		2.4 Port	10		1834.6	2.528		1835.5	
						188.4			959.5			960.6		
4	AC-3	42.76724280 N	80.06441785 W	4735392.4	576545.2		45.4 Port	11		2794.1	3.488		2796.1	
						143.0			306.7			306.9		
5	AC-4	42.76501881 N	80.06219539 W	4735147.5	576729.8		0.8 Port	11		3100.8	3.794		3103.0	
						142.2			1716.6			1717.6		
6	AC-5	42.75269285 N	80.04953634 W	4733790.3	577781.0		2.7 Port	12		4817.4	5.511		4820.6	
						139.5			449.5			449.7		
7	AC-6	42.74958682 N	80.04601371 W	4733448.7	578073.2		5.3 Stbd	13		5266.9	5.960		5270.3	
						144.8			400.7			400.7		
8	AC-7	42.74661424 N	80.04323791 W	4733121.1	578304.1		2.1 Port	12		5667.6	6.361		5671.0	
						142.7			1456.2			1457.0		
9	AC-8	42.73609048 N	80.03262501 W	4731962.4	579186.1		3.3 Stbd	14		7123.8	7.817		7128.0	
						146.0			845.2			845.7		
10	AC-9	42.72973171 N	80.02695084 W	4731261.7	579658.7		26.2 Stbd	16		7969.0	8.663		7973.7	
						172.2			475.5			476.1		
11	AC-10	42.72548267 N	80.02623251 W	4730790.5	579722.9		9.1 Stbd	18		8444.5	9.138		8449.8	
						181.3			456.7			457.3		
12	AC-11	42.72137245 N	80.02642085 W	4730333.9	579712.8		0.0	19		8901.2	9.595		8907.1	
						181.3			1539.2			1541.6		
13	AC-12	42.70751970 N	80.02705539 W	4728795.1	579678.5		6.9 Stbd	21		10440.4	11.134		10448.7	
						188.2			761.7			763.9		
14	AC-13	42.70074294 N	80.02849343 W	4728041.2	579569.4		1.9 Stbd	21		11202.1	11.896		11212.6	
						190.1			1582.5			1586.3		
15	AC-14	42.68674162 N	80.03208899 W	4726483.1	579292.7		3.8 Stbd	26		12784.6	13.478		12798.9	
						193.9			899.2			900.8		
16	AC-15	42.67890625 N	80.03485630 W	4725610.4	579076.0		13.5 Port	28		13683.8	14.378		13699.7	
						180.4			418.4			420.4		
17	AC-16	42.67513923 N	80.03495087 W	4725192.0	579073.0		8.3 Port	28		14102.2	14.796		14120.1	
						172.1			998.4			1000.8		
18	AC-17	42.66621985 N	80.03341708 W	4724203.0	579210.0		1.3 Stbd	29		15100.6	15.794		15120.9	
						173.4			1825.7			1830.7		
19	AC-18	42.64986918 N	80.03109428 W	4722389.6	579421.2		13.6 Port	34		16926.3	17.620		16951.6	
						159.8			3084.8			3092.9		
20	AC-19	42.62368571 N	80.01852787 W	4719494.0	580485.0		16.0 Port	39		20011.1	20.705		20044.5	
						143.8			1465.0			1470.4		
21	AC-20	42.61294463 N	80.00815814 W	4718311.2	581349.3		25.1 Port	41		21476.1	22.170		21514.9	
						118.7			2178.4			2182.0		
22	AC-21	42.60331923 N	79.98501901 W	4717264.8	583260.0		3.0 Port	44		23654.5	24.348		23696.9	
						115.7			1363.2			1367.4		
23	AC-22	42.59786051 N	79.97013560 W	4716673.4	584488.3		28.3 Stbd	46		25017.7	25.712		25064.3	
						144.0			913.0			914.8		
24	AC-23	42.59114728 N	79.96371156 W	4715934.4	585024.4		15.9 Stbd	48		25930.7	26.625		25979.1	
						159.9			781.1			783.6		
25	AC-24	42.58451422 N	79.96054444 W	4715201.1	585293.3		13.7 Stbd	50		26711.8	27.406		26762.7	
						173.6			1361.0			1369.4		
26	AC-25	42.57231797 N	79.95891026 W	4713848.4	585444.1		3.9 Stbd	51		28072.8	28.767		28132.1	
						177.5			3596.8			3629.4		
27	AC-26	42.53994413 N	79.95756289 W	4710254.9	585598.9		1.2 Port	57		31669.6	32.363		31761.5	
						176.3			80.5			81.1		
28	AC-27	42.53922043 N	79.95751183 W	4710174.6	585604.1		10.2 Stbd	57		31750.1	32.444		31842.6	
						186.5			425.8			429.1		
29	AC-28	42.53541628 N	79.95815793 W	4709751.6	585556.2		0.0	58		32175.9	32.870		32271.7	
						186.5			484.3			487.6		
30	AC-29	42.53108944 N	79.95889447 W	4709270.4	585501.6		12.8 Stbd	58		32660.2	33.354		32759.3	
						199.3			3896.1			3927.5		
31	AC-30	42.49812978 N	79.97514740 W	4705594.2	584211.1		17.9 Stbd	60		36556.3	37.250		36686.8	
						217.2			997.8			1004.7		
32	AC-31	42.49104134 N	79.98260905 W	4704799.8	583607.4		15.9 Stbd	61		37554.1	38.248		37691.5	
						233.1			678.9			684.4		

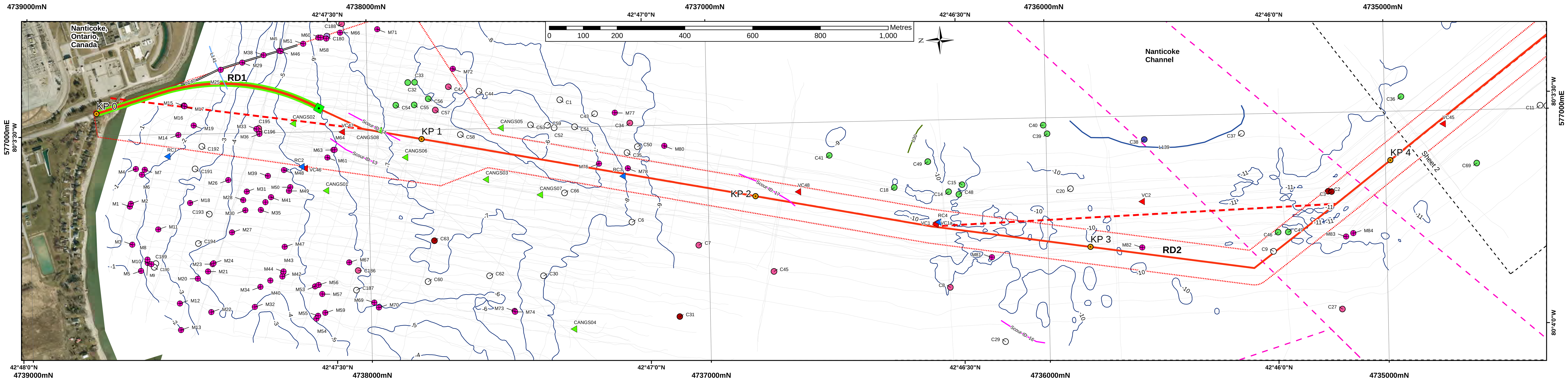
LEC Proposed Route RPL from Canadian HDD Exit to Survey Bathymetric Extent on USA Side
Version 1 (January 19,2016)

Point #	Comment	Latitude* NAD83	Longitude* NAD83	Northing** (UTM 17N)	Easting** (UTM 17N)	Bearing (Grid°)	Alter Course (Grid°)	Depth*** Chart Datum (m)	Horiz.Leg Distance † (m)	Cum. Horiz Distance † (m)	Station †† (KP)	Est. Cable Length (Slope) ‡ (m)	Est. Cum. Cable Length (Slope) ‡ (m)	Notes
33	AC-32	42.48743207 N	79.98927588 W	4704392.4	583064.3		28.0 Port	61		38233.0	38.927		38375.9	
						205.1			996.7			1006.7		
34	AC-33	42.47934757 N	79.99454383 W	4703489.6	582642.0		35.2 Port	62		39229.7	39.923		39382.6	
						169.9			2233.7			2243.5		
35	AC-34	42.45950575 N	79.99007939 W	4701290.7	583035.2		22.1 Stbd	44		41463.4	42.157		41626.1	
						192.0			1399.5			1402.3		
36	AC-35	42.44721117 N	79.99381843 W	4699921.9	582743.9		3.6 Stbd	44		42862.9	43.557		43028.4	
						195.6			1678.2			1682.8		
37	AC-36	42.43270431 N	79.99953860 W	4698305.5	582292.5		18.0 Stbd	44		44541.1	45.235		44711.2	
						213.6			1676.3			1679.6		
38	Border	42.42022980 N	80.01101226 W	4696909.3	581364.9		0.0	43		46217.4	46.911		72404.5	Canadian/USA Border
						213.6			25989.3			26013.7		
39	AC-37	42.22666743 N	80.18831898 W	4675262.2	566982.6		0.0	24		72206.7	72.901		72404.5	
						213.6			1002.6			1003.4		
40	AC-38	42.21919472 N	80.19513695 W	4674427.2	566427.8		8.7 Port	23		73209.3	73.903		73407.9	
						204.9			541.5			542.2		
41	AC-39	42.21479171 N	80.19795823 W	4673936.1	566199.6		11.8 Stbd	22		73750.8	74.445		73950.1	
						216.7			466.4			466.8		
42	AC-40	42.21144795 N	80.20137836 W	4673562.2	565920.7		0.0	22		74217.2	74.911		74416.9	
						216.7			508.7			509.0		
43	AC-41	42.20780086 N	80.20510819 W	4673154.3	565616.6		11.5 Stbd	22		74725.9	75.420		74925.9	
						228.2			501.9			502.5		
44	AC-42	42.20481951 N	80.20967834 W	4672819.8	565242.5		11.5 Port	21		75227.8	75.922		75428.4	
						216.7			4225.0			4227.1		
45	AC-43	42.17452372 N	80.24063497 W	4669432.7	562716.9		0.1 Port	22		79452.8	80.147		79655.5	
						216.6			4610.5			4614.3		
46	AC-44	42.14140955 N	80.27430372 W	4665731.8	559967.4		9.2 Stbd	16		84063.3	84.757		84269.8	
						225.8			3270.0			3272.6		
47	AC-45	42.12103613 N	80.30287309 W	4663450.0	557625.0		7.5 Port	15		87333.3	88.027		87542.4	
						218.3			610.5			610.6		
48	AC-46	42.11674737 N	80.30749339 W	4662970.7	557246.9		7.3 Stbd	14		87943.8	88.638		88153.0	
						225.6			2367.7			2368.6		
49	AC-47	42.10194282 N	80.32810342 W	4661313.3	555556.1		4.1 Stbd	13		90311.5	91.005		90521.6	
						229.7			1024.8			1025.0		
50	AC-48	42.09602391 N	80.33761168 W	4660650.0	554775.0		4.1 Port	13		91336.3	92.030		91546.6	
						225.6			3042.1			3042.6		
51	AC-49	42.07700173 N	80.36408323 W	4658521.3	552601.7		0.5 Stbd	13		94378.4	95.072		94589.2	
						226.1			4034.4			4035.1		
52	AC-50	42.05198182 N	80.39944345 W	4655722.2	549696.3		11.3 Port	13		98412.8	99.107		98624.3	
						214.8			1887.3			1887.7		
53	AC-51	42.03808491 N	80.41257382 W	4654171.7	548620.3		50.4 Port	12		100300.1	100.994		100512.0	
						164.4			2263.7			2264.5		
54	AC-52	42.01841504 N	80.40538061 W	4651991.8	549230.9		0.3 Stbd	6		102563.8	103.258		102776.5	
						164.7			464.3			464.4		
55	Data Extent	42.01437414 N	80.40393849 W	4651544.0	549353.4			2		103028.1	103.722		103240.9	Survey bathymetric extent on USA side

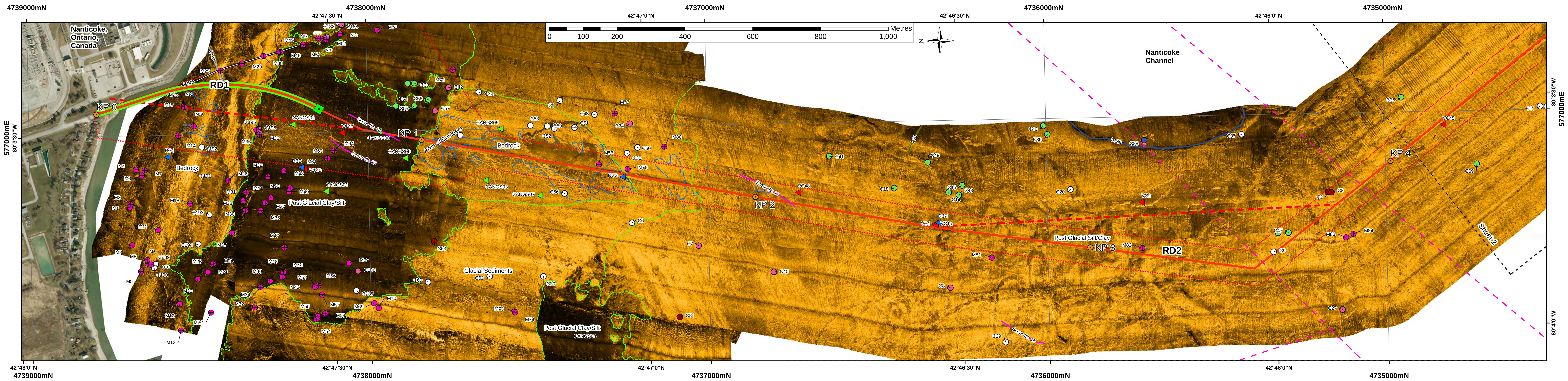
Notes

RPL Extent in this table:	Start:: Canadian HDD exit. End: Survey bathymetric extent on USA side.
*Geographic Coordinates:	NAD83, Decimal Degrees.
**Grid Coordinates:	NAD83, UTM Zone 17 North, metres.
***Depth:	Chart Datum.
† Horizonal Leg & Cumulative Dist:	Horizontal measurement in metres starting at Canadian HDD exit.
†† Station:	Horizontal measurement in kilometres starting at KP 0 of the LEC Proposed Route.
‡ Estimated Cable Length (slope):	Slope length calculated for the RPL is based on a 1m x 1m bathymetric grid of the lakebed and does not account for cable burial depth. The slope length includes depth deviations resulting from surficial boulders, scours and other features located on the Proposed Route. The bathymetry used to calculate slope length are representative of the lakebed conditions at the time of the survey.

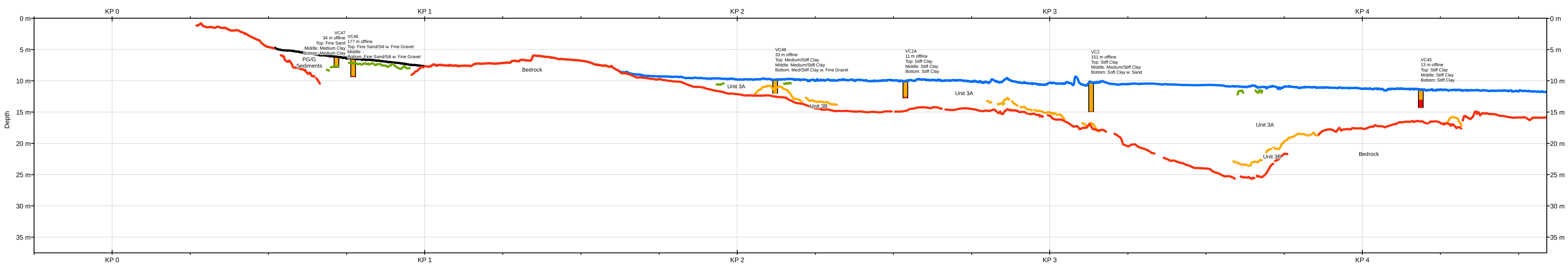
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

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- Magnetic Anomaly
- Buoy Mooring
- Linear Feature - Possible Cable
- Circular Contact
- Linear Feature - Probable Drag Mark
- Circular Contact (Probable Dredge Spoil)
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- Linear Contact
- Possible Dredge Boundary
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- Ice Scour
- Shipwreck
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- International Border
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	Vibracore sample recovery	
	Vibracore sample penetration	

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Sound Velocity Profiler:	SV Plus V1 Sound	Odom Digibar & SV Plus	SV Plus
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Shallow Seismic:	Applied Acoustics Boomer CSP-P 350 J Power Source	Klein 3200 Chirp	
Magnetometer:	Marine Magnetics Seaspy	Marine Magnetics Seaspy	Marine Magnetics Seaspy

BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
Latitude of Origin:	Equator
False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
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ROUTE

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HORIZONTAL DIRECTIONAL DRILLING PATH

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NANTICOKE CHANNEL

The location of the Nanticoke Channel was digitized from NOAA chart 14838.

SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Prepared For: **ITC Lake Erie Connector, LLC**

Black & Veatch

Canadian Seabed Research Ltd.

341 Myra Road, Porters Lake, Nova Scotia
Canada B3E 1G2
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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

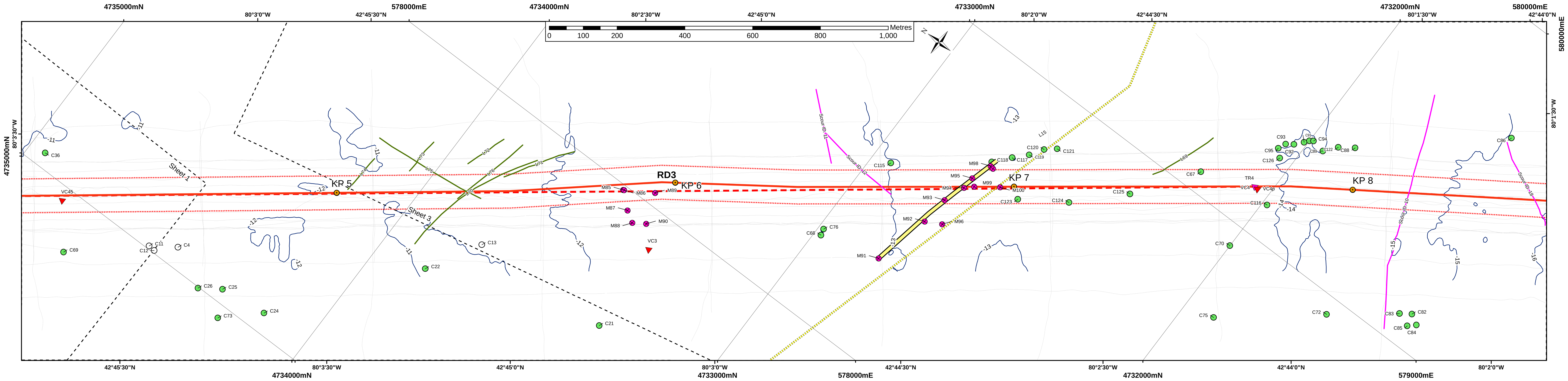
LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 1 of 15
KP 0 to KP 5

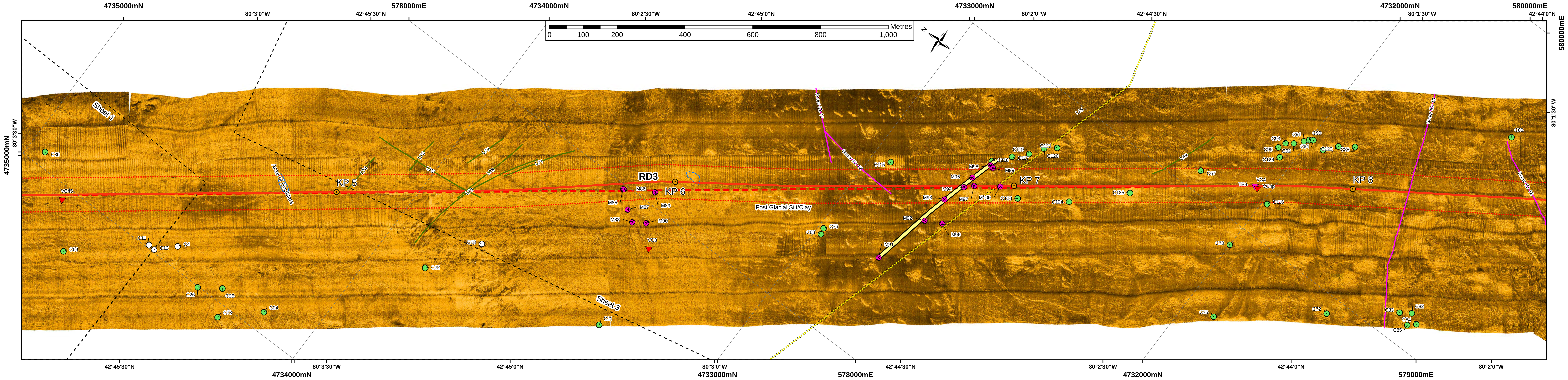
REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

SCALE: 1:5,000	PROJECTION: NAD 1983 UTM Zone 17N
PROJECT #: 1408	FILE: 1408_LakeErie_2015PanelMap

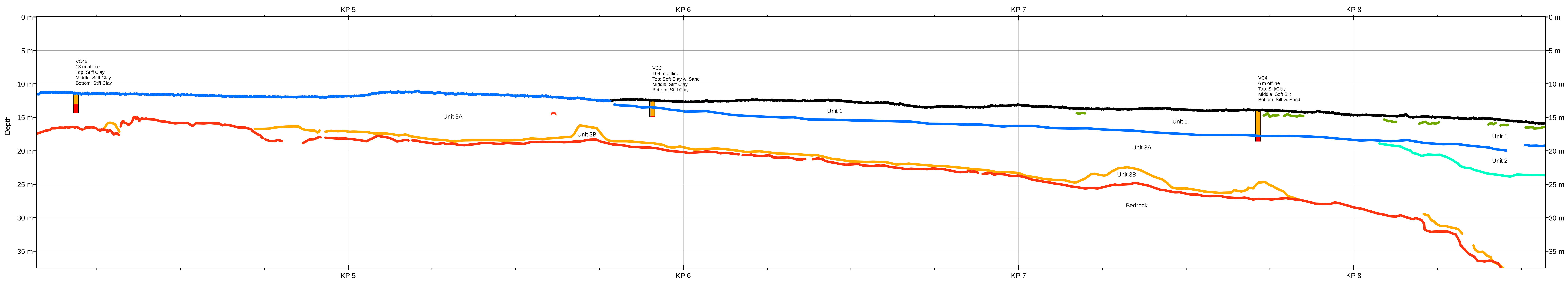
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

LEC Proposed Route — Kilometre Post — Routing Boundary

Survey Centreline — Survey Vessel Trackline

HDD Route — Bathymetric Contour (1 metre)

SURFICIAL GEOLOGY AND LAKEBED FEATURES

Anthropogenic Contact	Magnetic Anomaly
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Circular Contact	Linear Feature - Probable Drag Mark
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Area of Boulders	Rock Core Location
Surficial Boundary	Grab Sample
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Vibracore sample recovery

Vibracore sample penetration

NOTES

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BASEMAP

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SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 2 of 15
KP 4 to KP 9

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
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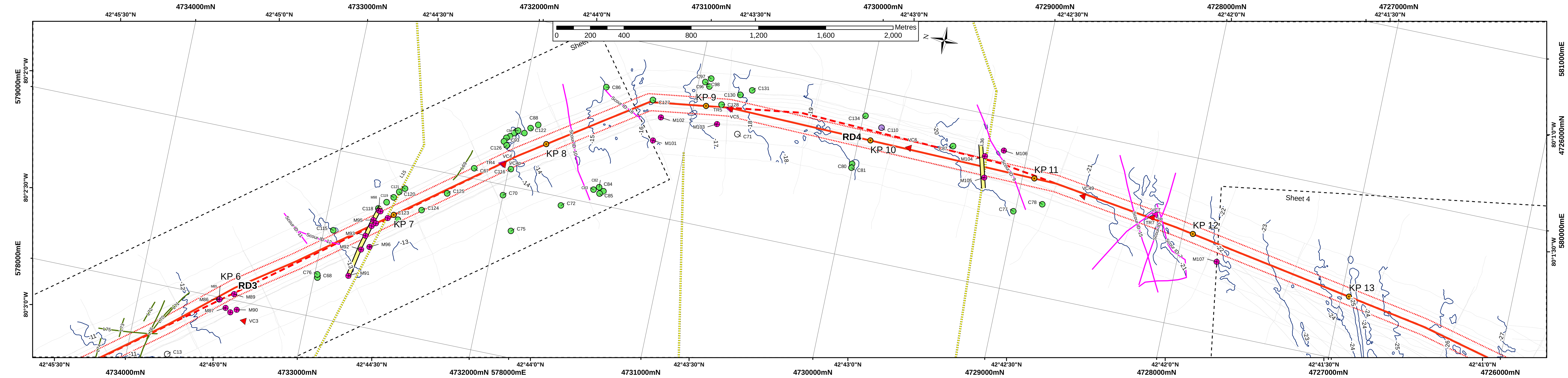
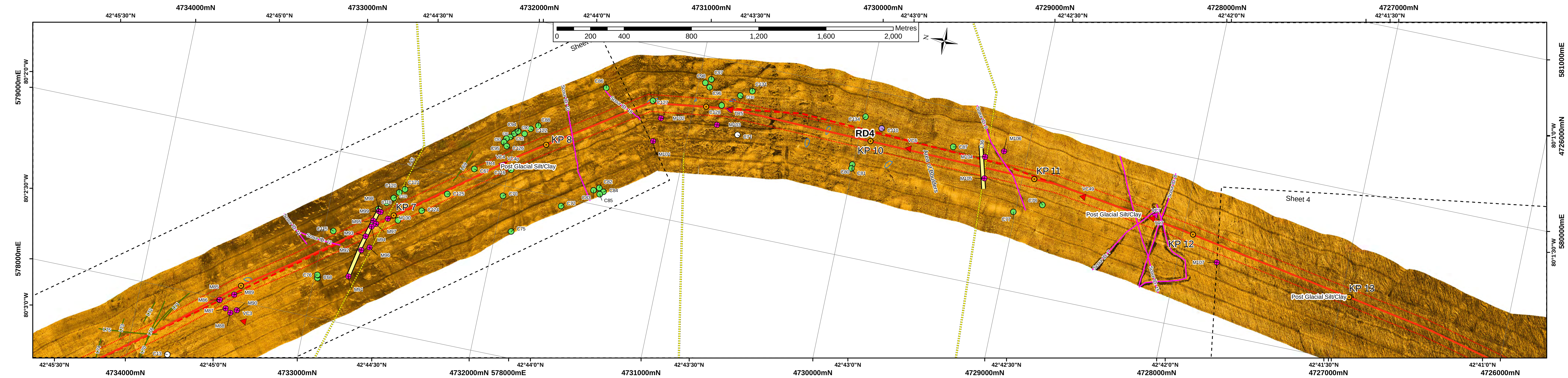
SCALE: 1:5,000 — PROJECTION: NAD 1983 UTM Zone 17N

PROJECT #: 1408 — FILE: 1408_LakeErie_2015PanelMap

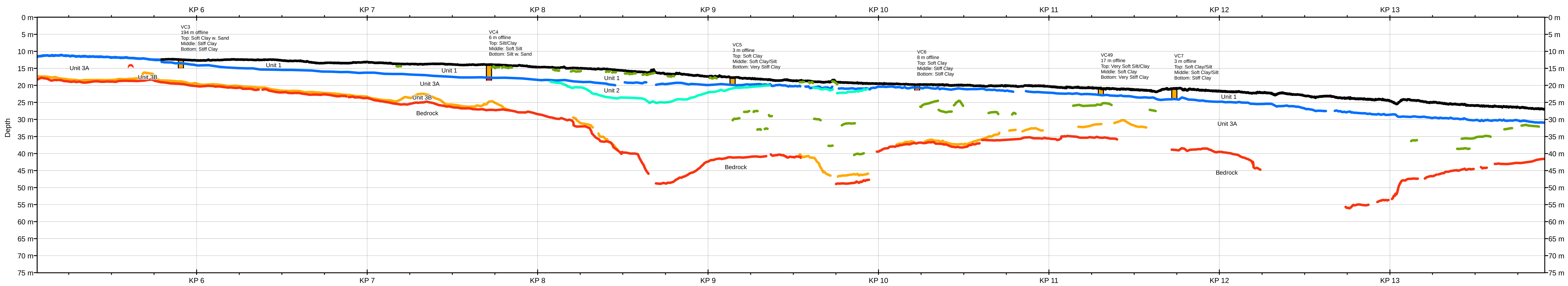
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

LEC Proposed Route
Kilometre Post
Routing Boundary
Survey Centreline
Survey Vessel Trackline
HDD Route
Bathymetric Contour (1 metre)

SURFICIAL GEOLOGY AND LAKEBED FEATURES

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 3 of 15
KP 5 to KP 14

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
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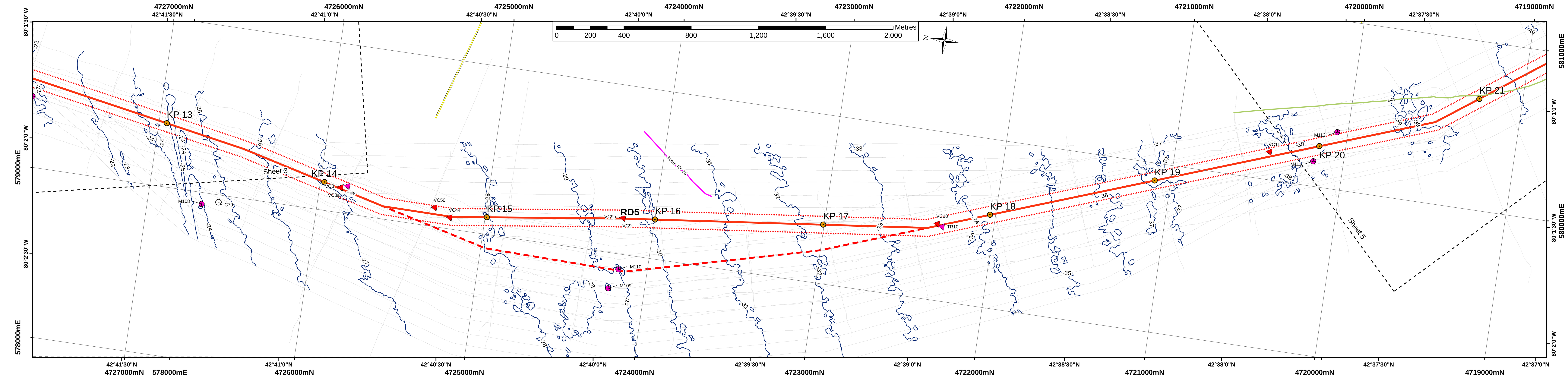
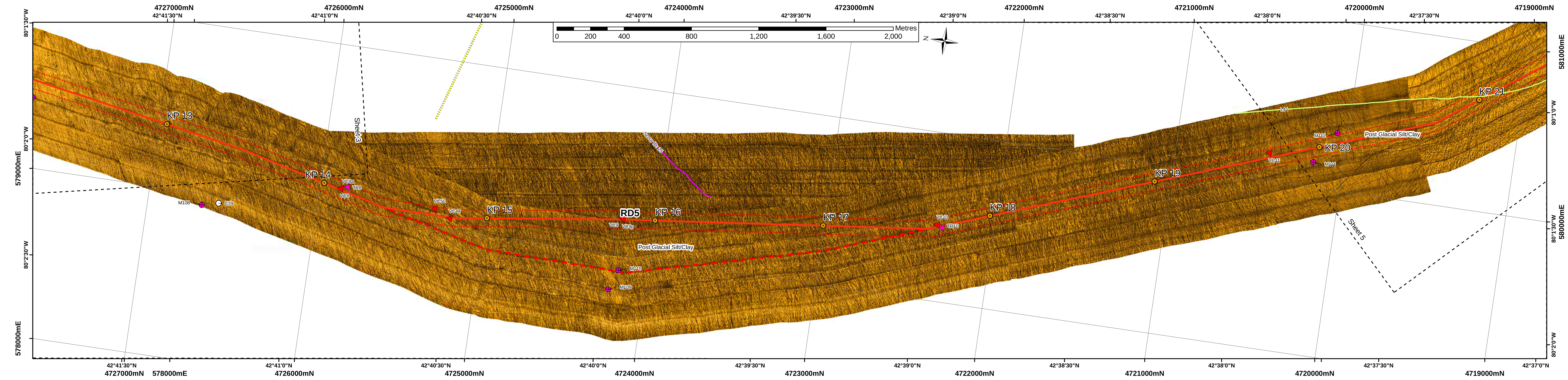
SCALE: 1:10,000 | PROJECTION: NAD 1983 UTM Zone 17N
PROJECT #: 1408 | FILE: 1408_LakeErie_2015PanelMap

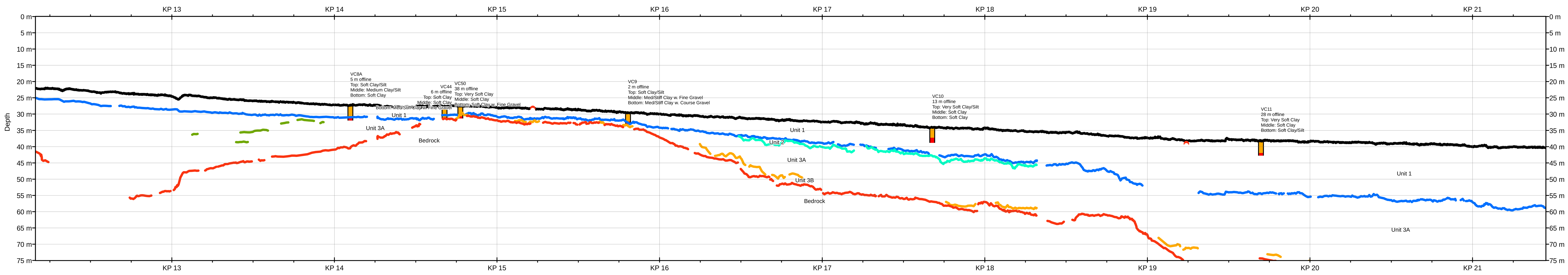
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

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LEGEND

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Routing Boundary
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False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
Vertical Datum:	Chart Datum (173.5 metres above International Great Lakes Datum (IGLD) 1985).
Horizontal Scale:	1:10,000
Vertical (Profile) Scale:	1:500
Units:	Metres

BATHYMETRY

Singlebeam data was collected during the Fall 2014 and nearshore Summer 2015 surveys. The soundings were corrected for vessel motion, sound velocity variations, and reduced to chart datum within Hypack. Multibeam data was collected during the Summer 2015 survey. Vessel offsets, sound velocity, and lake level corrections were applied within Caris.Soundings collected in Canadian waters were reduced to chart datum with observed lake level data from DFO Port Dover Lake Level Station 12710. Soundings collected in US waters were reduced with hourly observed lake level data from NOAA Erie Lake Level Station 9063038.

Processed sounding data were imported into Surfer 12 where 1 m x 1 m and 5 m x 5 m grid files were created using a kriging interpolation algorithm. The contours displayed in all enclosures were based on the 5 m x 5 m grid.

GEOLOGY

Surficial and sub-bottom geology interpretation were based on sidescan sonar, chirp profiler, and shallow seismic data. Depths below seabed were determined using a sound velocity of 1600m/s. A vertical exaggeration of 20 times was applied for visualization. Surficial seabed features were interpreted from sidescan sonar data while magnetic anomaies were derived from magnetometer data.

Numerous fishery related drag marks are visible on the lakefloor throughout Canadian waters.

ROUTE

All distances along line, offsets, and profile values have been calculated with the LEC Proposed Route with Route Deviations.

HORIZONTAL DIRECTIONAL DRILLING PATH

Canadian HDD path was provided by Black and Veatch on 2015/11/03. The USA landfall represents a straight line from the landfall coordinate provided by Deiss and Halmi Engineering.

NANTICOKE CHANNEL

The location of the Nanticoke Channel was digitized from NOAA chart 14838.

SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Prepared For: **ITC Lake Erie Connector, LLC**

Black & Veatch

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

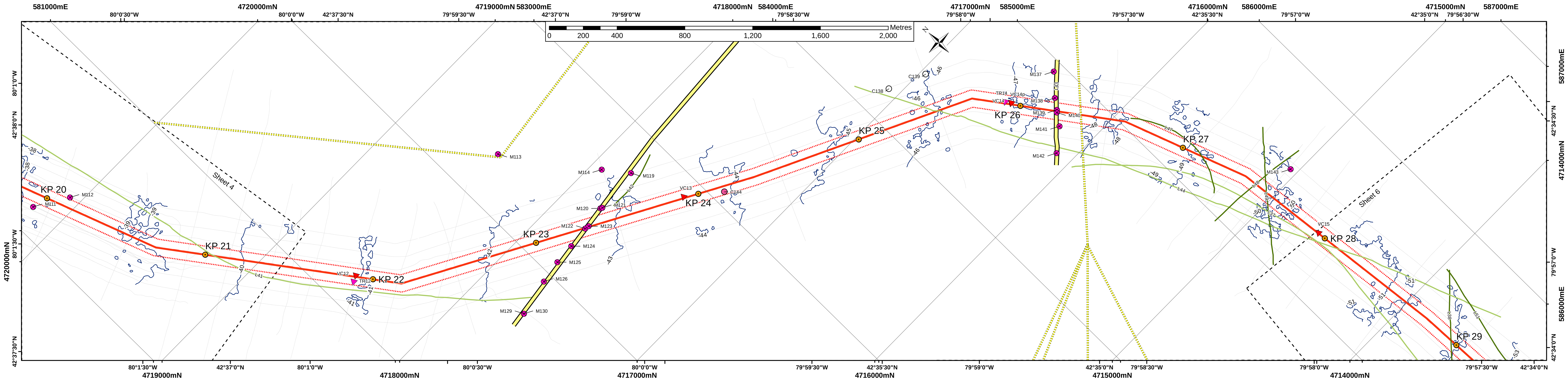
COMPOSITE PANEL MAP
SHEET 4 of 15
KP 12 to KP 21

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

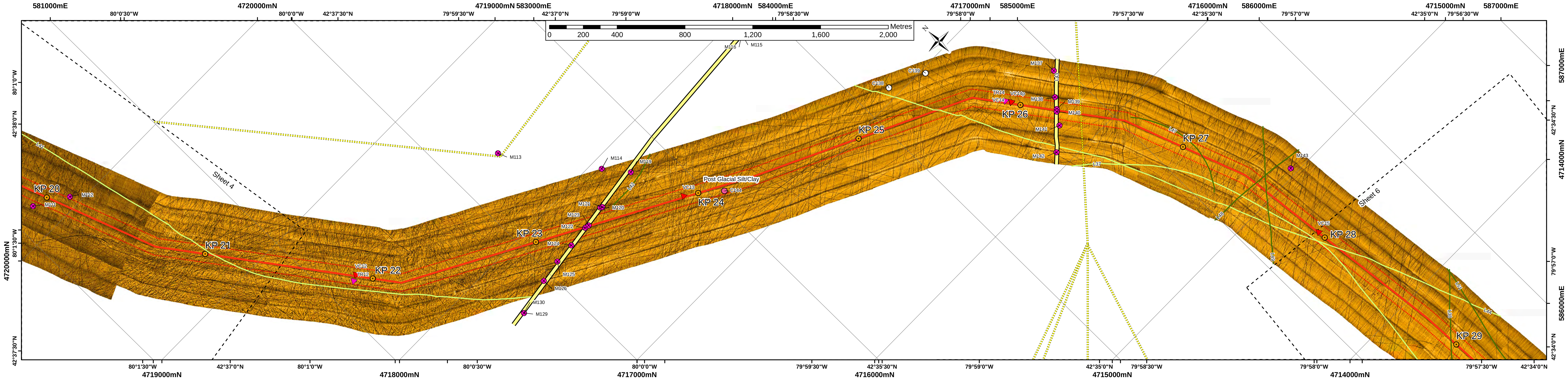
SCALE: 1:10,000 | PROJECTION: NAD 1983 UTM Zone 17N

PROJECT #: 1408 | FILE: 1408_LakeErie_2015PanelMap

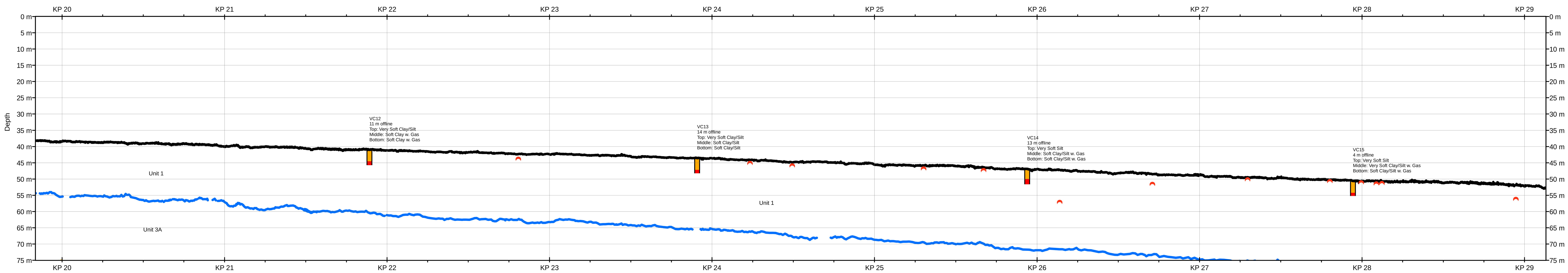
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

SURFICIAL GEOLOGY AND LAKEBED FEATURES

- Anthropogenic Contact
- Magnetic Anomaly
- Buoy Mooring
- Linear Feature - Possible Cable
- Circular Contact
- Linear Feature - Probable Drag Mark
- Circular Contact (Probable Dredge Spoil)
- Water Intake Pipe
- Linear Contact
- Possible Dredge Boundary
- Point Source Reflector
- Trench
- Rectangular Contact
- Ice Scour
- Shipwreck
- NanticokeChannel
- Sand Ripples
- International Border
- Area of Boulders
- Rock Core Location
- Surficial Boundary
- Grab Sample
- CSR Interpreted Pipeline
- Vibracore Sample
- Pipeline (Dundee Energy)
- Thermal Resistivity Station

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LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY

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- R2 Boundary between Unit 2 and Unit 3A.
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- Gas Interpreted areas of gas indicated by acoustic masking.
- Hyperbolic Reflection
- Vibracore sample recovery
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NOTES

FIELD SURVEY

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Party Chief: Colin Toole and Matt Savelle

SURVEY EQUIPMENT	2014	2015	2015-Nearshore
Vessel:	VAC (19.81 m Tug)	VAC (19.81 m Tug)	RF-18 Seabed
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Echosounder:	ODOM CV3 (200 kHz & 50 kHz)	ODOM MB1 (220 kHz)	ODOM CV100 (200 kHz & 33 kHz)
Sound Velocity Profiler:	SV Plus V1 Sound	Odom Digibar & SV Plus	SV Plus
Heave Compensator:	TSS HPR Sensor	DMS-05	TSS HPR Sensor
Sidescan Sonar:	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)
Shallow Seismic:	Applied Acoustics Boomer CSP-P 350 J Power Source	Klein 3200 Chirp	
Magnetometer:	Marine Magnetics Seaspy	Marine Magnetics Seaspy	Marine Magnetics Seaspy

BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
Latitude of Origin:	Equator
False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
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GEOLOGY

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ROUTE

All distances along line, offsets, and profile values have been calculated with the LEC Proposed Route with Route Deviations.

HORIZONTAL DIRECTIONAL DRILLING PATH

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NANTICOKE CHANNEL

The location of the Nanticoke Channel was digitized from NOAA chart 14838.

SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Prepared For: **ITC Lake Erie Connector, LLC**

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

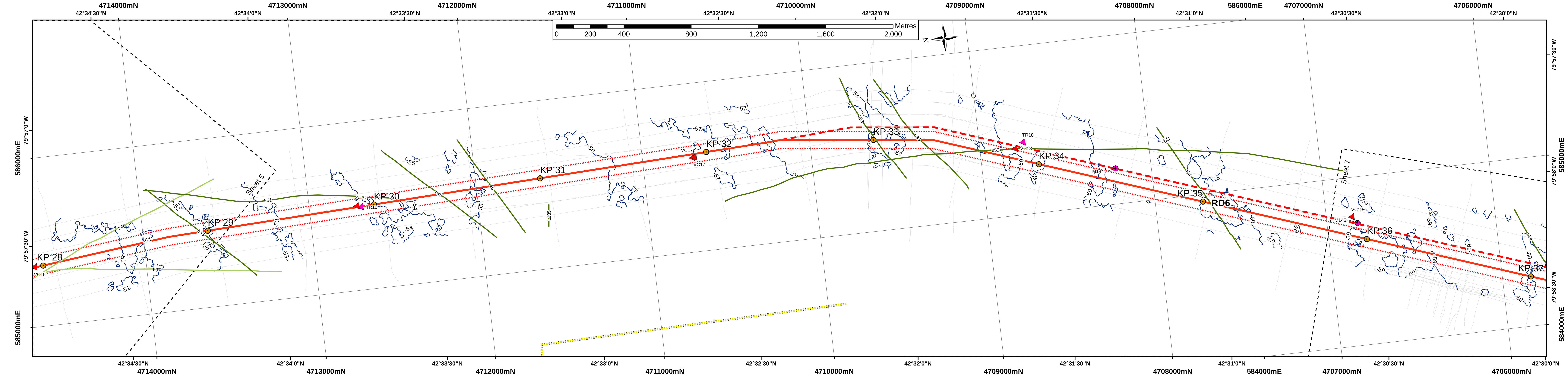
COMPOSITE PANEL MAP
SHEET 5 of 15
KP 20 to KP 29

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

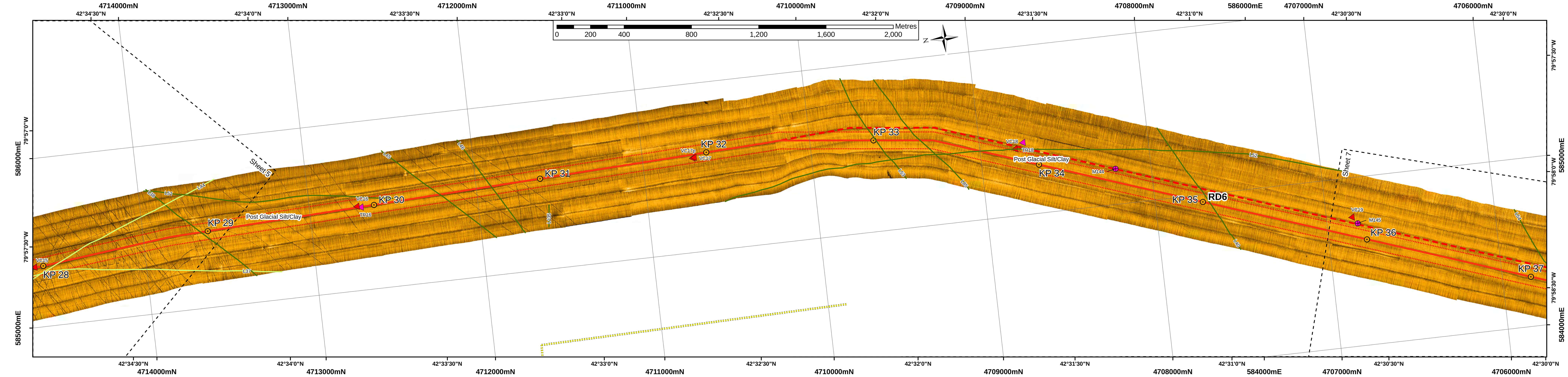
SCALE: 1:10,000 — PROJECTION: NAD 1983 UTM Zone 17N

PROJECT #: 1408 — FILE: 1408_LakeErie_2015PanelMap

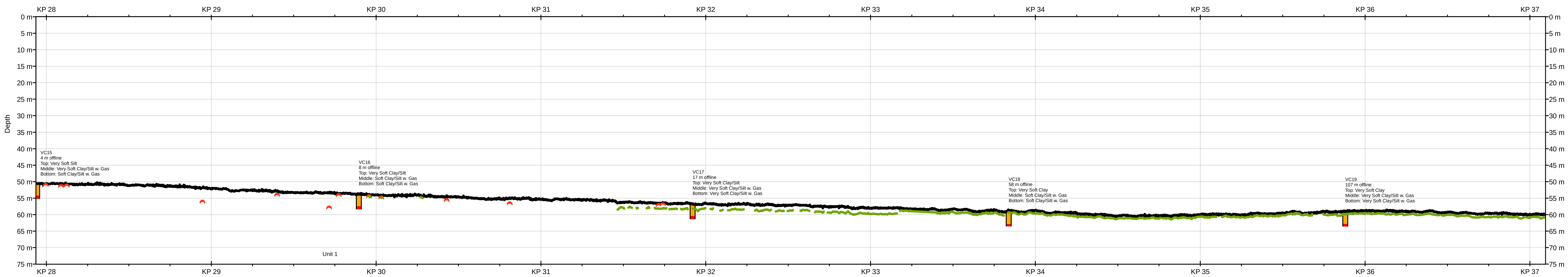
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

SURFICIAL GEOLOGY AND LAKEBED FEATURES

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- Trench
- Rectangular Contact
- Ice Scour
- Shipwreck
- NanticokeChannel
- Sand Ripples
- International Border
- Area of Boulders
- Rock Core Location
- Surficial Boundary
- Grab Sample
- CSR Interpreted Pipeline
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- Pipeline (Dundee Energy)
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- R1 Boundary between post-glacial and glacial sediments.
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NOTES

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Heave Compensator:	TSS HPR Sensor	DMS-05	TSS HPR Sensor
Sidescan Sonar:	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)
Shallow Seismic:	Applied Acoustics Boomer CSP-P 350 J Power Source	Klein 3200 Chirp	
Magnetometer:	Marine Magnetics Seaspy	Marine Magnetics Seaspy	Marine Magnetics Seaspy

BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
Latitude of Origin:	Equator
False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
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SHORE IMAGERY

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

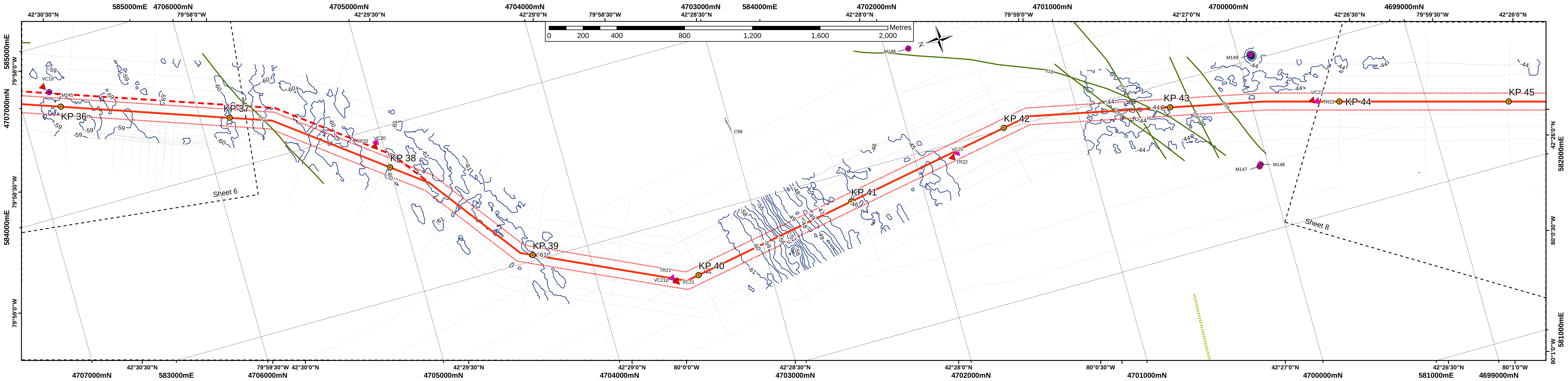
COMPOSITE PANEL MAP
SHEET 6 of 15
KP 28 to KP 37

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

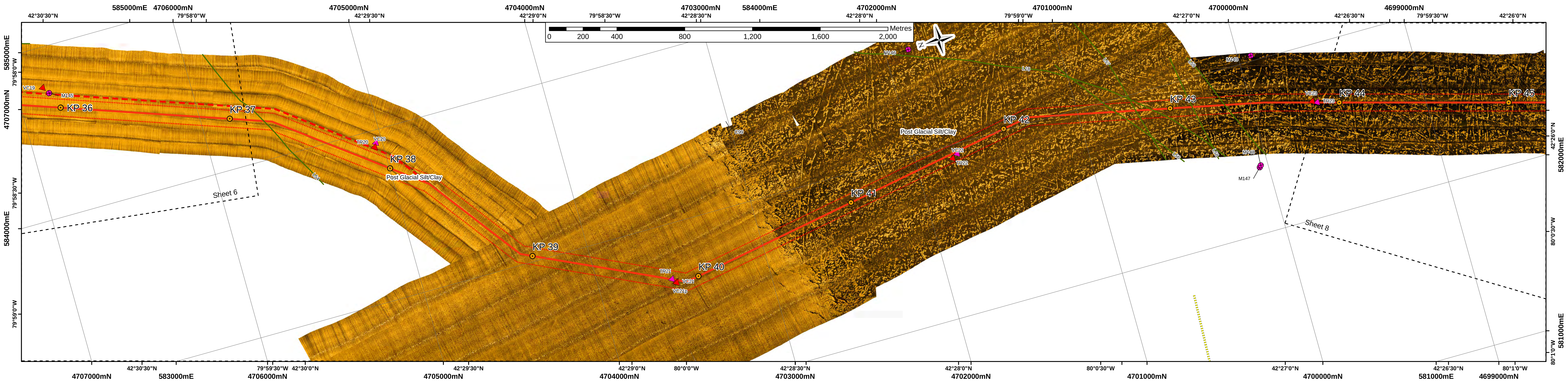
SCALE: 1:10,000 | PROJECTION: NAD 1983 UTM Zone 17N

PROJECT #: 1408 | FILE: 1408_LakeErie_2015PanelMap

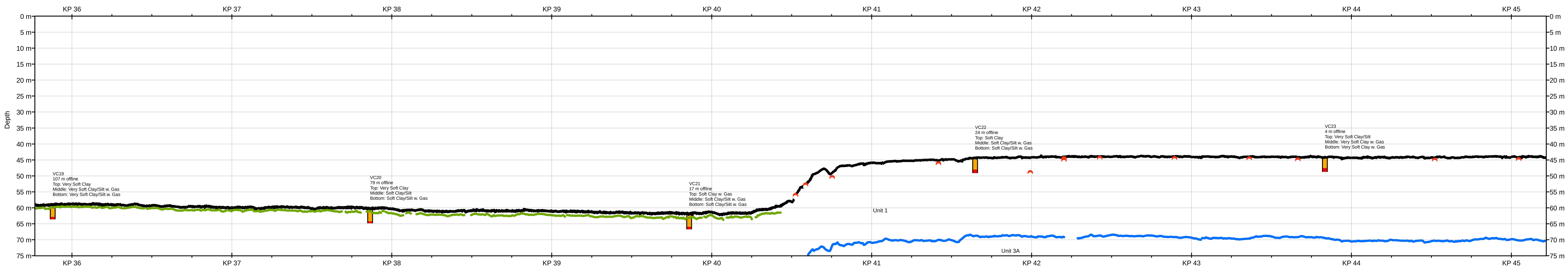
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

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- International Border
- Area of Boulders
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LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY

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Gas	Interpreted areas of gas indicated by acoustic masking.	Bedrock	Acoustic basement interpreted as bedrock.
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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

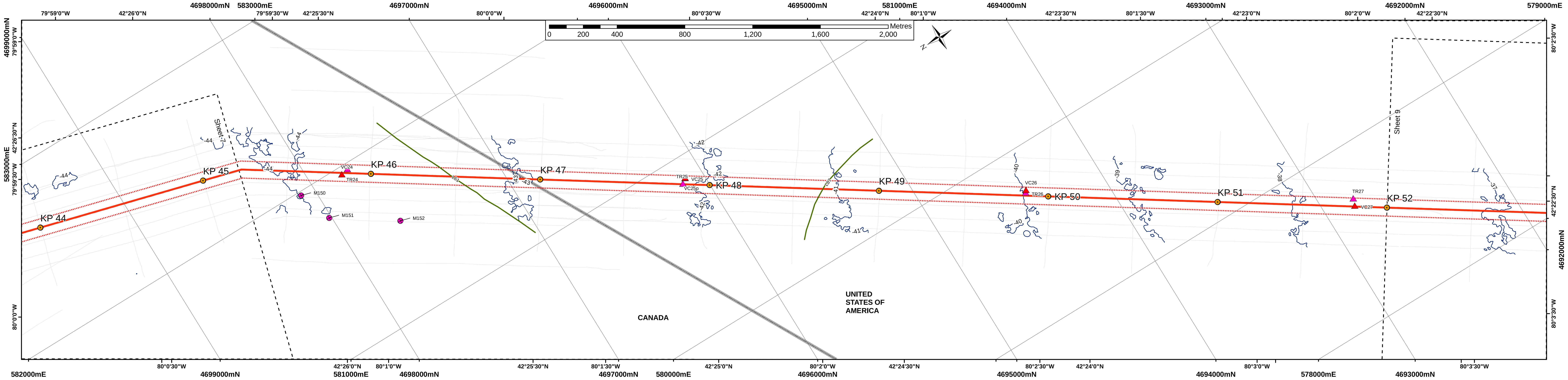
LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 7 of 15
KP 36 to KP 45

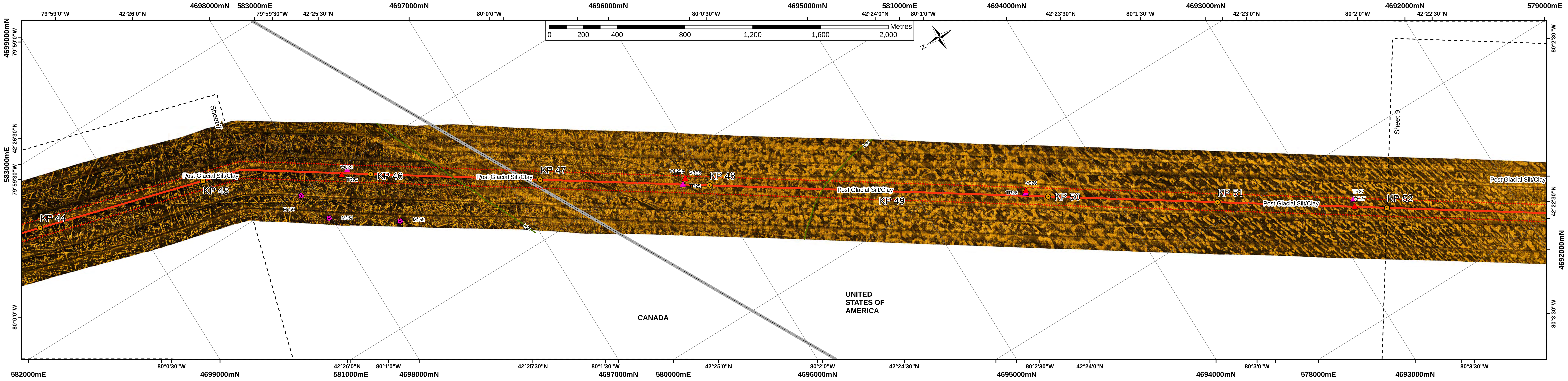
REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

SCALE: 1:10,000	PROJECTION: NAD 1983 UTM Zone 17N
PROJECT #: 1408	FILE: 1408_LakeErie_2015PanelMap

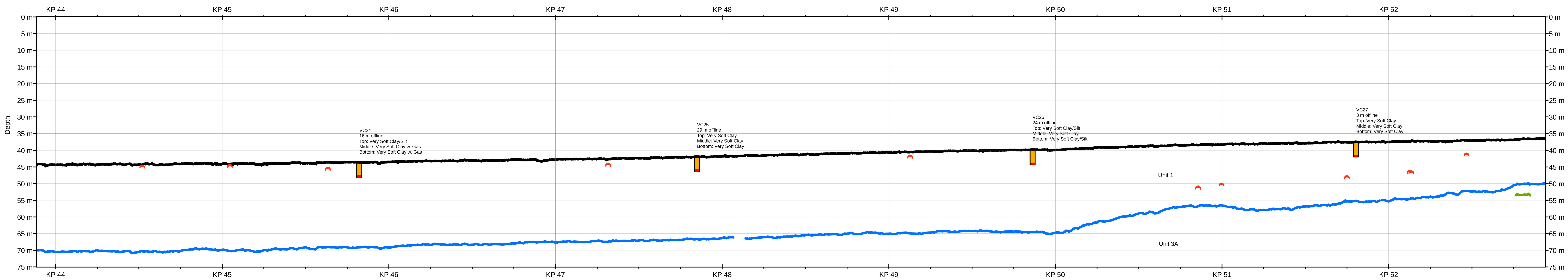
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

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- R3 Top of glacial till (Unit 3B).
- R4 Top of Bedrock
- Gas Interpreted areas of gas indicated by acoustic masking.
- Hyperbolic Reflection
- Vibracore sample recovery
- Vibracore sample penetration

Unit 1	Post-glacial sediments.
Unit 2	Homogeneous glacial sediments.
Unit 3A	Glacial lacustrine sediments.
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Bedrock	Acoustic basement interpreted as bedrock.
PG/G Sediments	Undifferentiated post-glacial and glacial sediments.

NOTES

FIELD SURVEY

Canadian Seabed Research Ltd. conducted survey work during the following time periods: 17/11/2014-19/12/2014 and 11/06/2015-02/10/2015

Party Chief: Colin Toole and Matt Savelle

SURVEY EQUIPMENT	2014	2015	2015-Nearshore
Vessel:	VAC (19.81 m Tug)	VAC (19.81 m Tug)	RF-18 Seabed
Positioning System:	Hemisphere R100 DGPS	Hemisphere VS330 DGPS	Hemisphere R100 DGPS
Survey Navigation Software:	Hypack 2010	Hypack 2013	Hypack 2013
Echosounder:	ODOM CV3 (200 kHz & 50 kHz)	ODOM MB1 (220 kHz)	ODOM CV100 (200 kHz & 33 kHz)
Sound Velocity Profiler:	SV Plus V1 Sound	Odom Digibar & SV Plus	SV Plus
Heave Compensator:	TSS HPR Sensor	DMS-05	TSS HPR Sensor
Sidescan Sonar:	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)
Shallow Seismic:	Applied Acoustics Boomer CSP-P 350 J Power Source	Klein 3200 Chirp	
Magnetometer:	Marine Magnetics Seaspy	Marine Magnetics Seaspy	Marine Magnetics Seaspy

BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
Latitude of Origin:	Equator
False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
Vertical Datum:	Chart Datum (173.5 metres above International Great Lakes Datum (IGLD) 1985).
Horizontal Scale:	1:10,000
Vertical (Profile) Scale:	1:500
Units:	Metres

BATHYMETRY

Singlebeam data was collected during the Fall 2014 and nearshore Summer 2015 surveys. The soundings were corrected for vessel motion, sound velocity variations, and reduced to chart datum within Hypack. Multibeam data was collected during the Summer 2015 survey. Vessel offsets, sound velocity, and lake level corrections were applied within Caris.Soundings collected in Canadian waters were reduced to chart datum with observed lake level data from DFO Port Dover Lake Level Station 12710. Soundings collected in US waters were reduced with hourly observed lake level data from NOAA Erie Lake Level Station 9063038.

Processed sounding data were imported into Surfer 12 where 1 m x 1 m and 5 m x 5 m grid files were created using a kriging interpolation algorithm. The contours displayed in all enclosures were based on the 5 m x 5 m grid.

GEOLOGY

Surficial and sub-bottom geology interpretation were based on sidescan sonar, chirp profiler, and shallow seismic data. Depths below seabed were determined using a sound velocity of 1600m/s. A vertical exaggeration of 20 times was applied for visualization. Surficial seabed features were interpreted from sidescan sonar data while magnetic anomaies were derived from magnetometer data.

Numerous fishery related drag marks are visible on the lakefloor throughout Canadian waters.

ROUTE

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HORIZONTAL DIRECTIONAL DRILLING PATH

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NANTICOKE CHANNEL

The location of the Nanticoke Channel was digitized from NOAA chart 14838.

SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Prepared For: **ITC Lake Erie Connector, LLC**

Black & Veatch

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

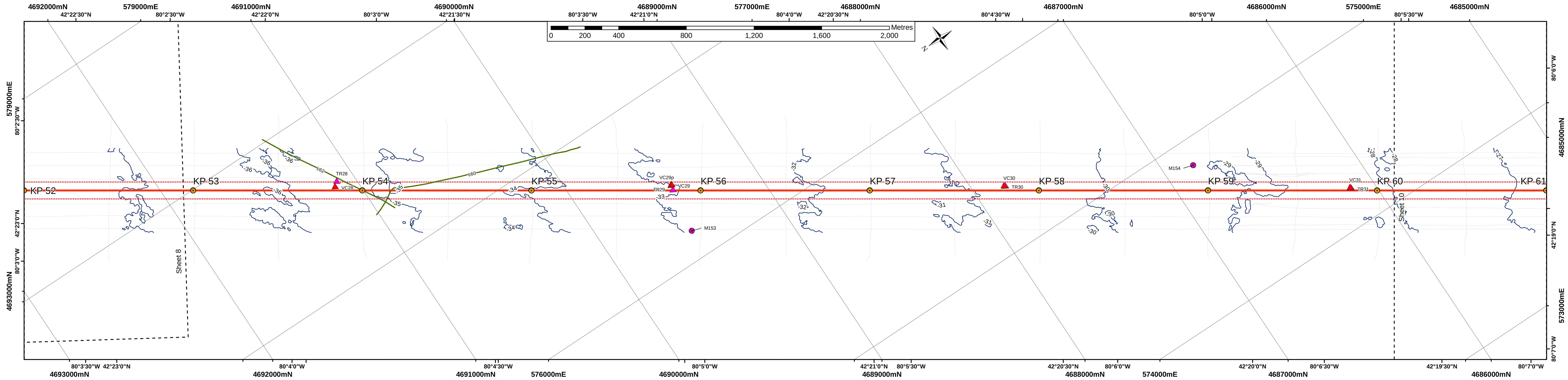
COMPOSITE PANEL MAP
SHEET 8 of 15
KP 44 to KP 53

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

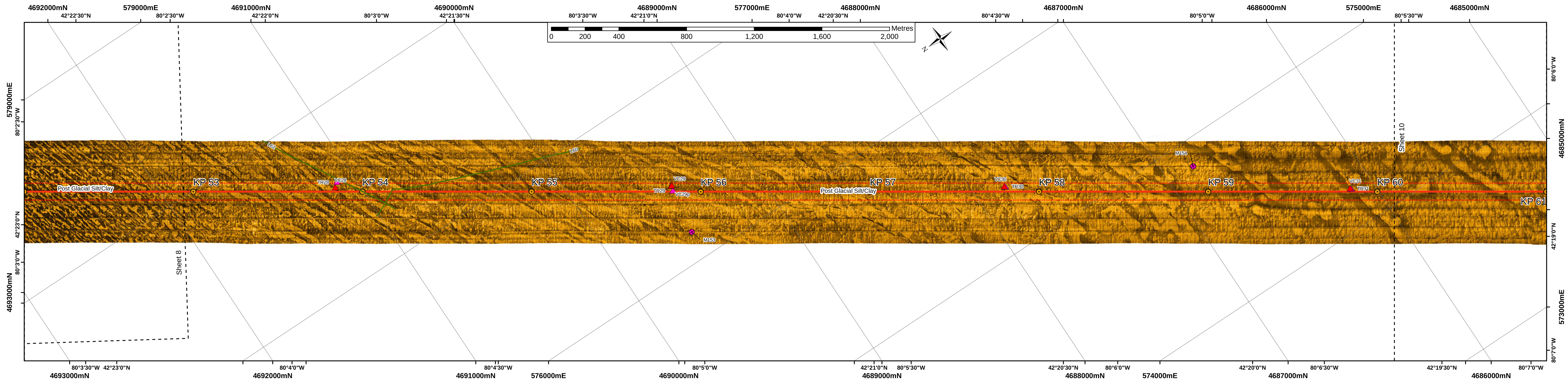
SCALE: 1:10,000 | PROJECTION: NAD 1983 UTM Zone 17N

PROJECT #: 1408 | FILE: 1408_LakeErie_2015PanelMap

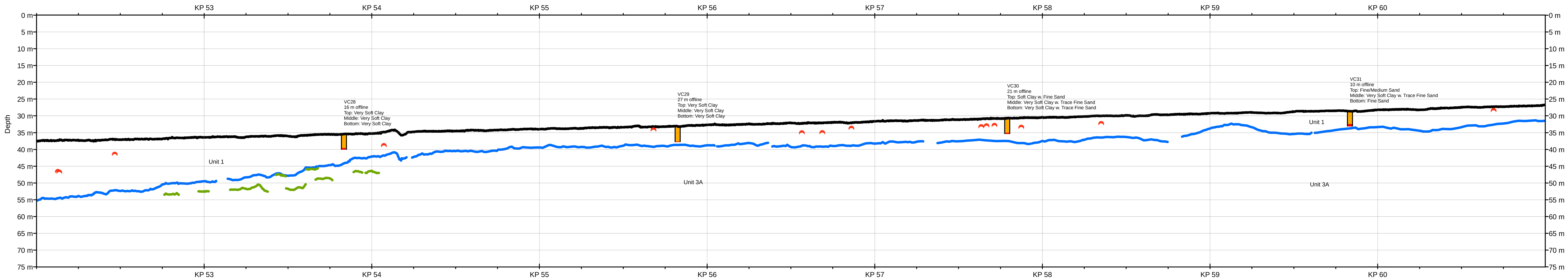
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

SURFICIAL GEOLOGY AND LAKEBED FEATURES

- Anthropogenic Contact
- Magnetic Anomaly
- Buoy Mooring
- Linear Feature - Possible Cable
- Circular Contact
- Linear Feature - Probable Drag Mark
- Circular Contact (Probable Dredge Spoil)
- Water Intake Pipe
- Linear Contact
- Possible Dredge Boundary
- Point Source Reflector
- Trench
- Rectangular Contact
- Ice Scour
- Shipwreck
- NanticokeChannel
- Sand Ripples
- International Border
- Area of Boulders
- Rock Core Location
- Surficial Boundary
- Grab Sample
- CSR Interpreted Pipeline
- Vibracore Sample
- Pipeline (Dundee Energy)
- Thermal Resistivity Station

Note: Lakebed feature labels displayed on this map represent the Class and feature ID (C for contact, L for linear, and M for magnetic). Sample labels represent how they were collected (VC for vibracore, TR for thermal Vibracore, RC for rock core, and GR for grab). See report for further information.

LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY

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- Vibracore sample recovery
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Shallow Seismic:	Applied Acoustics Boomer CSP-P 350 J Power Source	Klein 3200 Chirp	
Magnetometer:	Marine Magnetics Seaspy	Marine Magnetics Seaspy	Marine Magnetics Seaspy

BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
Latitude of Origin:	Equator
False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
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GEOLOGY
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Numerous fishery related drag marks are visible on the lakefloor throughout Canadian waters.

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HORIZONTAL DIRECTIONAL DRILLING PATH
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NANTICOKE CHANNEL
The location of the Nanticoke Channel was digitized from NOAA chart 14838.

SHORE IMAGERY
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Prepared For: **ITC Lake Erie Connector, LLC**

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

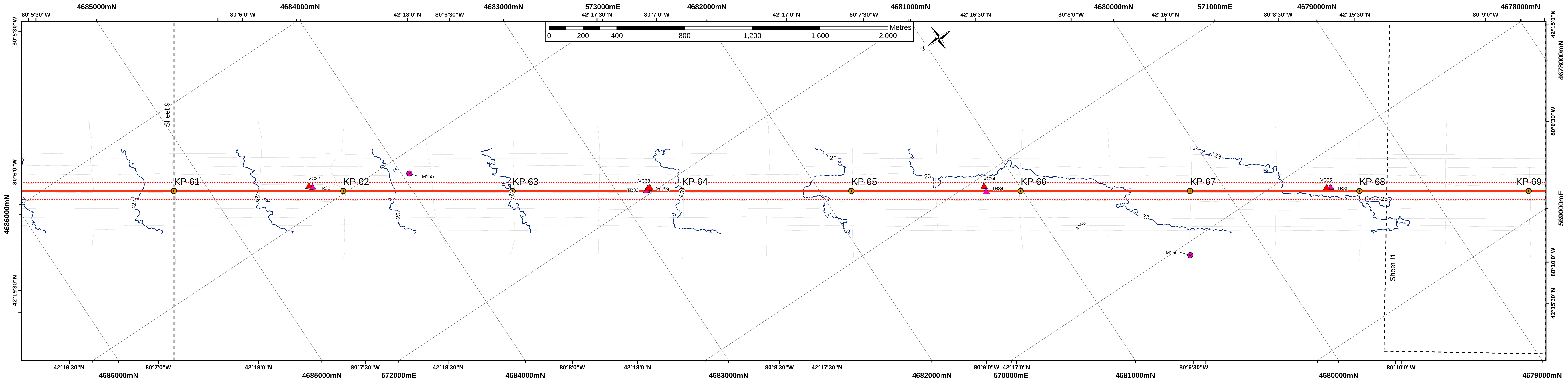
COMPOSITE PANEL MAP
SHEET 9 of 15
KP 52 to KP 61

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

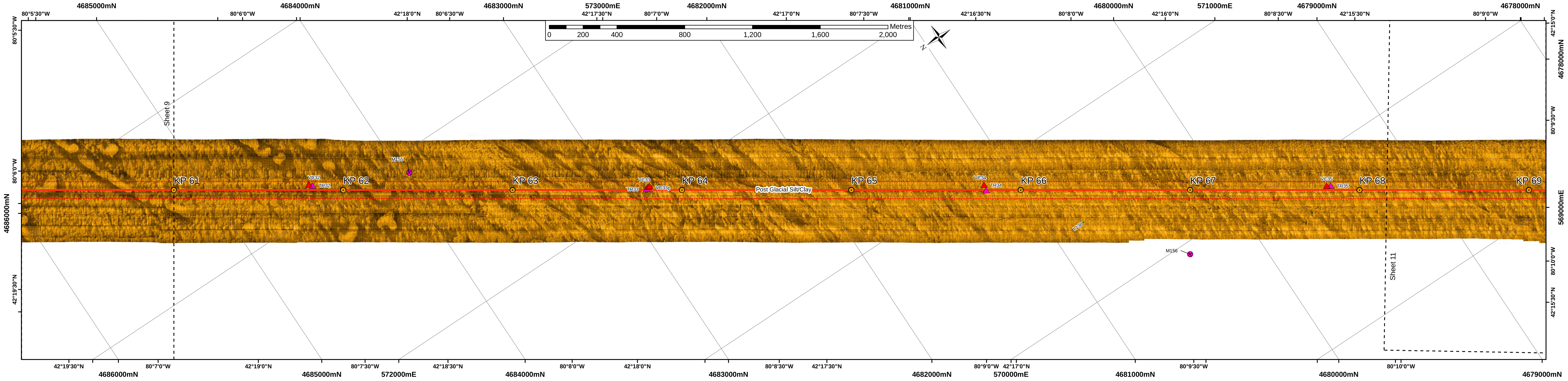
SCALE: 1:10,000 | PROJECTION: NAD 1983 UTM Zone 17N

PROJECT #: 1408 | FILE: 1408_LakeErie_2015PanelMap

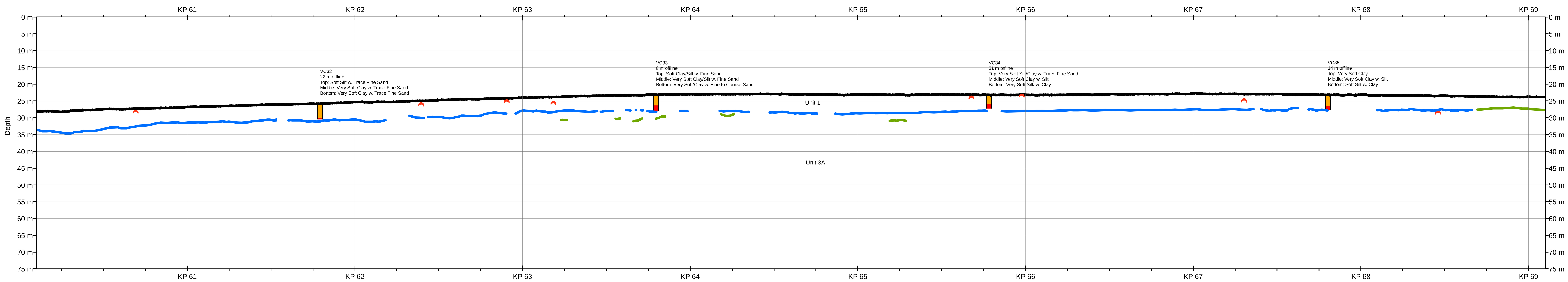
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

LEC Proposed Route | Kilometre Post | Routing Boundary
Survey Centreline | Survey Vessel Trackline
HDD Route | Bathymetric Contour (1 metre)

SURFICIAL GEOLOGY AND LAKEBED FEATURES

- Anthropogenic Contact
- Buoy Mooring
- Circular Contact
- Circular Contact (Probable Dredge Spoil)
- Linear Contact
- Point Source Reflector
- Rectangular Contact
- Shipwreck
- Sand Ripples
- Area of Boulders
- Surficial Boundary
- CSR Interpreted Pipeline
- Pipeline (Dundee Energy)
- Magnetic Anomaly
- Linear Feature - Possible Cable
- Linear Feature - Probable Drag Mark
- Water Intake Pipe
- Possible Dredge Boundary
- Trench
- Ice Scour
- NanticokeChannel
- International Border
- Rock Core Location
- Grab Sample
- Vibracore Sample
- Thermal Resistivity Station

Note: Lakebed feature labels displayed on this map represent the Class and feature ID (C for contact, L for linear, and M for magnetic). Sample labels represent how they were collected (VC for vibracore, TR for thermal Vibracore, RC for rock core, and GR for grab). See report for further information.

LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY

- R1 Boundary between post-glacial and glacial sediments.
- R2 Boundary between Unit 2 and Unit 3A.
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- Gas Interpreted areas of gas indicated by acoustic masking.
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Unit 1	Post-glacial sediments.
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NOTES

FIELD SURVEY

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Party Chief: Colin Toole and Matt Savelle

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Shallow Seismic:	Applied Acoustics Boomer CSP-P 350 J Power Source	Klein 3200 Chirp	
Magnetometer:	Marine Magnetics Seaspy	Marine Magnetics Seaspy	Marine Magnetics Seaspy

BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
Latitude of Origin:	Equator
False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
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BATHYMETRY

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NANTICOKE CHANNEL

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SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

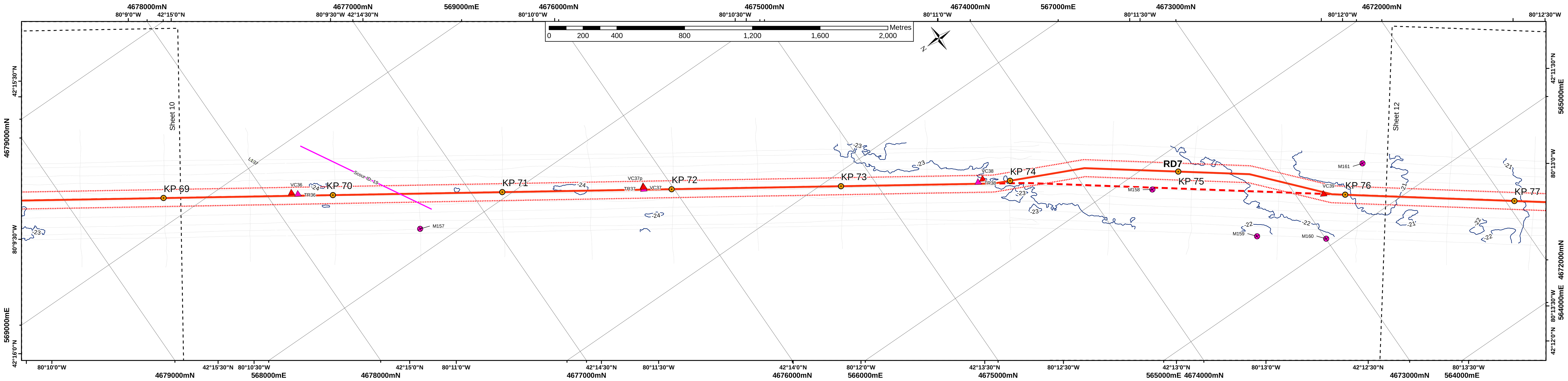
LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 10 of 15
KP 60 to KP 69

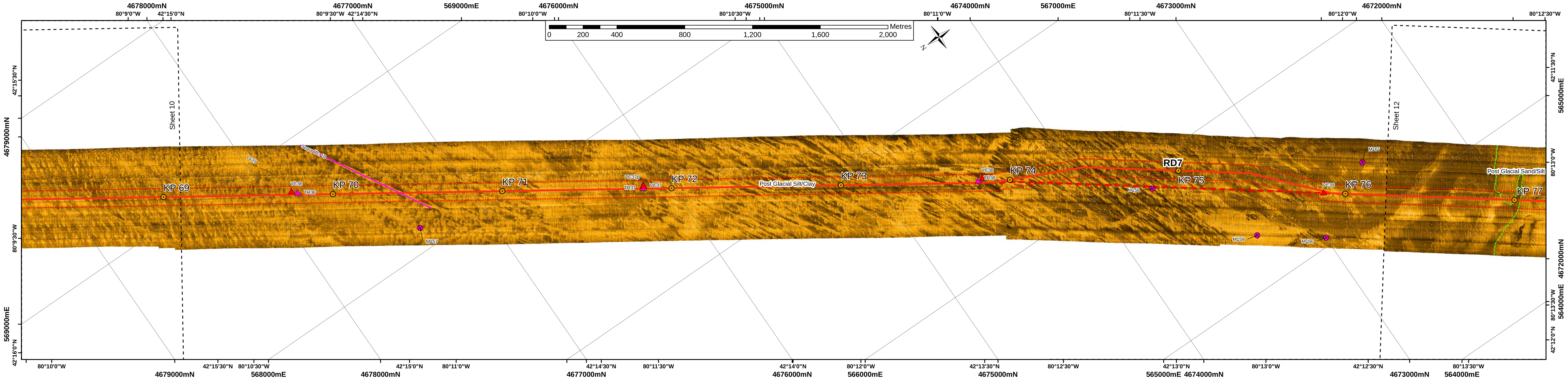
REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

SCALE: 1:10,000 | PROJECTION: NAD 1983 UTM Zone 17N
PROJECT #: 1408 | FILE: 1408_LakeErie_2015PanelMap

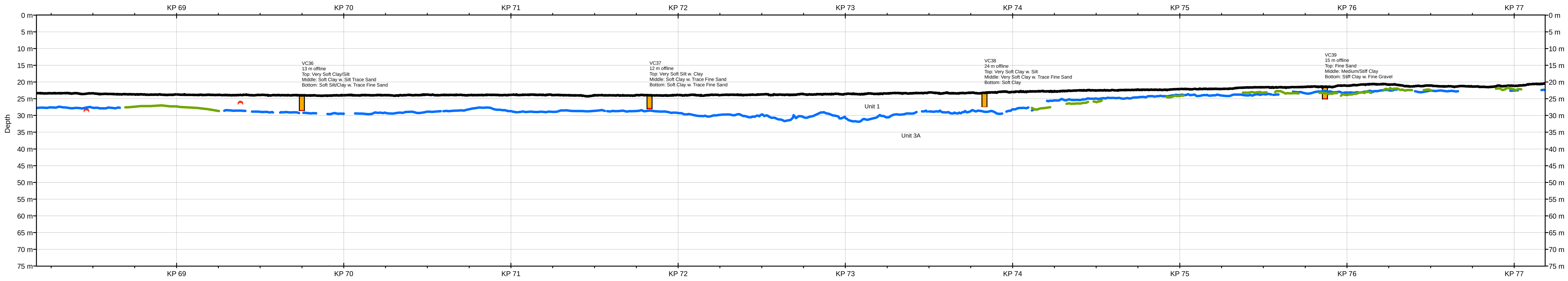
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

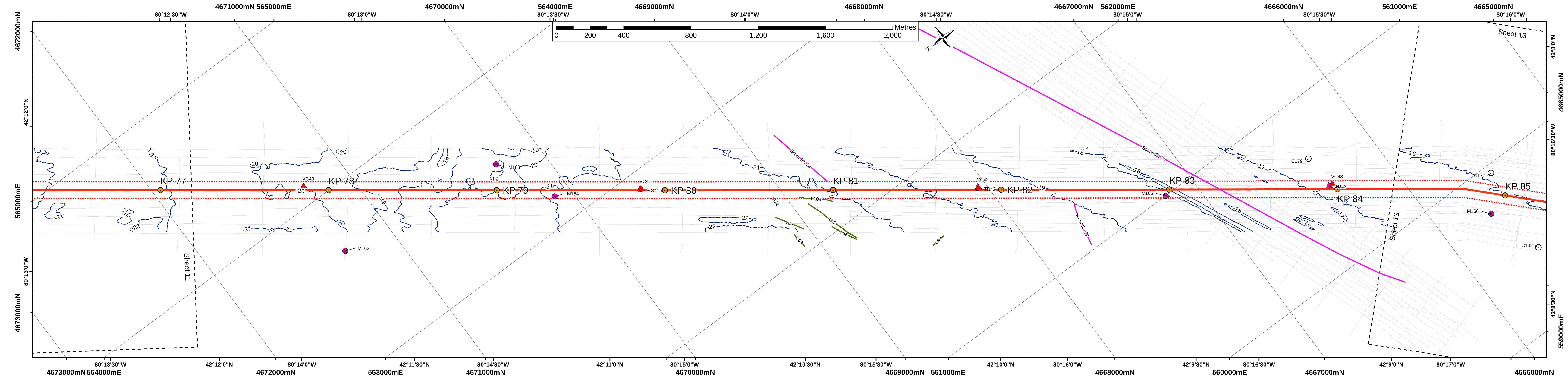
LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 11 of 15
KP 68 to KP 77

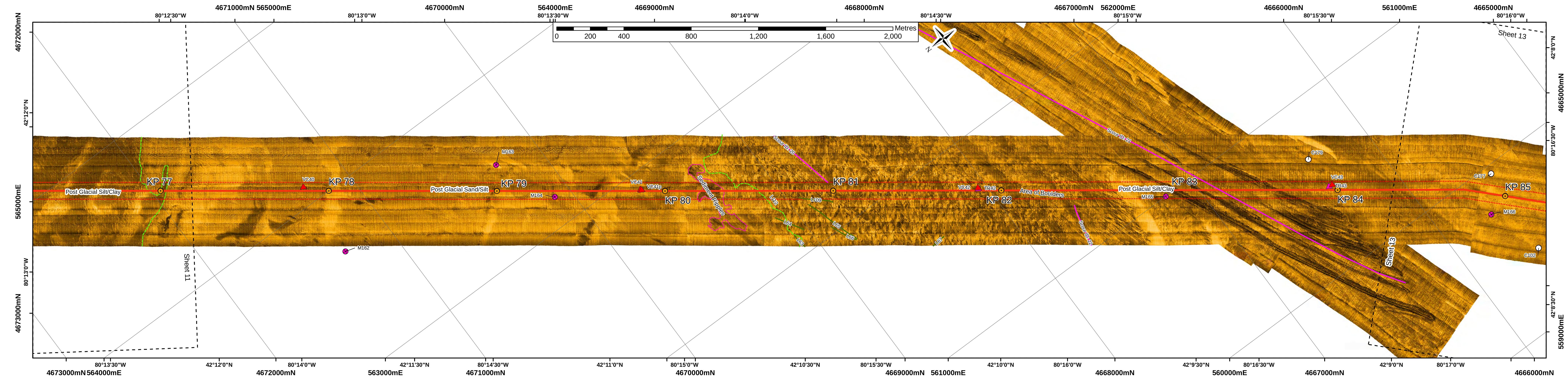
REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

SCALE: 1:10,000	PROJECTION: NAD 1983 UTM Zone 17N
PROJECT #: 1408	FILE: 1408_LakeErie_2015PanelMap

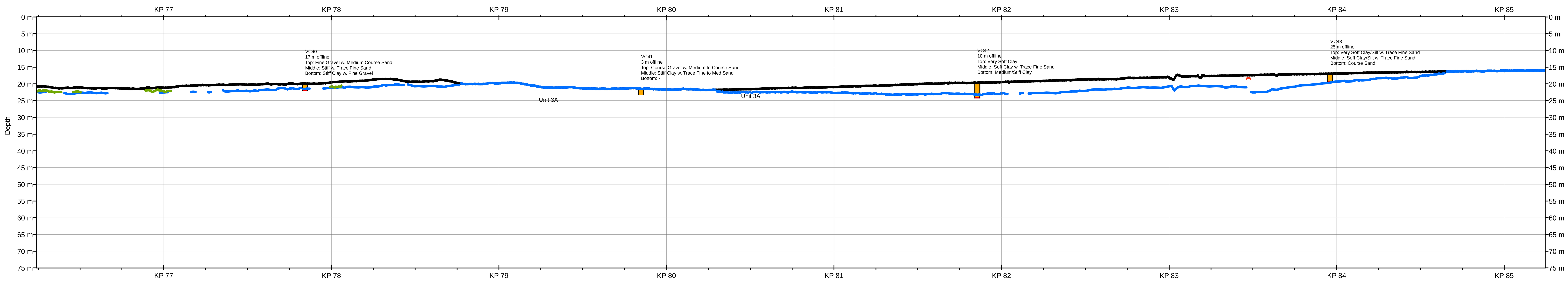
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

SURFICIAL GEOLOGY AND LAKEBED FEATURES

- Anthropogenic Contact
- Magnetic Anomaly
- Buoy Mooring
- Linear Feature - Possible Cable
- Circular Contact
- Linear Feature - Probable Drag Mark
- Circular Contact (Probable Dredge Spoil)
- Water Intake Pipe
- Linear Contact
- Possible Dredge Boundary
- Point Source Reflector
- Trench
- Rectangular Contact
- Ice Scour
- Shipwreck
- NanticokeChannel
- Sand Ripples
- International Border
- Area of Boulders
- Rock Core Location
- Surficial Boundary
- Grab Sample
- CSR Interpreted Pipeline
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- Pipeline (Dundee Energy)
- Thermal Resistivity Station

Note: Lakebed feature labels displayed on this map represent the Class and feature ID (C for contact, L for linear, and M for magnetic). Sample labels represent how they were collected (VC for vibracore, TR for thermal Vibracore, RC for rock core, and GR for grab). See report for further information.

LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY

- R1 Boundary between post-glacial and glacial sediments.
- R2 Boundary between Unit 2 and Unit 3A.
- R3 Top of glacial till (Unit 3B).
- R4 Top of Bedrock
- Gas Interpreted areas of gas indicated by acoustic masking.
- Hyperbolic Reflection
- Vibracore sample recovery
- Vibracore sample penetration

Unit 1	Post-glacial sediments.
Unit 2	Homogeneous glacial sediments.
Unit 3A	Glacial lacustrine sediments.
Unit 3B	Glacial till.
Bedrock	Acoustic basement interpreted as bedrock.
PG/G Sediments	Undifferentiated post-glacial and glacial sediments.

NOTES

FIELD SURVEY

Canadian Seabed Research Ltd. conducted survey work during the following time periods: 17/11/2014-19/12/2014 and 11/06/2015-02/10/2015

Party Chief: Colin Toole and Matt Savelle

SURVEY EQUIPMENT	2014	2015	2015-Nearshore
Vessel:	VAC (19.81 m Tug)	VAC (19.81 m Tug)	RF-18 Seabed
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Echosounder:	ODOM CV3 (200 kHz & 50 kHz)	ODOM MB1 (220 kHz)	ODOM CV100 (200 kHz & 33 kHz)
Sound Velocity Profiler:	SV Plus V1 Sound	Odom Digibar & SV Plus	SV Plus
Heave Compensator:	TSS HPR Sensor	DMS-05	TSS HPR Sensor
Sidescan Sonar:	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)
Shallow Seismic:	Applied Acoustics Boomer CSP-P 350 J Power Source	Klein 3200 Chirp	
Magnetometer:	Marine Magnetics Seaspy	Marine Magnetics Seaspy	Marine Magnetics Seaspy

BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
Latitude of Origin:	Equator
False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
Vertical Datum:	Chart Datum (173.5 metres above International Great Lakes Datum (IGLD) 1985).
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BATHYMETRY

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Processed sounding data were imported into Surfer 12 where 1 m x 1 m and 5 m x 5 m grid files were created using a kriging interpolation algorithm. The contours displayed in all enclosures were based on the 5 m x 5 m grid.

GEOLOGY

Surficial and sub-bottom geology interpretation were based on sidescan sonar, chirp profiler, and shallow seismic data. Depths below seabed were determined using a sound velocity of 1600m/s. A vertical exaggeration of 20 times was applied for visualization. Surficial seabed features were interpreted from sidescan sonar data while magnetic anomaies were derived from magnetometer data.

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ROUTE

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NANTICOKE CHANNEL

The location of the Nanticoke Channel was digitized from NOAA chart 14838.

SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Prepared For: **ITC Lake Erie Connector, LLC**

Black & Veatch

Canadian Seabed Research Ltd.

341 Myra Road, Porters Lake, Nova Scotia
Canada B3E 1G2
Tel: (902) 827-4200 Fax: (902) 827-2002
Email: info@csr-marine.com

ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

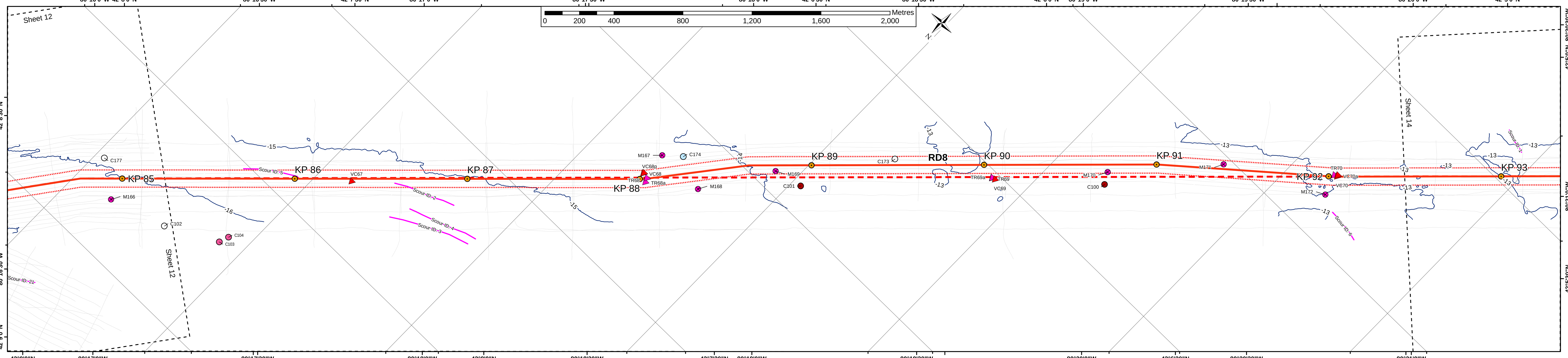
COMPOSITE PANEL MAP
SHEET 12 of 15
KP 76 to KP 85

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

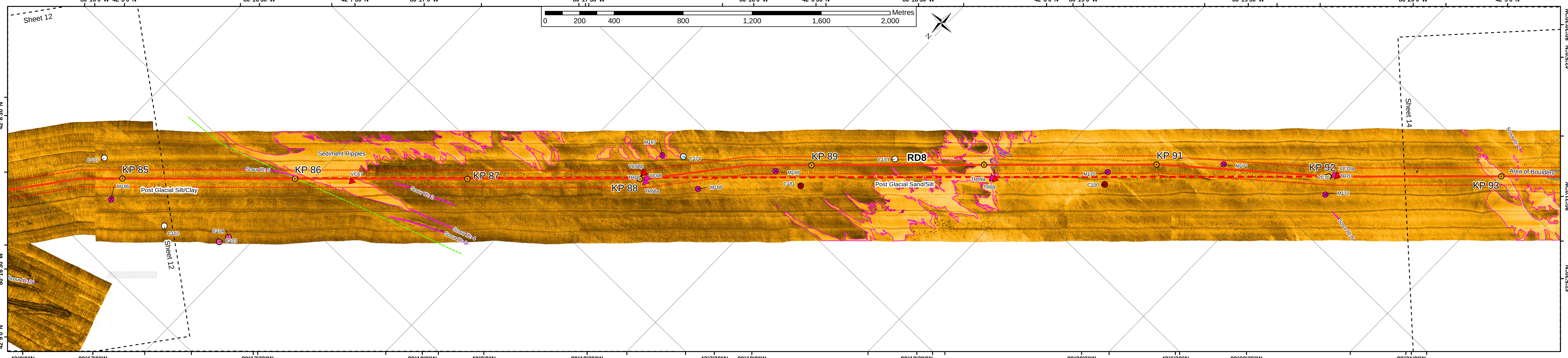
SCALE: 1:10,000 | PROJECTION: NAD 1983 UTM Zone 17N

PROJECT #: 1408 | FILE: 1408_LakeErie_2015PanelMap

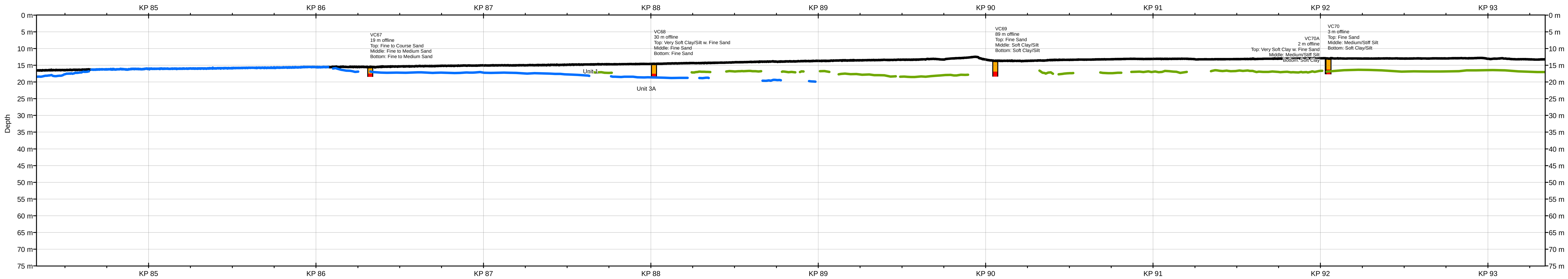
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

	LEC Proposed Route		Kilometre Post		Routing Boundary
	Survey Centreline		Survey Vessel Trackline		
	HDD Route		Bathymetric Contour (1 metre)		

SURFICIAL GEOLOGY AND LAKEBED FEATURES

Anthropogenic Contact	Magnetic Anomaly
Buoy Mooring	Linear Feature - Possible Cable
Circular Contact	Linear Feature - Probable Drag Mark
Circular Contact (Probable Dredge Spoil)	Water Intake Pipe
Linear Contact	Possible Dredge Boundary
Point Source Reflector	Trench
Rectangular Contact	Ice Scour
Shipwreck	NanticokeChannel
Sand Ripples	International Border
Area of Boulders	Rock Core Location
Surficial Boundary	Grab Sample
CSR Interpreted Pipeline	Vibracore Sample
Pipeline (Dundee Energy)	Thermal Resistivity Station

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LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY

R1	Boundary between post-glacial and glacial sediments.	Unit 1	Post-glacial sediments.
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R4	Top of Bedrock	Unit 3B	Glacial till.
Gas	Interpreted areas of gas indicated by acoustic masking.	Bedrock	Acoustic basement interpreted as bedrock.
	Hyperbolic Reflection	PG/G Sediments	Undifferentiated post-glacial and glacial sediments.
	Vibracore sample recovery		
	Vibracore sample penetration		

NOTES

FIELD SURVEY

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Sidescan Sonar:	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)	Klein 3000 (100 kHz & 500 kHz)
Shallow Seismic:	Applied Acoustics Boomer CSP-P 350 J Power Source	Klein 3200 Chirp	
Magnetometer:	Marine Magnetics Seaspy	Marine Magnetics Seaspy	Marine Magnetics Seaspy

BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
Latitude of Origin:	Equator
False Co-ords of Origin:	500,000m East Nil m North
Horizontal Datum:	North American Datum of 1983 (NAD83)
Vertical Datum:	Chart Datum (173.5 metres above International Great Lakes Datum (IGLD) 1985).
Horizontal Scale:	1:10,000
Vertical (Profile) Scale:	1: 500
Units:	Metres

BATHYMETRY

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GEOLOGY

Surficial and sub-bottom geology interpretation were based on sidescan sonar, chirp profiler, and shallow seismic data. Depths below seabed were determined using a sound velocity of 1600m/s. A vertical exaggeration of 20 times was applied for visualization. Surficial seabed features were interpreted from sidescan sonar data while magnetic anomaies were derived from magnetometer data.

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ROUTE

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HORIZONTAL DIRECTIONAL DRILLING PATH

Canadian HDD path was provided by Black and Veatch on 2015/11/03. The USA landfall represents a straight line from the landfall coordinate provided by Deiss and Halmi Engineering.

NANTICOKE CHANNEL

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SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Prepared For: **ITC Lake Erie Connector, LLC**

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Email: info@csr-marine.com

ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

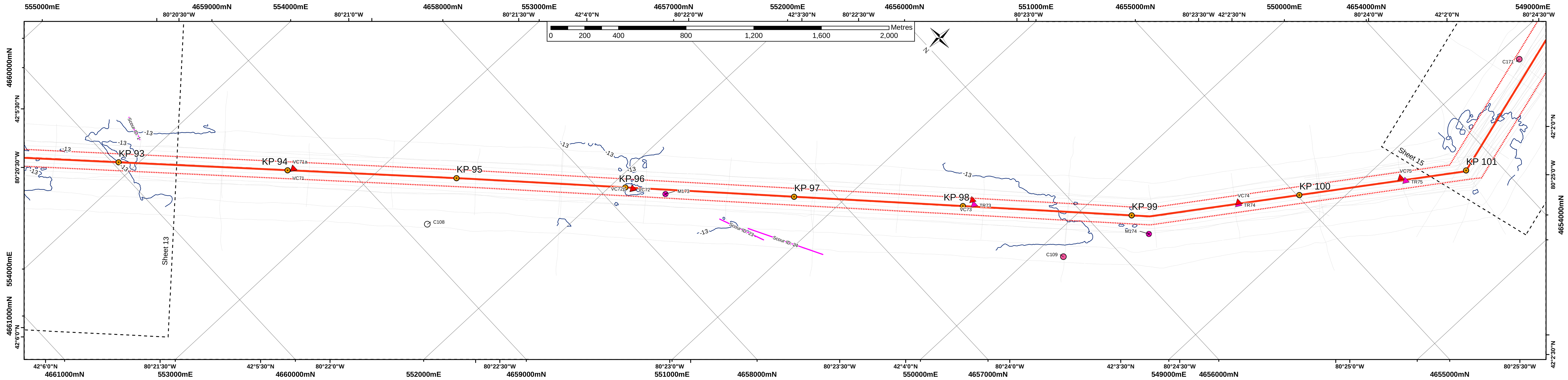
LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 13 of 15
KP 84 to KP 93

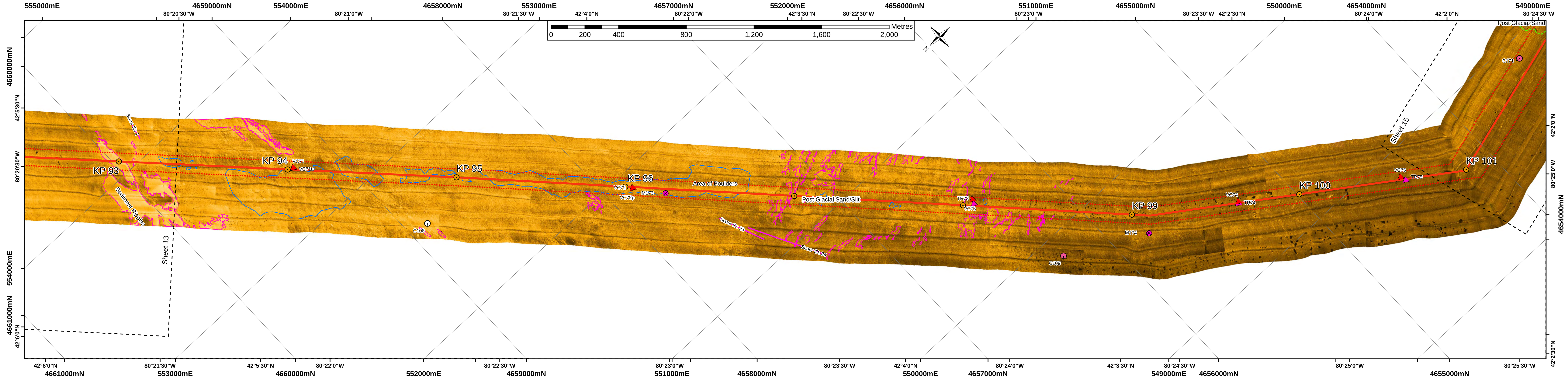
REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

SCALE: 1:10,000	PROJECTION: NAD 1983 UTM Zone 17N
PROJECT #: 1408	FILE: 1408_LakeErie_2015PanelMap

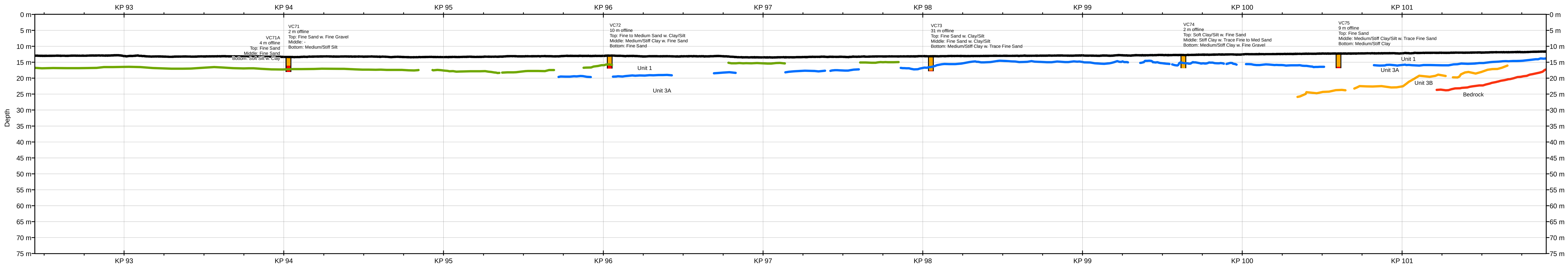
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
- Kilometre Post
- Routing Boundary
- Survey Centreline
- Survey Vessel Trackline
- HDD Route
- Bathymetric Contour (1 metre)

SURFICIAL GEOLOGY AND LAKEBED FEATURES

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- Magnetic Anomaly
- Buoy Mooring
- Linear Feature - Possible Cable
- Circular Contact
- Linear Feature - Probable Drag Mark
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- Linear Contact
- Possible Dredge Boundary
- Point Source Reflector
- Trench
- Rectangular Contact
- Ice Scour
- Shipwreck
- NanticokeChannel
- Sand Ripples
- International Border
- Area of Boulders
- Rock Core Location
- Surficial Boundary
- Grab Sample
- CSR Interpreted Pipeline
- Vibracore Sample
- Pipeline (Dundee Energy)
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Note: Lakebed feature labels displayed on this map represent the Class and feature ID (C for contact, L for linear, and M for magnetic). Sample labels represent how they were collected (VC for vibracore, TR for thermal Vibracore, RC for rock core, and GR for grab). See report for further information.

LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY

- R1 Boundary between post-glacial and glacial sediments.
- R2 Boundary between Unit 2 and Unit 3A.
- R3 Top of glacial till (Unit 3B).
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- Gas Interpreted areas of gas indicated by acoustic masking.
- Hyperbolic Reflection
- Vibracore sample recovery
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Unit 1	Post-glacial sediments.
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PG/G Sediments	Undifferentiated post-glacial and glacial sediments.

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FIELD SURVEY

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BASEMAP

Projection:	Universal Transverse Mercator (Zone 17 N)
Meridian of Origin:	81° West of Greenwich
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Horizontal Datum:	North American Datum of 1983 (NAD83)
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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 14 of 15
KP 92 to KP 102

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
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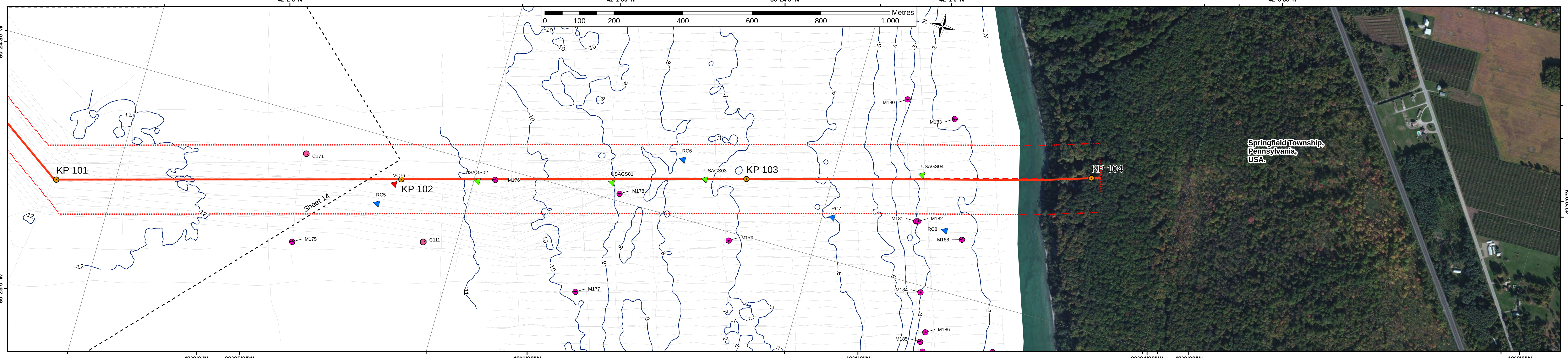
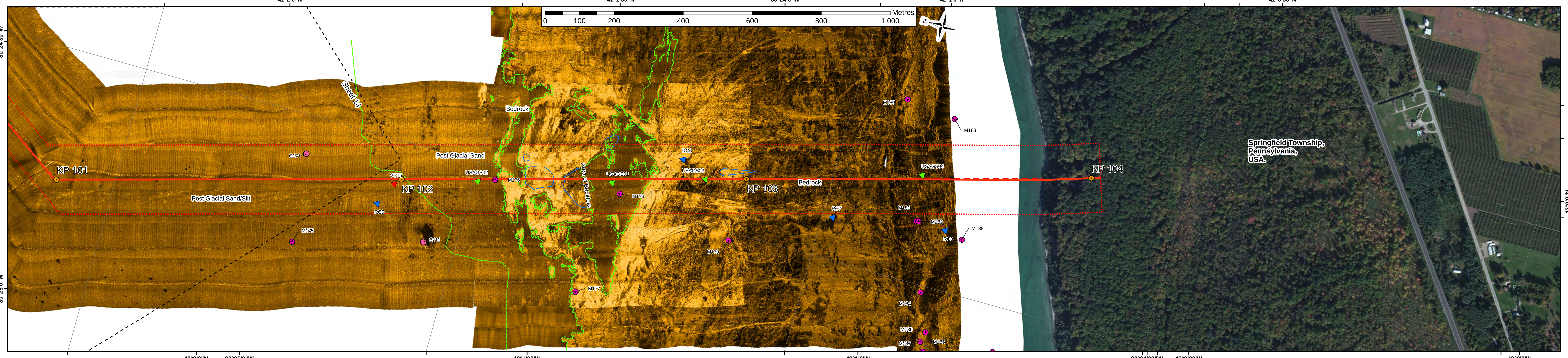
SCALE: 1:10,000	PROJECTION: NAD 1983 UTM Zone 17N
PROJECT #: 1408	FILE: 1408_LakeErie_2015PanelMap

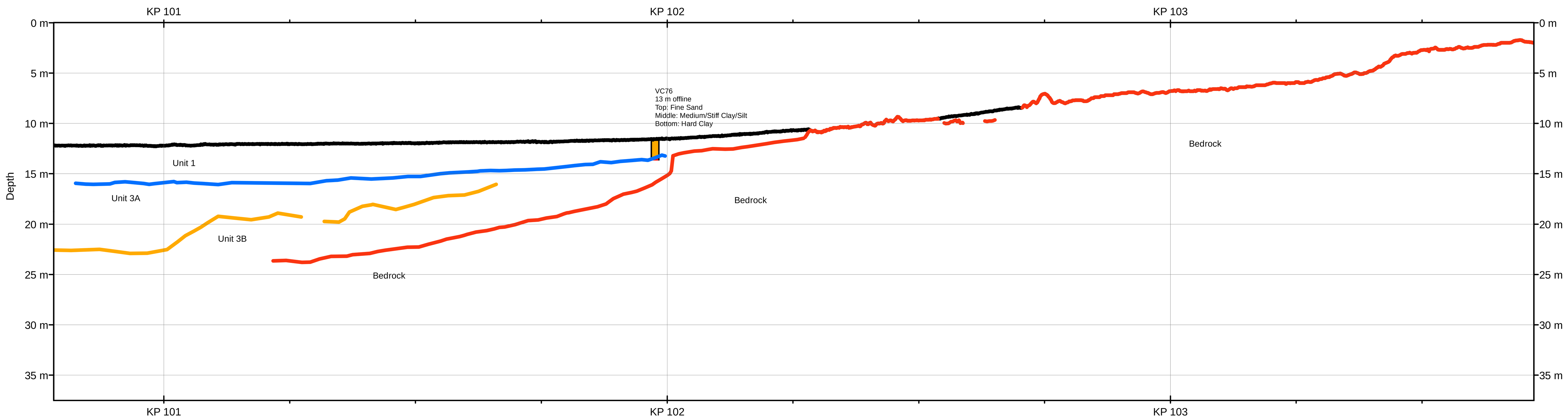
BATHYMETRY



SURFICIAL GEOLOGY AND LAKEBED FEATURES



LEC PROPOSED ROUTE PROFILE AND SUB-BOTTOM GEOLOGY



NOTES

KEY MAP

LEGEND

- LEC Proposed Route
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- Routing Boundary
- Survey Centreline
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The location of the Nanticoke Channel was digitized from NOAA chart 14838.

SHORE IMAGERY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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ENGINEERING AND ENVIRONMENTAL GEOPHYSICS

LAKE ERIE CONNECTOR

COMPOSITE PANEL MAP
SHEET 15 of 15
KP 101 to KP 104

REVISION	DATE	REMARKS	INTERPRETED BY	COMPILED BY	CHECKED BY
0	2015-11-26	Draft	AD, GK, MS, MW	MK	CT & MW
1	2015-12-16	First Revision	AD, GK, MS, MW	MK	CT
2	2016-01-13	Final	AD, GK, MS, MW	MK	CT & MW

SCALE: 1:5,000	PROJECTION: NAD 1983 UTM Zone 17N
PROJECT #: 1408	FILE: 1408_LakeErie_2015PanelMap