4 CONCLUSIONS

A geophysical investigation involving Georadar was carried out at the Mary River Project, Baffin Island, Nunavut.

Subsurface ice mapping was carried out at nine sites along the proposed rail alignment. Results of the survey are presented in Drawings GPR17 – MILNE INLET, GPR17 –KM19, GPR17 –KM20, GPR17 –KM39.6, GPR17 –KM49, GPR17 –KM82.2, GPR17 –KM97, GPR17 –KM100.1, GPR17 –KM109. Ice was only found in Km 49, seen in drawing GPR17-KM49.

Interpretation of the geophysical data has been performed by Mauritz van Zyl. This report has been written by Milan Situm, P.Geo.

Milan Situm

Milan Situm, P.Geo.
Manager

APPENDIX A

Drawings GPR17 – MILNE INLET,

GPR17 –KM19,

GPR17 –KM20,

GPR17 –KM39.6,

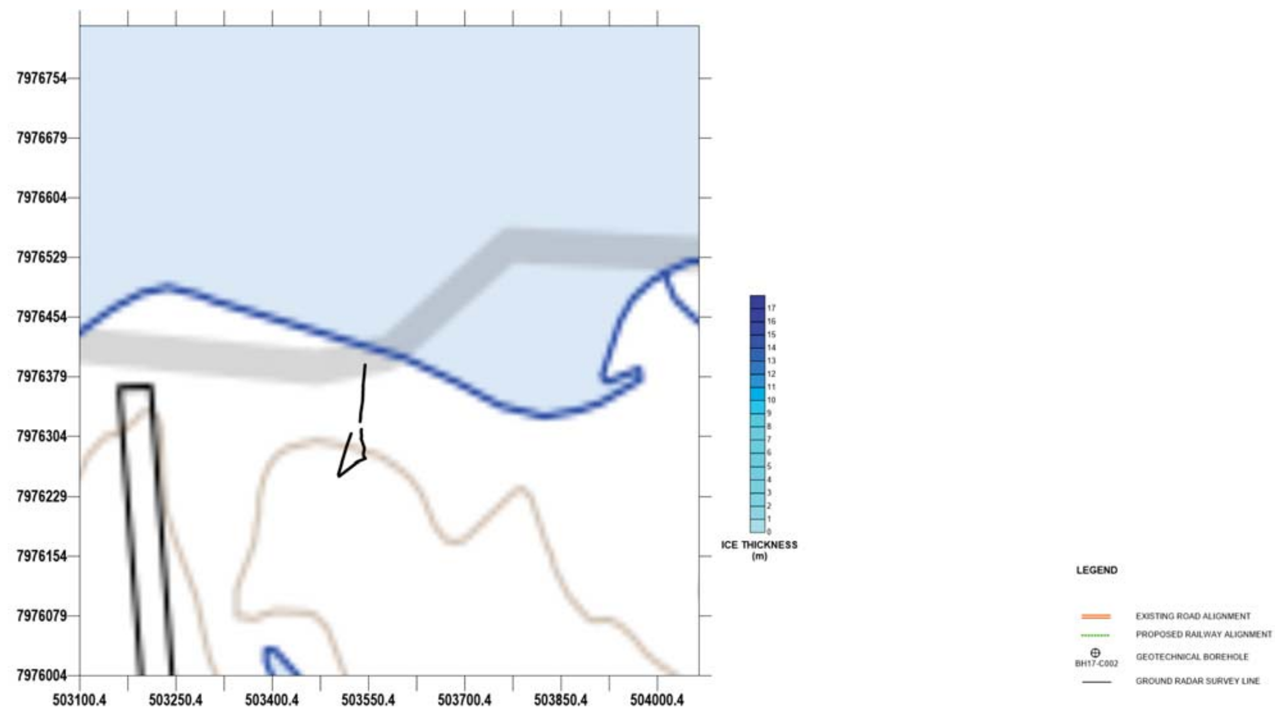
GPR17 –KM49, Ice was only found in Km 49, seen in drawing GPR17-KM49.

GPR17 –KM82.2,

GPR17 –KM97,

GPR17 –KM100.1,

GPR17 –KM109.



No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17N
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
5	
6	

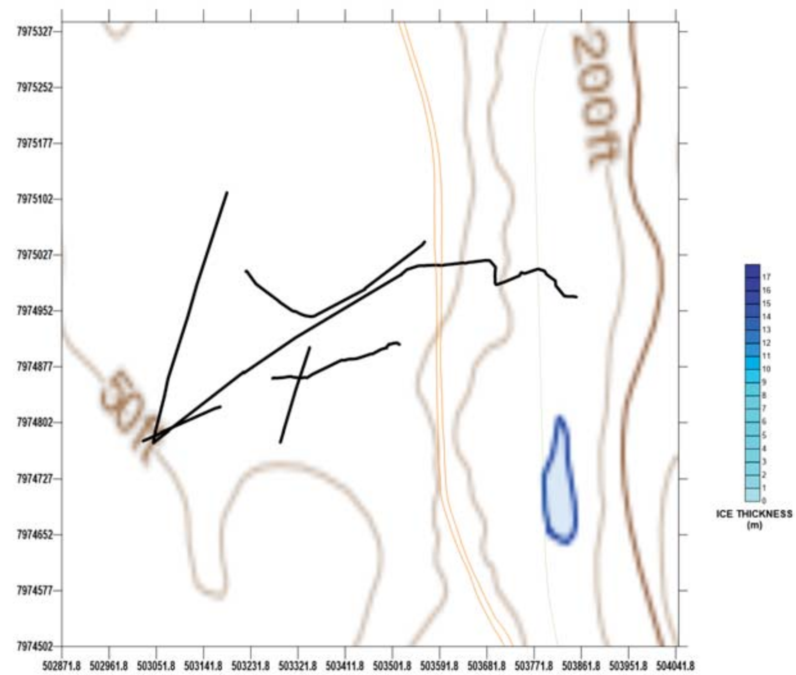
No	DATE	MODIFICATIONS	GPR

SCEAU PROFESSIONNEL / PROFESSIONAL SEAL

GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. Van Zyl
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Sikum, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT / CLIENT	HATCH
PROJET / PROJECT	BAFFINLAND EXPANSION
TITRE / TITLE	GROUND RADAR SURVEY GPR17-MILNE INLET



LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
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GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. Van Zyl
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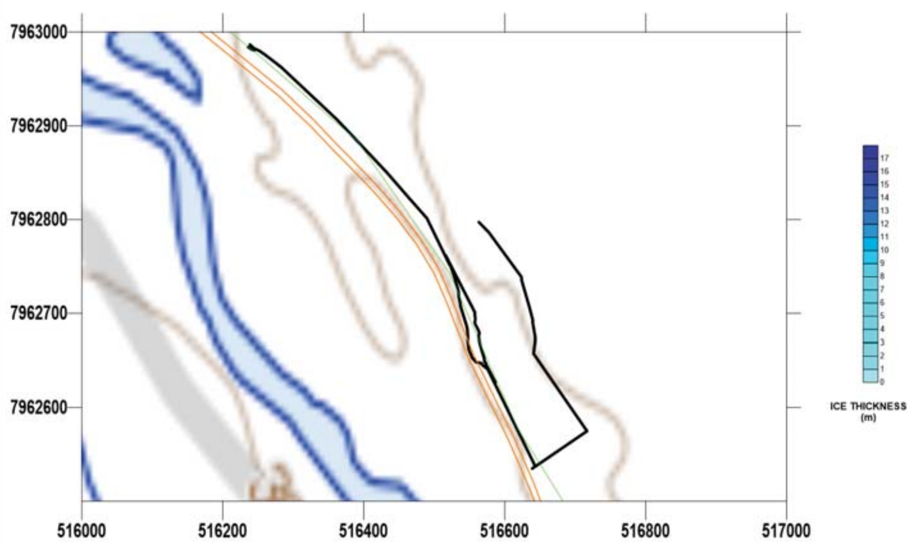
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo.
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

SCEAU PROFESSIONNEL / PROFESSIONAL SEAL

CLIENT: **HATCH**

PROJET / PROJECT: **BAFFINLAND EXPANSION**

TITRE / TITLE: **GROUND RADAR SURVEY GPR17-MILNE INLET**



LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
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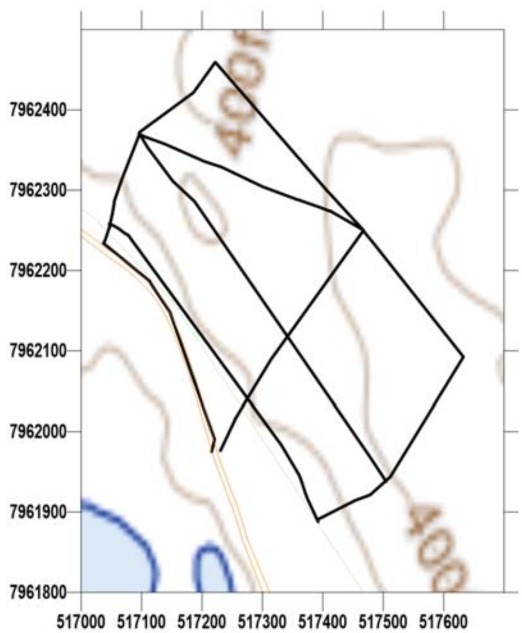
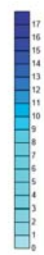
APPROUVÉ PAR / APPROVED BY	M.Sikum, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT: **HATCH**

PROJET / PROJECT: **BAFFINLAND EXPANSION**

TITRE / TITLE: **GROUND RADAR SURVEY GPR17-KM19**





LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17N
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
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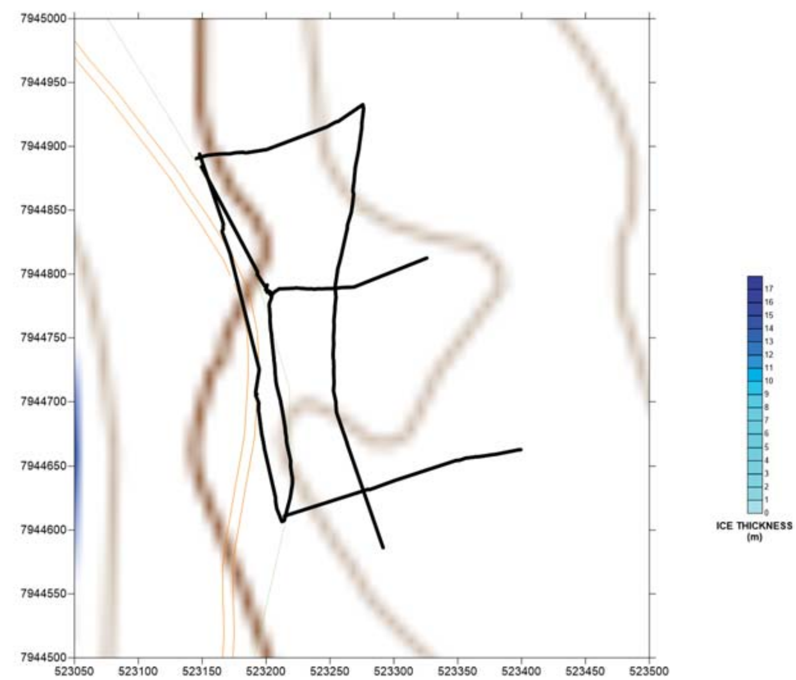
No	DATE	MODIFICATIONS	GPR

SCEAU PROFESSIONNEL / PROFESSIONAL SEAL

GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. Van Zyl
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Sikum, P. Geo
# CONTRAT / CONTRACT #	T17201b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17201b-A2

CLIENT / CLIENT	HATCH
PROJET / PROJECT	BAFFINLAND EXPANSION
TITRE / TITLE	GROUND RADAR SURVEY GPR17-KM20



LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17N
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
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No	DATE	MODIFICATIONS	GPR

SCEAU PROFESSIONNEL / PROFESSIONAL SEAL

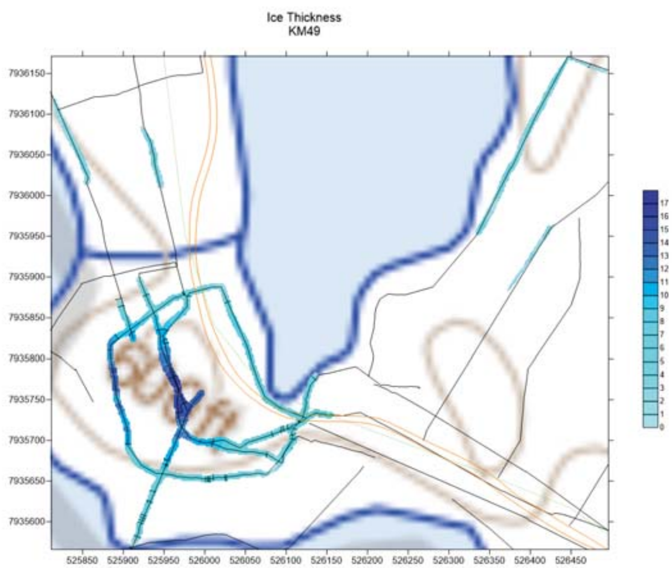
GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. Van Zyl
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Sikum, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT: **HATCH**

PROJET / PROJECT: **BAFFINLAND EXPANSION**

TITRE / TITLE: **GROUND RADAR SURVEY GPR17-KM39.6**



LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE
- 1 INTERPRETED ICE LAYER EXTENT

PRELIMINARY

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
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GEOPHYSICS GPR INTERNATIONAL INC.

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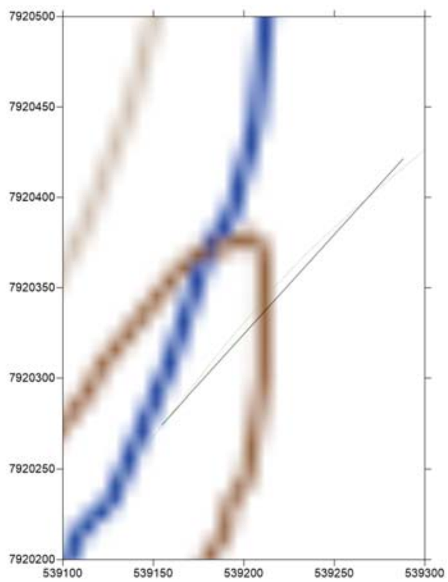
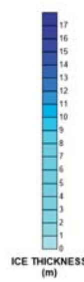
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Sikum, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A1-1

CLIENT / CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY GPR17-SITE 1





LEGEND

EXISTING ROAD ALIGNMENT
PROPOSED RAILWAY ALIGNMENT
BH17-C002 GEOTECHNICAL BOREHOLE
GROUND RADAR SURVEY LINE

PRELIMINARY

No	NOTES	No	DATE	MODIFICATIONS	GPR
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017				
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W				
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS				
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SCEAU PROFESSIONNEL / PROFESSIONAL SEAL

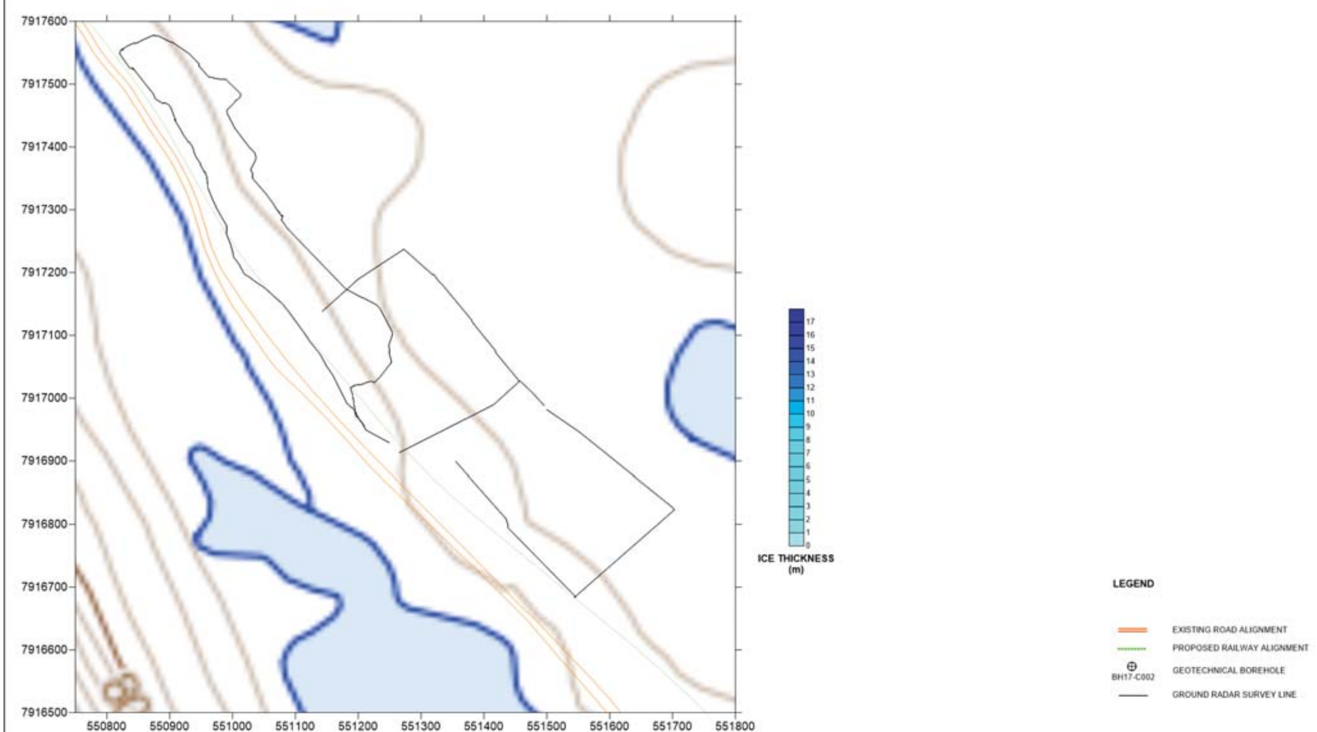
GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. Van Zyl
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Situm, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT / CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY GPR17-KM82.2



No.	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
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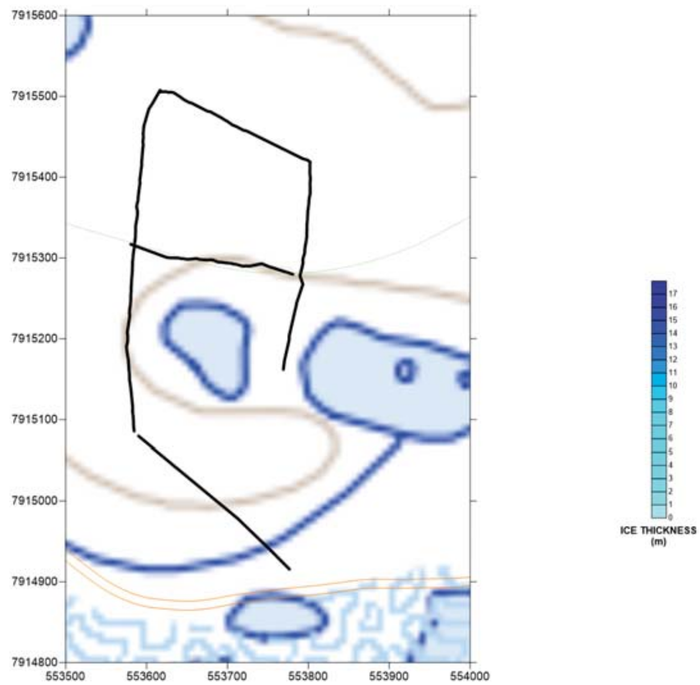
APPROUVÉ PAR / APPROVED BY	M.Sbum, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY GPR17-KM97



LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
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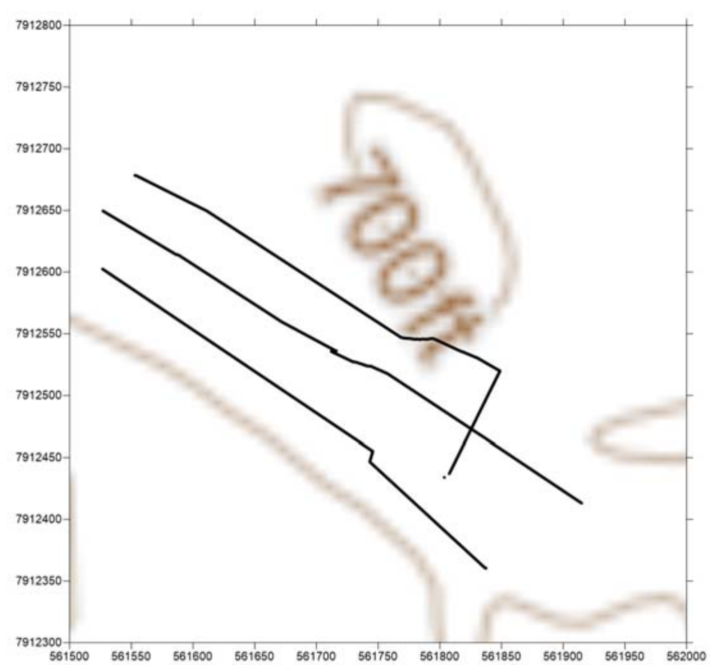
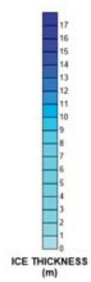
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT / CLIENT	HATCH
PROJET / PROJECT	BAFFINLAND EXPANSION
TITRE / TITLE	GROUND RADAR SURVEY GPR17-KM100.1





LEGEND

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

No	NOTES
1	THE RADAR SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. NOVEMBER 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
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No	DATE	MODIFICATIONS

SCEAU PROFESSIONNEL / PROFESSIONAL SEAL

GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. Van Zyl
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Sbum, P. Geo
# CONTRAT / CONTRACT #	T17001b
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001b-A2

CLIENT: **HATCH**

PROJET / PROJECT: **BAFFINLAND EXPANSION**

TITRE / TITLE: **GROUND RADAR SURVEY GPR17-KM109**

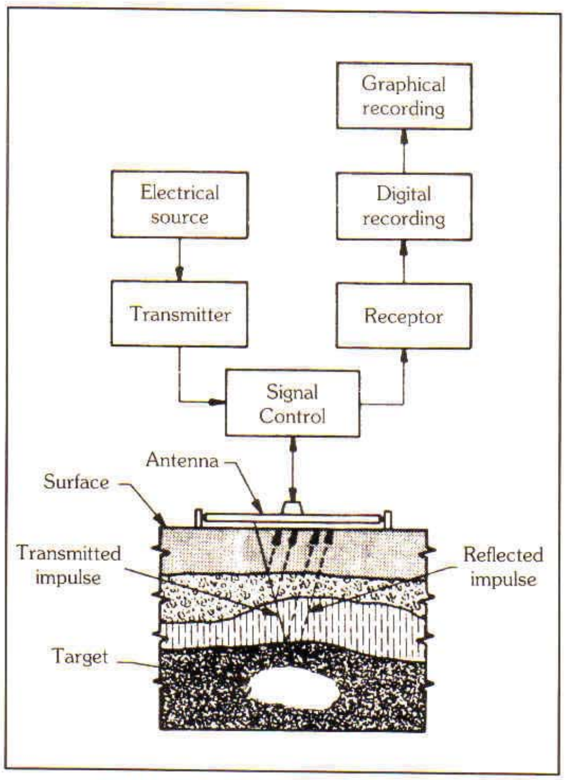
APPENDIX B

Additional Georadar information

GEOPHYSICS G P R INTERNATIONAL INC.

GEORADAR

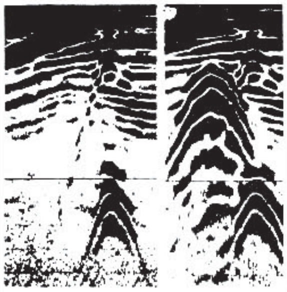
As indicated by its name, georadar combines high resolution radar with geology. The underlying principle is based on the propagation of electromagnetic wave impulses (VHF) that are reflected by anomalies in the terrain (joints, irregularities, interfaces, etc.) at different depths, and then captured by the antenna. The georadar records the time taken by each transmitted signal to complete the cycle in order to calculate the depth of the anomaly. The result is similar to a seismic reflection profile where all the reflections are displayed graphically. This technique is used to solve problems for which there had previously been no practical solution.



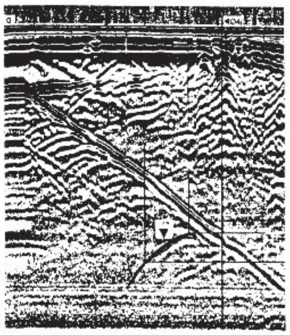
PRINCIPLES OF GEORADAR

FEATURES

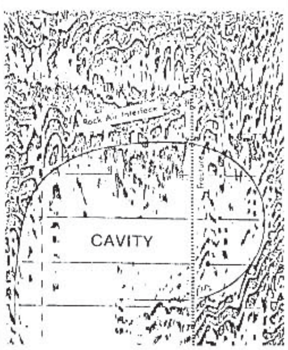
- Penetration of more than 20 metres in certain materials (penetration being inversely proportional to conductivity).
- Surveying in continuous mode.
- Identification of objects measuring only a few centimeters.
- Light and manoeuvrable equipment.
- Detection of conductivity, open spaces and/or holes (cavities).
- Detection of breaks: faults, fractures, joints, cavities.
- Results similar to seismic reflection: continuous underground profile.
- Results available immediately.
- Can be used in land, sea or airborne surveys.



PIPES



JOINTS



CAVITIES

FIELDS OF APPLICATION

Civil Engineering / Mining Exploration-Exploitation / Research / Archaeology / Environment

- Geotechnology: investigation of soils and surface deposits.
- Optimal selection of anchor bolts in mines and quarries.
- Detection of buried pipes before beginning excavation.
- Detection of liquid or gas leakage in soils.
- Detection of cracks in concrete structures.
- Checking material homogeneity.
- Detection of cavities beneath road pavement.
- Determination of water saturation level.
- Detection of girders in reinforced concrete.
- Detection of pollutant leakage in water bodies.
- Inspection of buried disposal sites and or dangerous deposits.
- Continuous measurement of ice thickness.
- Archaeological research: ancient foundations, artifacts.
- Non-destructive method for measuring road pavement thickness.
- Localization and measurement of soil's thickness (swamps, peat bogs).
- Determination of rock beddings (location and thickness).
- Bathymetric studies (depth sounding).
- Calculation of the thickness of permafrost and ice.
- Geotechnical studies for the installation of aqueducts.

SPECIAL FEATURES

The equipment is practical, easy to manoeuvre, and multi-faceted. The field of application of georadar continues to expand in various sectors, particularly in geotechnology (aqueducts), civil engineering (excavation, structures) and mining (structures).

GEOPHYSICS G P R INTERNATIONAL INC.

GUIDELINEGEO

MALÅ GroundExplorer

GROUND PENETRATING RADAR

GPR with exceptional range and resolution

MALÅ GroundExplorer (GX) is an integrated GPR solution with four MALÅ GX antenna options: GX80, GX160, GX450 and GX750. Through unique hyperstacking HDR technology, MALÅ GX offers significantly faster data acquisition rates, with outstanding signal-to-noise ratio and depth penetration. An easy-to-use GPR solution on a rugged platform, with excellent detection capabilities for a wide range of applications.

MALÅ GX CONTROLLER

Processor	1.6 GHz Intel Atom
Display	1024 x 768 mm
OS	Linux
Memory	8 GB compact Flash memory
Data output resolution	32 bit
Comms	Ethernet, WiFi (optional), USB 3.0, RS232 (serial)
GPS	Integrated support for built-in GPS, or external GPS via USB/serial port (NMEA 0183 protocol)
Power supply	Internal 12V/20.8 Ah Li-Ion battery, or any external 10-15 V DC source
Charger	Internal. Unit can also be charged from any external 12 - 15 V DC source
Power consumption	1.3 – 2.0 A
Operating time	8 – 10 h
Dimensions	326 x 216 x 92 mm including handles 326 x 216 x 52 mm excluding handles
Weight	3.2 kg
Operating temp	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

GX WIFI OPTION

Wireless standard:	IEEE802.11 g
Power consumption:	0,3 A

MALÅ

MALÅ GX ANTENNAS

MALÅ GX750 HDR

Technology	MALÅ Semi-Real- Time pat pending
Antenna center freq.	750 MHz
SNR	97 dB
No. of bits	16 bit
Scans/second	> 1290, time window 75 ns
Survey speed	460 [km/h] point distance 10 cm
Bandwidth	120%, fractional, -10 dB
Time window	75 ns
Positioning	Built-in DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	375 x 235 x 170 mm
Weight	3.6 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX450 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	450 MHz
SNR	101 dB
No. of bits	> 16 bit
Scans/second	> 770, time window 300 ns
Survey speed	275 [km/h] point distance 10 cm
Bandwidth	>120%, fractional, -10 dB
Time window	300 ns
Positioning	Inbuilt DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	430 x 360 x 180 mm
Weight	5.5 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX160 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	160 MHz
SNR	> 107 dB
No. of bits	> 17 bit
Scans/second	> 880, time window 625 ns
Survey speed	320 [km/h] point distance 10 cm
Bandwidth	>120 %, fractional, -10 dB
Time window	625 ns
Positioning	Inbuilt DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	720 x 480 x 190 mm
Weight	10.7 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX80 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	80 MHz
SNR	> 114.4 dB
No. of bits	> 19 bit
Scans/second	> 1200, time window 812 ns
Survey speed	430 [km/h] point distance 10 cm
Bandwidth	>120 %, fractional, -10 dB
Time window	812 ns
Positioning	Built-in DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	1010 x 780 x 220 mm
Weight	24,6 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

ABEM | MALÅ

***Guideline Geo** is a world-leader in geophysics and geo-technology offering sensors, software, services and support necessary to map and visualize the subsurface. Guideline Geo operates in four international market areas: Infrastructure – examination at start-up and maintenance of infrastructure, Environment – survey of environmental risks and geological hazards, Water – mapping and survey of water supplies and Minerals – efficient exploration. Our offices and regional partners serve clients in 121 countries. The Guideline Geo AB share (GGEO) is listed on NGM Equity.*

GUIDELINEGEO

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sales@guidelinegeo.com
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465 Deanna Lane
Charleston, South Carolina 29492, USA
Tel: +1 843 852 5021
sales@guidelinegeo.com
www.guidelinegeo.com

GEOPHYSICS GPR INTERNATIONAL INC.

GEOPHYSICAL INVESTIGATION FOR BAFFINLAND RAILWAY, MARY RIVER PROJECT, NUNAVUT

PREPARED FOR:
Baffinland Iron Mines Corporation

Presented to:

4342 Queen Street, Suite 500
Niagara Falls, Ontario
L2E 7J7

May 2018

Geophysics GPR International Inc.
6741 Columbus Road, Unit 14
Mississauga (Ontario) L5T 2G9
Tel. : +1 905.696.0656
info@geophysicsgpr.com

May 2018 T-18552

TABLE OF CONTENTS

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List of Appendices

1 INTRODUCTION

Geophysics GPR International Inc. was requested by Hatch Ltd. to carry out a geophysical survey to aid in projection and planning of a proposed railway for the Mary River Project, Baffin Island, Nunavut.

The purpose of this investigation was to determine the extent of, as well as the thickness of subsurface ice.

The ground penetrating radar (georadar) method was applied to determine the presence of ice and calculate its thickness.

Data was collected from April 16 to May 2, 2018.

The investigation included the following:

1. Georadar mapping of subsurface ice at seven sites across the 'deviation' of the proposed rail alignment.
2. Further exploration with gridded georadar lines were conducted in regions of ice to delineate the extent.

Figure 1 presents an overview map of the investigation area with the locations of the respective sites.

The following report describes the various aspects of the survey including field techniques, survey design, interpretation techniques, and finally an interpretation in the form of ice thickness maps.

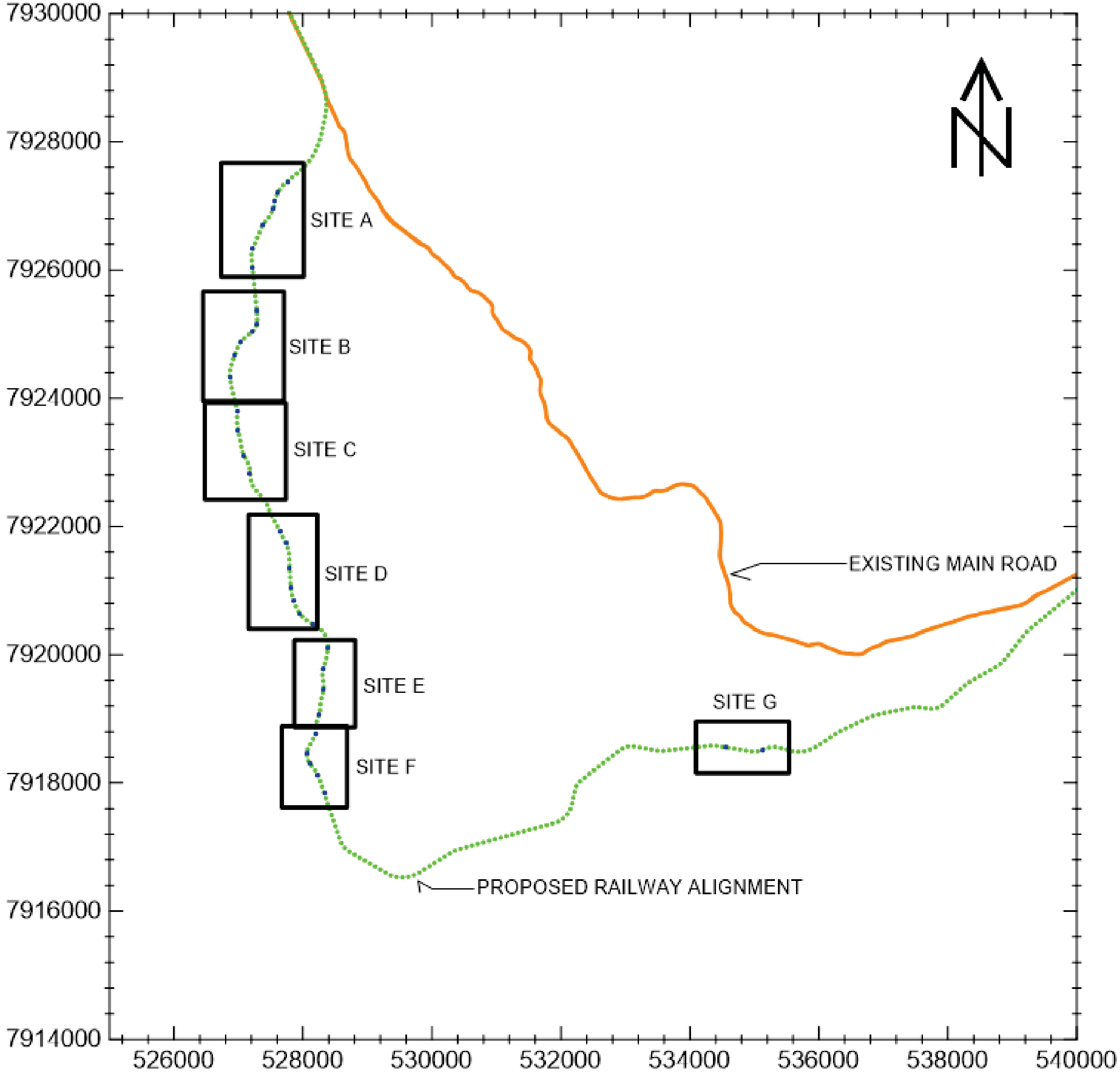


Figure 1: Overview map of the investigation area

2 METHODOLOGY

2.1 Positioning, Topography and Units of Measurement

The emplacement of the survey areas was determined by the client.

The locations of the georadar survey lines for the purpose of subsurface ice mapping were oriented to align with the design of the proposed railway. Length and number of the lines were chosen based on in-field interpretation of georadar data. Positioning was controlled by the GPS device integrated into the georadar antenna. The UTM coordinates should be accurate to within +/- 2.0 m.

Table 1: UTM coordinates of GPR survey lines

Point	**Chainage**	**Northing**	**Easting**
Site A			
a	58.9	7927382.002	527756.0006
b	59.1	7927213.037	527611.0001
c	59.2	7927079.046	527557
d	59.3	7926949.981	527539.0009
e	59.7	7926703.946	527376.0013
f	60.1	7926329.02	527225.0004
Site B			
a	60.4	7926033.002	527218.0006
b	61	7925358.001	527285.0006
c	61.2	7925154.024	527288.0003
d	61.4	7925033.038	527212.0001
e	61.6	7924885.943	527029.0013
f	61.9	7924671.045	526944
g	62.2	7924334.034	526861.0002
h	62.7	7923796.949	526977.0012
i	63	7923502.003	526993.0006
j	63.5	7923106.979	527087.0009

k	63.8	7922823.019	527178.0004
Site C			
a	64.7	7921919.978	527644.0009
b	64.9	7921741.995	527734.0007
Site D			
a	65.3	7921350.032	527795.0002
b	65.6	7921050.977	527812.0009
Site E			
A	65.8	7920854.939	527851.0014
B	66	7920630.979	527956.0009
c	66.3	7920475.027	528152.0003
Site F			
a	66.9	7920106.987	528386.0008
b	67.2	7919773.977	528306.0009
c	67.5	7919452.95	528323.0013
d	68	7919071.027	528247.0003
e	68.3	7918765.022	528193.0003
f	68.6	7918471.991	528056.0007
g	68.7	7918297.02	528103.0002
h	69	7918131.944	528231.0014
i	69.3	7917838.974	528329.001
Site G			
a	77.4	7918561.942	534544.0017
b	78	7918521.023	535132.0004

The provided coordinates are NAD83/WGS84, UTM zone 17N.

The depth measurements are noted as depth from surface.

All geophysical measurements were collected in SI units.

In addition to Table 1, further georadar survey lines were created to further explore the given areas. These additional survey lines were generated in a grid-like fashion with the topography dictating the spacing of the lines.

2.2 Ground Penetrating Radar (Georadar)

Basic Theory

Georadar utilises radar technology to obtain a near-continuous profile of the subsurface. The basic principle is to emit an electromagnetic impulse into the ground at a predetermined frequency rate (typically 10 to 80 scans/second). This pulse will travel through the sub-surface and reflect off boundaries of differing dielectric constants (contrasts of EM impedances). The reflected pulse returns to the surface and is recorded by a receiver and displayed in real-time as a cross-sectional image. Only by moving the antennas along a profile directly over the targets can the locations and depths be determined. Examples of radar reflecting boundaries include air/water (water table); water/earth (bathymetry); earth/metal, PVC, or concrete (pipe locating); and differing earth materials (stratigraphic profiles, including bedrock profiles).

The depth of investigation is controlled by the frequency and power of the antenna limited by attenuation and diffraction of the radar signal. Lower frequency antennas provide greater depth penetration at the expense of resolution. The radar signal is attenuated by conductive ground materials (e.g. clays, dissolved salts etc.). The radar signal is diffracted by irregular shaped material (e.g. boulders, debris etc.) that prevents the clear return of the reflected pulse.

More information on the georadar operating principle can be found in Appendix B.

Survey Design

The georadar data were collected with a MALA Ground Explorer system and 160 MHz antenna. This antenna provides a favourable trade off between depth and resolution for ice detection. As well, this antenna has sufficient durability for the terrain and weather conditions for Baffin Island.

Positioning for the georadar survey was controlled by built-in GPS receiver.

Interpretation Method

Processing of the radar images involved basic horizontal normalization, elevation corrections and gain adjustments.

The vertical scale on all radar images is a two-way time scale representing the time taken for a radar pulse to transmit to a reflector and back to the receiver. In order to convert the time scale to a depth scale a signal velocity must be applied. The velocity with which the pulse travels through the given material is determined by the dielectric constant. This dielectric will vary with the type of material.

Calculating a velocity can be done in many ways but the most reliable method is with a test pit or borehole where the real rock contact can be exposed. Based on in-situ measurements or borehole data, the dielectric value can be approximated depending on the expect material type.

An underestimate of the dielectric will result in an over estimate of the signal velocity and in turn an over estimate of the depths. For this site a dielectric of 4 (velocity of 15 cm/ns) was assumed based on the expected soil type and tables of relative dielectric values for commonly encountered materials. In this case the materials were mostly frozen granular/boulders with high ice content.

Interpretation of the data is based primarily on the qualitative analysis of three characteristics of radar reflections: continuity, amplitude and shape. The interpreter then identifies reflectors and textures within the radar records that represent subsurface contacts, objects or zones. The true nature of the interpreted features can only be assumed without corroborating evidence.

Ice bodies have a distinctive appearance on radar images. Granular host material appears as "noise" on the images, whereas uniform ice layer looks transparent with clearly defined top and bottom contacts and can be confidently identified. An example of a uniform ice lens is presented in Figure 2.

Non-uniform ice bodies (stratified or containing layers of soil) are more challenging for interpretation since structure irregularities create multiple reflections within the ice body. Often a borehole is needed to confirm the presence of ice. Other features such as increasing depth of investigation in the presence of thick ice layer may corroborate the interpretation.

In summary, ability of georadar is limited by the structure of the ice layer being surveyed and its composition. The identification of an ice layer may be impacted by irregularities inside the ice body, such as layering, fractures and soil inclusions. However, it is possible to create two categories of ice lenses, the obvious and less obvious that may need some ground truthing.

3 RESULTS

3.1 Subsurface Ice Mapping

Georadar data was collected at seven sites along the proposed railway deviation. Most sites collected were in the Western region (Sites A – F).

Locations of the survey lines and results of the georadar survey are presented in drawings GPR18_SITE_A, GPR18_SITE_B, GPR18_SITE_C, GPR18_SITE_D, GPR18_SITE_E, and GPR18_SITE_F.

GPR18_SITE_A

Thin ice lenses were possibly detected – neither the shape nor reflection of georadar data appeared well. This could possibly indicate an ice lens with poor homogeneity or structural breakages. Area was explored with subsequent radar profiles; data continued to be generally poor in this area. Estimation of ice depth from surface; 5-8m.

GPR18_SITE_B

The data indicates a considerable amount of ice in this area with varying thickness. The thickest region appeared to have a 12m thick chunk. Estimation of ice depth from surface; 4 to 9m. Topography constrained ability to delineate further.

GPR18_SITE_C

Region appears rich in ice – delineation was able to encapsulate lenses. Estimation of ice depth from surface; 7 to 9m.

GPR18_SITE_D

Region appears to have shallow and small ice lenses. Estimation of ice depth from surface; 4 to 5m.

GPR18_SITE_E

Single possible ice lens found and delineated. Topography limited the amount of delineation possible. Estimation of ice depth from surface; 4 to 5m.

GPR18_SITE_F

Possible ice lenses found in area – region had poor signal attenuation. Topography also limited the amount of delineation possible. Estimation of ice depth from surface; 6m.

No ice found in Eastern end of delineation, chainage 77.4 to 78km.

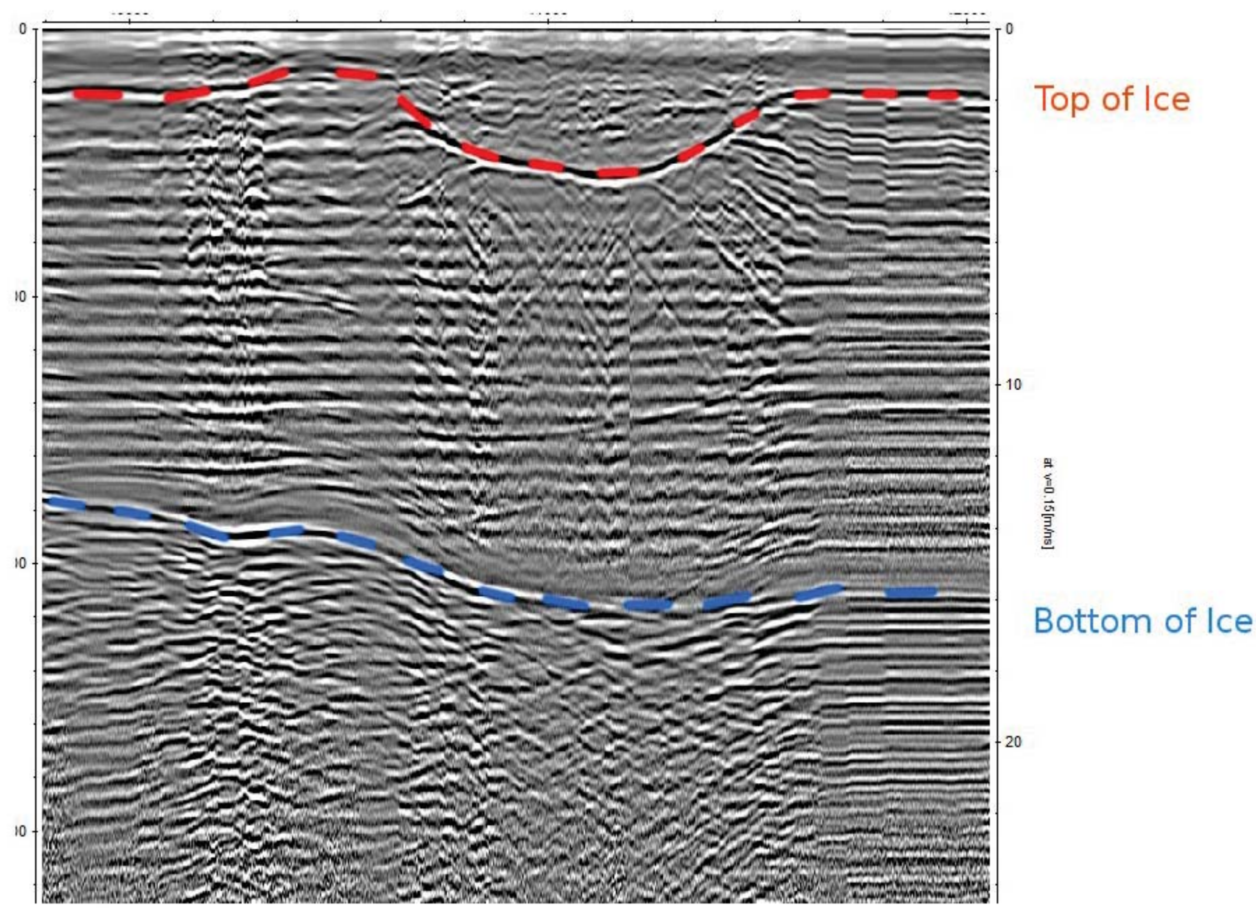


Figure 2: *Interpreted georadar image showing a typical ice body*

4 CONCLUSIONS

A geophysical investigation involving Georadar was carried out at the Mary River Project, Baffin Island, Nunavut.

Subsurface ice mapping was carried out at nine sites along the proposed rail alignment. Results of the survey are presented in Drawings GPR18_SITE_A, GPR18_SITE_B, GPR18_SITE_C, GPR18_SITE_D_GPR18_SITE_E, and GPR18_SITE_F.

Interpretation of the geophysical data has been performed by Mauritz van Zyl. This report has been written by Milan Situm, P.Geo.

Milan Situm, P.Geo.
Manager

APPENDIX A

DRAWINGS

GPR18_SITE_A

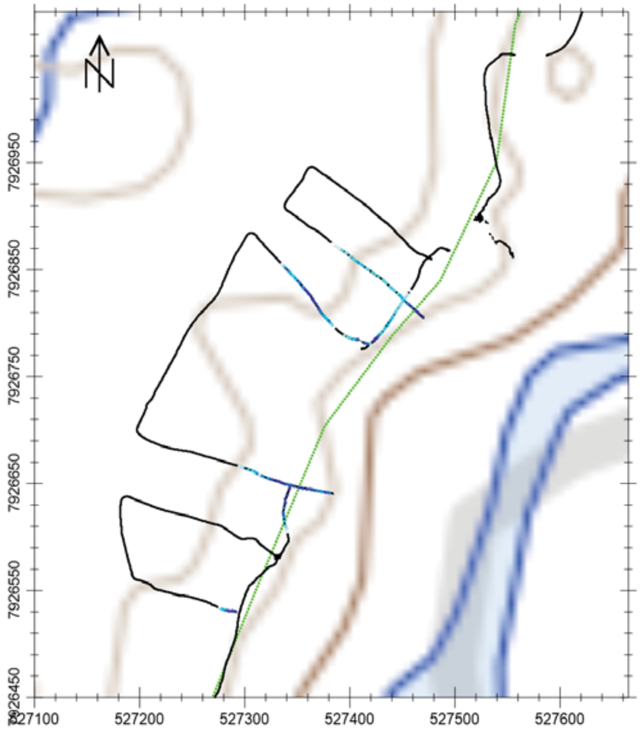
GPR18_SITE_B

GPR18_SITE_C

GPR18_SITE_D

GPR18_SITE_E

GPR18_SITE_F



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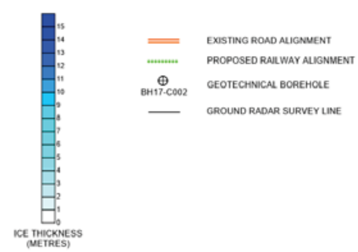
SCALE 1:10000

OVERVIEW MAP

LEGEND



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2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W				
3	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS				
4	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES				
5					
6					

SCEAU PROFESSIONNEL
PROFESSIONAL SEAL

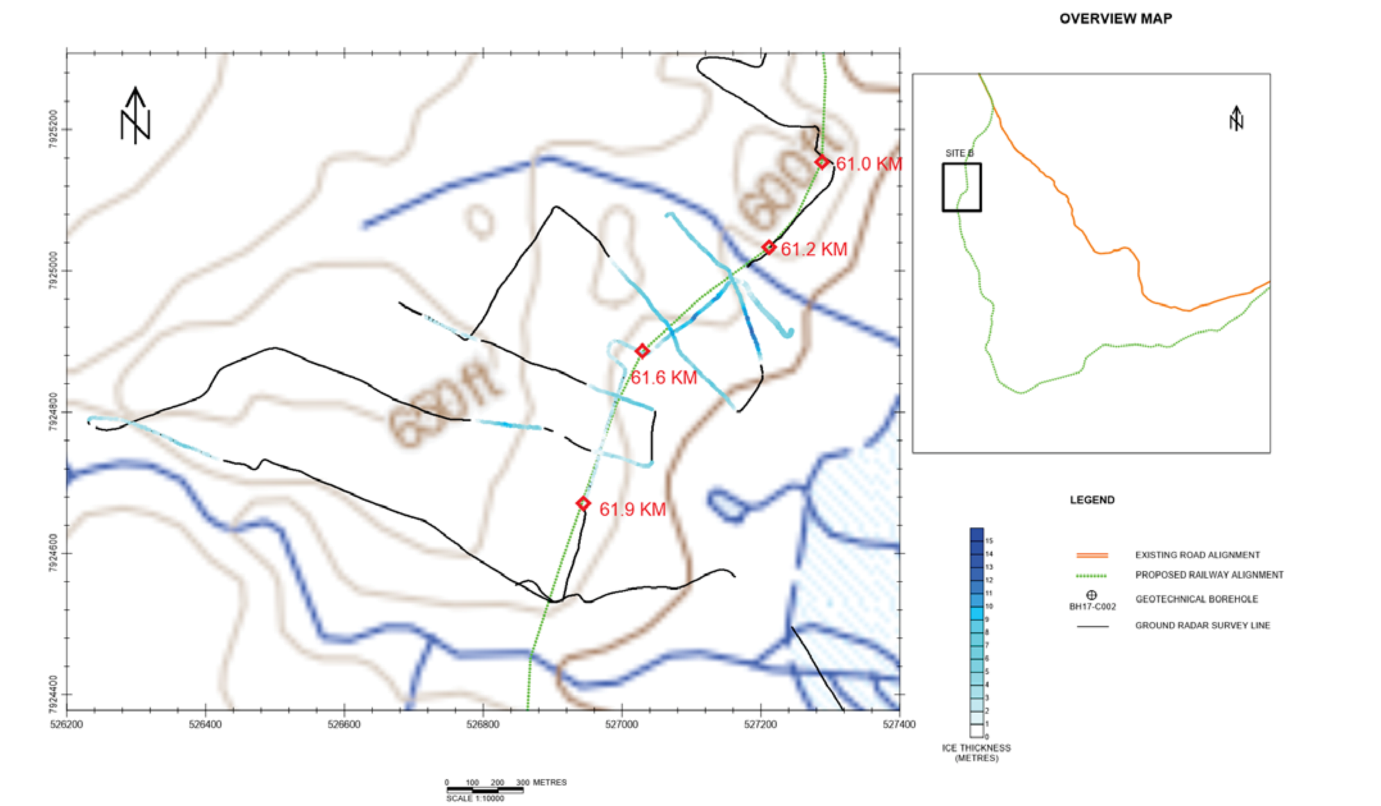
GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR / DRAWN BY	M. van Zyl
VÉRIFIÉ PAR / CHECKED BY	
APPROUVÉ PAR / APPROVED BY	M.Sturn, P. Geo
# CONTRAT / CONTRACT #	T17001
ÉCHELLE / SCALE	AS SHOWN
# DESSIN / DRAWING #	T17001-A2-3

CLIENT
HATCH

PROJET / PROJECT
BAFFINLAND EXPANSION

TITRE / TITLE
GROUND RADAR SURVEY
GPR18 - SITE A



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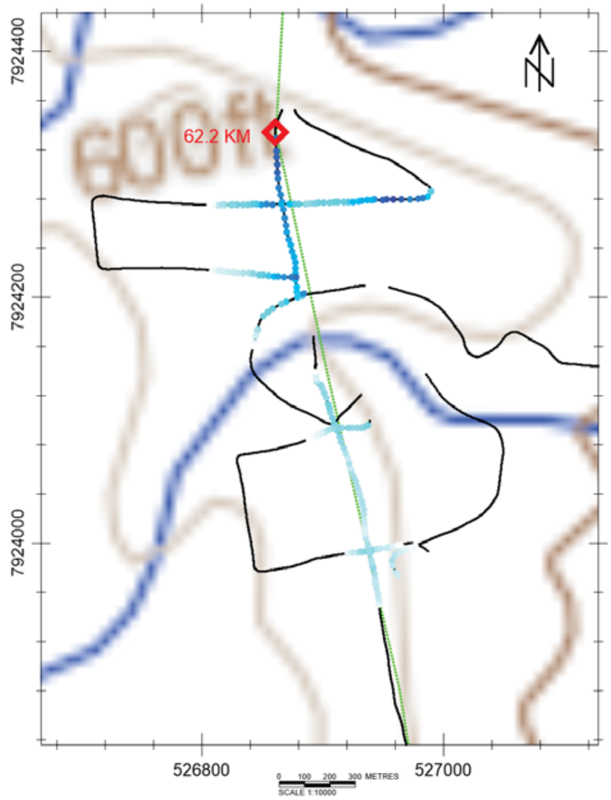
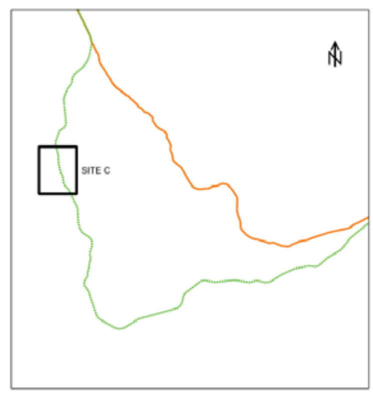
CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY GPR18 - SITE B



OVERVIEW MAP



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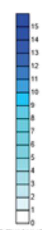

- EXISTING ROAD ALIGNMENT
- PROPOSED RAILWAY ALIGNMENT
- BH17-C002 GEOTECHNICAL BOREHOLE
- GROUND RADAR SURVEY LINE

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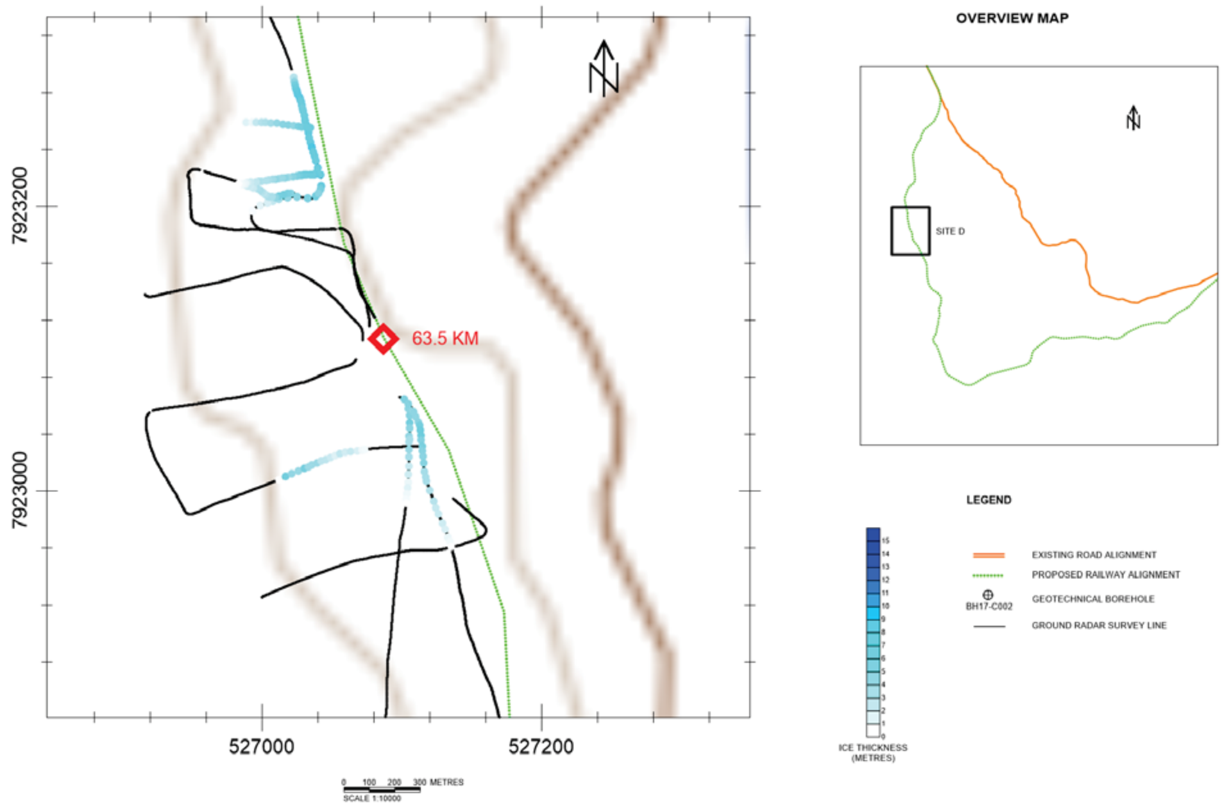
CLIENT / CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: GROUND RADAR SURVEY GPR18 - SITE C



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APPROUVÉ PAR / APPROVED BY: M. Situm, P. Geo
CONTRAT / CONTRACT: #T17001
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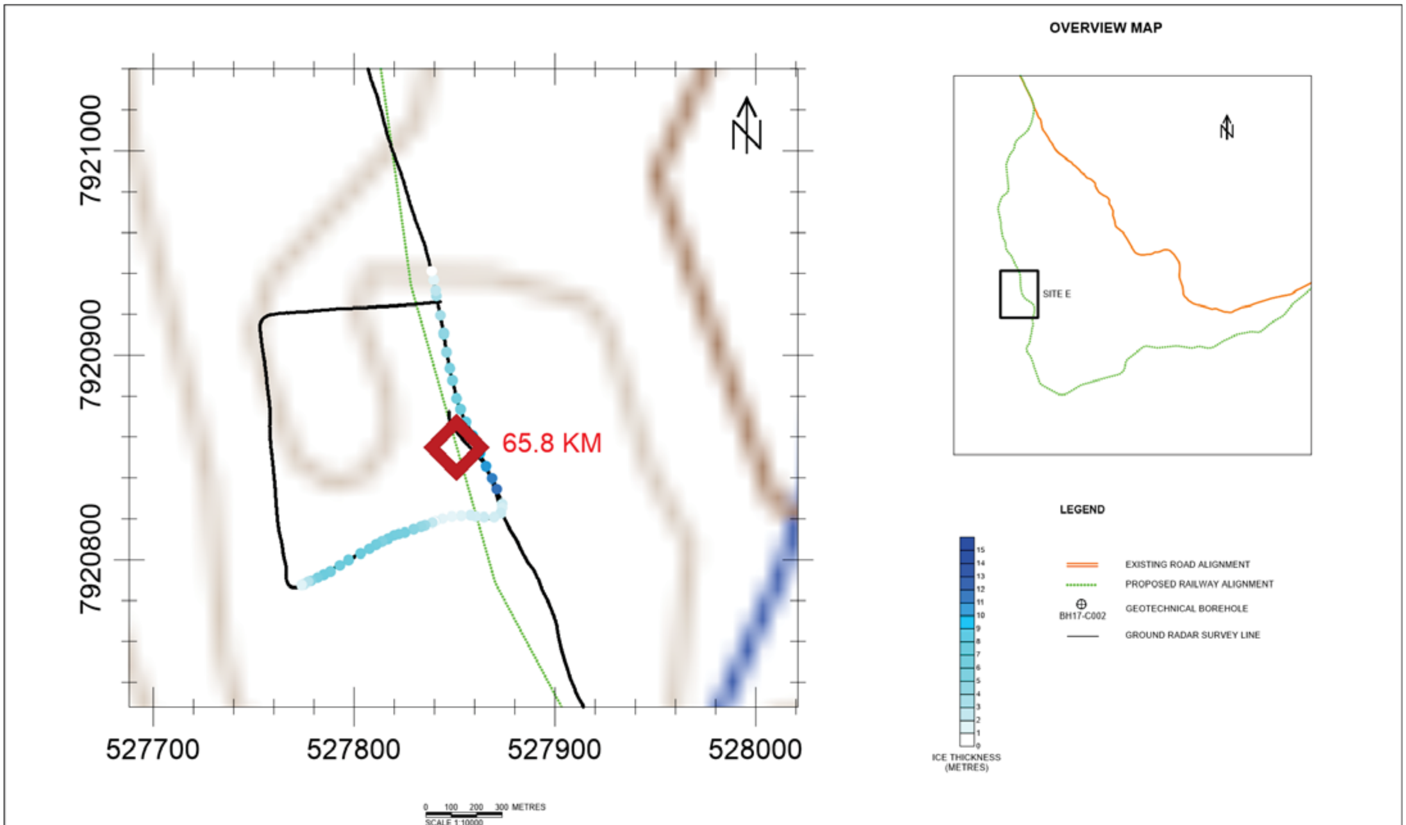
HATCH

PROJET / PROJECT
BAFFINLAND EXPANSION

TITRE / TITLE
GROUND RADAR SURVEY
GPR18 - SITE D



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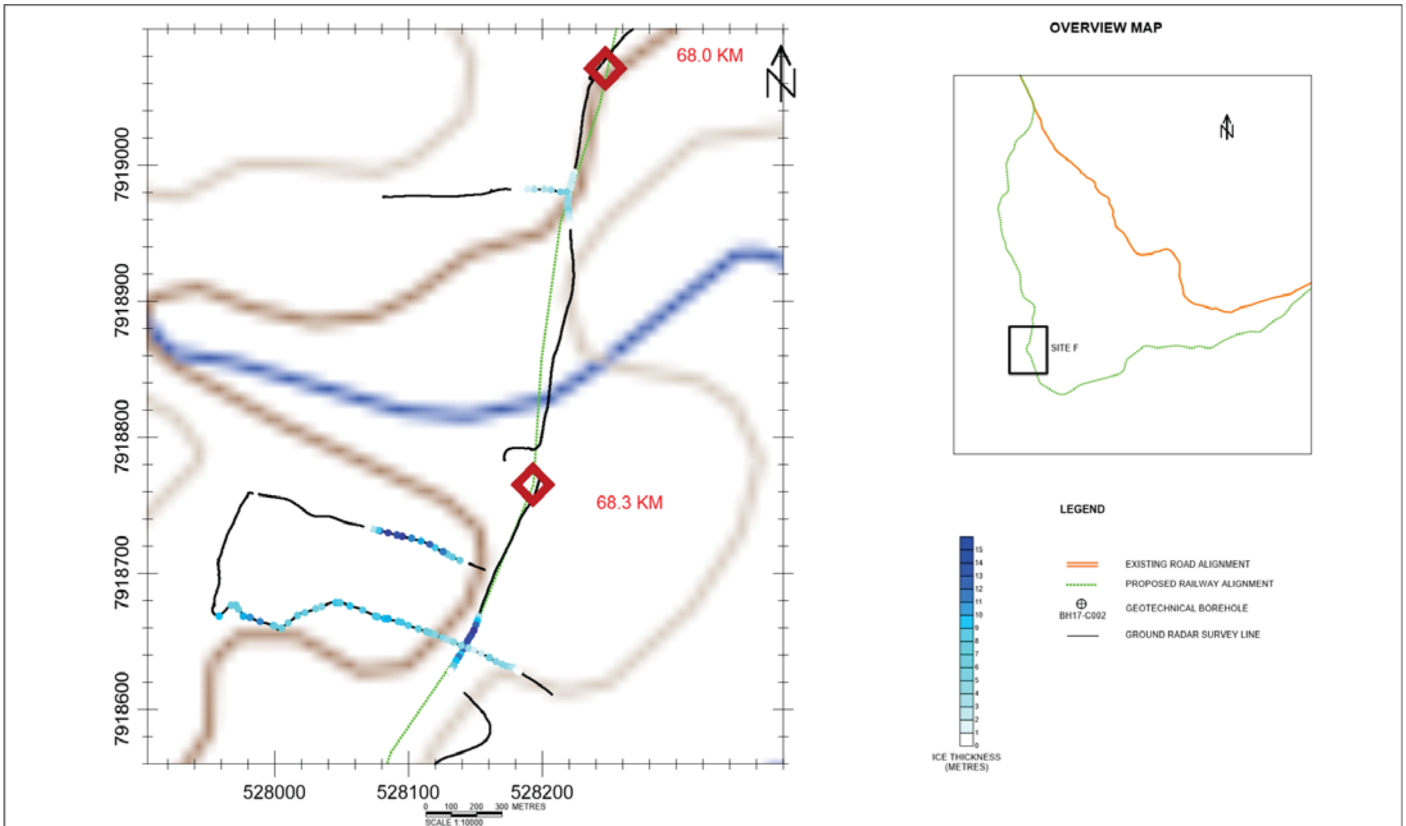
APPROUVÉ PAR / APPROVED BY: M. Situm, P. Geo
CONTRAT / CONTRACT #: T17001
ÉCHELLE / SCALE: AS SHOWN
DESSIN / DRAWING #: 001-A2-3

CLIENT: HATCH
PROJET / PROJECT: BAFFINLAND EXPANSION
TITRE / TITLE: GROUND RADAR SURVEY GPR18 - SITE E



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APPROUVÉ PAR / APPROVED BY: M. Blum, P. Geo
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DESSIN / DRAWING #: 001-A2-3

CLIENT: HATCH
PROJET / PROJECT: BAFFINLAND EXPANSION
TITRE / TITLE: GROUND RADAR SURVEY GPR18 - SITE F

APPENDIX B

Additional Georadar information

GUIDELINEGEO

MALÅ GroundExplorer

GROUND PENETRATING RADAR

GPR with exceptional range and resolution

MALÅ GroundExplorer (GX) is an integrated GPR solution with four MALÅ GX antenna options: GX80, GX160, GX450 and GX750. Through unique hyperstacking HDR technology, MALÅ GX offers significantly faster data acquisition rates, with outstanding signal-to-noise ratio and depth penetration. An easy-to-use GPR solution on a rugged platform, with excellent detection capabilities for a wide range of applications.

MALÅ GX CONTROLLER

Processor	1.6 GHz Intel Atom
Display	1024 x 768 mm
OS	Linux
Memory	8 GB compact Flash memory
Data output resolution	32 bit
Comms	Ethernet, WiFi (optional), USB 3.0, RS232 (serial)
GPS	Integrated support for built-in GPS, or external GPS via USB/serial port (NMEA 0183 protocol)
Power supply	Internal 12V/20.8 Ah Li-Ion battery, or any external 10-15 V DC source
Charger	Internal. Unit can also be charged from any external 12 - 15 V DC source
Power consumption	1.3 – 2.0 A
Operating time	8 – 10 h
Dimensions	326 x 216 x 92 mm including handles 326 x 216 x 52 mm excluding handles
Weight	3.2 kg
Operating temp	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

GX WIFI OPTION

Wireless standard:	IEEE802.11 g
Power consumption:	0,3 A

MALÅ

MALÅ GX ANTENNAS

MALÅ GX750 HDR

Technology	MALÅ Semi-Real- Time pat pending
Antenna center freq.	750 MHz
SNR	97 dB
No. of bits	16 bit
Scans/second	> 1290, time window 75 ns
Survey speed	460 [km/h] point distance 10 cm
Bandwidth	120%, fractional, -10 dB
Time window	75 ns
Positioning	Built-in DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	375 x 235 x 170 mm
Weight	3.6 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX450 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	450 MHz
SNR	101 dB
No. of bits	> 16 bit
Scans/second	> 770, time window 300 ns
Survey speed	275 [km/h] point distance 10 cm
Bandwidth	>120%, fractional, -10 dB
Time window	300 ns
Positioning	Inbuilt DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	430 x 360 x 180 mm
Weight	5.5 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX160 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	160 MHz
SNR	> 107 dB
No. of bits	> 17 bit
Scans/second	> 880, time window 625 ns
Survey speed	320 [km/h] point distance 10 cm
Bandwidth	>120 %, fractional, -10 dB
Time window	625 ns
Positioning	Inbuilt DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	720 x 480 x 190 mm
Weight	10.7 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

MALÅ GX80 HDR

Technology	MALÅ Semi-Real-Time pat pending
Antenna center freq.	80 MHz
SNR	> 114.4 dB
No. of bits	> 19 bit
Scans/second	> 1200, time window 812 ns
Survey speed	430 [km/h] point distance 10 cm
Bandwidth	>120 %, fractional, -10 dB
Time window	812 ns
Positioning	Built-in DGPS, external GPS (NMEA 0183 protocol), wheel encoder
Operating time	5 h
Power supply	Interchangeable 12 V Li-Ion batt. or ext. 12 V DC source
Power consumption	1.3 A
Acq. mode	Wheel, time or manual
Dimensions	1010 x 780 x 220 mm
Weight	24,6 kg
Operating temp.	- 20° to + 50° C or 0° to 120° F
Environmental	IP 65

ABEM | MALÅ

Guideline Geo *is a world-leader in geophysics and geo-technology offering sensors, software, services and support necessary to map and visualize the subsurface. Guideline Geo operates in four international market areas: Infrastructure – examination at start-up and maintenance of infrastructure, Environment – survey of environmental risks and geological hazards, Water – mapping and survey of water supplies and Minerals – efficient exploration. Our offices and regional partners serve clients in 121 countries. The Guideline Geo AB share (GGEO) is listed on NGM Equity.*

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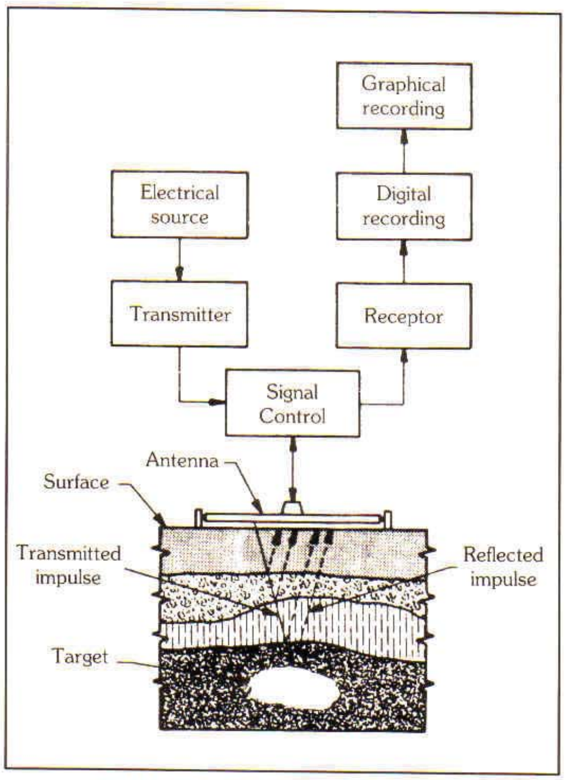
GEOPHYSICS G P R INTERNATIONAL INC.

GEORADAR

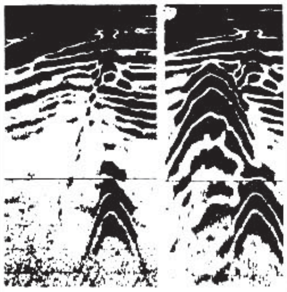
As indicated by its name, georadar combines high resolution radar with geology. The underlying principle is based on the propagation of electromagnetic wave impulses (VHF) that are reflected by anomalies in the terrain (joints, irregularities, interfaces, etc.) at different depths, and then captured by the antenna. The georadar records the time taken by each transmitted signal to complete the cycle in order to calculate the depth of the anomaly. The result is similar to a seismic reflection profile where all the reflections are displayed graphically. This technique is used to solve problems for which there had previously been no practical solution.



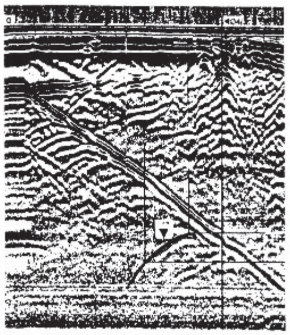
PRINCIPLES OF GEORADAR

FEATURES

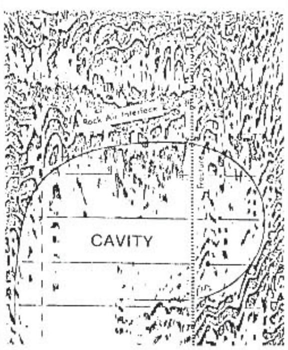
- Penetration of more than 20 metres in certain materials (penetration being inversely proportional to conductivity).
- Surveying in continuous mode.
- Identification of objects measuring only a few centimeters.
- Light and manoeuvrable equipment.
- Detection of conductivity, open spaces and/or holes (cavities).
- Detection of breaks: faults, fractures, joints, cavities.
- Results similar to seismic reflection: continuous underground profile.
- Results available immediately.
- Can be used in land, sea or airborne surveys.



PIPES



JOINTS



CAVITIES

FIELDS OF APPLICATION

Civil Engineering / Mining Exploration-Exploitation / Research / Archaeology / Environment

- Geotechnology: investigation of soils and surface deposits.
- Optimal selection of anchor bolts in mines and quarries.
- Detection of buried pipes before beginning excavation.
- Detection of liquid or gas leakage in soils.
- Detection of cracks in concrete structures.
- Checking material homogeneity.
- Detection of cavities beneath road pavement.
- Determination of water saturation level.
- Detection of girders in reinforced concrete.
- Detection of pollutant leakage in water bodies.
- Inspection of buried disposal sites and or dangerous deposits.
- Continuous measurement of ice thickness.
- Archaeological research: ancient foundations, artifacts.
- Non-destructive method for measuring road pavement thickness.
- Localization and measurement of soil's thickness (swamps, peat bogs).
- Determination of rock beddings (location and thickness).
- Bathymetric studies (depth sounding).
- Calculation of the thickness of permafrost and ice.
- Geotechnical studies for the installation of aqueducts.

SPECIAL FEATURES

The equipment is practical, easy to manoeuvre, and multi-faceted. The field of application of georadar continues to expand in various sectors, particularly in geotechnology (aqueducts), civil engineering (excavation, structures) and mining (structures).

GEOPHYSICS G P R INTERNATIONAL INC.